Human Biology - Ecology

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The Program in Human Biology,
Stanford University, (HumBio)

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AUTHORS
The Program in Human Biology, Stanford University, (HumBio)

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Chapter 1 Introduction to Ecology

Contents

Authors

H. Craig Heller, Principal Investigator

Mary L. Kiely, Project Director

Text Author

Robert B. Blair

Activity Authors

Heidi Ballard, Susan E. Schultz, Geraldine Horsma, Marjorie Gray

Project Editor

Dennis McKee

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Editorial

Steve Mico, Leslie Morrison, Susan Zeitner

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CHAPTER 2 You and the Environment - Student Edition (Human Biology)

What is your environment and how is it related to ecology?

What is your environment? Does it include only natural things? Does it include things that people make? Are there living things like houseplants and spiders in your environment? Does it include only things that wiggle, bite, and grow? Or does it include other things, too-things that don't wiggle, bite, and grow-things such as rocks, sunshine, and water? So what is your environment, anyway? This section, as well as the entire unit that follows, is going to help you learn about the environment all around you.

"The beauty of nature includes all that is called beautiful, as its flowers; and all that is not called beautiful, as its stalk and roots."

John Burroughs, quoted in *The Earth Speaks.*

Your **environment** (in-VI-ren-ment) includes everything outside your body that affects you or that you affect. It may include your friend, your neighbor, the walls of your home, the water in the school's water fountains, birds and insects you see on your way to school, the concrete in the roads, and the trees and plants in your neighborhood. Your environment includes all of these things and thousands of others.

Did You Know?

The word *affect* is a verb meaning "to bring about change." The word *effect* is a noun that refers to the change itself. Therefore, when you affect something you cause an effect!

Scientists usually divide things in the environment into two groups called **biotic** factors and **abiotic** factors. Biotic factors in the environment are those things that are alive or were recently alive. For example, biotic factors include such things as you, your favorite tree, the neighbor's dog, the grass in the cracks of the sidewalk, fallen leaves, and the fly that just buzzed by. Abiotic factors, on the other hand, are things that have never been alive. Abiotic factors include such things as rain, sunshine, rocks, soil, water that runs in a stream, the glass you use for a refreshing drink of water, and the air that rustles the leaves in the trees.

Apply Your KNOWLEDGE

Name something that was once alive but has now been dead for thousands (or even millions) of years? Explain why you think it would be considered a biotic factor or an abiotic factor now.

How do you think we've learned so much about the environment? Scientists called **ecologists** (ee-KAHL-ah-jists) study the environment and try to figure out how it works. Ecologists investigate how biotic factors affect one another. For example, these scientists may observe how salmon swim upstream to reproduce and how grizzly bears wait at waterfalls for their salmon dinner. Ecologists also think about how abiotic factors affect biotic ones. For example, they may study how a drought kills plants that need a lot of water, but allows plants that don't need a lot of water to thrive. Ecologists also investigate what effect the pollution of abiotic factors such as water have on biotic factors such as people. In general, ecologists study where **organisms** (OR-ga-niz-ems) are found, why they are found there, how many there are, what factors bring this about, how they interact with their environment, and how their environment interacts with them.

What Do You Think?

Would you consider a career studying the environment? Why or why not? Find out about some of those careers and imagine yourself in ten years with one of those careers.

Journal Writing

You are an ecologist. Write about a typical day in your life as you study plants, animals, and their interactions with their environment and each other.

Journal Writing

Why should we study ecology?

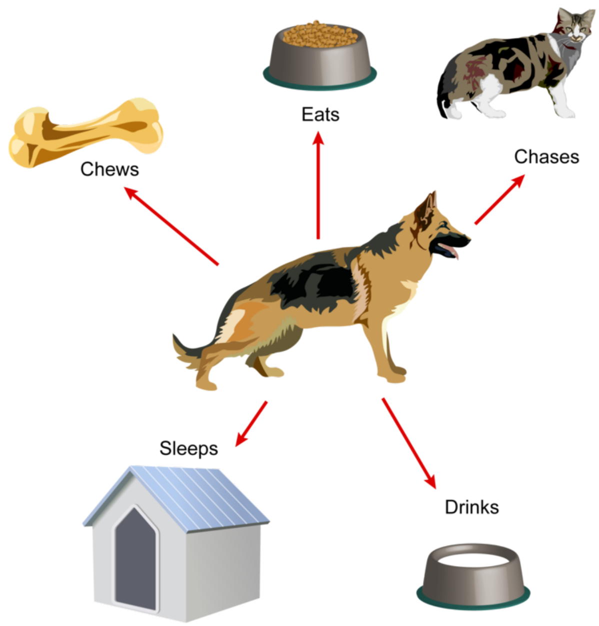


Figure 1.1 What is important for a dog to have in its environment?

Activity 1-1: Map Your Environment!

Introduction

You are an important part of your environment just as much as any other animal is. You affect biotic and abiotic factors just as they affect you. In this activity you draw a map to analyze how you are connected to various parts of your environment.

Materials

- 1 Piece of butcher paper or other large piece of paper
- Colored marking pens, pencils, or crayons
- Activity Report

Procedure

Step 1 Draw a self-portrait in the middle of the piece of large paper.

Step 2 Think about all the biotic and abiotic factors you can that are in your environment. List the factors on your Activity Report. Around your picture write the names of the six most important biotic factors in your environment and draw them. Then do the same for the six most important abiotic factors.

Step 3 Draw lines to show the connections between you and the different factors in your environment. Use one color to represent connections to biotic factors and a different color to represent connections to abiotic factors. Label each line with a word that describes how you interact with that factor. (Hint: Look at **Figure 1.1**. The illustration shows the factors that are important to a dog.)

Step 4 Use another color to draw lines between factors that are connected with each other.

Step 5 Consider these questions and write responses to them on your Activity Report.

- Which of these factors is the most important to you?
- Which factors, if any, could you live without?

Step 6 Compare your finished map with those of your classmates, and write responses to them on your Activity Report.

- What factors in your environment do you have in common?
- How are your environmental factors similar? How are they different?

What do you think?

Consider the factors you found to be important in your environment. How do you think these factors differ from those of a student who lives in a village in the Brazilian rain forest, in a Japanese city, and near the Sahara Desert?

Review Questions

1. What is your environment?
2. What is the difference between a biotic and an abiotic factor? Give three examples of each that are not mentioned in this book.
3. What are ecologists and what do they do?

CHAPTER 3 Food Chains: How Energy Gets to You - Student Edition (Human Biology)

Where do you get the energy to live?

Grass grows. Dogs run and bark. Birds sing. Maybe you sing, too. You think and read, run and play, and go to school. But where do you think living things get the energy to do everything they do? Let's start with how energy works in your body. Everything you do is a chain reaction of events. Moving your finger, scratching an itch, and even reading this page is the result of a series of actions that begins in your brain.

"Each living thing is a spark of sunlight energy, a crystal bead in the net of life."

Steve Van Matre, *The Earth Speaks*

Suppose you want to move your finger. The action starts with an idea-"I want to move my finger."

Figure 2.1 The action starts in your brain.

Then your brain sends the message to move your finger. The message travels through your nervous system. When the message reaches your finger, tiny structures called filaments deep inside your muscles contract. The contractions move your finger.

What allows this chain of events to take place? Energy makes everything happen. Energy is what moved the message from the brain to the finger-and moved the finger. Your body gets energy from the food you eat. Food also provides minerals and vitamins that help your cells work properly. Your digestive system processes the food you eat and drink into tiny molecules sent to every cell in your body. Let's see how the breakfast you eat is broken down and transported from your mouth to the cells in your body.

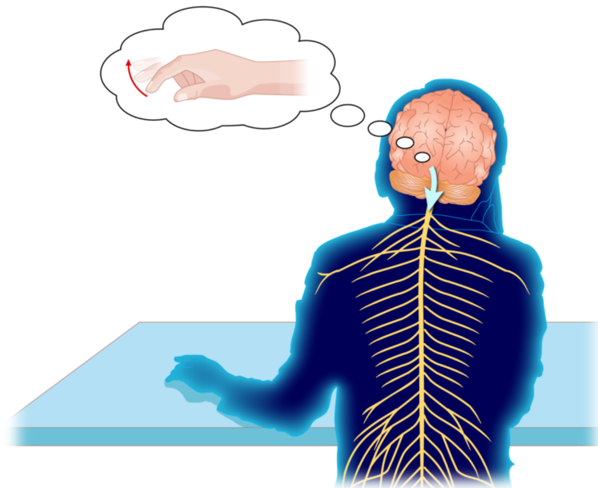


Figure 2.2 The brain sends the message.

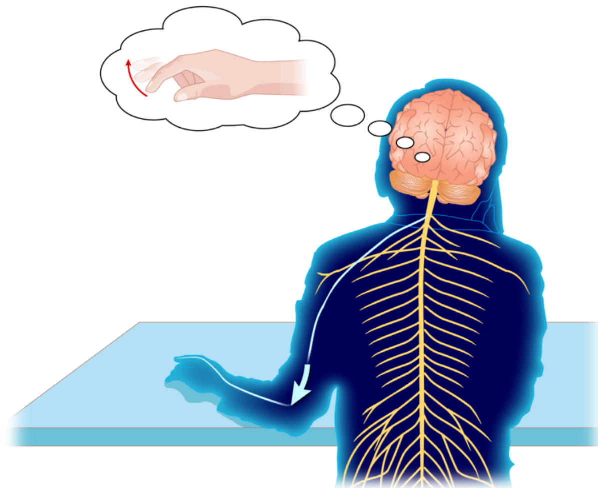


Figure 2.3 The message reaches your finger and the muscles contract.

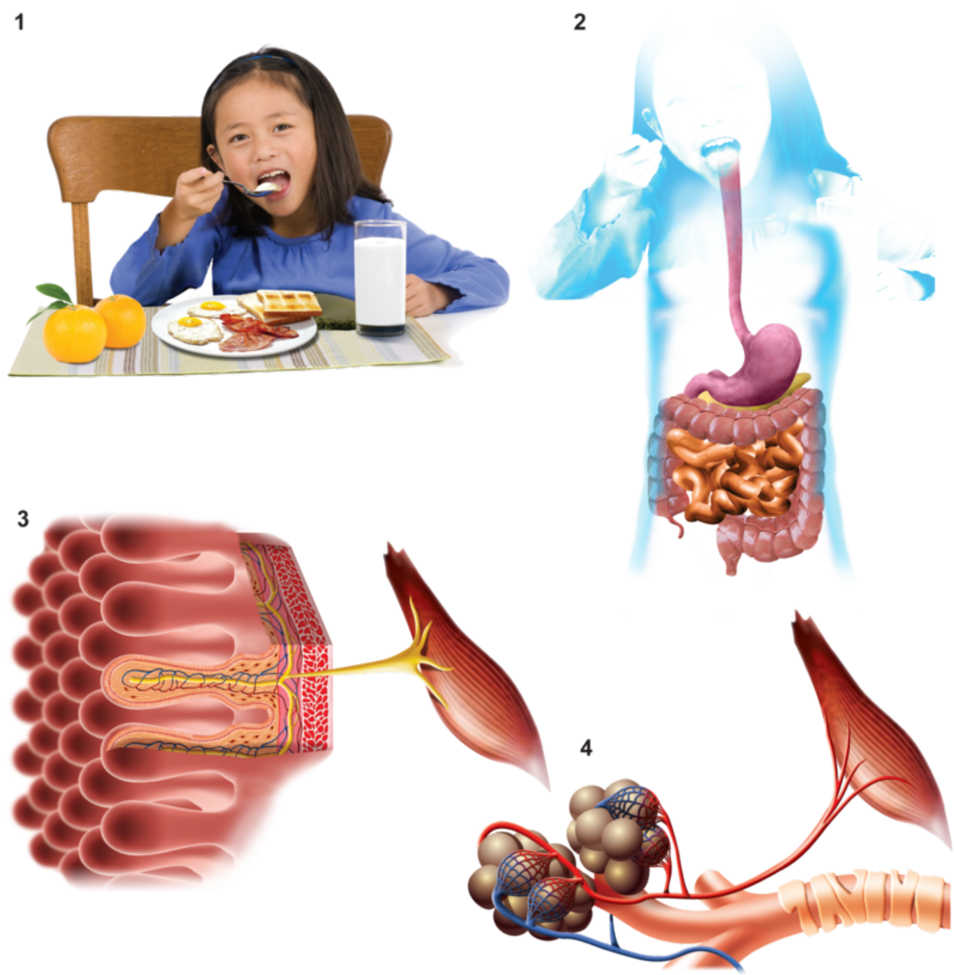


Figure 2.4 Your body obtains energy from two main ingredients-food and oxygen.

a. You start the day with a healthy breakfast-maybe a couple of eggs, a piece of toast, some fruit, and a glass of milk.
b. The food travels into your stomach and intestines. There it is broken down into smaller and smaller bits such as sugars and other molecules your cells need.
c. Blood traveling through your stomach and intestines picks up these molecules and takes them to your muscle cells. There they are absorbed.
d. At the same time, your blood picks up oxygen from your lungs and delivers it to cells in your muscles. So oxygen and the molecules from food get to your cells.

Tiny bits of the food you ate break down into a simple sugar called glucose. In your cells, energy from the sugar is released when oxygen and glucose combine in a reaction. The reaction produces water, carbon dioxide, and energy in the form of ATP. This chemical process is happening all the time in your cells. The chemical process is called **aerobic respiration** (ayr-ROH-bik res-pur-AY-shun).

Did You Know?

Aerobic means "with oxygen." Aerobic exercise refers to exercise in which your muscles are getting enough oxygen. When your muscle cells don't have enough oxygen, they get energy by a process that produces acidic wastes. These acidic wastes can give you a muscle cramp!

The process of aerobic respiration can be written like this.

Oxygen + Glucose → Carbon dioxide + Water + Energy

Or it can be written like this.

$6O_2 + C_6H_{12}O_6 \rightarrow 6\ CO_2 + 6H_2O + 36ATP$

Did You Know?

The symbol for carbon dioxide is CO_2 .

The symbol for water is H_2O .

So your cells obtain energy when sugar and oxygen react in a specific way. But you probably noticed the reaction produces carbon dioxide and water, too. You know what water is. And you know that water is very important to living things. But did you also know that two-thirds of your body is water? You exhale water as a vapor when you breathe. You can see the exhaled water vapor when it's chilly. You perspire excess water produced in your cells when you exercise. And you also get rid of excess water when you urinate.

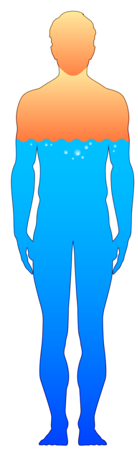


Figure 2.5 About $\frac{2}{3}$ of the human body is water! But don't be confused by the drawing. You are not like a glass that fills from the bottom to the top. Instead, the water is distributed throughout your body.

The other product from the reaction of sugar and oxygen is carbon dioxide (CO_2) . There is a lot of CO_2 in the air you exhale. You and other animals need to get rid of CO_2 because it is a waste product of aerobic respiration. However, plants need CO_2 to live and they absorb it easily.

The energy released when sugar reacts with oxygen can't just bounce around. It has to be stored somewhere. The energy is stored in a chemical compound called ATP (or Adenosine Triphosphate). Your cells can make ATP molecules. When you eat, you provide sugar for your cells. When you breathe, you provide oxygen for your cells. In your cells, the sugar and oxygen combine and the energy released is stored in bonds that hold the atoms together in molecules of ATP. ATP is not energy itself. It is a storage place for energy. When energy is needed to do something, your cells break down ATP and the stored energy is used. For example, your cells break down ATP to get the energy to move a finger.

Did You Know?

You may be familiar with CO_2 as the gas that puts the fizz in soft drinks.

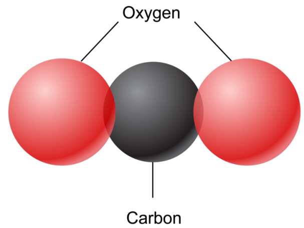


Figure 2.6 A carbon dioxide molecule, CO_2 , is made up of one atom of carbon and two atoms of oxygen. A water molecule, H_2O , is made up of one atom of hydrogen and two atoms of oxygen. Bonds hold the atoms together. And energy is stored in those bonds.

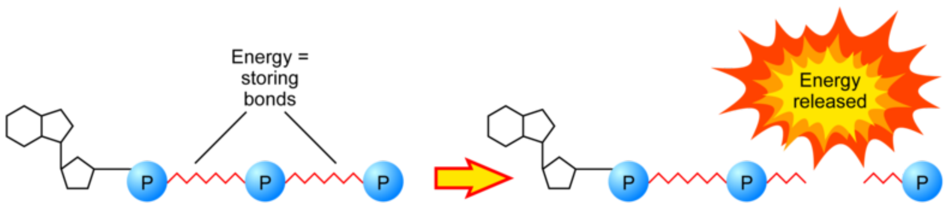


Figure 2.7 ATP is a molecule that stores energy in cells. Cells use the energy released when ATP breaks apart.

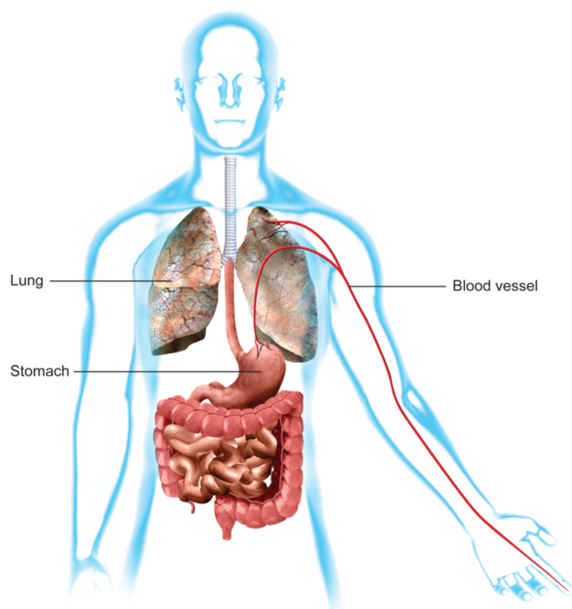


Figure 2.8 Trace the path by which the energy in food is transported from your mouth to your finger so that your finger can move.

Okay, now you know that your body needs food to produce energy. But where does the food you eat get the energy that it passes along to you? Let's think back to breakfast and those eggs. The eggs came from a chicken. The chicken needed energy to produce and lay the eggs. To get that energy, the chicken ate something, too. If it was a free-range chicken, it might have eaten a grasshopper that jumped into its barnyard. As the chicken digested the grasshopper, the chicken's circulatory system carried tiny food molecules and oxygen to the chicken's cells to make ATP for energy. This process is like the one taking place in your body that you read about earlier.

Journal Writing

Think about the last time you were exercising so hard that you were panting and gasping for breath. Describe what it felt like in your mouth, your throat, your chest and lungs. Now describe what you imagine is happening to the oxygen and carbon dioxide as it moves in and out of your body.

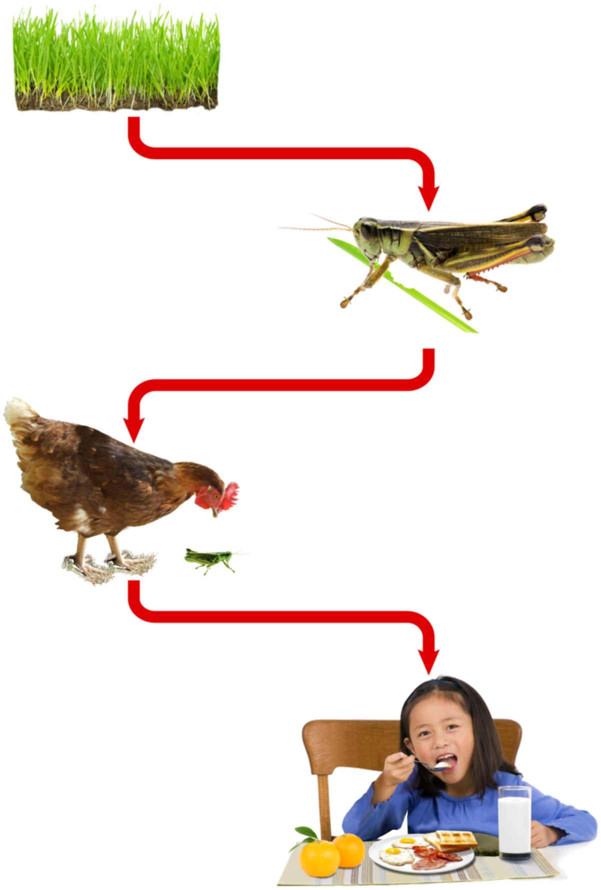


Figure 2.9 Energy is passed from organism to organism in the form of food.

Did You Know?

Plants capture sunlight with colored pigments the most common of which is green chlorophyll. However, some algae and bacteria use pigments that are blue, red, brown, and even yellow!

So the chicken ate the grasshopper. But where did the grasshopper get the energy to live, grow, and hop into that barnyard? The grasshopper ate something that was full of energy, too, such as grass or leaves. As you can probably see, there is no simple answer to the question, "Where did you get the energy to move your finger?" The energy came from the egg that came from the chicken, which ate the grasshopper, which ate the grass. But we still don't have an answer to the question, because the story doesn't end with the grass. Grass can't grow without energy. Where did the grass get the energy that was passed on to the grasshopper?

Apply Your KNOWLEDGE

If oxygen and sugar are the only things required to provide energy to move our muscles, why do we bother to eat other foods? Why do you think we eat other foods, such as potatoes, pasta, meat, ice cream, pizza, and spinach?

Photosynthesis

Grass is not like you, the chicken, or the grasshopper. Grass can't eat something to get the energy it needs to grow. Grass has to get the energy it needs in another way. Like other plants, grass captures energy from the sun by a process called **photosynthesis** (foh-toh-SIN-thuhsis). In photosynthesis, a plant uses sunlight, water, and carbon dioxide to produce sugar and oxygen. Now read that sentence again. Then read this sentence: Your cells use sugar and oxygen to produce energy, carbon dioxide, and water. How do you think those two processes relate to each other?

What Do You Think?

You might say that you have the energy to wiggle your finger because the sun shines. Read the quote from Steve Van Matre again: "Each living thing is a spark of sunlight energy, a crystal bead in the net of life."

What do you think the author meant when he wrote that sentence?

Mini-Activity

Photosynthesis and Respiration Play Put on a play about photosynthesis and respiration. Brainstorm a list of roles. People will need to play the roles of the "Sun," "Sugar," and "Carbon Dioxide." Think of other roles in the processes of photosynthesis and aerobic respiration. Write a script. Design and create signs, props, or costumes so that the audience knows what each person represents. Now act out the play!

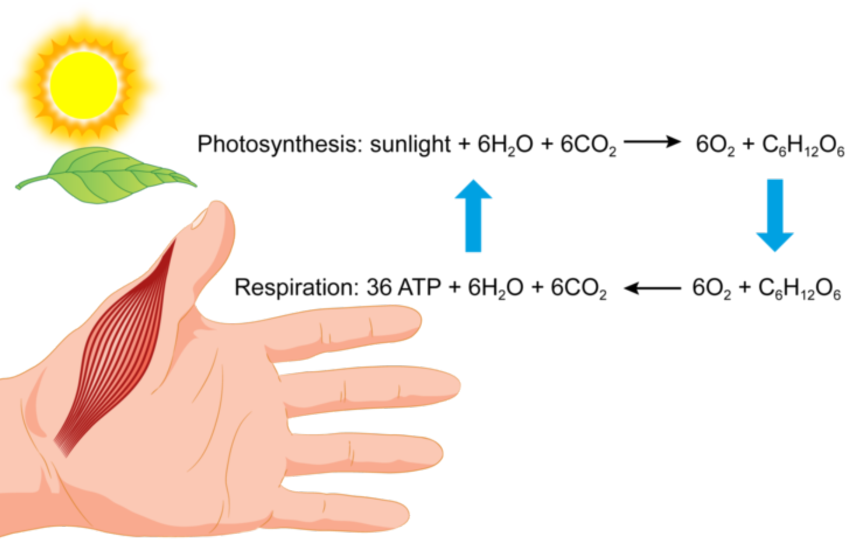


Figure 2.10 Notice the connection between photosynthesis and respiration. Can you find a beginning or end in this cycle?

Photosynthesis uses energy to make sugar and oxygen. Aerobic respiration uses sugar and oxygen to make energy. Photosynthesis is the opposite of aerobic respiration. Plants produce what animals need. Animals produce what plants need. Follow this cycle shown in **Figure 2.10**.

Apply Your KNOWLEDGE

- **During what parts of the day does respiration occur in a plant cell? Explain your reasoning.**

- **Can plants photosynthesize in the dark? Explain your answer.**
- **Give an example of energy used by a living organism that cannot be traced back to the sun.**

We began this section by asking how you get the energy you need to move your finger. Now you know that the energy that moves the muscles in your finger passes through a long chain of organisms and events. You got the energy by eating food such as an egg that came from an organism, which ate another organism, which ate a plant that captured the sun's energy through photosynthesis. Ecologists call this series of events a **food chain.** A food chain is a description of the path by which energy gets from the sun to an animal so that it can move, grow, and reproduce. The food chain in **Figure 2.11** is just one of the possible food chains that leads to you!

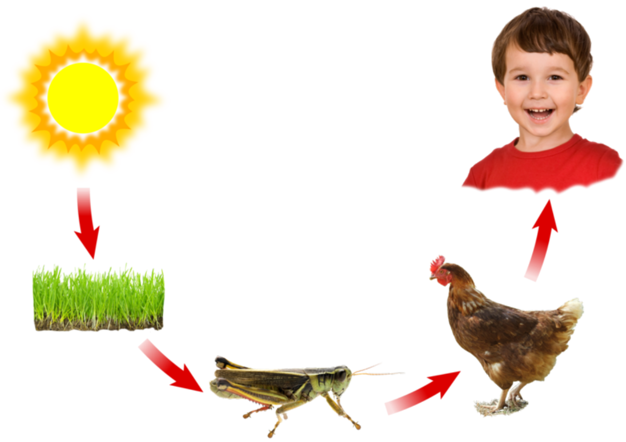


Figure 2.11 Trace the movement of energy through this food chain.

Activity 2-1: Draw a Food Chain

Introduction

What is the source of energy in your breakfast? One way that you are connected to various parts of your environment is by the many different organisms that provide you with the energy in food. In this activity you analyze what organisms contributed to your breakfast by creating a food chain. You also create a food chain based on the breakfast of a bird of prey.

Materials

- Colored marking pens, pencils, or crayons
- Paper
- Activity Report

Procedure

Step 1 Make a list of all the things you ate for breakfast this morning. If you didn't eat much, use a big breakfast that you have eaten recently. Try to include something that came from an animal-such as bacon or milk. Write your list on your Activity Report.

Step 2 Draw yourself at the top of your paper eating breakfast. Pick a food item that came from an animal and draw it under your picture. Draw the plant or animal that was the source of the food under the breakfast item. Then determine where that plant or animal got its energy. Was it from another animal, a plant, or the sun? Draw its source of energy. Continue doing this until you trace the original source of energy in the food chain back to the sun.

Step 3 Follow Step 2 as you determine and draw the steps to the sun for each item that you ate for breakfast. (Hint: Take a look at **Figure 2.11**.)

Step 4 Look at **Figure 2.12** to see one kind of food a Peregrine falcon and a Golden eagle eat. Follow Step 2 as you draw a food chain leading up to a bird of prey of your choice. You can use the birds in **Figure 2.12** or another one you may know about such as an owl, pelican, or hawk. List the foods your chosen bird might eat. Then list, on your Activity Report, the foods each of the prey might eat.

Step 5 How many steps are in each of your food chains? Which food chain that you drew has the most steps? Write your answers on your Activity Report.

Apply Your KNOWLEDGE

Long ago, when the land was beginning to be inhabited by living organisms, which do you think came first-animals or plants? Explain your answer.

Figure 2.12 Golden eagles (top left) and owls (top right) are birds of prey that capture and eat small animals.

Did You Know?

Golden eagles are relatives of the bald eagle. They live throughout much of the United States but are more common in the west. These eagles favor open habitats and feed on small mammals, snakes, and dead animals. They have been protected since 1962. Before they were protected, more than 20,000 eagles had been killed in the previous ten years by sheep ranchers. These ranchers mistakenly thought that the eagles attacked their livestock. Currently, golden eagles are threatened. Many are killed by power lines and by poisoned bait intended for coyotes.

Review Questions

1. Where do cells get their energy?
2. What process do plants use to capture the sun's energy?
3. How are respiration and photosynthesis related?
4. Where do plants get their energy? Where do animals get their energy?
5. What is the original source of almost all energy used by living things?
6. What is a food chain?

CHAPTER 4 Energy Flow in a Community - Student Edition (Human Biology)

CHAPTER OUTLINE

4.1 Energy Flow in a Community

How does energy flow through a biological community?

Now that you can trace the path energy takes from your breakfast to your muscles, let's think about how energy flows on a larger scale. This section will introduce you to the movement of energy throughout a **biological community**. You will explore the different ways organisms get their energy.

"At the junction of every pair of threads in this net of life there is a crystal bead, and each crystal bead is a living thing, shining forth with its own glow, its own radiance into space. And the glow of every crystal bead in the net of life reflects the glow of every other bead."

Steve Van Matre

The Earth Speaks

Energy moves through biological communities, keeping the organisms alive and functioning. But keep this in mind: An energy pathway isn't 100 percent efficient. Little bits of energy are lost along the way.

Single food chains, such as the ones described in *Food Chains: How Energy Gets to You*, show only one type of path that energy can take from the sun to an organism. There are many different types of paths energy can follow. Think about the food chain shown in **Figure 2.11**. You eat many other things besides eggs for breakfast, lunch, and dinner. And free-range chickens eat more than just the occasional grasshopper that jumps into the barnyard. You get energy from many different sources, and so does the chicken. By putting food chains together, you create a **food web**. A food web shows the important links between connected food chains. Food webs show a more accurate picture of how energy is passed around in the real world than one food chain does.

Mini-Activity

Draw Your Community List the ten people you consider to be the most important members of your community. Explain why you think each is important and how they interact within your community. Draw a picture or create a collage showing how these people interact to support your community.

Communities

What does the word *community* mean to you? Many people think of a community as all the people they see on a daily or weekly basis. These people might be family, neighbors, friends, teachers, mail carriers, police officers, and other people who live or work in a certain area. As a matter of fact, a **human community** does consist of all of the people who live around you and help you live where you do.

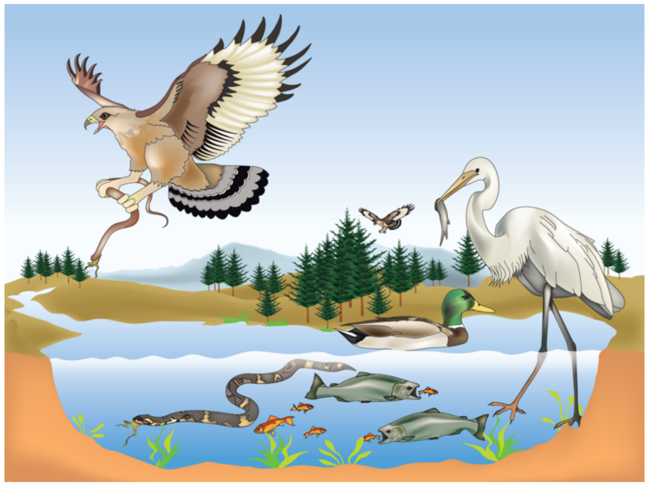


Figure 3.1 Who eats whom in this pond community?

Mini-Activity

Draw the Community of a Largemouth Bass Think of ten things that belong in the community of a largemouth bass. Draw a picture of the community showing each part of the food web.

Imagine you are an organism that lives in the pond. You can be the largemouth bass, the algae on the surface of the pond, the crawfish, or any organism you decide to be. When you decide which organism you want to pretend to be, write a story or poem about a day in your life in the community.

However, ecologists think of a community in a slightly different way. They recognize that each organism lives in a community that includes all of the other organisms with which it interacts. For example, a frog's community includes most of the organisms that live and grow in and around the frog's pond. The frog's community includes the algae that grow on the bottom of the pond, because algae are eaten by the snails and insects that the frog eats. The frog's community might include a lily pad on which the frog rests. It might even include a great blue heron, which could eat the frog if it's not careful. The frog's community would also include all of the other organisms that the snail, insects, lily pad, and blue heron need to stay alive.

Food Webs Can Be Complicated

A food web describes how energy flows between members of a community. Tracing the specific path of one food chain can be pretty simple. For example, the person-chicken-grasshopper-grass-sun food chain is very easy to follow. However, tracing the many paths through a food web is a little more complicated. The food web connects and interconnects all of the possible food chains in a community. For example, think carefully about the chicken in our food chain example. In a food web, me chicken will eat more than an occasional grasshopper. The chicken will eat feed corn and maybe a worm brought up by a rainstorm. A fox, which has been circling the barnyard, might break in and eat the chicken. Remember the grasshopper? What else do you think it might eat besides the grass described in our simple food chain? The grasshopper might eat some of the feed corn, also eaten by the chicken, or some of the wheat grain spread in the nesting area. So as you can see, food webs can get complicated. **Figure 3.2** illustrates just the start of a barnyard food web.

Figure 3.2 This shows a very simple barnyard food web. Try to think of some other organisms that can be added to fill out this food web.

Mini-Activity

What Can You Add to the Web? Try to make the food web in **Figure 3.2** more realistic. Think of other organisms you can add to the barnyard food web started in **Figure 3.2**. List the organisms you can think of. Then draw the food web in **Figure 3.2**. Draw the other organisms you listed on your food web, and link the organisms together to show how they interact.

Food webs in the wild are usually more complicated than our barnyard example. An ecologist named R. D. Bird described a real food web of a willow forest that he studied in central Canada. Even though this food web was fairly simple, it still included several different kinds of willow trees, six different kinds of birds, various spiders, many insects, frogs, snails, and garter snakes. **Figure 3.3** is a simplified version of the web that he described. The arrows show the direction that energy flows within the system.

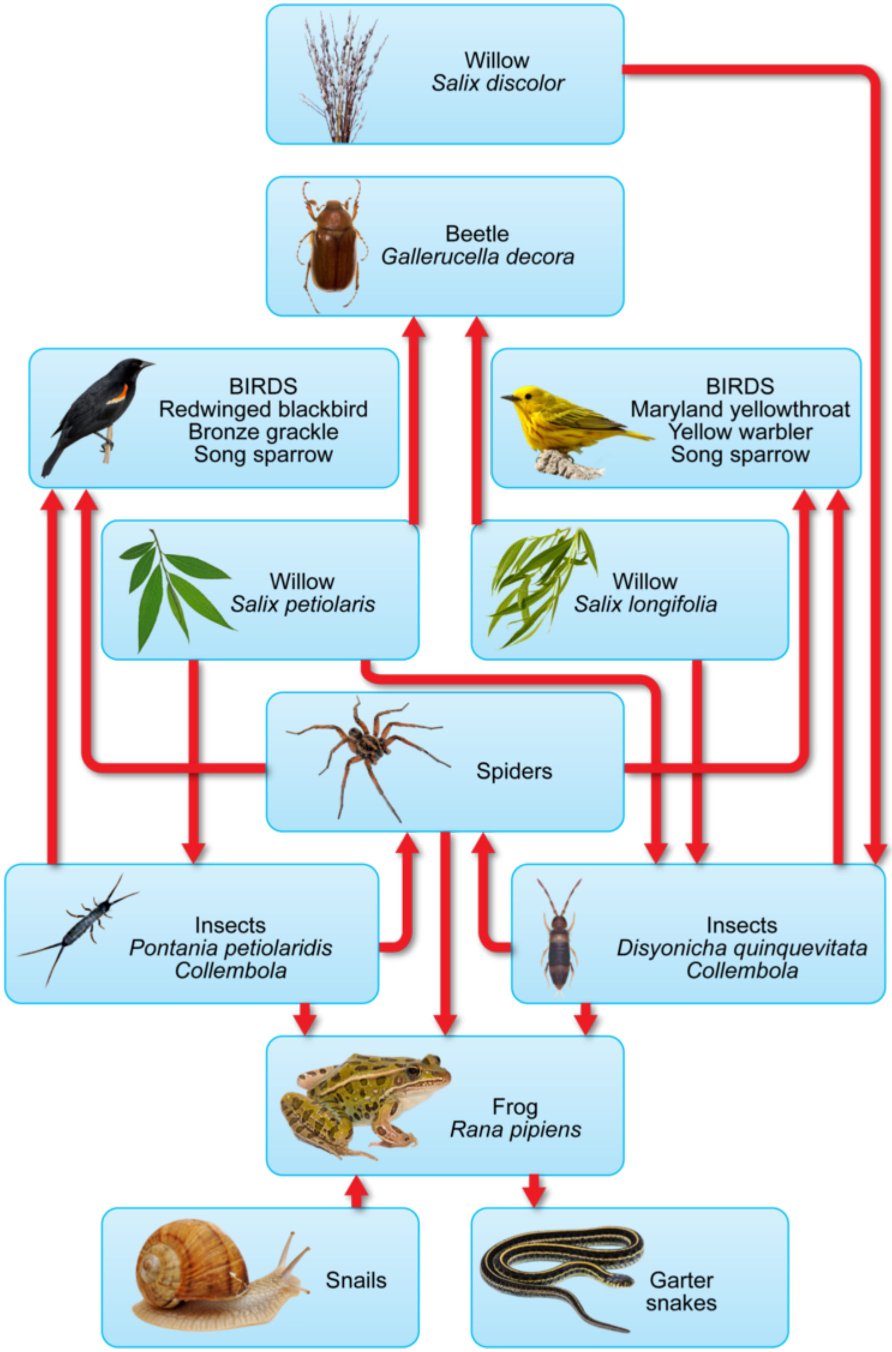


Figure 3.3 This illustration shows the organisms R. D. Bird observed and linked in the willow forest food web he studied in Central Canada.

Look at **Figure 3.3**. The energy in this picture moves in the direction the arrows are pointing. What organisms get their energy directly from the willows? Notice the word *directly* in that question before you answer it. The arrow at the top center of the willow forest food web starts at the willows and ends at the beetles. What other organisms get their energy directly from the willows? Again, notice the word *directly*. Also, notice that there are several kinds of willows.

Did You Know?

People who eat no meat, but do consume animal products such as milk and eggs are usually known as *vegetarians*. People whose diets consist only of plants with no animal products are called *vegans*.

The beetles and insects eat willow leaves in this willow forest. Now locate the frogs. Where do the frogs get their energy? What do they eat? Which organism gets energy from the frogs? After studying this food web for a little while, it sure looks like a "snake-eats-frog world"! One source of energy not shown in this food web is where the willow trees get their energy. You probably remember that the source of energy for almost all plants, including willow trees is-the sun!

Participants in a Food Web

In general, ecologists can divide organisms into two main groups on the basis of how they obtain energy. Ecologists call organisms that get their energy from the sun **producers** because they produce sugars that other organisms can eat to move, grow, and reproduce. Most producers are green plants because they capture the sun's energy through photosynthesis.

Journal Writing

Would you ever consider being a vegetarian? Why or why not? Would you ever consider being a vegan? Why or why not?

Organisms that get their energy by eating other organisms are called **consumers**. They consume the energy that is produced by other living things. Consumers can also be divided into several groups. Consumers, such as cows and rabbits, which eat only plants, are called **herbivores** (HURB-ih-vors). Some humans choose to be herbivores. Consumers, such as bald eagles or wildcats, which eat only other animals, are called **carnivores** (KARN-ih-vors). Consumers, such as blue jays and most humans, which eat both plants and animals, are called **omnivores** (OM-nih-vors). **Decomposers** are the other major group of consumers. Decomposers get the energy they need by eating the remains of organisms that are already dead. Decomposers include such organisms as worms, some snails, mushrooms, dung beetles, and vultures.

Apply Your KNOWLEDGE

List 5 foods that might be included in a vegetarian diet that would not be included in a vegan diet.

What Do You Think?

if you had your choice, would you rather be a producer, consumer, or decomposer? Why?

Energy Pyramids

As energy flows through a community, it changes form. Whenever energy changes form, some energy is lost. For example, when a light bulb changes electricity into light, the light bulb gets hot. The energy converted to heat is not converted to useful light, so it is considered lost. In the same way, a car engine changes gasoline into motion, but some of the energy in the gasoline is lost as heat. Even you lose energy. Your body changes a bowl of cereal into energy you can use to study or play. However, part of the energy in the cereal is used to keep you warm, to help you digest, and to do a lot of other chores your body does to maintain itself. Even though digesting and staying warm are important, scientists call this a loss of energy.

It's important to scientists to observe energy flow in biological communities. So ecologists study how energy flows and is lost in biological communities. In one study, a group of ecologists counted all of the producers, herbivores, and carnivores in a field of bluegrass. They found that 5,842,424 weeds and blades of grass fed 708,624, herbivores such as grasshoppers. These herbivores fed 354,904 carnivores such as spiders, ants, and beetles. The 354,904 carnivores fed the three top carnivores, such as birds and moles. The food web these ecologists studied and described forms an **ecological pyramid.** What's an ecological pyramid? First, what's a pyramid? It's a structure in which each level is made up of fewer stones than the level below. In a similar way, each layer in an ecological pyramid has fewer organisms than the level below it. In an ecological pyramid, many producers feed a few herbivores, which feed even fewer carnivores. This is shown in the bluegrass field food web. Each step up the bluegrass field food web supports many fewer individuals than the level below it.

Why do you think there are only three top carnivores in the bluegrass field and 5,842,424 grass plants?

Apply Your KNOWLEDGE

What do you think is meant by the phrase "eating low on the food chain"? Could you feed more or fewer people from the same amount of land if everyone was a herbivore or if everyone was a carnivore?

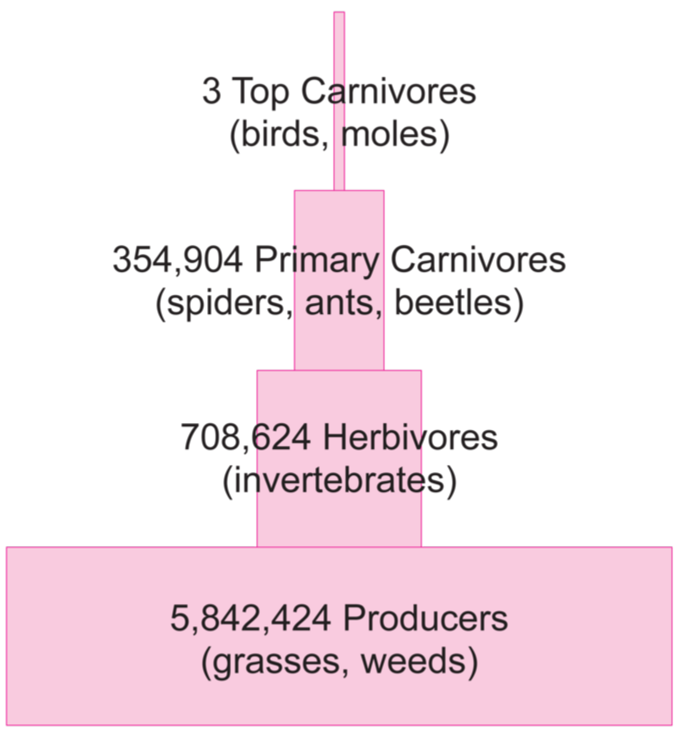


Figure 3.4 This ecological pyramid was prepared by ecologists who counted the numbers of organisms at each feeding level in a bluegrass field.

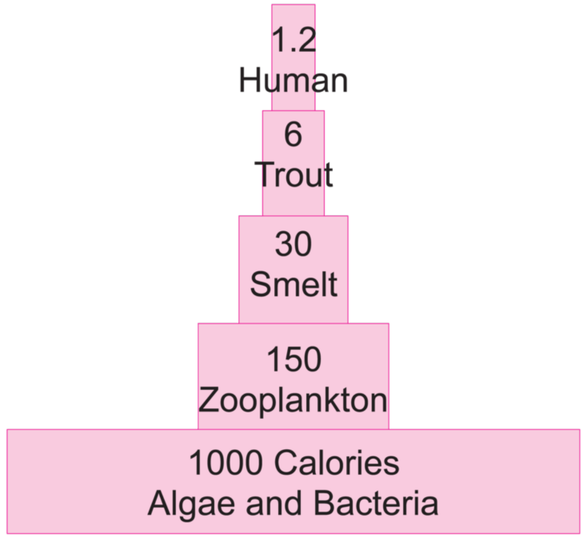


Figure 3.5 This energy pyramid explains the flow of energy in Cayuga Lake.

Energy is lost as it is transferred from one level of the community to the next. The herbivores use up nearly ninety percent of the energy they get from eating the grass. They use it up by running around, digesting, and reproducing. Only about ten percent of the energy from the grass is changed into energy that can be used by the consumers, which eat the herbivores. So only ten percent of the energy that was in the grass is available for a carnivore to eat. Generally, only about ten percent of the energy in each level of the food chain transfers to the next level. For that reason, a community usually has many more producers than herbivores, and many more herbivores than carnivores.

Counting the number of individuals in a community and observing how they fit into different food chains is one way ecologists determine energy flow in a biological community. Another method scientists use to determine the amount of energy is to measure the amount of energy passed along at each step. One way to measure energy is in units called **calories** (KAL-or-rees). One calorie is the amount of energy it takes to raise the temperature of one gram of water one degree Celsius.

Lamont Cole, a scientist at Cornell University, decided to measure the calories passed along a food chain in Cayuga Lake. He found that for every 1,000 calories produced by the algae in the lake, only 150 calories were transferred to the little herbivores called zooplankton, which ate the algae. Of the 150 calories stored in the zooplankton, only 30 calories made it into a small fish called smelt, which ate the zooplankton. Of the 30 calories that made it into the smelt, only 6 calories made it to the humans who ate the smelt. In other words, of the 1,000 calories originally found in the algae, only 6 calories reached the humans as useful energy. **Figure 3.5** shows an energy pyramid that summarizes the transferred energy in the Cayuga Lake food web Dr. Cole studied.

Apply Your KNOWLEDGE

Look at the energy pyramid in Figure 3.5**. Suppose a trout eats a smelt and then a human eats the trout. About how many of the original 1000 calories contained in the algae reach the human? How does this compare to a situation in which the human ate the smelt directly?**

Activity 3-1: Classifying the Players in a Willow Forest

Introduction

To really understand the flow of energy through a food web, it is important to classify the major players and their sources of energy. In this activity you examine the roles of organisms in the web and analyze how they relate to one another.

Materials

- Colored marking pens, pencils, or crayons
- Resource
- Activity Report

Procedure

Step 1 Look at the food web of the willow forest illustrated on your Resource. On your Activity Report, classify all of the "players" in the system as producers or consumers, using two different colored pens or different symbols. (We've left out the decomposers to make it a bit simpler.)

Step 2 Now using three other colored pens, classify the consumers as herbivores, carnivores, or omnivores. Make a key to show which color or symbol represents each classification.

Step 3 Imagine you live in the willow forest and eat only beetles and red-winged blackbirds. How would you be classified? Using the appropriate color or symbol put yourself in your classification system. Then draw yourself on your Willow Food Web Diagram.

Step 4 On your Activity Report, explain what would happen to the rest of the web if all frogs were removed.

Step 5 What do you think would happen to the web if one kind of willow tree such as the *Salix petiolaris* were removed? Explain your answer on your Activity Report.

Review Questions

1. What is a producer?
2. What is a consumer?
3. What happens to useful energy when it is transformed from one form to another?
4. What happens to the energy in an organism when that organism is eaten by another organism?
5. Draw an ecological pyramid using producers, herbivores, and carnivores.

Chapter 5 Cycling - Student Edition (Human Biology)

Chapter Outline

5.1 Cycling

Why don't natural systems run out of the materials they need?

You learned that abiotic factors are nonliving materials, such as rain, sunshine, and soil. These factors provide energy and materials that are used by living organisms in the environment. You have seen how energy flows through natural systems. Now let's take a look at how abiotic factors in the environment move through the environment and are used.

"It is always sunrise somewhere; the dew is never all dried at once; a shower is forever falling; vapor is ever rising."

John Muir

quoted in *The Earth Speaks*

Water is one of the most important abiotic factors in the environment. Maple trees put down roots so they can take up water. Largemouth bass absorb water across their skin and gills. Coast redwood trees trap water from fog with their needles. Desert kangaroo rats find water in the seeds they eat. And you get the water you need from what you eat and drink. Every living thing needs water in one form or another to stay alive

Water comes from rain or snow. But where does water go in the environment? Let's find out by investigating a sample water cycle where it rains and snows a lot. Meteorologists use the word **precipitation** (pruh-sip-ih-TAY-shun) to describe rain, sleet, hail, mist, and snow. Let's start by tracing the flow of water from a New Hampshire backyard as an example. First, it rains or snows in that backyard fairly often throughout the year. In the summer, some of the rain flows into a pond near the backyard. The pond is an example of **open water**. Other examples of open water include lakes, ponds, puddles, swamps, and marshes.

Did You Know?

Underground lakes and streams are called *aquifers.* San Antonio, Texas, is one of the largest cities in the United States to obtain much of its water from an aquifer.

Most of the precipitation that reaches the backyard soaks into the soil. This underground water is called **groundwater.** There is so much space between the soil particles that make up dirt that a lot of water can be stored in those spaces. In fact, 96 percent of the fresh water in North America is actually underground! Sometimes groundwater is near the surface of Earth and you can dig a well to reach it. Sometimes the water is too far under the ground to get at easily. If the ground surface dips below the level of the groundwater, it becomes open water. Look at Figure 4.1 to get an idea of how all of this water is interconnected.

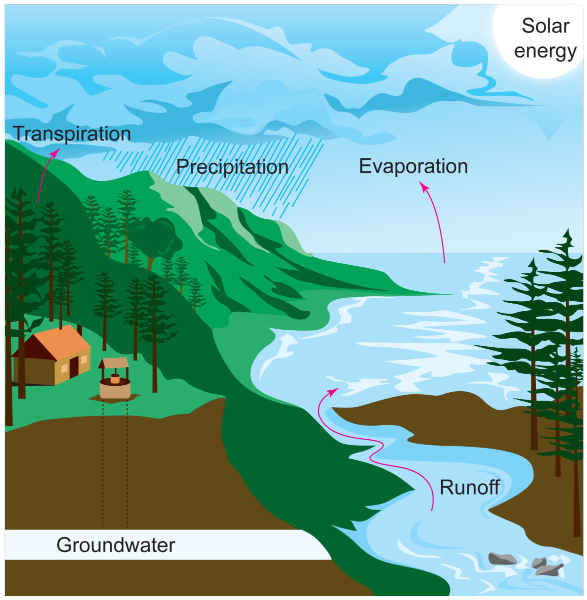


Figure 4.1 How does water get to the bottom of a well? Look at this diagram of the water cycle to see if you can discover the answer.

"Saving water isn't just something to do in a drought, when the resource is scarce. Each drop of water wasted is a drop less of a wild and scenic river; a drop less of a salmon run, a drop more in a dam filling a glorious valley."

Katrina Lutz

50 Simple Things You Can

Do to Save the Earth

Once the rainwater from that New Hampshire backyard flows into the pond, it can take different paths. Some of the water will evaporate, or change into water vapor. Then the water vapor directly resupplies the clouds that rain on New Hampshire. Some of the pond water will form a stream that flows from the pond into a river and from the river to the ocean a few miles away. Once the water reaches the ocean, it may circulate in the ocean water for a while. But eventually, it will evaporate and resupply rain clouds that carry the water all over the world.

Let's go back to the backyard again. The water that soaks into the soil and enters the groundwater supply may stay underground for many years. But eventually the groundwater will seep into a lake, pond, or the ocean. There it will evaporate and join the water in clouds.

Did You Know?

You can use 20 liters of water or more if you leave the tap running while you brush your teeth.

You just traced water from the clouds to the ground, to a pond, to the ocean, to the clouds, and back to the ground again. This movement of water is a cycle. Have you ever heard the saying, "What goes around, comes around"? Well, that's a pretty good description of a cycle. A **cycle** is a process that has no distinct beginning or end but simply keeps repeating itself.

What is the source of the energy that keeps the water cycle operating? As you might suspect from what you know about food chains, the ultimate source of energy is the sun! Heat energy from the sun causes the open water to **evaporate**. When the amount of evaporated water in the air is more than the air can hold, clouds form. Gravity helps the clouds return the water to Earth's surface. There it can evaporate again.

Activity 4-1: A Day in the Life of a Water Molecule

Introduction

You are going to investigate where water is found and how water moves through our environment. In this activity you listen to a story and use your imagination to visualize taking a journey as a water molecule. You then have a chance to act out some of the events in the day of a water molecule.

Procedure

Step 1 When you start the activity, the story will be read to you. Close your eyes and listen carefully to the story. Imagine that you are the water molecule in the story. When the story is finished, you will be able to share your thoughts through the discussion questions below.

Step 2 Think about what happened in this story. Describe in your own words the importance of:

- evaporation
- condensation
- precipitation
- transpiration

Step 3 Discuss the following questions.

- How could this water cycle vary, depending upon your location?
- Do the same water molecules continue to cycle through the environment? Why is this important?
- What other questions do you have about water?

Step 4 If each person in your group was a water molecule, how would you physically represent the parts of the water cycle as described in the story? Make sure you include:

- raising up in the air
- sticking together with other water molecules
- falling from the sky
- landing on the ground and
- traveling through a plant

Step 5 Plan a role-play in your small groups. Describe the events you planned in your group to the whole class.

Step 6 Work with the whole class to create a class play using parts of each group play. Act out the events in the day of a water molecule as the story is read aloud again.

Can you describe this cycle?

What Do You Think?

Many scientists are now recommending the planting of trees on a large scale to reduce the effects of global warming. Why do you think this would help? What do you think are some ways to motivate and organize your classmates to volunteer their time to plant trees in your neighborhood?

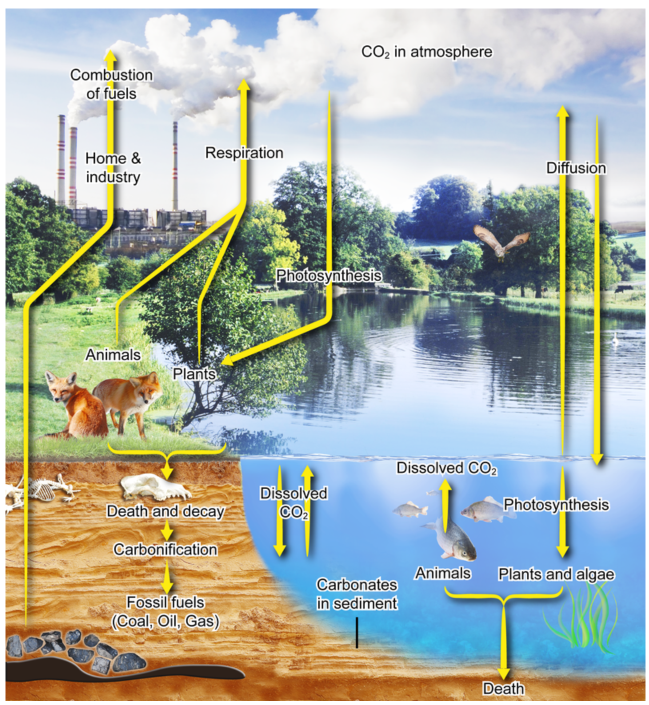


Figure 4.2 To understand this carbon cycle diagram, pick a place to start such as *Animals* and *Plants.* Follow the arrows through the diagram until you get back to where you started.

Did You Know?

Diamonds and graphite (the "lead" inside pencils) are both forms of pure carbon. Differences in properties, such as color and hardness, result from different arrangements of the carbon atoms and the bonds that hold them together.

The Carbon Cycle

Carbon is another very important abiotic element that cycles through the environment. Carbon plays many vital roles in the environment. Carbon combines with oxygen to form the gas called *carbon dioxide* (Co_2) . Remember that carbon dioxide is one of the raw materials needed for photosynthesis. Without carbon dioxide, the process of photosynthesis could not take place. Plants could not manufacture the sugars that provide you and all other consumers the energy to live!

Look at Figure 4.2 to trace how carbon moves through the carbon cycle.

Remember that cycles have no definite beginning or ending. So let's pick a place to begin investigating the carbon cycle. Since plants are so important to the carbon cycle, let's start there. Plants use carbon in the form of carbon dioxide to photosynthesize. The carbon is transferred to animals when they eat plants. Both plants and animals carry on respiration so that their cells will have the energy they need. Respiration releases carbon dioxide to the atmosphere. Plants use carbon dioxide to photosynthesize. They also manufacture and release some carbon dioxide when they respire. Even though plants do release some carbon dioxide when they respire, they take in a lot more than they release.

Plants and animals living in the ocean also cycle carbon. However, their cycle has one additional step. They release their carbon dioxide as tiny gas bubbles into the water. The carbon dioxide gas then seeps from the water back into the atmosphere.

Did You Know?
Phosphorus is a nutrient needed for the formation of ATP as well as other important parts of a cell.

Apply Your KNOWLEDGE

What would happen to humans if all the plants on Earth died?

The bodies of plants and animals contain many carbon compounds. So carbon passes up a food chain from producer to herbivore to carnivore. Then decomposers start their work when living organisms die and begin to decay. The decomposers consume the dead material and use the dead organism as energy. This process also releases carbon dioxide as a waste product of respiration.

Mini-Activity

A Day in the Life of a Carbon Atom Trace the path of a carbon atom. Imagine yourself as a carbon atom in a carbon dioxide molecule being exhaled from the nose of a lion.

Write a story of what happens to you for the rest of the day. Be sure to include all the major parts of the carbon cycle.

If a dead plant or animal is not completely eaten by decomposers, it may undergo **carbonification** (kar-bon-ih-fih-KAY-shun). The dead plants and/or animals are squished together with other dead animals and plants. Then, under huge amounts of pressure for a very long time, they eventually turn into coal, oil, or natural gas. These are fuels we use for many purposes. Coal, oil, and natural gas are called **fossil fuels** because they are made up of the remains of ancient plants and animals.

Our use of fossil fuels also adds to the naturally occurring carbon cycle. Fossil fuels are a good source of easy-to-transport energy. So humans uncover fossil fuels and use them to provide fuel for heat, electricity, and transportation. When coal, oil, and natural gas are burned, the carbon that was stored in them is released to the atmosphere as carbon dioxide.

Carbon dioxide is a **greenhouse gas**. Greenhouse gases are found in a blanket of air that surrounds Earth. These gases allow more of the sun's heat to enter Earth's atmosphere than to leave it. The greenhouse gases trap heat from the sun in the atmosphere much like glass traps the heat of the sun in a greenhouse. Some carbon dioxide has always been present in the atmosphere. But too much carbon dioxide released by burning fossil fuels can cause environmental problems.

Normally, the carbon in fossil fuels is trapped underground in a liquid or solid form. But burning fossil fuels releases large amounts of carbon to the atmosphere as carbon dioxide. The level of carbon dioxide in the atmosphere has doubled since humans have started burning fossil fuels. As the levels increase, Earth will most likely get warmer. This warming trend is called **global warming**.

Apply Your KNOWLEDGE

What was the original source of energy for the plants and animals that eventually became coal, oil, or natural gas?

Other Cycles

Have you ever heard someone say, "You can't really throw anything away. There is no 'away!' "? They really mean that when you throw something away, it doesn't leave Earth. This is true for everything from old comic books to air pollution to carbon dioxide to water.

Mini-Activity

Create a Cycle Poster Choose one of three cycles-oxygen, nitrogen, or phosphorus-and create a poster to illustrate how the resource you chose cycles through a natural community. Use library and other references to find out about the cycle you chose.

Every drop of water in every ocean, pond, or lake evaporated from somewhere else on Earth. No matter what, every drop of water will continue to be somewhere on Earth as a part of the water cycle. Unless it is transported on a shuttle mission to another planet, a water molecule can't get to the Moon, Mars, Venus, Alpha Centauri, or anywhere outside of Earth's atmosphere. Earth is a closed system. This means that almost everything on Earth will always be on Earth in one form or another.

Apply Your KNOWLEDGE

- **Explain if it is possible that you could be breathing an atom of carbon that was exhaled by a dinosaur.**
- **Explain why you think it is or is not possible to remove elements from their natural cycles.**

Journal Writing

Imagine the journey that a carbon atom took from the moment it was exhaled by a dinosaur to the moment you exhaled it yourself in a carbon dioxide molecule. Write a story about that carbon atom's journey. Be creative. Try to think of the many plants, animals, and famous historical people of which the carbon atom could have been a part.

Almost all elements on Earth have their own cycles in Earth's closed system. Ecologists have described cycles for many of the nutrients required by organisms to live. They described an oxygen cycle because almost every living thing needs oxygen for respiration. They described a nitrogen cycle because plants need nitrogen to grow. They've even described a phosphorus cycle because plants need a tiny bit of phosphorus to grow and for ATP. And animals-including you-can get nitrogen and phosphorus from eating plants or other animals that once ate plants.

Review Questions

1. Why don't forests in Wisconsin run out of the things such as water and carbon dioxide that they need to live and function?
2. What provides the energy for the water cycle?
3. Where can you find most of the fresh water in the United States?
4. Why is the carbon cycle studied by ecologists?

Chapter 6 Cycling in Biological Communities - Student Edition (Human Biology)

Chapter Outline

6.1 Cycling in Biological Communities

Hubbard Brook Watershed.

How do resources cycle in a forested watershed?

You've seen that biological communities tend to reuse the resources that they have. Natural resources recycle constantly. This section will help you to learn about biological recycling.

"Life on Earth represents a continual process of birth and death, decay and rebirth as the building materials are used over and over again by all living things."

Steve Van Matre

The Earth Speaks

Nutrient cycles in a biological community naturally recycle and reuse materials. It's easy to say that, but it makes a lot more sense when you can actually observe nutrient cycles in nature. A group of ecologists in New Hampshire demonstrated nutrient cycles in an experiment that will help you observe the natural **recycling** and reuse of materials.

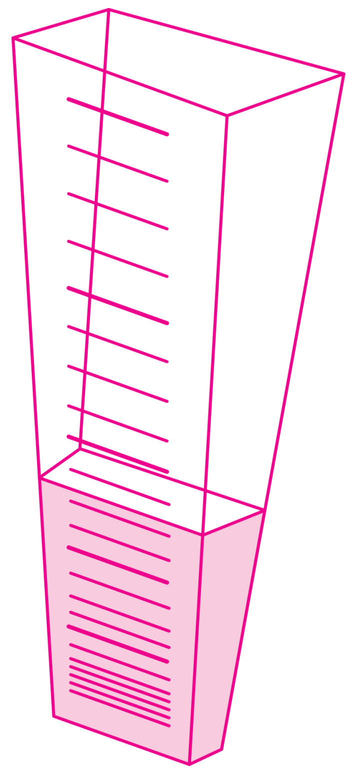


Figure 5.1 A rain gauge captures both the water and the nutrients that are found in rain.

These ecologists wanted to find out how nutrients in a forest were recycled. They wanted to try to answer three questions: What was being cycled? How much was being recycled? And how fast did the materials complete the cycle? They tackled these questions in a very clever way. They realized they wouldn't be able to study all parts of every nutrient cycle. They would have to study the whole Earth to do that. So they decided to study one specific area. They selected one stream called Hubbard Brook. Then their plan was to study everything that was happening in the part of the forest that surrounded Hubbard Brook.

The ecologists realized they had to do some planning before they began their study. They knew they would have to be able to measure all the materials, such as the water and nutrients, brought into their piece of the forest by raindrops. So they set up rain gauges like the one illustrated in Figure 5.1 to catch the precipitation coming in. They also wanted to measure all of the nutrients leaving the forest. They solved this problem by defining the edges of the study area as the watershed of Hubbard Brook.

Figure 5.2 The top figure shows a sample of a small watershed drained by a creek. The shaded area on the map of the United States in the bottom figure shows the huge watershed drained by the Mississippi River.

What is a watershed? A **watershed** is the area of land drained by a stream or river. Watersheds can be relatively small or very large. For example, the watershed of a creek is the land drained by the creek and might include only part of one or two hillsides. On the other hand, the watershed of the Mississippi River is all of the area drained by the Mississippi and all of the streams that drain into the Mississippi. The Mississippi watershed includes most of the middle of the United States. So you see that watersheds can be small or large. Compare the watersheds in Figure 5.2.

Did You Know?

A hectare is 10,000 square meters or 2.47 acres.

The watershed around Hubbard Brook was fairly small. It was only about 16 hectares or slightly more than 32 football fields. The ecologists chose this watershed to study for a good reason. They knew the only way most nutrients could leave the forest was by flowing out with the water of Hubbard Brook. They also knew all of the water of Hubbard Brook flowed past one point. So all they had to do was measure the concentration of nutrients at that one place. They built a small dam at that place where they could collect samples of water easily. The drawing in Figure 5.3 shows how the dam was shaped to make water collection easy for the ecologists.

Figure 5.3 All of the water that drains from the Hubbard Brook watershed flows past a dam like this one. The V-shaped notch makes it easier for scientists to take samples and measure the rate of water flow.

Journal Writing

Now that you have a good idea of what makes up a watershed, use a map and describe the watershed closest to your community. Include the name of the river and/or creeks that are a part of your local watershed.

So what did the ecologists find out? There were some surprises and some puzzles. First, they observed that a lot of rainwater fell on the forest. The surprise was that not very much of the water left the watershed at the bottom of the hill where they built the dam. They made several conclusions from their observations and measurements. They concluded that three things happened to the water coming into the watershed: The trees used a lot of the rainwater to grow and photosynthesize. Some rainwater evaporated, and some rainwater soaked into the ground.

The ecologists also knew that the trees in the forest needed more than rain to survive and grow. The trees needed other nutrients, including carbon dioxide, nitrogen, potassium, and calcium. So the ecologists had another question to answer: Where were the trees getting these nutrients?

The trees could get the required carbon dioxide from the atmosphere. But the other nutrients the trees needed had to come from within the watershed of Hubbard Brook.

The next thing the ecologists did was pretty clever. They reasoned that, if the trees were recycling these nutrients, they could stop the recycling by cutting down the trees. This may sound drastic as a part of an experiment. But it was a good way to find out what happens to a functioning forest when it is clear-cut by foresters.

Figure 5.4 A clear-cut watershed

What do you think happened when the ecologists clear-cut the trees? The flow of water running by the dam at the bottom of Hubbard Brook increased by 40 percent! This change meant that all of the extra water was used by the trees before they were cut down. The ecologists also noticed that the flow of nutrients past the dam went up dramatically. You can see these results in Figure 5.5 on page 30. The arrow in each chart points to the time when the scientists removed all the trees. You can see what happened to the nitrogen flow. The nitrogen (in the form of nitrates) that flowed past the dam increased more than 5,000 percent! It's hard to imagine a 5,000 percent increase of anything, isn't it? You can see that the flows of calcium and potassium increased, too.

The ecologists wanted to make sure they could support their results. So they used a control watershed where the trees were not clear-cut. The white, dotted line in Figure 5.5 represents the flow of a nearby watershed that the ecologists used as their control. The scientists compared the two sites. They concluded that the changes in flow occurred because of the tree cutting and not because of something else, such as a period of extra-heavy rain.

The differences observed in the experiment demonstrated that the forest had been recycling the nutrients. Younger trees growing in the area absorbed the nutrients from trees that died and decayed before the area was clear-cut. Tree roots absorbed nutrients from decaying leaves and wood on the ground. The next activity will help you to find out what went into the ecologists' study of the Hubbard Brook Watershed. You are actually going to build a watershed model yourself.

Apply Your KNOWLEDGE

Why doesn't the concentration of nutrients flowing past the dam jump immediately after the trees have been cut down?

Mini-Activity

How Do Scientists Know? The Hubbard Brook Watershed study is an example of how scientists use the scientific method to find answers to their questions about how the world works. How do they do it? Look at the graphs of nutrients found in Hubbard Brook before and after deforestation and discuss the following questions:

- What question did the scientists ask?
- What methods did they use?
- What data did they collect?
- What conclusions did they reach?
- Do you think these conclusions are valid?
- What are some questions that could follow up on this research?

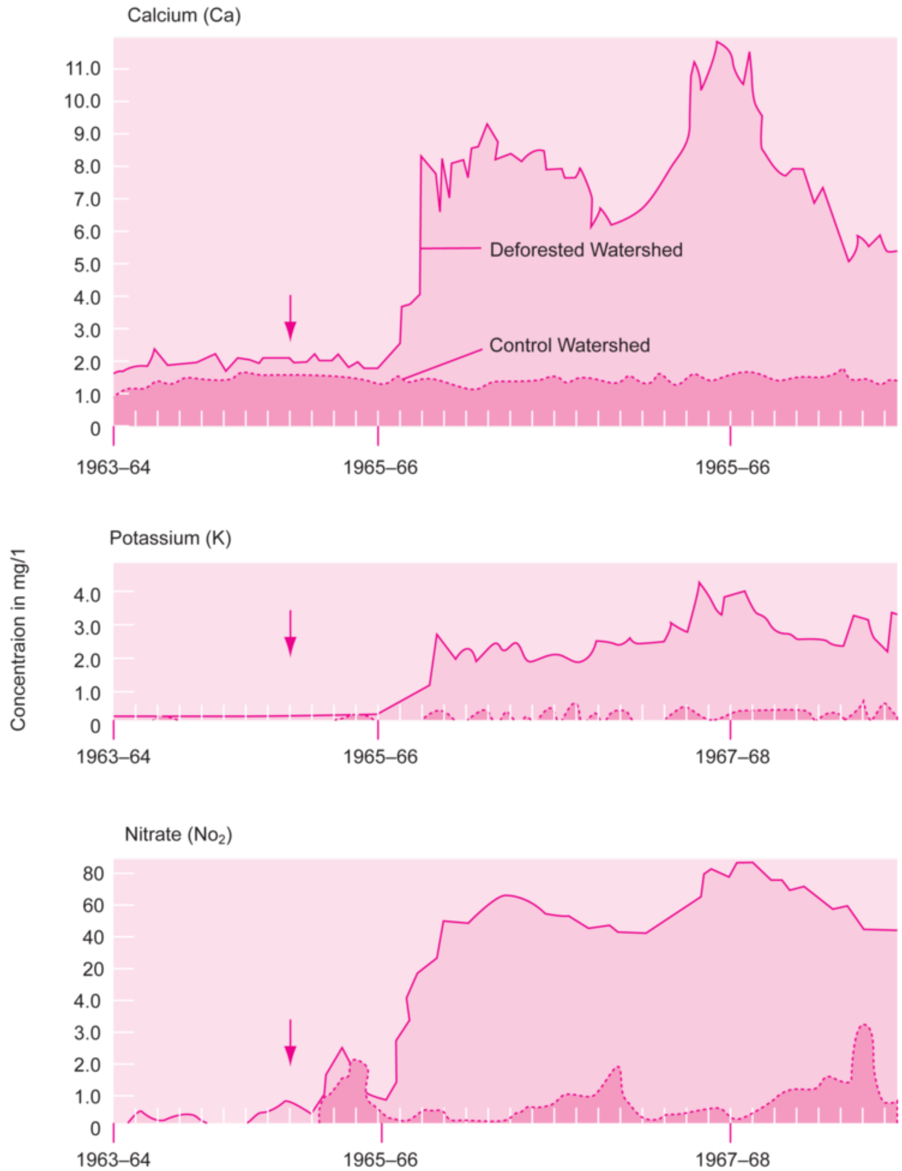


Figure 5.5 The solid, pink line up to the arrow shows the concentration of nutrients flowing past the dam at Hubbard Brook before the trees were clear-cut. The dark arrow indicates when the trees were clear-cut. The solid, pink line shows the concentration of nutrients flowing after the clear-cut. The dotted, pink line shows the concentration of nutrients from the control watershed where the trees were not clear-cut.

What Do You Think?

Look at Figure 5.5. The solid, white line represents the concentration of nutrients flowing past the dam at the bottom of the watershed clear-cut by the scientists. The dotted, white line is the flow past a dam at the bottom of a watershed that was not clear-cut. Explain why you think the scientists measured the nutrients at the "control" watershed.

Activity 5-1: Go with the Flow: Hubbard Brook Watershed

Introduction

What role do trees play in the cycling of water and nutrients within a community?

Nutrients dissolved in water don't just drain through a forest. They enter the soil, pass through trees, and pass through the forest as runoff, too. In this activity you investigate the effects of clear-cutting a forested area and observe the impact that clear-cutting has on the cycling of nutrients in the surrounding area.

Materials

- 8 to 10 Half-liter milk cartons, rinsed and opened
- One 1-liter pitcher
- Graduated cylinder
- Water
- Large tray with sides at least 4 – cm high
- Stapler or tape
- Large piece of sturdy cardboard-1 meter square
- Resource 1
- Resource 2
- Activity Report

Procedure

Step 1 Read about the Hubbard Brook watershed. You are going to construct a model of this watershed.

- The large piece of cardboard represents Hubbard Hill.
- The milk cartons represent the trees that cover the hill as a thick forest.
- The bucket or large tray is the stream at the bottom of Hubbard Hill.
- The pitcher of water represents a rainstorm that will shower Hubbard Hill.

Step 2 Open the milk cartons. Then attach the open milk cartons to the cardboard using staples or tape. The empty milk cartons must be completely open, clean, and not leaking. Place the cartons evenly over the cardboard. Attach them so that they are flush with the cardboard and so that no water will pass between the milk cartons and the cardboard.

Step 3 Place the bottom of the cardboard in the tray. Lean the top of the cardboard up against a wall.

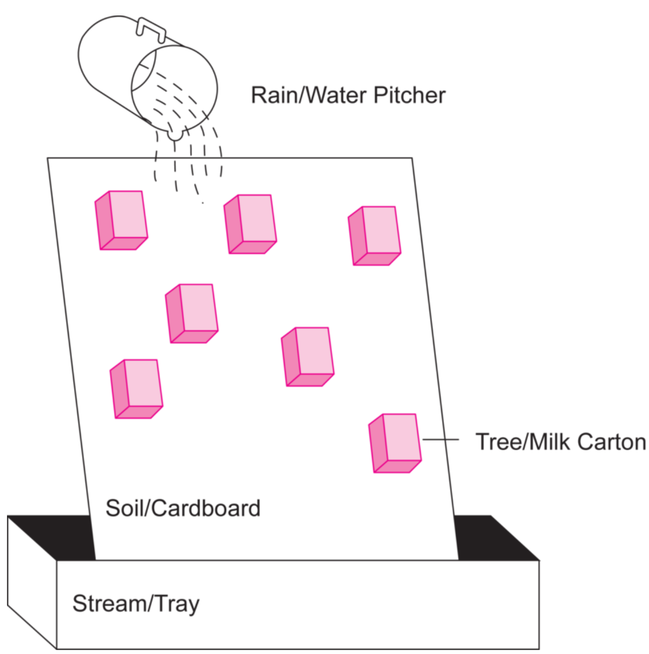


Figure 5.6 Your watershed model should look like this.

Step 4 Fill one pitcher with water. Measure and record the amount of water in the full pitcher on Question 1 of the Activity Report.

Step 5 A rainstorm is approaching Hubbard Hill. You're about to see the effect of the rain on the hillside and trees. Standing over the cardboard, slowly pour all the water from the pitcher onto the cardboard, moving from side to side to cover the whole hillside with water. On Question 2 of the Activity Report, describe what you observe.

Step 6 Carefully remove the cardboard from the tray. Measure and record the amount of water that collected in the tray. Answer Questions 3, 4, and 5 on the Activity report.

Step 7 A local logging company has clear-cut Hubbard Hill. The workers have removed all of the trees from the hillside. How could you use your model to simulate the effects of deforestation on your hill? Design a simulation to observe the effects of deforestation on the hill. Explain your design in Question 6 of the Activity Report.

Step 8 Repeat steps 4 and 5 of the procedure. Use exactly the same amount of water. Record this amount in Question 7 of the Activity Report. Pour the water from the pitcher as you did in ***Step 5.***

Step 9 Carefully remove the cardboard from the tray. Measure and record the amount of water that collected in the tray on Question 8 of the Activity Report. Then answer Question 9.

step 10 Analyze the graphs on Resource 2. These graphs were produced from data that was collected by the scientists who studied the flow of nitrogen in the Hubbard Brook watershed. In Questions 10 to 12 on the Activity Report describe what happened to the amount (or concentration) of each of the nutrients before and after the area was clear-cut.

Review Questions

1. What is a watershed?
2. What happens to most of the nutrients, such as water and nitrogen, in a forest that is undisturbed by humans?
3. What happens to these nutrients if all of the trees in the forest are cut down?

Chapter 7 Recycling in Human Communities - Student Edition (Human Biology)

Chapter Outline

7.1 Recycling in Human Communities

How can humans cycle their resources?

You've seen how materials cycle and recycle throughout biological communities. It is very important that we all remember the saying in Section 4: "You can't ever really throw anything away. There is no 'away'!" What is on Earth now, stays on Earth. So we need to be careful how we use and reuse our resources. This section will help you discover some ways we can reuse and recycle our resources.

"Awareness is becoming acquainted with the environment, no matter where one happens to be."

Sigurd Olson

quoted in *The Earth Speaks*

It has taken humans a long time to figure out that we need to do what biological communities have always done. Like biological communities, we need to recycle the materials that allow all living organisms on Earth to grow and survive. People in the United States are realizing that, when they throw things "away" they are merely putting them someplace else-usually where they don't have to see them. Unfortunately, most of the things that people throw away end up in a landfill somewhere. These items have been removed from their normal cycles and dumped so they are no longer serving any useful purpose.

What happens when you throw a piece of paper in the garbage can in your classroom? Does it magically disappear? No! If your school is typical of most schools in the United States, your paper goes on a very long and complicated journey.

Did You Know?

People in the United States produce 154 million tons of garbage every year-enough to fill the New Orleans Superdome from top to bottom twice a day-every day!

Let's follow that paper on its journey. First, your paper travels from the garbage can in your classroom to the custodian's garbage. Eventually it's dumped into the school's dumpster. The paper and everything else with it in the dumpster is picked up by a community garbage truck. The truckload of garbage is driven to a transfer station and emptied into an even bigger garbage truck. When the bigger garbage truck is full, it is driven to a clay-lined landfill where its load of garbage is emptied. At a typical sanitary landfill, the garbage is covered with soil or crushed rock at the end of each day. A landfill is covered with a clay cap when it's full so that rainwater can't get in. Rainwater must be kept out, because it could leach out chemicals from the garbage that might contaminate the groundwater beneath the landfill.

Figure 6.1 Throwing a piece of paper into a garbage can is just the first step of many until it is sealed in a landfill.

What Do You Think?

What sources of energy are used in the process of throwing away a piece of paper? Do you think that the energy sources are being used wisely? Explain your answer.

Does that sound like a long trip to you? Well, it is. And that piece of paper doesn't just take up space. No, disposing of that piece of paper also requires the work of many people. The school custodian, two garbage truck drivers, the people who work at the transfer station, the bulldozer operator at the landfill, and many other people are involved! And there's another problem with the way that paper was disposed of. That paper resource can't be used again. The paper was wasted when it could have been recycled and used again.

Landfills end the long trip your trash takes. There is no "cycle" for things put in a landfill. Many people think that landfills are wonderful places where garbage decomposes, and is turned into soil by decomposers such as worms and microbes. Unfortunately, that is not the case. Decomposers need water, sunlight, and air to decompose things quickly. The clay cap put on landfills to prevent groundwater contamination keeps out water, sunlight, and air. As a result, very little decomposition happens.

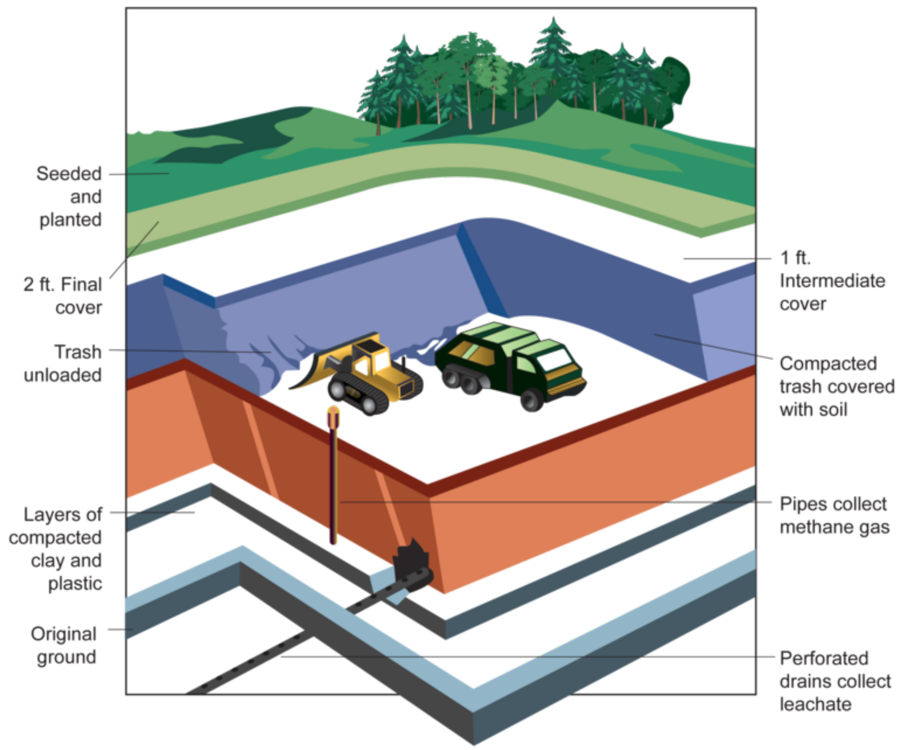


Figure 6.2 A landfill is more than a simple hole in the ground. What do you think are some of the things in this landfill that keep garbage from decomposing?

Mini-Activity

Draw a Paper Cycle Think about a pine tree in a forest. The paper in your notebook probably came from such a tree. Paper can be thought of as a resource that flows through the environment just as water, nitrogen, or carbon does. Is this flow a cycle? Draw a path showing the flow of paper from its source to where it ends up. How would the flow of paper in your drawing change if you lived in a community that recycles paper products? Add this to your drawing.

One self-named garbologist-William Rathje-has made a career of excavating (or digging up) landfills to see what actually happens to garbage in a landfill. He has found that newspapers do not decompose. So he regularly uses them to estimate the age of the garbage where he is digging. How do you think Mr. Rathje uses newspapers to estimate the age of the garbage? He has found hot dogs that look as if he could eat them. (But he doesn't, of course!) He has found five-year-old heads of lettuce that look no worse than lettuce that has been sitting in a refrigerator for a couple of weeks. But the hot dog and the lettuce were disposed of long ago. His discoveries have shown that little decomposition takes place in a landfill. Figure 6.2 illustrates how a landfill is constructed. You can see from the illustration that the clay and plastics used to enclose the landfill actually help to keep the garbage from decomposing quickly.

Apply Your KNOWLEDGE

What do you think happens to paper bags in a landfill?

Activity 6-1: What's in Your Garbage and Where Does It Go?

Introduction

What is in your garbage can? How many items in your garbage could be reused or recycled? Recent research indicates that people in the United States are creating more garbage than ever before. In this activity you analyze the types of things you throw away and where they go after you throw them away. Then you determine how you might reduce the amount of garbage generated.

Materials

- A bag of typical garbage
- Scale
- Tape measure
- Paper and pencil
- Plastic bags
- Cardboard box
- Gloves
- Calculator (optional)
- Activity Report

Procedure

Step 1 Weigh the bag of garbage on the scale and record this information on your Activity Report.

Step 2 Empty the bag of garbage into a cardboard box and record the volume of the garbage on your Activity Report. The volume can be determined by using the following equation. Volume = (length of box) × (width of box) × (height of garbage in box)

Step 3 Assume that this bag of garbage was produced in one day. Calculate the volume and weight of garbage produced by this household for a 30-day period. What would be the volume and weight of garbage produced during one year? Show your work and record the information on your Activity Report.

Step 4 Look at the garbage and discuss with your group how you could sort the garbage into categories such as plastic, paper, aluminum, and whatever other categories you can identify. Put the gloves on and sort the garbage into piles.

Step 5 Now remove all the materials that could be reused, recycled, or composted. List these items on your Activity Report. Then write how you think they could be reused or recycled.

Step 6 Calculate the volume and weight of the garbage after you have removed all of the items that could be reused or recycled. What would be the volume and weight for a 30-day period? What would be the volume for one year? Show your work and record the information on your Activity Report.

Step 7 Now choose one of the items you separated from the garbage because it could be recycled. Make a list on your Activity Report of the people who would handle it and the places it could travel on its recycling journey.

Here's another saying for you to remember. *"Reduce, Reuse, Recycle!"* We can partially avoid the problems landfills present by following this slogan. By following those three steps, in that specific order, we can significantly lower the amount of garbage that is thrown away. Let's examine each step, one at a time.

Mini-Activity

Overpackaging How can you change the amount of refuse that goes into a landfill? You can reduce the amount of waste you create by buying products that have less packaging or recyclable packaging.

Bring in examples of products you think are overpackaged. Propose alternative packaging methods. Create a commercial to convince your Classmates that your alternative packaging method is better than the existing method. You may want to include posters or models to illustrate your point.

Reduce

Reduce is the most important step because it is much easier to not make garbage than it is to dispose of it once it is made. Reducing the amount of materials we use helps in several ways. Energy isn't wasted in making the product. Time and energy aren't wasted in transporting the product to you. And time, energy, and space aren't wasted in taking it away as garbage to bury it in a landfill.

Let's look at a good example of a product whose use can be reduced or totally eliminated. Grocery stores use a lot of paper bags. Why chop down a tree, turn it into paper, and fashion the paper into a bag, just so you can take your groceries home from the store and throw the bag away? It's just as easy to use cloth grocery bags that can be washed and reused. Try to think of some other ways you can reduce the use of paper bags or eliminate their use altogether. Surprisingly, the people who work on solutions to the problems of landfills often ignore this strategy. Perhaps it is too simple. What do you think?

Journal Writing

Select a packaged item from home or school that you think is overpackaged. Write a letter to the company that produced the item and suggest alternative packaging ideas.

Reuse

Reuse resources, products, and materials. The next easiest step in reducing the wastes that go to landfills is to reuse the things you have. For example, you can take the grocery bags with you the next time you go shopping, and reuse them. You can also save the bag you got at the grocery store and use it to take your lunch to school. You accomplish two goals at once! You are reducing the amount of disposable items that you are using by not buying manufactured lunch bags, and you are reusing bags that you already have!

Did You Know?

One dollar out of every eleven dollars that people in the United States spend on food goes for packaging. In fact, we spent more on the packaging for our food last year than American farmers received in net income.

Recycle

The last step is not the easiest step, but is very important to conservation and keeping our Earth healthy. *Recycle* the wastes you produce. This task is harder than reducing or reusing products. Recyclable items have to go through several steps and processes. Recycled wastes have to be taken to a recycling collection center. From there they are transported to a recycling plant and remanufactured into new products. Then the new products are returned to a store for someone to buy again. Think about it. You can recycle a paper bag by taking it to a recycling center. There it can be prepared for a paper recycling plant. The paper bag is turned into a new paper product and sold again. It seems a lot simpler and more considerate to our environment to not have picked up the bag in the first place.

Most Common Recyclables

- Newspapers
- White office paper
- Corrugated cardboard
- Magazines not coated with clay (not glossy)
- Aluminum cans
- Steel cans
- Glass (must be sorted by color)

- Plastics are coded. (See Figure 6.4.)

Figure 6.3 You usually have to sort recyclable items when you prepare them for recycling.

Recycling is an important option for reducing the amount of waste you send to a landfill. Many communities in the United States have recycling programs that can handle most of your household wastes. The most commonly recycled materials are aluminum, steel, glass, newspapers, office paper, and some plastics.

Did You Know?

It takes an entire forest (over 500,000 trees) to supply people in the United States with their Sunday newspapers every week. Newspapers take up almost 25 percent of the room in a typical landfill in the United States!

In order for wastes to be recycled, they have to be sorted into their different types. You can't turn a garbage can full of assorted garbage into recycled paper. But you can turn a stack of newspapers into recycled paper. Some cities collect recyclable materials all mixed up together, and the materials are then sorted mechanically or by people. However, most cities with recycling programs require that the people who are throwing things away do the sorting. Perhaps you have separate bins for bottles, cans, and paper in your kitchen because you recycle already.

Did You Know?

- Making aluminum products from recycled aluminum cans uses 90% less energy than making aluminum products from scratch.
- The energy saved from recycling one glass bottle could light a 60watt bulb for four hours.
- Recycled plastic can be used to make products such as plastic lumber and fiberfill sleeping bag insulation.

Recycling your wastes can be simple and fun. But before you start setting up bins and sorting everything from foil balls to toothpaste tops, you should check with your local recycling program. The people at the recycling program probably want you to sort your recyclables in a very specific way. Their goal is to have you sort the recyclables in a way that is useful for the people in your area who use those recyclables to make new products.

The world of recycling changes constantly. Your community might recycle some of the above-mentioned things, all of these things, or maybe even more than what was described here. Be sure to check with your local recycling program so that you can save energy, save resources, and keep your local landfill from filling up quite as fast.

Figure 6.4 Plastics are coded 1-7. Objects coded 1 are easy to recycle. Objects coded 2-6 are increasingly harder to recycle. Objects coded 7 cannot be recycled at all. Mixing the coded objects can spoil an entire batch at a recycling plant.

Apply Your KNOWLEDGE

Name ten things that are thrown away but aren't on the list of most common recyclables.

There is one type of material you may be able to recycle completely in your own home. Yard waste, such as grass clippings and leaves, are **biodegradable** (by-oh-dee-GRAY-duh-bul) materials. Biodegradable means that decomposers can turn them into soil fairly easily. You can recycle yard wastes by building a compost pile in your yard.

Review Questions

1. Why do people who work on waste disposal say that there is no "away"?
2. What are the three steps you can follow to limit the amount of garbage that you send to a landfill?
3. Why is it important to properly sort items for recycling?
4. What is meant by biodegradable? Give two examples of biodegradable items, and explain why each is biodegradable.

CHAPTER 8 Resources, Niches, and Habitats - Student Edition (Human Biology)

CHAPTER OUTLINE

8.1 Resources, Niches, and Habitats

What are the things you, or any organisms, need to survive?

What do you need to stay alive every day? Do you have to hear your favorite music or watch a certain show on TV? Do you need a hair dryer? Will you die if you don't have a can of soda or a bag of chips? The answer to all of these questions is, "Probably not!" But you do need some basic things to keep you going. This section will introduce some of the important resources living organisms need to survive, grow, and reproduce.

"People. . . [who]. . . live in a skyscrapered city . . . will likely forget who and where they are. If people are stopped on the street of a major city today and asked what supports the life of the earth, they will probably reply that their city does."

Steve Van Matre

The Earth Speaks

Resources

First, you need water in some form or another. You may not often drink a glass of fresh, plain water to quench your thirst. So you may think you don't drink much water. But you probably drink plenty of water that is in juice, milk, or soft drinks. You also get some water you need from foods you eat. Without water you would dry up and die!

Food is another important requirement you need to stay alive. Remember that you need food to generate the energy to run around, grow, eat, think, talk, and do all of the other things you do. Occasionally you may miss a meal. But on the whole, you need food to stay healthy.

The last big requirement for you to stay alive is space. You probably live in some sort of structure such as an apartment building, a house, or some other dwelling. Where you live provides you the space you need to live. But the space you need to live is not restricted to your home. The space you regularly occupy probably includes your school, stores, play areas, and many more places you visit. Finally, the areas you travel through to get to all of these places are part of the space you use, too.

Figure 7.1 Common loons summer on lakes across Canada and the northern United States.

You are not the only living organism which needs water, food, and space. Water, food, and space are three of the **resources** you and all other organisms need to survive. A resource is something needed by an organism to live, grow, and reproduce. What are some other resources you can think of?

Resource needs can differ from person to person. For example, people who exercise a lot need more food and oxygen than people who do not exercise. Different kinds of living organisms have different resource needs, too. Compare what you need to stay alive to what an average hummingbird needs. You probably would not do very well hovering over a morning glory trying to drink its nectar. You would also have a lot of trouble building and living in a nest high in a tree.

A loon's Resources

Let's explore the world of just one species-the common loon-to find out more about resources. A **species** is a group of organisms that look alike and can reproduce with one another. The common loon is a species of bird. It is a black and white bird that spends its summers on lakes across the northern United States and Canada. If you saw one, you might think it was a duck, because it spends most of its time on the water paddling around, hunting, and raising its chicks. On the other hand, if you heard its call, you would never mistake it for a duck. The loon has an eerie, haunting voice that moviemakers sometimes use as background sounds for horror movies!

Loons are water birds. They have webbed feet for swimming and they are excellent divers. They have long and pointed bills for catching fish. Their dense feathers keep them warm and dry even though they spend most of their time in or on water. Swimming comes naturally to loons. Little loon chicks can swim within hours of hatching. As a matter of fact, loons are so attached to water that they leave it only when they are flying, mating, or trying to hatch eggs on their nests in the spring. In the winter, loons fly to the coasts of North America to feed, rest, and wait for the lakes on which they spend the summer to thaw.

Figure 7.2 Loons need a running start (or in their case, a paddling start) to become airborne.

After reading about the loons' attraction to water, what resource do you think a loon might need to survive? First, they need water, of course-and lots of it! Loons rarely venture onto land. They have to have a large expanse of water to use as a "runway" when trying to take off. Unlike ducks, which are light enough to take off from a standstill, loons need a chance to build up their speed before they can become airborne. If they land on a pond that is too small, they may become trapped and be unable to take off.

What do you think is another resource loons need? If you think food, you're correct. Loons need fish for food. A loon goes fishing everyday as it swims on the surface of its lake watching for fish to swim beneath it. To catch the fish, a loon first spots it swimming below. Then the loon swims swiftly underwater to grab the fish in its beak. Loons need lots of fish. One researcher calculated that a pair of loons and their two chicks could eat 430 kilograms of fish in a summer. A loon weighs only about four kilograms, which means the adults eat approximately 50 times their weight each summer. Just imagine- if you weighed 50 kilograms (about 110 pounds), you would need to eat about 2,500 kilograms (5,500 pounds) of fish in one summer to keep up with a loon!

In order for the loons to be able to spot their fish dinners, the water in the lake has to be clear, because loons chase fish underwater. The loons won't be able to see well enough to fish successfully if a lake is too cloudy. Besides being fresh, clear water, the lakes must also support lots of producers to feed the herbivores, which feed the fish the loons eat. Unfortunately, many of the producers that live in the lakes where loons live are algae. And algae tend to make lake water cloudy. So like many other organisms, loons must balance their needs. Loons balance their need between clear waters and waters rich with food.

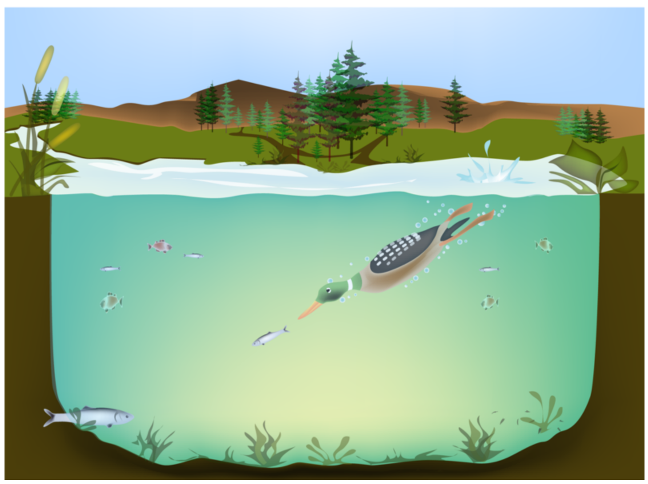


Figure 7.3 Loons are good swimmers and can catch fish by chasing them underwater.

Journal Writing

Think about the resources you use in a typical day. If you had to give up three resources, what would you give up? How difficult would it be to do this? Compare your resource use to a loon's. How difficult would it be for a loon to give up three of its resources?

Loons need space to survive just like we do. Loons need a large amount of space on a lake just to take off. They also need a lake big enough to support the large amount of fish they need to eat. Loons also prefer lakes with one or more small islands. Small islands are less likely than large islands, or the mainland, to have predators such as skunks, which might attack nesting loons or their eggs. Because of these space requirements, loons usually spend the summer on lakes that have more than 40 hectares of surface area. That's a lake about the size of 80 football fields.

Now review what you've just learned about the resources loons need. How would you describe the resources a loon needs each summer? A Short description of the resources might simply be water, food, and space. A more specific description would be clear lakes in the northern United States or Canada with enough surface area for taking off, and with lots of fish and small islands.

Apply Your KNOWLEDGE

How do the three main categories of resources differ for plants and animals?

Obviously, too little of something is not good. But sometimes too much of a resource isn't good for living organisms either. In most cases, organisms need a certain amount of a resource to survive successfully-not too much or too little. For example, to grow lettuce in your garden you have to provide it with all of the resources it needs in the proper amounts. You need to provide adequate sunlight, water, and nutrients. If you try to grow lettuce in a dark closet, it simply won't grow. However, if you plant it in an extra-hot place in your garden where it gets full sun all day long, it won't grow there either. If the lettuce in your garden doesn't get enough water from rain, you have to provide additional water. But if you flood your garden, you will kill the lettuce.

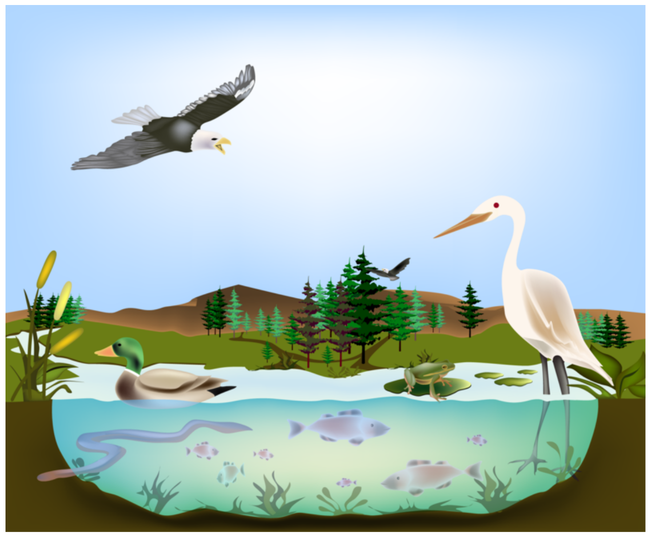


Figure 7.4 A freshwater pond habitat contains all of the resources in the correct amounts for many different organisms to survive, grow, and reproduce.

You also have to provide your lettuce with the appropriate space it needs to grow. And the space has to provide the right conditions for the lettuce. You wouldn't think of sowing lettuce seeds in the middle of a driveway. You also have to provide the lettuce with enough room to grow. You won't get a healthy lettuce plant growing on one square centimeter of dirt. However, it doesn't seem likely that you could provide a lettuce plant with too much space. Sometimes resources such as space have only a lower limit or an upper limit, but not both. For example, lettuce needs a minimum amount of space, but no maximum amount.

What Do You Think?

How do you think the resources you use differ from those used by a teenager living in Bangladesh or Budapest? Which is a better use of the resources?

So you've learned what loons and lettuce plants need to live and grow. The garden or farm field where the lettuce grows is its habitat. The clear lakes in the northern United States or Canada where the loon lives is the loon's habitat. A **habitat** is the physical place where a plant or animal usually lives. A habitat contains all the resources required by an organism to live. But a habitat usually contains more than what is required by only one type of plant or animal. For example, freshwater lakes provide a habitat not only for loons, but also for many fish, algae, other water birds, aquatic plants, and probably a frog or two or three-or hundreds. The habitat of a lettuce plant is usually a garden that is also a habitat for other types of garden plants, slugs, beetles, and weeds. The habitat of a dog, cat, flies, ladybugs, and spiders might be where you live, too!

Activity 7-1: Too Many Bobcats

Introduction

How many squirrels can live in Central Park in New York City? At first you might think that Central Park could support millions of squirrels. But when you take a closer look, you find something very different. Central Park cannot support millions of squirrels because resources are limited. Food, water, and space are called limiting resources. Food, water, and space determine the number of squirrels that can survive in an area. The ability of a habitat to supply these resources for a species is called its **carrying capacity**. In this activity you pretend to be bobcats while investigating the carrying capacity of a habitat. What happens when there are more bobcats than the habitat can support?

Materials

- Pieces of colored paper (6 different colors that are cut into rectangles)
- 1 Sandwich-size plastic bag
- Masking tape
- Large open area
- Activity Report
- Resource

Procedure

Step 1 You and your classmates are bobcats in this game of survival. But remember, survival is not a *game* for organisms such as the bobcat. So here are some rules you have to follow in this activity. (Remember that these rules are for this activity only. Real bobcats don't actually behave this way in nature.)

- Bobcats do not fight because it takes energy away from the food-gathering activities.
- Bobcats do not eat more than they need of one kind of food or drink more water than they need.
- Bobcats do not snatch food away from other bobcats.
- Bobcats do not take food from the den if it belongs to another bobcat.

Step 2 Gather all of the bobcats in your group in the den of your habitat area. Collect your plastic bag. Write your name on a piece of masking tape. Put your name on your bag, using the masking tape. The plastic bag will be used for collecting your food and water. Water and food items are represented in this game by rectangles of colored paper. Your collecting bag must remain in the den at all times.

Step 3 In round one, only five bobcats line up. Then, at the signal from your teacher, the bobcats go out into their habitat to get food and water. You need to collect one of each of the foods available (one rectangle of each color), as well as one sample of water (blue rectangle).

rabbits	*red*
rodents	*green*
fawns	*black*
birds	*yellow*
reptiles	*orange*
water	*blue*

Altogether, you need to collect 6 rectangles in your plastic bag in order to survive as a bobcat. You can collect only one rectangle at a time. After you collect each one, you must bring it back to the den. You must put the rectangle in your plastic bag before you go out to collect the next one.

Step 4 When all five bobcats in your den have collected the required food and water rectangles, you may rest. Your teacher will collect and redistribute the rectangles for the next round.

Step 5 At the signal for round two, ten bobcats (the bobcats who haven't had a turn yet) will go out to collect their required food and water according to the same rules. After all the food and water have been collected, the bobcats can return to the den to rest. Your teacher will collect and redistribute the rectangles for the next round.

Step 6 At the signal for round three, all 15 bobcats will go out to collect food and water according to the same rules. When all available food and water has been collected, all bobcats return to the den.

Step 7 Find out which bobcats have survived. Remember that each bobcat needs six rectangles to survive-one of each color that represents water and five types of food.

Step 8 Analyze the game by discussing and answering the following questions. Summarize your group's discussion by writing your answers on your Activity Report.

- What happened to the bobcats in your den during each of the three rounds?
- What factors determined whether bobcats survived or not?
- What other factors might affect the carrying capacity of a habitat for bobcats? How could you alter the game to include these other factors?
- Analyze the graph on the Resource. Explain what is happening to the growth in section 2 of the graph. Why isn't the line a straight line?
- Compare the graph to what happened in the bobcat activity.
- What do you think is happening in section 4 of the graph? Why?
- Do you think the bobcats follow the rules you followed in this game of survival?
- Do you think that the Earth has a carrying capacity for humans? Explain your answer.

Mini-Activity

Define the Niche of an Animal Describe the niche of an animal of your choice. What are the resources it needs to survive? In what amounts does it need each of these resources?

If a habitat is where an organism lives, then what is a niche? Ecologists use the term **niche** in a very specific way. When they investigate an organism's niche, ecologists find out what resources are needed in order for it to survive, grow, and reproduce in its habitat. They look at the limits of these resources and how the organism fits in with the rest of the community. Finally, ecologists combine all of this information to describe the organism's niche-where it lives, what it needs to survive, and how it interacts with other organisms.

What is your niche in life? How do you fit in? What are the resources you need to survive? What do you like to do? What do you have to do? How do you interact with the other organisms around you in your environment?

Review Questions

1. What is a resource? Describe three general categories of resources.
2. Do all organisms require the exact same resources? Give an example or two to support your answer.
3. Is it possible to have too much of a needed resource? Support your answer with an example.
4. What is the difference between the habitat and the niche of a plant?

CHAPTER 9 Species Interactions - Student Edition (Human Biology)

CHAPTER OUTLINE

9.1 Species Interactions

How do different species affect one another?

As you can see from what you've read so far, and from what you've observed in your own environment, no organism lives by itself. Plants are crowded out by other plants, eaten by animals, used for shelter, stepped on, and uprooted. Animals are working hard looking for food, watching out for other animals that want to eat them, and trying to find something to use for shelter. In other words, every plant and every animal interacts with other plants and animals in some way. This section will introduce some different ways animals and plants interact in the environment.

"We need the tonic of wilderness to wade sometimes in marshes where the bittern and the meadow-hen lurk, and hear the booming of the snipe; to smell the whispering sedge where only some wilder and more solitary fowl builds her nest, and the mink crawls with its belly close to the ground."

Henry David Thoreau

quoted in *The Earth speaks*

Ecologists spend a lot of time trying to understand interactions between organisms. They try to take the point of view of each organism in the interaction to see if it is good or bad for that organism. For example, if they see a spider catch a fly in its web, the ecologist observes that the interaction is good for the spider, because the spider gets to have dinner. On the other hand, they observe that the interaction is not very good for the fly, because the fly is becoming the spider's dinner! Sometimes one organism wins while the other loses. Sometimes both organisms lose. And sometimes interactions benefit both organisms.

Did You Know?

Two species of barnacles compete for space on rocks in tide pools in Scotland. One barnacle actually crowds the other off the rocks, undercutting it and replacing it even where it had begun to grow.

Organisms Compete

Ecologists define **competition** as what happens when one organism uses a resource in such a way that another organism can't use it. For example, if two species of birds eat the same kind of seeds, they may be competing with each other to get the most seeds. One species of tree may compete for water with another by growing roots that spread out over a larger area or go down farther. Competition usually occurs only when a resource is in short supply. For example, trees may compete for water but not for carbon dioxide and oxygen. There's usually plenty of carbon dioxide and oxygen to go around.

Mini-Activity

How Do I Interact With Other Species? List ten ways you interact directly with other species in your environment. Are these generally harmful or helpful for the other species? For example, do you provide a habitat for animals in your backyard? List ten ways you affect and are affected by other species on a global level. Are these harmful or helpful interactions for the other species? How could you make these more positive interactions?

Figure 8.1 Competition occurs when two species or individuals try to gain control of the same limited resource. Who do you think is competing in this picture? Who do you think will win?

Sometimes organisms compete without ever directly interacting with one another. They do this by using the same resource that happens to be in short supply. For example, squirrels and jays both like to eat acorns. If the squirrels manage to gather all of the acorns in an area and store them before the jays can find them, the squirrels and the jays are competing (and the squirrels are winning).

Did You Know?

A scientist in Chicago put two kinds of flour beetles in a container of flour to study competition between species. One species always out competed the other. Which one survived depended on the conditions. One species survived if it was hot and damp. The other species survived if it was cool and dry.

Another example of this type of competition occurs between two types of trout that live in the Ausable River in Michigan. Both species of trout like to rest on the bottom of streambeds, but they rest in the same location. The brook trout like to rest in shady areas of the stream where the water isn't flowing very fast. However, when brown trout are present, they take the spots and the brook trout give them up. In this case, the two types of trout compete for space in the river. And often they don't even come in contact with each other.

Humans compete for space, too. The central plains of the United States were once a vast prairie that supported many diverse species of plants and animals. However, when large numbers of humans arrived in the area, they cleared the native grasses to plant crops. They killed or drove away native animals and fenced off grazing areas for cattle and sheep. The humans, their crop plants, and domestic animals took over the resources of the plains area to meet their own needs. As a result, these resources became unavailable to other species.

What Do You Think?

Humans are usually pretty good at competing with other species for resources. Does this mean that humans have a right to use any resources they can get in any way that they think fit? Explain your answer.

Did You Know?

How does grass keep growing back when grazing animals keep eating it? Unlike most plants that grow from the tips, new grass tissue grows from the base of the plant. So when the top of the plant is cut off, the grass continues to grow.

Figure 8.2 Hummingbirds compete for sources of nectar by guarding distinct territories.

Sometimes competition occurs when two organisms actually fight to gain control of the resources within a certain area. For example, hummingbirds eat nectar from flowers. They may guard several flowers and chase away any other hummingbirds that try to feed from their flowers. Sometimes the hummingbirds carry this behavior so far that they even chase away moths, which try to sip nectar at "their" flowers.

Did You Know?

Owls are very successful predators partly because of their silent flight. The leading flight feathers of their wings form a cushion that reduces the noise they make as they slice through the air.

Another example of this sort of competition happens between the common loon and people who fish in the loons' lake. Loons eat large amounts of fish. Sometimes humans who fish feel that the loons are eating the fish that they would like to catch. They get angry about the lost catch and shoot the loons. This is illegal, and more than one person has been arrested for trying to stop loons from eating fish. Generally, in this and other kinds of competitive interactions, one species wins and the other loses.

Figure 8.3 A lynx preys on hares. The graph in Figure 8.4 shows the effect lynx and hares have on each other.

Predator-Prey

Another sort of species interaction in which one species wins and the other loses is when a predator eats its prey. This interaction, called **predation** (preh-DAY-shun), occurs everywhere. When a cat catches a bird, that is predation. When an owl catches a mouse or a jay eats the eggs of another bird, that is also predation. Some ecologists even claim that a deer eating grass is a kind of predation.

One of the most famous examples of the interaction between predators and their prey is the story of lynx and hares in northern Canada. Lynx are cats that eat snowshoe hares (rabbit-like animals). Both of these species have been hunted for their fur. For more than a hundred years hunters have been trapping lynx and hares and selling their pelts to the Hudson Bay Company. Throughout that time the company has kept careful records of the number of pelts they bought each year.

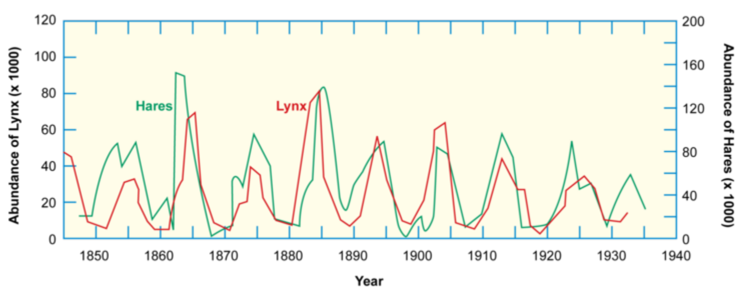


Figure 8.4 The lines on this graph show the changing abundance of lynx and hares in northern Canada during the years 1845-1935.

Ecologists realized that the Hudson Bay Company records were great sources of information on lynx and hare populations. The ecologists assumed that the number of pelts reflected how well the lynx and hare populations were doing. So they graphed the numbers of each type of pelt bought each year. What they discovered is shown in Figure 8.4.

Figure 8.5 American bitterns are masters of camouflage.

Look at the graph in Figure 8.4. The dotted line represents the number of hares caught each year, and the solid line represents the number of lynx caught. You can see that the numbers move up and down in cycles. For example, in 1869 almost no hares were caught. But over 100,000 were caught only six years later in 1875. This data shows that the number of hares can go up and down dramatically.

The interesting thing is that the number of lynx closely follows the number of hares. When there are a lot of hares, there are also a lot of lynx. This pattern makes sense because lynx eat the hares. When there are a lot of hares around, the lynx can easily feed themselves and their kittens. So the number of lynx increases. On the other hand, in bad years when there are few hares to be caught, not many lynx kittens survive and the number of lynx goes down.

What helps a prey animal avoid being eaten by a predator? One answer is **camouflage**. Camouflage is the color, markings, or body shape that helps to hide an animal or plant in its surroundings. With camouflage, an animal (or plant) can blend in with its surroundings. Blending in keeps the predator from easily seeing its prey. You can probably think of many examples. Insects seem to be the masters of camouflage. Moths often look like the bark of the trees upon which they rest. Katydids look like leaves when they fold up their wings. Walking sticks look like little sticks, and you would never know that they were insects unless you saw them move.

Larger animals use camouflage, too. One example is the American bittern. The bittern is a big brown and white wading bird that likes to hunt in the plants growing at the edge of freshwater lakes. Bitterns have long brown streaks that run up their white necks. They stand with their beaks in the air so that the brown streaks line up with the plants around them. To top it off, the bitterns sway with the breeze like the plants around them. Some animals such as the stoat, a mink-like animal, change color in different seasons. In winter, where it snows, the stoat changes from its normal brown and black to white except the black end of its tail.

Did You Know?

Monarchs are poisonous to birds because monarch caterpillars feed on milkweed. Milkweed has a toxic compound in it that remains in the monarchs after they emerge as adults.

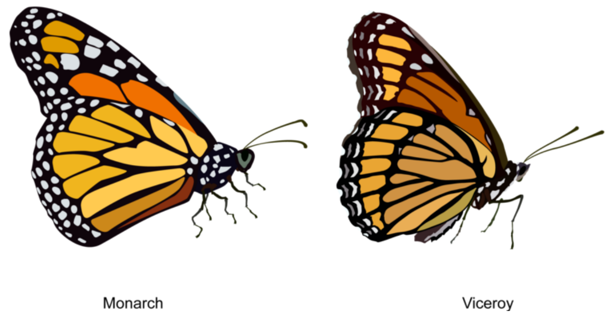


Figure 8.6 Viceroy butterflies mimic monarchs. What differences can you find between the monarch and viceroy butterflies?

Mimicry is another way that prey fool their predators. In mimicry, one species of organism looks like another species. One classic example is the viceroy butterfly. Viceroy butterflies look very much like monarch butterflies, which are the big orange and black butterflies that you may see flying south every fall. But why would it help a viceroy butterfly to look like a monarch butterfly? Birds like to prey on butterflies. But they don't prey on monarch butterflies because monarchs are toxic to birds. In fact, if a bird does eat a monarch it vomits almost immediately. This situation works to the advantage of the viceroy. Birds, which have learned not to try to eat a monarch, will avoid viceroys, too. And this relationship may be beneficial to the monarch butterfly. Viceroys, too, are distasteful to birds. Consequently, if a bird eats either a monarch or a viceroy it will learn to leave any big orange and black butterfly alone!

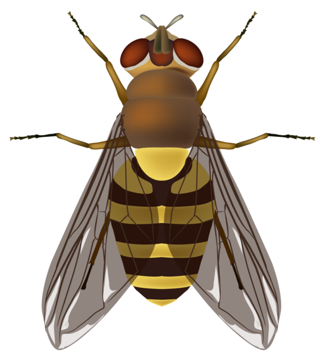


Figure 8.7 Flower flies mimic another flying insect. Which other insect do you think the flower fly is mimicking? Why do you think this might be a good insect to mimic?

Apply Your KNOWLEDGE

Another example of mimicry is the flower fly, which is shown in Figure 8.7. It is actually a fly and a lot like the ones that buzz around garbage on a hot summer day. But it is black with bright yellow stripes. What do you think the flower fly is mimicking and why? What might be the advantage of this mimicry for the flower fly?

Did You Know?

Many parasites actually live inside their hosts. One example is the tapeworm, which lives inside the intestines of animals.

Parasites

Another type of interaction between two species in which one species wins and the other loses is the interaction between a parasite and its host. **Parasites** are organisms that get their food from a host organism without killing it.

The parasite you may know best is the flea. Fleas live on a host such as a dog and feed on the host's blood. A **host organism** is an organism that is used as food by a parasitic organism without being killed. The difference between parasites and predators is that parasites usually don't kill their hosts.

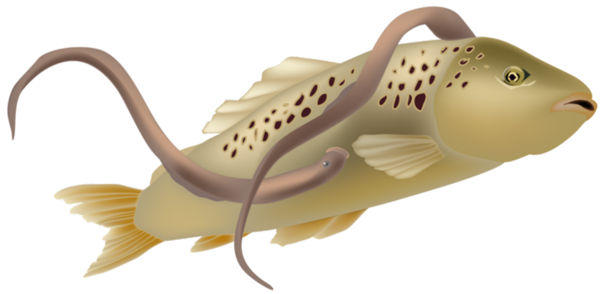


Figure 8.8 Parasites such as the lampreys attached to this fish usually don't kill their host immediately.

One parasite, the lamprey, is damaging fish populations in the Great Lakes. Lampreys are jawless fish that attach themselves to the sides of other fish. There they scrape out a shallow wound and feed on the body fluids that leak out. Generally, lampreys don't kill the fish to which they attach. But they do leave it in a weakened state with a big hole in its side. Lampreys moved into the Great Lakes from the Atlantic Ocean along the St. Lawrence Seaway. They are causing economic problems because they are contributing to the decline of the Great Lakes fishery.

Brown-headed cowbirds are birds that act as parasites by laying their eggs in other birds' nests. The host bird doesn't know that the cowbird has laid an egg in its nest, and will incubate the cowbird egg and feed the chick when it hatches. The host bird is being parasitized because it is spending time and energy feeding the brown-headed cowbird chick instead of its own chicks. In fact, the brown-headed cowbird chick usually hatches before the host's chicks. Some cowbirds may even push the other nestlings out of the nest to gain the full attention of its host parent!

Figure 8.9 The indigo bunting nestling is being pushed from the nest by a cowbird nestling. A video recording of this type of nest interaction was taken by D. C. Dearborne.

Plants can be parasites, too. Mistletoe is a parasitic plant that grows in trees. When a mistletoe seed lands in the crotch of a tree, it germinates and sends its roots into the tree instead of to the ground. As the mistletoe grows, it parasitizes its host tree by using some of the tree's water and nutrients.

Mutualism

Every interaction between two species isn't necessarily a win-lose situation. Sometimes two species actually help each other out. Ecologists call this kind of interaction **mutualism**.

Did You Know?

The rhinoceros and the tickbird are two unlikely animals to help each other. The tickbird eats ticks living on the rhinoceros and receives protection by riding on the back of the rhinoceros. The rhinoceros is healthier because it has the ticks removed.

One example of mutualism occurs between one ant species and a type of violet. Violets are flowering plants and reproduce with seeds. One of the problems a plant has is that it can't move around and drop its seeds where they are most likely to grow. To overcome this problem, this violet produces seeds that have nutritious tidbits on them that the ants eat. The ants look for these seeds, carry them back to their nests, and eat the tidbits. When they're done, the ants abandon the rest of the seed that may sprout and grow. Both the violet and the ant benefit in this interaction, shown in Figure 8.10. The violet's seeds are carried away to new places to grow and the ants have a meal!

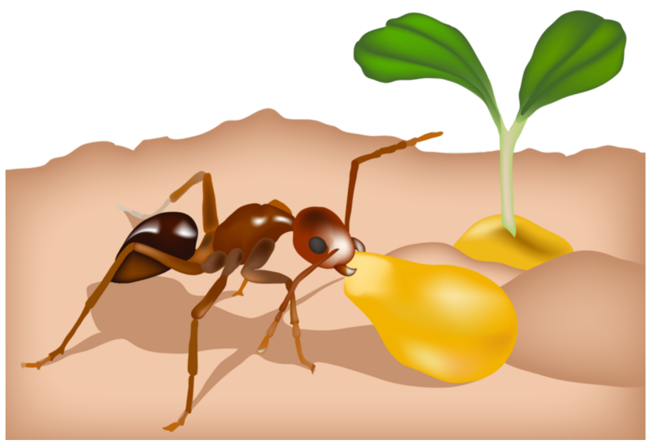


Figure 8.10 Mutualism occurs when both species benefit in the interaction. In this interaction, the violet has its seeds carried to new places and the ants receive something to eat.

Activity 8-1: Once upon an Oak Tree

Introduction

You have been studying how organisms live together and how they can help or harm each other. In this activity you have an opportunity to think more about species interactions by considering what happens in a community of organisms that live on and around an oak tree.

Materials

- Writing materials
- Drawing materials (optional)
- Resource

Procedure

Step 1 Listen carefully as the story is read to you. Close your eyes and imagine that you are observing the species interactions in the story.

Step 2 After hearing the story, read the story on the Resource. Identify each interaction described in the story and discuss the questions below as they apply to each organism in the interaction.

- Is the interaction primarily for food?
- Is the interaction helpful or harmful?
- Is the interaction intentional or unintentional?
- What else do you notice about these interactions?

Step 3 After you have identified the types of interactions that have already been described in the story, think about other interactions that might exist. Select an organism in the story, or a new organism that could survive on the oak tree. Complete the story by writing about the interactions the organism has with other species. You may get some helpful ideas by looking at the following questions:

- What other animals and plants can be included in the oak tree environment? In the forest? In the meadow nearby?
- How do these species interact with each other?
- Are these interactions harmful or helpful to each organism?
- How do these interactions relate to the overall number of other organisms in the area?
- Do you think these organisms interact with organisms from other areas? How? Give some examples.

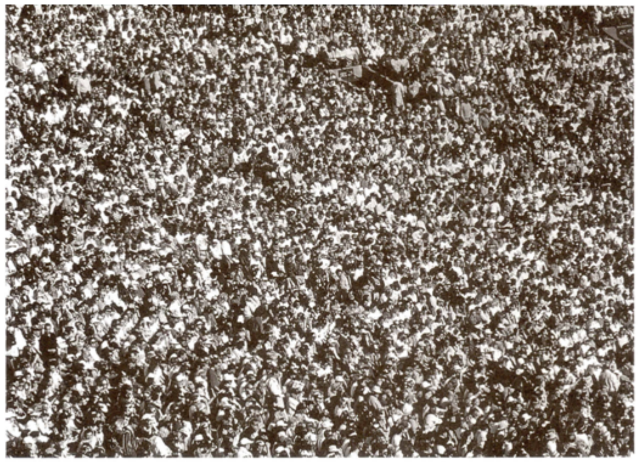
Review Questions

1. What do ecologists mean by the word *competition*?
2. What is the difference between a predator and a parasite?
3. Describe an example of mutualism with which you are familiar, and that isn't explained in this book.

Chapter 10 Human Population Growth - Student Edition (Human Biology)

Chapter Outline

10.1 Human Population Growth



How do humans affect other species?

How do you and other humans fit into the environment? Are humans separate from the environment? Do they compete with other species for resources? Let's find out!

"You must teach your children that the ground beneath their feet is the ashes of our grandfathers. So that they will respect the land, tell your children that the earth is rich with the lives of our kin. Teach your children what we have taught our children-that the earth is our mother. Whatever befalls the earth, befalls the sons of the earth."

Chief Seattle, as translated by Dr. Henry Smith

quoted in *The Earth Speaks*

How do you think ecologists use the term population? Do they mean the people in your town? Do they mean the people in the world-what about all the frogs in a pond or the trees in a watershed? Actually, if you answered yes to all of those examples, you are correct! A **population** is all of the organisms of a certain type living in a certain area at a certain time. Most often, people think only of human populations. But ecologists may study the populations of any type of organism.

Let's talk about the population of people living in Pellston, which is a small town in Michigan. The size of the human population in the town can do only three things: It can go up. It can go down. Or it can remain the same. What are ways to increase the number of people in Pellston? People living in Pellston can have children or people from elsewhere can move to the town. Moving into an area is called **immigration** (ih-muh-GRAY-shun). What are some ways to decrease the number of people in Pellston? People can die or people can move away. Moving away from an area is called **emigration** (eh-muh-GRAY-shun). Those four occurrences-birth, death, immigration, and emigration-cause the size of any population anywhere to change.

Did You Know?

According to the World Bank, half of the population in developing countries will be under 15 years of age by the year 2000. That means that more than 600 million jobs will be needed in those countries in the next few years.

It is important to remember that population size means only the number of individual organisms. For example, the number of individuals who actually live in Pellston is constantly changing. People are moving there and people are leaving. Babies are being born and people are dying. However, the number of people in Pellston seems to stay around 530. That is the population size listed on the sign posted at the outskirts of town.

Apply Your KNOWLEDGE

What is the population size of your class? Your school? Your town?

In many ways, Pellston is like other places in the world because its population can change. However, Pellston is not typical because its population remains pretty stable. A population is stable when the number of births and the number of people immigrating in is balanced by the number of deaths and the number of people emigrating out. Most human populations are growing. A population grows if more people are born or immigrate into the area than die or emigrate out. Some human populations are shrinking. Populations shrink if more people die or emigrate from the area than are born or immigrate into the area.

Now let's look at a human population that is a bit bigger than Pellston's-the world's population. In 1997, the world's human population was over 5.9 billion. But it hasn't always been that large. Look at the graph in Figure 9.1 on page 57.

The graph shows the approximate growth of the world's population since 8000 B.C. Notice how the line wobbles up and down but basically stays flat from 8000 B.C. until after 1000 A.D. After 1000 A.D., the population starts to increase dramatically. The graph shows that it took thousands of years for the human population to reach 1 billion, another 130 years to reach 2 billion, another 30 years to reach 3 billion, another 15 years to reach 4 billion, and another 12 years to reach 5 billion! This pattern is alarming because it shows that it is taking less and less time for humans to add another billion people to the world's population.

What Do You Think?

How many people do you think the world needs? Did we have enough in 1900? In 1950? Do we still need more people? Explain your reasoning.

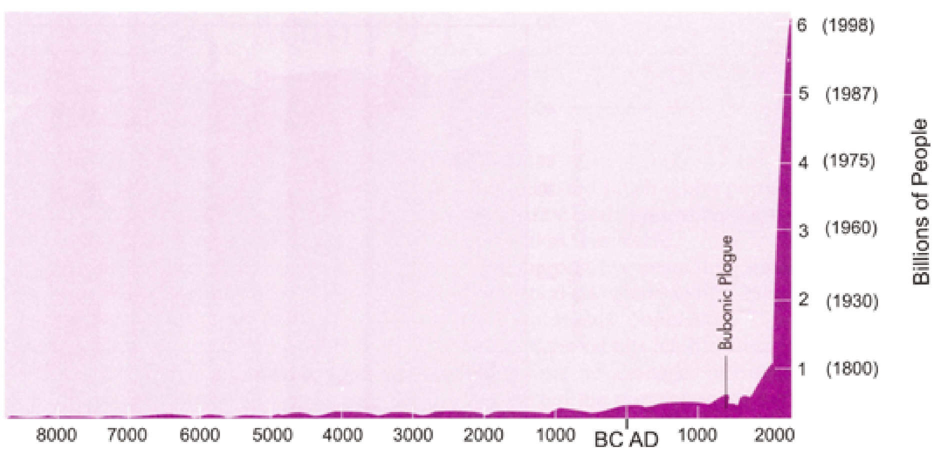


Figure 9.1 This graph shows how the world human population has grown. The years shown in brackets along the right side indicate when the population reached the numbers along the vertical axis.

What is happening with the world's human population as shown in Figure 9.1? You may remember that populations grow only if the birthrate increases, the death rate decreases, or more people immigrate into the population. Immigration and emigration are not involved when studying the world's human population. That's pretty obvious since people aren't moving away from Earth. So what occurrences are affecting population increase in our world? More babies are being born and fewer people are dying.

Ecologists who keep track of human populations are called **demographers** (dem-OG-rah-fers). Demographers tell us that the most dramatic change in the world population has been the result of fewer people dying. Advances in medicine, sanitation, and food production have allowed people to live longer and to have children who also live longer and eventually have more children.

Mexico is one example of a country whose population size has been greatly affected by these changes. Approximately 40 people in 1,000 died each year around 1920. This number shows the **mortality rate**, or death rate. By 1990, the mortality rate had greatly decreased. Only 6 people in 1,000 died each year. So, on average, 34 more people out of 1,000 are now surviving, living, and having children every year. Contrast this change with what has happened with the **birthrate.** The birthrate is the number of children born each year. In 1920, approximately 40 babies were born per 1000 people. In 1990, approximately 30 babies per 1,000 people were born.

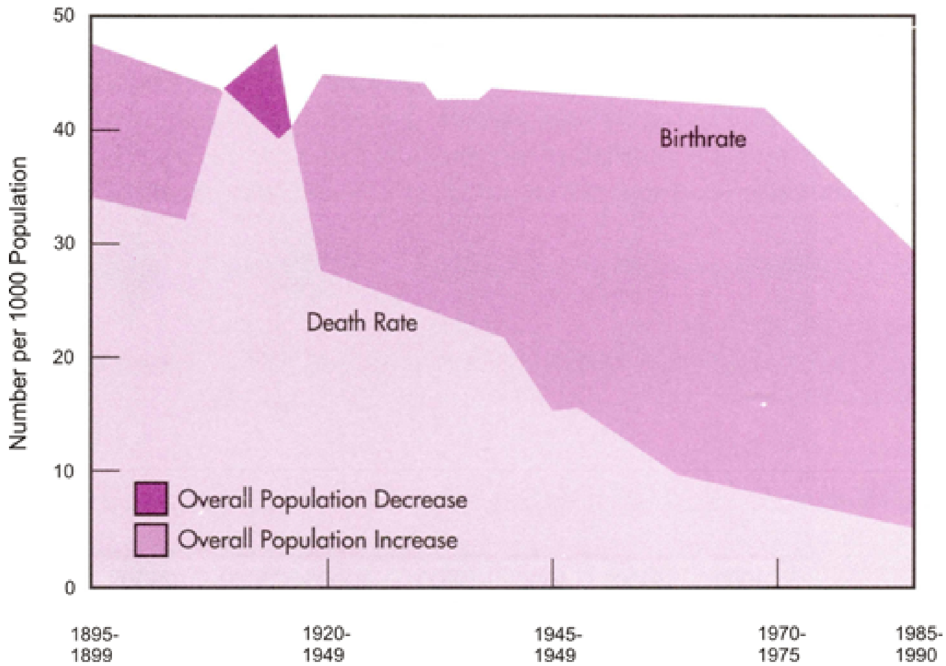


Figure 9.2 Birth-and Death Rates in Mexico, 1895-1990.

The mortality rate and birthrate combine to affect population growth. For example, approximately the same number of people were being born as were dying in Mexico around 1915. That kept the population stable. But many more people are being born than are dying now. As a result, the population is growing.

Did You Know?

Today's physicians effectively treat diseases that once killed hundreds of thousands of people. Furthermore, fewer children are dying right after birth. For example, in the past a woman in Kenya who gave birth to eight children could expect only four to survive beyond infancy. Today a woman in a similar situation would probably see most of her children survive to have children of their own.

One way of thinking about population growth is to calculate the **doubling time** of a population. The doubling time is the amount of time it takes for a population to double in size. Most developed countries such as the United States and most European countries are growing slowly and have long doubling times. For example, demographers predict that the population of the United States will double in about 89 years. Most developing countries such as many countries in Africa, Asia, and South America are growing more quickly than developed countries. So developing countries have short doubling times. The average doubling time for many developing countries is approximately 34 years. That may seem like a long time to you. But 34 years really isn't a long time. Just think: In 34 years a developing country will need twice as many houses, twice as much energy, and twice as much food as it does now. This growth is bound to cause some problems. Imagine what would happen if the number of people in your neighborhood doubled. Where would you put the extra apartments, houses, roads, grocery stores, schools, and everything else people need to live?

Activity 9-1: Brush Rabbit Boom

Introduction

Brush rabbits live throughout the state of California. In order to survive, brush rabbits need dense, brushy areas for their nests. They also need grasslands and meadows for grazing in the spring and summer. In the fall and winter, they need leaves, twigs, buds, and bark. If the rabbits have the food, water, shelter, and space they need, they will keep reproducing. They can produce about three litters per year, with three or four bunnies per litter. Their predators-bobcats and coyotes-keep the population in check. When all of these factors are in balance, the brush rabbit population remains relatively stable. In this activity you investigate how changes in resources can affect the brush rabbit population.

Materials

- Pencils
- Data Sheet: Graph A
- Data Sheet: Graph B
- Resource
- Activity Report
- Graph paper (optional)

Procedure

Step 1 Using the information given below, complete the Data Sheet for Graph A.

Population Growth Information for Graph A

In one habitat, the brush rabbit population has been growing steadily. The rabbits have enough food and water. They also have enough space and brush cover for their nests. While the bobcat population has remained stable, the population of one of their predators-the coyote-has been decreasing over the past five years. Farmers have been trapping coyotes to protect their chickens, and some of the coyotes have been killed.

The following assumptions give you numbers for the brush rabbit and coyote populations for the last five years. Use this information to fill out the Data Sheet for Graph A.

Assumptions

- The estimated brush rabbit population was 250 rabbits five years ago when the coyote population was stable.
- Over the past five years the estimated rabbit population has increased by 25 rabbits per year over the original population.
- None of the rabbits left the area.
- There were no shortages of essential resources that limited the population.

Step 2 Using the information given below, complete the Data Sheet for Graph B.

Population Growth Information for Graph B

Use the same brush rabbit habitat described above. But assume that the coyote population was reduced to zero and that hunters have killed all but three bobcats. This drastic change in the predator population has resulted in the brush rabbit population doubling each year for five years, starting with year one.

The following assumptions give you numerical information for the brush rabbit and coyote population for the last five years. Use this information to fill out the Data Sheet for Graph B.

Assumptions

- The brush rabbit population doubled every year from year one to year five.

- The number of brush rabbits five years ago was 250.
- None of the rabbits left the area.
- There were no shortages of essential resources that limited the population.

Step 3 Use your completed graphs to answer the questions on the Activity Report.

Did You Know?

People living in the United States consume more resources than people living in most other countries do. We also produce more waste by processing all those resources.

Population Growth and Resource Use

The number of people is just one part of the story of human population growth. The other part is how people use the resources that are available to them. For example, as a person living in the United States, during your lifetime you will probably consume;

- a number of calories equal to that contained in 100,000 hamburgers, 2 million French fries, 50,000 chocolate shakes, 50,000 apples, and 4,000 gumdrops,
- 500,000 gallons (2,272,500 liters) of water just to shower
- 1 ton of soap (0.9 metric ton)
- enough energy to drive a car around the world 1,500 times
- 150 trees for wood and paper
- tons of metals, cloth, plastics, and glass

A typical person living in a developing country would use far less of all of these products.

It can be hard to compare the resources used by people in different countries. For example, you may eat hamburgers or other meat several times a week, while a student in India may never eat meat. Ecologists have tackled this problem by trying to reduce all comparisons to the amount of energy used by people in different parts of the world.

One way to measure energy is to measure the number of calories in food or fuel. Another unit used to measure the amount of energy in something is a **gigajoule** (GIG-uh-jool). A joule is equal to 0.24 calories, and *giga* means 'one billion'. Ecologists have calculated that the average person living in the United States uses about 300 gigajoules of energy each year to do everything from heating their homes, to growing the food they eat, to traveling. The average person living in Mexico uses about 50 gigajoules each year. The average person living in Nigeria uses less than 10 gigajoules of energy per year.

Apply Your KNOWLEDGE

How many calories are there in 300 gigajoules?

People in developed countries such as the United States use about 10 times as much energy per person as people in many developing countries. For example, farmers in developing nations may use only human muscle power and a few domestic animals to work their fields. In contrast, farmers in developed countries use machines and products that consume a lot of energy such as tractors, loaders, combines, fertilizers, and pesticides.

The difference in energy use shows how differently the various people around the world use resources. One person in the United States uses about 6 times as many resources in a year as one person in Mexico, and about 100 times as many resources as one person in Nigeria. In other words, you can raise one child in the United States or 100 children in Nigeria with the same amount of resources.

Journal Writing

Suppose you wanted to reduce the amount of resources that humans consumed in an area.

- Explain one strategy to keep the number of people in the area from growing.
- Explain one strategy to reduce the amount of resources that each person used.

Which countries would you advise to use each strategy?

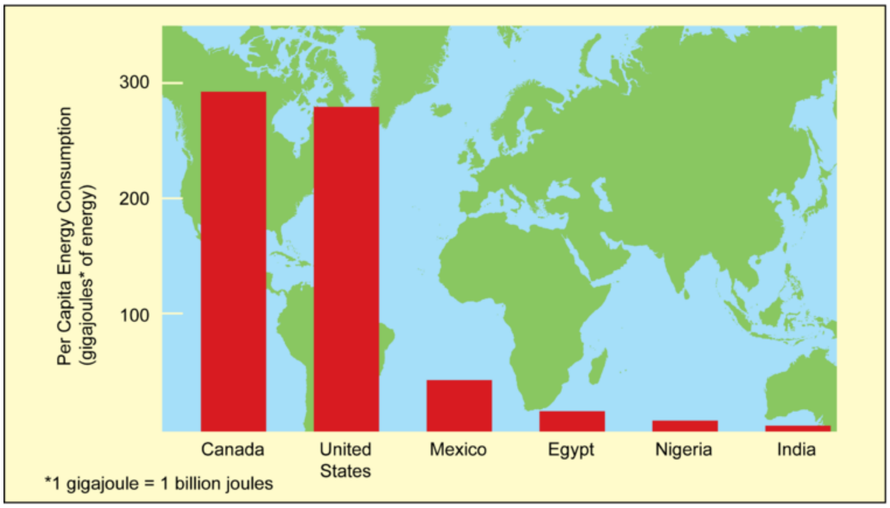


Figure 9.3 Compare the average energy use per person in these six countries.

These energy comparisons show that it doesn't matter only how many people live in an area. It also matters how they use their resources. Ecologists estimate that humans are using about 40 percent of the world's **terrestrial net primary productivity.** Terrestrial net primary productivity is a name for all of the sun's energy that is trapped and stored by all of the plants on the Earth's land surfaces during photosynthesis. Remember how all energy can be ultimately traced back to the sun?

Population growth and the use of resources are the keys to many environmental problems we have. More people use more and more resources. This increasing use is depleting our supply of important resources. And the more resources we use, the more waste and pollution we are dumping into the environment.

Apply Your KNOWLEDGE

Suppose that the world's population doubles in 40 years, and energy consumption rates remain the same. What percentage of the world's net primary productivity will be used by humans in 40 years? What percentage will be left over for all of the other living things on Earth?

Review Questions

1. What is a population? What are four ways in which its size may change?
2. Suppose the doubling time for a population of algae in a pond is 24 hours. Also suppose the pond is now at capacity for algae. How long ago was the pond only half full of algae? How long ago was the pond one fourth full of algae?
3. Is the size of the world's human population growing or shrinking? Is it doing this at a constant rate?
4. Do 100 people living in developing countries such as Nigeria have the same impact on the environment as 100 people living in the United States? Explain your answer.

CHAPTER 11 Global Change - Student Edition (Human Biology)

CHAPTER OUTLINE

11.1 Global Change

How do the activities of humans affect the environment on a continental and worldwide scale?

Human activities have led to continental and even worldwide changes in the environment. The result is called **global change**, because the changes occur on a huge scale over the entire globe called Earth. Often, the direct causes of these changes are not immediately clear. For example, traces of pesticides can be found in the snow at the North Pole even though humans do not use pesticides anywhere near there. The pesticides somehow traveled thousands of miles through the atmosphere from places where farmers used them to control agricultural pests. In this section you will explore two major examples of global change-acid rain and global warming.

"Whatever befalls the Earth befalls the sons of the earth. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself. . ."

Chief Seattle, as translated by Dr. Henry Smith

quoted in *The Earth Speaks*

Acid Rain

One of the problems created by excessive energy use in North America is **acid rain.** What is acid rain? How is it formed? How can rain be acidic? What can be done to prevent its formation?

Did You Know?

A better name for acid rain is acid precipitation, because snow as well as rain can be acidic. An even better name is acid deposition, because it also includes dry particles that can fall out of the atmosphere and combine with water to form acids.

Rain, in most cases, is naturally acidic. But sometimes it contains impurities that can make it highly acidic. **Acidity** is the amount of acid in a substance. Measuring the acidity of a liquid is measuring of one property of that liquid. You probably know other measurements of the properties of a liquid, such as its temperature, volume, and weight. Acidity is measured in terms of pH, much like temperature is measured in degrees. Vinegar, lemon juice, and cola are some examples of acidic liquids that you know. The opposite of acidity is alkalinity (al-ka-LIHN-ih-tee). Shampoo and milk are examples of alkaline liquids.

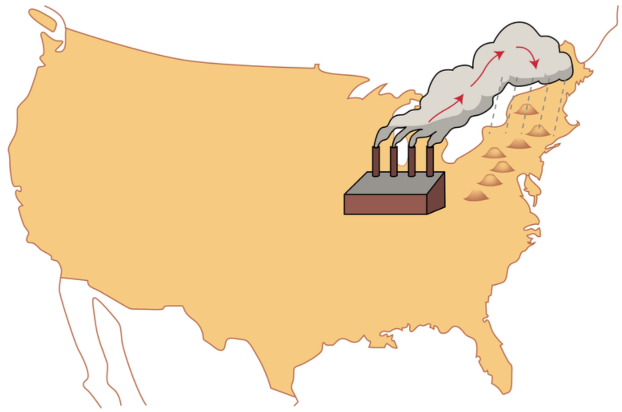


Figure 10.1 The sources of acid rain may be located far from where the acid rain has the most damaging effects.

Did You Know?

The most acidic rain ever measured in the mountains of the eastern United States was 2,000 times more acidic than unpolluted rain. That means it was like lemon juice falling from the sky!

Sulfur dioxide and nitrogen oxides are gases in the atmosphere. These gases can mix with water in the atmosphere. When enough of these gases mix with water, they change into sulfuric and nitric acids. The acids mix with water vapor and fall to earth when it rains. Sulfur dioxide is a chemical with molecules that are made up of one atom of sulfur and two atoms of oxygen. Sulfur dioxide is written SO_2 in scientific shorthand. Nitrogen oxides are chemicals with molecules made of one atom of nitrogen and one or two molecules of oxygen. Scientific shorthand for nitrogen oxides is NO

x *.The* x *indicateseitheroneortwoatomsofoxygen.*

What Do You Think?

How would you solve the problems caused by acid rain in the Northeastern United States? Would your solution be fair to the people in the Midwest? Would it be fair to the people in the Northeast? Explain your reasoning.

How do sulfur dioxide and nitrogen oxides get into the atmosphere? Most come from the smokestacks of power plants and factories and the tailpipes of automobiles. SO_2 and NO

x *arereleasedasbyproductswhenfossilfuelssuchasgasolineorcoalareburned.* SO_2 *and* NO_x *intheaircandriftthundredsofmil*

Did You Know?

Acid rain affects land organisms and water organisms. The needles of evergreen trees can be. damaged by acid rains.

Acid rain tends to acidify the lakes and rivers on which it falls. Many aquatic organisms are affected by the acidity of the water in which they live. Acid rain has caused the decline of fish populations in lakes in the Adirondack Mountains of New York and in the rivers in Nova Scotia. Some insects such as water boatmen can live in lakes with a wide range of acidities. Other organisms such as fresh water mussels are very sensitive to acidity and can live only in fairly neutral waters. The bar graph in Figure 10.2 on page 64 compares how much acidity some different organisms are able to tolerate.

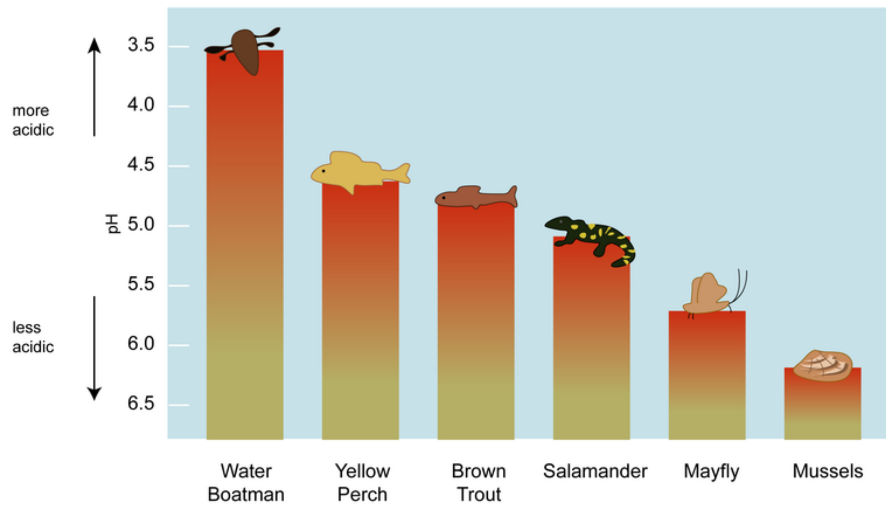


Figure 10.2 Different aquatic organisms can tolerate different amounts of lake acidity. The shaded bars on this graph show the range of acidities in which these organisms can live.

Apply Your KNOWLEDGE

Suppose you found a water boatman, a salamander, and a may fly while you were exploring a stream. What would you guess the pH of the stream would be? If you found only water boatmen in a second stream, would you guess that the second stream has a higher or lower pH than the first? (Hint: Look at Figure 10.2 and make sure that you notice that pH gets lower as you go up the vertical axis.)

Acid rain washes away calcium that normally cycles in forests. When this happens, calcium isn't available in the food chain, and birds can't get the calcium they need to make strong eggshells. As a result, birds living in areas with heavy acid rain are more likely to lay thin, fragile eggs. The fragile eggs break when the birds try to sit on them to keep them warm.

Journal Writing

Which of the effects of global warming do you think is more dangerous to humans: sea levels rising or rainfall patterns changing? Why? Should people who are not directly affected by these global warming effects do anything to decrease greenhouse gases? Why or why not?

Limiting the release of sulfur dioxide and nitrogen oxides would reduce the problem of acid rain. This can be done in several ways. For example, using more fuel-efficient automobiles and installing scrubbers that clean smokestack emissions will reduce the release of harmful gases. These changes sound easy but often are not done because they are expensive. Also, the people who suffer the effects of acid rain are often not the ones who cause the problems. Most of the pollution that causes acid rain in the northeastern United States actually comes from big Midwestern cities such as Chicago, Detroit, Cleveland, and Pittsburgh. So people in the Northeast have to convince people in the Midwest to burn their fossil fuels more wisely, even though the Midwest people don't benefit directly. In fact, it may cost them more money!

Another problem you've probably heard about on the news is global warming. You read a little about global warming on page 24. **Global warming** is the continuing increase of Earth's temperature. If the present trend continues over the next hundred years, the average temperature of the earth's atmosphere may become warmer than it has been for the past million years. Although this change doesn't sound that bad, even a small increase in temperature could lead to some harmful changes. Melting ice caps can increase ocean waters and cause flooding of low-lying areas near the ocean. Global warming can increase the length of the hurricane season. Also, global warming can increase the amount of rain in some areas and decrease the amount of rain in others. Although most places will become warmer, weather patterns may change so that a few could become cooler.

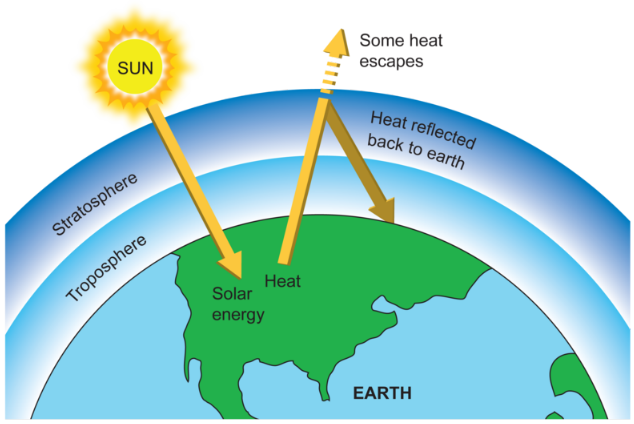


Figure 10.3 Greenhouse gases trap the sun's energy in the Earth's atmosphere.

Many scientists think global warming is likely to happen because humans have added excessive amounts of carbon dioxide to the atmosphere by burning fossil fuels. Gases called **CFCs** (chlorinated fluorocarbons) found in some air conditioners and refrigerators also are being released into the atmosphere. Carbon dioxide and CFCs are greenhouse gases that have the ability to trap heat in the atmosphere.

Did You Know?

Sometimes simple changes can stop the production of substances that can harm the environment. One disk-drive factory in California was the single largest source of CFC-113 emissions in the United States in 1987 because it used CFC-113 to clean circuit boards. Now, the company simply dunks the circuit boards in soapy water and blow-dries them. This is a good example of a corporation seeing a problem and finding a solution to the problem. It's important for other corporations, individuals, and groups of people to do the same type of problem solving.

Remember that greenhouse gases trap heat in the atmosphere. This process of trapping heat is similar to the way that glass keeps the sun's heat trapped in automobiles and greenhouses. Normally, energy from the sun reaches Earth, warms it, and then some bounces back to space. But when greenhouse gases are in the atmosphere, the heat that would normally bounce out into space is trapped and stays to warm the atmosphere. This process, sometimes called the **greenhouse effect**, is shown in Figure 10.3.

What are some of the possible effects of global warming? One of the most dramatic effects would be the rise in sea levels. Because water takes up more room when it is warmer, the volume of the world's oceans will increase. Scientists predict that sea levels around the world will rise anywhere from 0.2 meters to 2.2 meters. Many low-lying areas near the ocean would be permanently flooded. For example, most of the Florida Keys and the Everglades would be completely underwater!

Another likely effect of global warming would be a change in precipitation patterns. Some places that receive a lot of rain now could dry up, while others that don't get much rain now could be flooded! Currently, scientists predict that the central United States will be much drier. This region is sometimes called the nation's "breadbasket." But continued global warming could make the area too dry even to grow wheat.

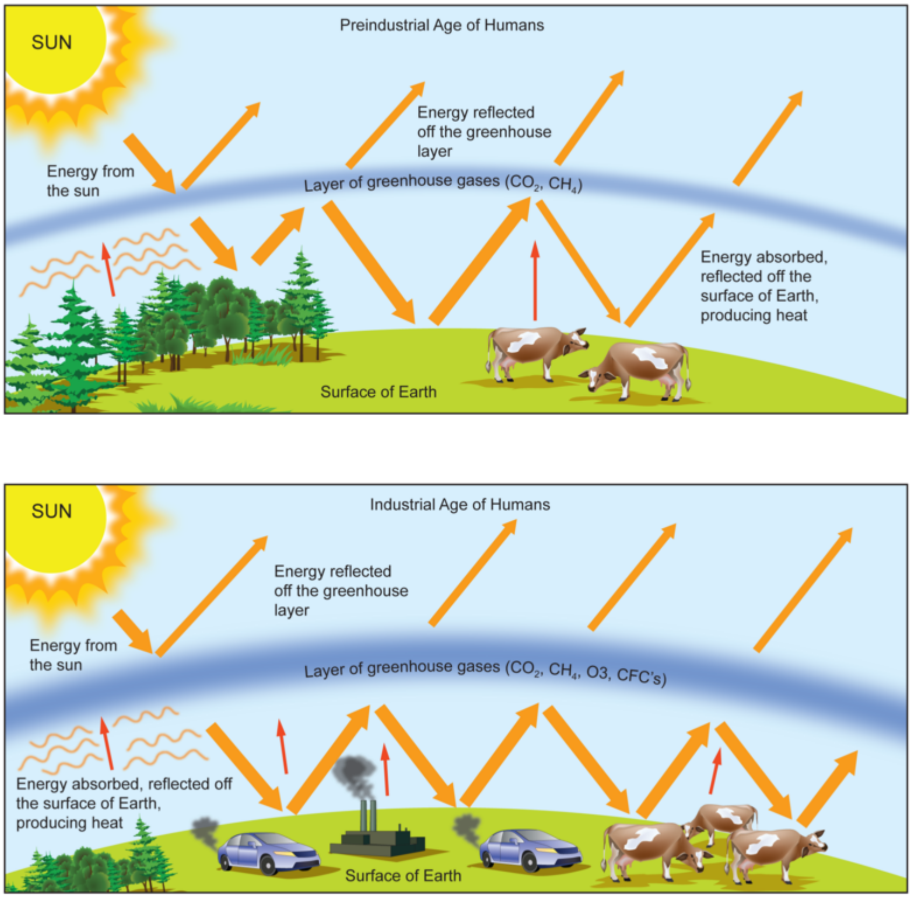


Figure 10.4 Greenhouse gases have increased significantly during the industrial age.

Did You Know?

Carbon dioxide is responsible for about 71% of the greenhouse effect. Every year people in the U.S. add at least 1.5 billion tons (1.36 billion metric tons) of carbon dioxide to the atmosphere by burning fossil fuels.

One way to prevent global warming is to reduce the amount of greenhouse gases that human activities put into the atmosphere. This could be done by reducing the amount of fossil fuels burned and, perhaps, replace them with fuels that don't produce carbon dioxide. Scientists are now looking at ways to use hydrogen-based fuels and solar energy to achieve this goal.

Activity 10-1: Feeling the Heat: The Greenhouse Effect

Introduction

There is evidence that human activities are causing the Earth's average temperature to rise at a slow but steady rate, Scientists have called this phenomenon the *greenhouse effect.* What exactly is the greenhouse effect? What causes it? What are its consequences? Are there possible solutions?

Materials

- Glass bowls or containers of various sizes
- Lamp

- Dirt
- Ice
- Water
- Colored paper
- Thermometers
- Activity Report

Procedure

Step 1 Discuss the following questions, Write your responses on your Activity Report.

- Why do scientists think gases such as CO_2 trap heat in the atmosphere?
- Will increased CO_2 in the atmosphere cause an increase in global temperature? Explain.
- How is the greenhouse effect expected to influence your life? Human life in general? The environment?

Step 2 Design and create physical models of Earth under two different conditions-without high levels of greenhouse gases and with high levels of greenhouse gases.

- What part(s) of your physical model represents "normal" levels of greenhouse gases? What part(s) represents high levels?
- How does changing your model's "atmosphere" affect other parts of your model, such as air temperature?
- How can you change parts of your model such as temperature to lessen the effects of a rise in greenhouse gases?

Step 3 Discuss the following questions, Write your responses on your Activity Report.

- How closely does your model represent real life?
- In what ways could your model be improved?

Step 4 Use your model to create a presentation to teach the class about the greenhouse effect. Your presentation should include its causes, consequences, and possible solutions. Use the responses on your Activity Report to begin developing your presentation.

Review Questions

1. What causes acid rain?
2. Does acid rain affect only the people who live near its source?
3. What is global warming?

Chapter 12 Defining Biological Diversity - Student Edition (Human Biology)

Chapter Outline

12.1 Defining Biological Diversity

Rain forest in Queensland, Australia.

What is biological diversity?

What is an endangered species? What can you do to keep a species from disappearing or becoming extinct (ek-STINKT)? These are questions that conservation biologists try to answer. Conservation biology is a field of study in which scientists try to find ways to maintain biological diversity.

"What is life? It is the flash of a firefly in the night. It is the breath of a buffalo in the wintertime. It is the little shadow which runs across the grass and loses itself in the Sunset."

Crowfoot

quoted in *The Earth Speaks*

Biological Diversity

What is biological diversity? The word **diversity** means variety. Diversity refers to how things are different. If you have a box full of purple crayons, the colors in me box are not diverse. On the other hand, if each crayon is a different color, your box of crayons is very diverse. The word *biological* refers to life or living processes. So **biological diversity** means the variety of life mat exists in an area.

Conservation biologists tend to look at three levels of biological diversity-habitat diversity, species diversity, and genetic diversity.

Remember that **habitats** are the places that contain all me resources an organism needs to live. A bullfrog's habitat may be a pond.

A **species** is a group of organisms that are so much alike that they can reproduce and make others like themselves. Bullfrogs, sugar maples, and dogs are three different species.

Genes are contained in almost every living cell. Genes carry genetic information from one generation to the next. Genes are responsible for most of the different characteristics of individuals and of a species. Different versions of genes may make a dog's hair brown or black, your hair curly or straight, or the leaves on a tree in your yard greener or more yellow.

Figure 11.1 How many habitats can you find around your school?

Mini-Activity

Count Your Habitats How many habitats can you find at school? Count all the habitats you can find in your school. Then write them down on a piece of paper or in your journal. Describe what makes each habitat different.

Now let's investigate the different levels of biodiversity you might see around your school. First, think about the habitat diversity around the building. Is there an open-space habitat, such as a sport field, for grass, dandelions, and ants? Are there any woods or parks near the school that provide a habitat for some birds, squirrels, and raccoons? You might even discover that the drain in the boiler room provides a perfect habitat for silverfish. But you'll see silverfish only if you look very fast when you turn on the light. The field, woods, and drain are very different from one another. But each offers a habitat for different species.

Mini-Activity

Local Species Use the same list you started that includes the different habitats around your school. List the species of living organisms you can think of or observe in each habitat. When you finish your list, look over it again. Are there any species that live in more than one of the habitats?

Now think about the species diversity you might find in various habitats around your school. You probably have many different species in each of these habitats. Some of these species may include grass, dandelions, trees, ants, birds, raccoons, animals kept in the classrooms, silverfish, spiders, and cockroaches. Can you think of any other species? Don't forget about the species sitting next to you.

Now let's investigate the genetic diversity in a species around your school. It's probably easier to focus on one species and think about how the individuals in that species differ. So let's pick you, your classmates, and your teacher! What makes you different from the people around you? What makes them different from everybody else? Do some people have black hair? Do others have blond hair? Does anyone have brown or red hair? Hair color is one example of genetic diversity in humans. What are some other types of genetic diversity you can think of? After you identify some characteristics that make humans different, think of some characteristics that make humans similar. What characteristics do humans have in common?

Now let's investigate a larger area than that around your school. Let's take an imaginary trip to the Congo River region of west and central Africa to investigate the levels of biodiversity. Flying over the region, you can see many different types of habitats. The habitat diversity of the Congo River region includes swamps, grassland, the tropical dry forest, the tropical rain forest, human villages, and the Congo River (also called the Zaire River).

Did You Know?

Rain forests aren't the only habitats so biologically diverse that they contain thousands and even millions of species. Coral reefs team with hundreds, even thousands of species. And wetlands such as marshes and estuaries support an incredible variety of birds, insects, and other organisms.

When we land and get a closer look at the living organisms, we can observe a lot of species diversity in each habitat. Our trip takes us into the tropical rain forest near the Congo River. The tropical rain forest is a large habitat, which contains millions of different species. A few of these are wild pigs, driver ants, African elephants, *Myrianthusarboreus* (an edible fruit tree), duikers (deer-like animals), lemurs, and gorillas.

Did You Know?

Rain forests make up only two percent of the Earth's surface. But more than half the world's wild plant and animal species live there.

As we make our way through the Congo River rain forests, we notice a band of gorillas. The gorillas would be a good species in which to investigate genetic diversity. Every once in a while a gorilla is born with a gene that does not produce *melanin* (MEL-uh-nin), which is the pigment that gives color to hair, skin, and eyes. These gorillas are called *albinos*. Albino gorillas have white fur and pink eyes. Most gorillas are dark in color. So these few albinos represent one unusual example of genetic diversity occurring among gorillas.

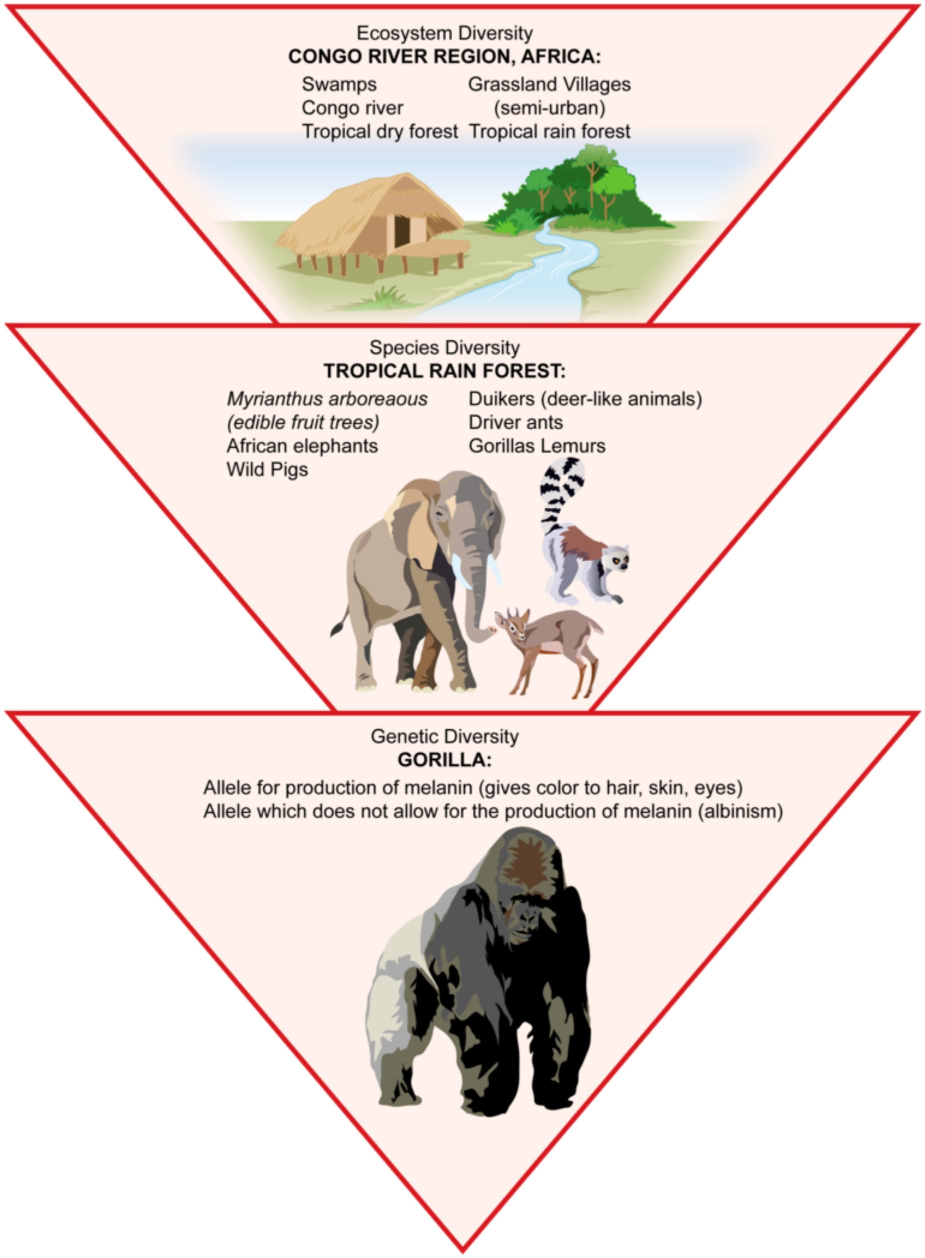


Figure 11.2 This figure shows examples of biological diversity in the Congo River region. Notice how biological diversity exists at many different levels.

Activity 11-1: Expedition to the Kalimantan Rain Forest

Introduction

Your environment contains many different kinds of organisms. However, rain forests contain a wider variety of organisms than almost any other environment. In this activity you plan an expedition to study the biological diversity of the Kalimantan rain forest on the island of Borneo in Indonesia. Imagine that you have been invited by the government to measure the species diversity of the forest. You must count the number of different kinds of organisms you observe there. You have been given enough money to pay for supplies and three assistants to help you during one month of field study.

Materials

- Marking pens, colored pencils, crayons
- Paper
- Maps, drawings, photographs of the rain forests of
- Indonesia
- Resource 1
- Resource 2
- Activity Report

Procedure

Step 1 You must prepare yourself and your team for your imaginary expedition into the rain forest. You will be working and living in harsh environmental conditions. Use the following questions as a guide to find out more about the rain forest's location, climate, and surroundings as described on Resources 1 and 2:

- What is the weather like? How hot or cold is it? How much rain falls there? What animals (especially insects) and plants will you be observing?
- What equipment and clothing will you need to live in these conditions?
- What scientific equipment will you need to study and record your observations in the rain forest?

Step 2 Use the information you researched to write out a packing list for what you will bring on your trip. Don't forget. The forest is so dense that you and your team will have to carry everything you need in your backpacks!

Step 3 Draw a picture of you and your team prepared to walk into the forest to begin your expedition.

Step 4 Now you are ready to explore the Kalimantan rain forest. Listen carefully while the reader describes your journey through the Kalimantan. Picture in your mind the plants and animals described in the story. Use all your senses to gather information about the forest-the sights, sounds, smells, and sensations. Then when the story is finished, discuss the questions on your Activity Report and write your answers.

Conservation biologists strive to preserve biological diversity at all levels-from genes to species to habitats. One challenge in achieving this goal is measuring biological diversity. Conservation biologists need to measure diversity so that they can track it and monitor whether or not they are achieving their goal.

One of the most common ways of measuring biodiversity is to count the numbers of species in an area. This task may seem easy to you. But it can be very challenging. For example, ecologists who want to count the species living in a specific section of the tropical rain forest have to be able to observe all of the living things in the treetops called the *canopy*. They also have to measure everything they observe on the ground.

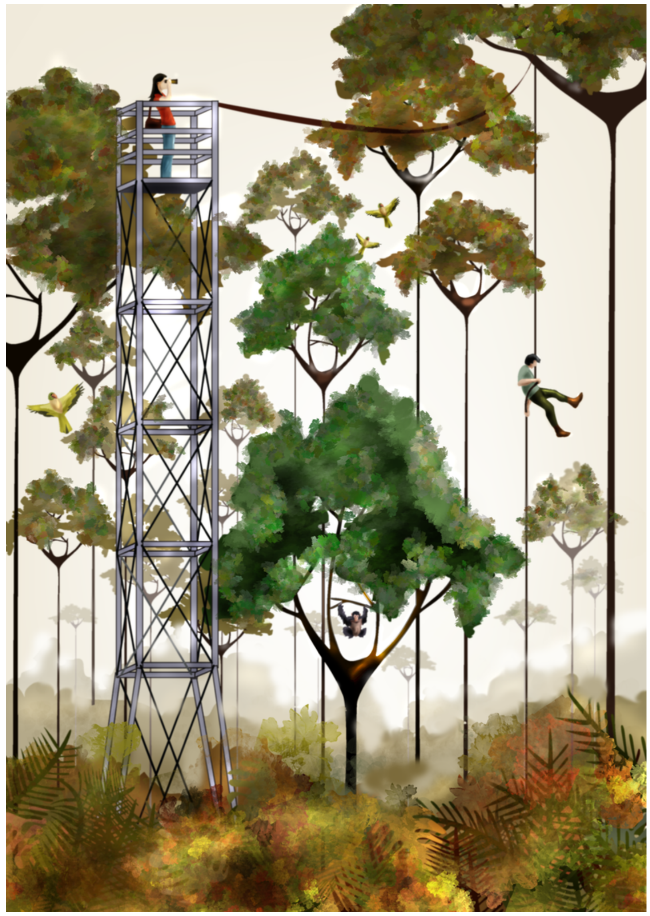


Figure 11.3 Researchers have to use scaffolding and climbing gear to reach the top of the tree canopy to count the species in a rain forest.

So the ecologists counting species have to count every living organism from the ground to the canopies towering above. Making these observations can be a challenge because the treetops may be 30 meters up in the air! The ecologists often have to use ropes, climbing gear, and scaffolds just to reach the tree canopy.

Once in the canopy, the ecologists may see many insects, birds, and even plants. But they will probably miss a lot, too. Many animals are afraid of humans. Some animals are active only at night. And some animals pass through an area for only a few minutes in a day. So researchers often look for signs of animals, such as burrows, nests, chewed up food, and scat (animal droppings). As you can see, trying to count all of the species in an area can be a lot of hard work.

One of the reasons it's important to measure biodiversity is that humans tend to destroy plants and animals when they alter habitats for their own use. Although there are some habitats that haven't been significantly altered by human activities, most habitats are disturbed in one way or another. Some disturbances caused by humans are major disturbances, such as building roads, cutting down trees, and damming rivers. But humans alter habitats in more subtle ways, too, such as when they replace a meadow with a lawn.

Did You Know?

Forests provide essential services to humans. It is estimated that one mature tree consumes almost 6 kilograms (about 13 pounds) of carbon dioxide per year.

Why does biodiversity matter? Who cares if species become extinct? Don't things become extinct naturally? A species is **extinct** when no members of that species exist. The dinosaurs are extinct.

Passenger pigeons are extinct. American chestnut trees are an **endangered** species, which means they may soon become extinct. In fact, many species do become extinct eventually. But usually it takes millions of years. Currently humans are causing an extinction crisis. We are altering many of Earth's habitats more and more drastically. Now species are becoming extinct at a rate much faster than at any other time, as shown in the fossil record.

Journal Writing

The huge biological diversity of rain forests, coral reefs, and wetlands has been attracting many tourists to areas with these habitats. These tourists learn and appreciate the biodiversity, but also consume local resources and create waste. How should the local communities deal with this new development? What policies would best promote a balance between these two concerns?

As long as we have enough food, why should we care if biodiversity is decreasing and species are becoming extinct?

First of all, you know that species constantly interact with other species. All of these species' interactions affect one another and create healthy, functioning communities. If these communities fall apart, many of these services that the species provide will fall apart, too.

Here's one big example of a service provided by intact communities: What do you think would happen if all the decomposers in the world became extinct? Soon we would be up to our necks in dead animals and plants that would not decay. The cycling of nutrients would stop. Eventually, no new organisms would be able to grow, because they couldn't get the nutrients that were locked up in all of the dead bodies.

But that example is pretty dramatic. Let's look at a less drastic example of what might happen if one species, such as honeybees, became extinct. Honeybees, like other organisms in a community, provide valuable services. The pollination of plants occurs when pollen is carried from one flower to another so that the flower can be fertilized and make fruit and seeds to produce new plants. Often honeybees carry the pollen. What do you think would happen if honeybees became extinct? One obvious change is that there would be no more honey. A more important result would be that no apple tree blossoms would be pollinated, so no apples would grow. The same thing would be true for all bee-pollinated fruit crops. You would not be the only living organism to suffer. Other animals, which rely on the fruit, would be affected, too.

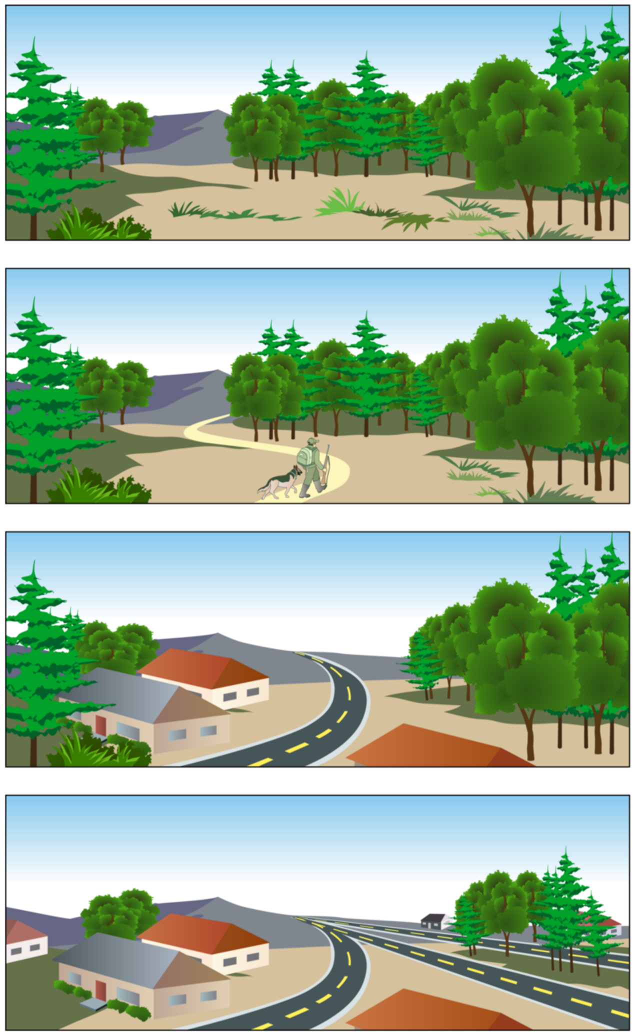


Figure 11.4 Disturbance of a habitat by humans can occur at different levels. Here is a meadow that becomes more and more disturbed by development.

Apply Your KNOWLEDGE

Take a moment to consider how disturbance affects species diversity. Which do you think would have more species in Figure 11.4, the undisturbed meadow or the street with buildings? Explain the reasons for your answer.

Did You Know?

One-quarter of all medicines comes from tropical rain forest plants.

A second reason to preserve biological diversity is the present and future economic value of biodiversity. All of our domestic plants and animals came from wild species. Researchers often study the wild forms of these organisms to see if they can breed better versions for farmers. One study of better breeding is the production of drought-tolerant wheat or pestresistant potatoes. We don't know which wild species may be useful for humans in the future. So we don't want to lose any today.

Figure 11.5 Honeybees do most of the pollination of apple blossoms. If apple blossoms are not pollinated, then apples will not grow.

Wild species are an important source of medicine. About a third of all modern medicines come from different types of plants and molds. No one knows when a new medicine might be discovered. Drug companies continually test many wild plants to see if they have medicinal value. In fact, two drugs that have revolutionized the treatment of leukemia came from a little-known plant called the Madagascar periwinkle, which is shown in Figure 11.6.

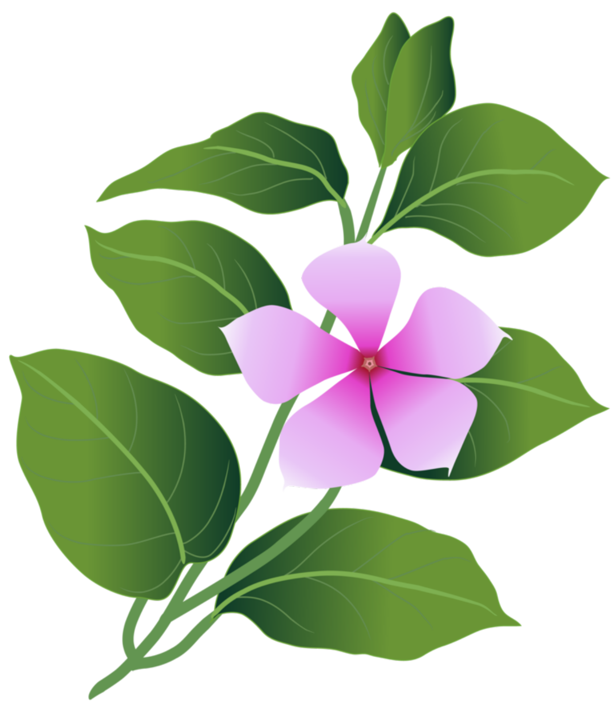


Figure 11.6 The Madagascar periwinkle is a plant that is the source of two drugs used in treating leukemia.

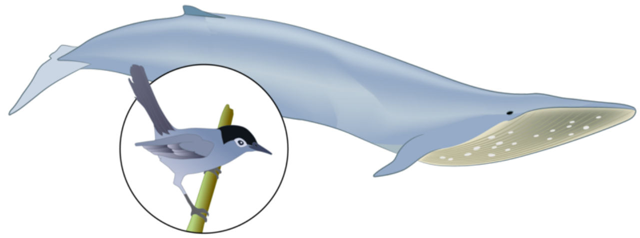


Figure 11.7 The California gnatcatcher and the blue whale are just two of the thousands of species that are close to extinction.

A third reason to preserve all species is **aesthetics** (as-THET-iks). Aesthetics is beauty. The aesthetics of nature refers to the fact that the sights and sounds of nature are beautiful and pleasing to have around. For example, it's nice to have different species of plants and animals outside. Many people enjoy walking in the woods, strolling along the beach, or climbing a mountain to interact with nature's diversity. More than 30 million people in the United States say they are bird watchers. About one family out of every three feeds birds for fun. And together they spend over half of a billion dollars a year doing it! If bird diversity wasn't naturally interesting, millions of people wouldn't have so much interest in bird watching.

What Do You Think?

Do you think that it is important for humans to keep other species from becoming extinct? Review the four reasons listed. What are some other reasons you can think of for humans to preserve biodiversity?

A fourth reason to preserve biodiversity is **ethics**. Many people believe that all species have a right to exist whether they serve a need for humans or not. Is it our right to destroy all of the habitats of the tiny California gnatcatcher? Is it our right to hunt all of the blue whales, which are Earth's largest animals, out of existence?

Review Questions

1. What is biological diversity?
2. What are three levels of biodiversity?
3. Who are conservation biologists and what do they do?
4. How do humans affect biodiversity?
5. What are three reasons to preserve biodiversity?

CHAPTER 13 Conserving Biological Diversity - Student Edition (Human Biology)

CHAPTER OUTLINE

13.1 Conserving Biological Diversity

How do species become extinct and what can humans do to prevent this loss of biodiversity?

We lose biodiversity when species become extinct. In this section you will explore some of the causes of extinction and investigate some ways conservation biologists are helping to preserve biodiversity.

". . . twilight is a time for sharing-and a time for remembering-remembering the things of beauty wasted by our careless hands-our frequent disregard of other living things-the many songs unheard because we would not listen-listen tonight with all the wisdom of your spirit-listen too with all the compassion of your heart-lest there come another night-when there is only silence-a great and total silence-"

Winston Abbott

"Have You Heard the Cricket Song?"

quoted in *The Earth Speaks*

Disappearing Acts: Extinction

A first step in preventing the loss of biodiversity is to figure out how we are losing biodiversity. For this reason, conservation biologists study species that are about to become extinct. They also try to determine what happened to a species that has already become extinct. Remember that a species is said to be extinct when all individuals of that species have died.

The first step biologists take in analyzing how a species becomes extinct is to identify the ultimate and proximate causes of extinction. Those two words-*ultimate* and *proximate*-may be unfamiliar to you. But they are fairly simple ideas. An **ultimate cause** is an action that starts a series of events. In this case, the events lead up to the extinction of a species. A **proximate cause** is an action that happens right before an event that causes the event to happen at that moment. To understand the difference between a proximate and ultimate cause, think about this example: Your little brother is crying. The proximate cause is that you yelled at him. However, the ultimate cause is that he stole your candy bar, which led up to you yelling at him. So is your brother crying because you yelled or because he took your candy bar without permission? The answer is both!

Did You Know?

Rain forests are one of the most biologically diverse, natural communities in the world. But they are being destroyed at a rate of 74,000 acres per day!

The story of the brown pelican demonstrates a good example of ultimate and proximate causes of a near-extinction. The brown pelican almost became extinct in d1e 1970s. Biologists discovered that the pelicans were laying eggs that had extremely thin shells. The shells were so soft that they crushed under the weight of the mother pelican. The proximate cause for the pelican's near-extinction was that the mothers were crushing the eggs during incubation before any chicks could be hatched.

Did You Know?

You can get rid of insect pests naturally without using pesticides such as DDT. Instead, you can use insects, such as ladybugs, which are natural predators of the pests you're trying to get rid of.

The biologists then had to track down why the pelicans were laying eggs with such thin shells. They found out that the pelicans' food was contaminated with DDT, a pesticide used by farmers. DDT stopped the production of the calcium needed to make the eggshells thick. As a result, the pelicans laid eggs with shells that were too thin. Therefore, the ultimate cause for the near-extinction of the pelican was the use of DDT by farmers!

Apparently farmers sprayed DDT on their fields and it washed off the fields into ponds and lakes. Eventually the DDT ended up in the ocean. There, producers called phytoplankton (FI-toh-plank-tun) absorbed the DDT. The phytoplankton were eaten by herbivores called zooplankton (ZOH-oh-plank-tun), which were eaten by small fish. The little fish were eaten by bigger fish, which were eventually eaten by the pelicans. The DDT simply traveled up the food chain!

Luckily this story has a happy ending. The federal government banned the use of DDT. Since farmers no longer used DDT, it no longer washed off the fields and ended up in the ocean. Eventually DDT no longer contaminated the fish the pelicans ate. The pelicans then began laying eggs with thicker shells. More pelican chicks were hatched. Finally, the population increased. The biologists had to discover the ultimate cause of the population decline-DDT use-to solve the problem of the proximate cause-thin eggshells.

What Do You Think?

The federal government banned the use of DDT in the United States. But the government did not ban its manufacture or exportation. Several U.S. companies still make and sell DDT to farmers in other countries. Should the U.S. ban the manufacture and sale of DDT to people in other countries or should those people have the right to buy DDT if it helps them grow food?

Figure 12.1 DDT worked its way through the food chain and almost caused the extinction of brown pelicans and other fish-eating birds.

Journal Writing

When a species such as the brown pelican becomes endangered, how much money, time, and effort do you think humans should spend trying to save it from extinction? Do you feel it is as important for governments to spend money on endangered species as on health care, homeless people, education, military and weapons, roads and transportation? Why or why not?

Designing a Nature Reserve

One way that conservation biologists preserve biodiversity is by creating protected areas called **nature reserves.** Nature reserves are one strategy for keeping species from becoming extinct. Establishing nature reserves makes sure that the habitat of a species will not be changed or disturbed by humans for the foreseeable future.

Mini-Activity

You can create a simple wildlife refuge in your backyard. Find out from a local nursery which plants will attract local animals and help provide a habitat for them.

Designing a reserve can be a tricky task. Sometimes nature reserves are too small. Sometimes they are inappropriately shaped. Sometimes they have to be managed to keep conditions suitable for the different species that live there. Sometimes things happen outside of the reserve, such as acid rain or global warming. These factors can't be controlled within the reserve. The reserve's conservation biologists, planners, and managers do their best to consider all these factors and more.

Reserve planners ask themselves a lot of questions when they are designing a reserve. These are some of the most important questions planners ask, questions to which they seek answers:

- What are we trying to protect? Are we protecting a particular species? A community? A population of a species? Asking these questions helps planners create a goal for their reserve.)
- What resources does the species, population, or community need? What types of food, shelter, and plants are required?
- How big of a population do we need to preserve the species? (In general, the bigger the population, the better chance there will be for survival. Very small populations tend to become extinct more quickly.)
- What is the minimum area required by a population of a specific size? (Reserve planners know that all organisms need a certain amount of space and they have to decide how much space will be required.)
- Are there any species upon which the species we are trying to save depends? Are any species interactions crucial for its survival?
- What is happening on neighboring lands and how does it affect the reserve?
- How much will it all cost? (Often the amount of money a planner has to spend is the biggest limitation for reserve planners and designers.)
- Where will we obtain the money to support the reserve?
- Will the reserve need active management or will it be able to take care of itself?
- Last of all, do we need one large reserve or several small ones? Is it better to put all of the eggs in one basket (so to speak)?

After planners and designers have answered all of these questions, they begin their planning phase. They discuss locations and map out the reserve. They decide issues such as the reserve's future management and budgets. Then, they purchase the land. Their hope is that they designed a reserve that will successfully preserve some facet of biological diversity!

Activity 12-1: Design a Nature Reserve

Introduction

How can we prevent species from becoming endangered? How can we keep endangered species from becoming extinct? One way is to design and maintain a nature reserve. In this activity you design a nature reserve for the Kirtland's warbler, an endangered songbird.

Materials

- Butcher paper
- Marking pens or colored pencils
- Resource 1
- Resource 2

Procedure

Step 1 Imagine that you are a conservation biologist for the Fish and Wildlife Service. You have been asked to make recommendations for the new nature reserve for the Kirtland's warbler. Your job is to design a plan for the set-up and continuing management of the reserve. Your plan must include:

- your recommendation for the kind of habitat in which you will place the reserve so that the species will survive and reproduce in a healthy population. (Include food, water, space, and nesting requirements.)
- an explanation of the threats to this species. (Include human activities as well as natural events that threaten this species.)

- your recommendations for the management practices (strategies) you will use to protect the reserve's habitat, keep the population of the warblers at a stable level, and any other long-range plans for maintenance of the reserve.

Step 2 Prepare a plan for the nature reserve and submit it to the Nature Conservancy, which is the organization that will buy the land for the reserve. Prepare a presentation to give to the Nature Conservancy board members (your teacher and classmates). Include drawings, maps, and other graphics if needed.

Review Questions

1. What is the difference between a proximate and an ultimate cause? How does this apply to the causes of extinction of a species?
2. What are nature reserves? How do they help prevent the loss of biodiversity?
3. If the Department of Parks put a wire fence around an empty lot in your town and claimed that it was a reserve for grizzly bears, would you say that the reserve designers had done a good job? Why or why not?

Chapter 14 Conclusion: You and the Environment - Student Edition (Human Biology)

Chapter Outline

14.1 Conclusion: You and the Environment

What is your environment and how is it related to ecology?

Think about the above question. This is the same question that began this book. Do you think you're able to answer this question better now than when you started studying ecology and the environment?

"The frog does not drink up the pond in which he lives."

Proverb

The Earth Speaks

You have become a student ecologist! You are able to look at your surroundings and ask questions about how things in the environment work. By doing this, you can begin to figure out how those things function the way they do.

Now when you hear about environmental issues on the news or read about them in your local paper, you can consider the many different points of view. You can ask questions such as these:

Journal Writing

Find a newspaper article that is related to the topics you've studied in this ecology unit. Write a letter to the author of the article explaining what you think he or she should have included about ecology in the article to make it more thorough. What questions are left unanswered that could be researched?

"Does this make sense? Is it likely that it is happening the way that the person says it does? How does it affect other things in the environment? How does it affect the people that are mentioned? Does it affect other people who are not mentioned? Does it affect me?" And most importantly you can ask, "Is there anything that I, my friends, or my family can do about it?"

Last of all, you've observed that your everyday decisions and actions affect many different things in your environment-and that your environment affects you. Congratulations on completing this unit!

Activity 13-1: Map Your Environment, Revisited

Introduction

Now is a good time to reinvestigate how you fit into the environment. What is your relationship with the biotic and abiotic parts of your surroundings? You've learned about how biotic and abiotic factors interact with each other and how you interact with them. So now you can use the new information you've accumulated to evaluate your place in your environment again. You are a part of your environment just as much as any other animal. You affect biotic and abiotic factors, just as they affect you. In this activity you draw a map to analyze again how you are connected to various parts of your environment.

Materials

- 1 Piece of butcher paper or other large piece of paper
- Colored marking pens, pencils, or crayons
- Activity Report

Procedure

Step 1 Draw a self-portrait in the middle of the piece of large paper.

Step 2 Think about all the biotic and abiotic factors you can that are in your environment. List the factors on your Activity Report. Around your picture write the names of the six most important biotic factors in your environment and draw them. Then do the same for the six most important abiotic factors.

Step 3 Draw lines to show the connections between you and the different factors in your environment. Use one color to represent connections to biotic factors and a different color to represent connections to abiotic factors. Label each line with a word that describes how you interact with that factor. (Hint: Look at Figure 1.1, which shows the factors that are important to a dog.)

Step 4 Use another color to draw lines between factors that are connected with each other.

Step 5 Consider these questions and write responses to them on your Activity Report:

- Which of these factors is the most important to you?
- Which factors, if any, could you live without?

Step 6 Compare your finished map with those of your classmates. Discuss these questions and write responses to them on your Activity Report:

- What factors in your environment do you have in common?
- How are your environmental factors similar? How are they different?

Step 7 Compare your finished map with the map you created at the beginning of this unit. Describe some ways this unit has changed how you view your environment and your place in it.

Review Questions

1. What is your environment and how do you affect it?
2. What are ecologists and what do they do? Do you think that you can devise and answer questions about your environment now that you are a student ecologist?
3. How has studying this unit changed your views of how you fit into the workings of the world?

CHAPTER 15 Ecology Glossary - Student Edition (Human Biology)

CHAPTER OUTLINE

15.1 Ecology Glossary

abiotic non-living materials

acidity The amount of acid in a substance.

acid rain Precipitation containing impurities that can make it highly acidic.

aerobic respiration A chemical process that uses oxygen and produces water and carbon dioxide. It stores energy in the form of ATP.

aesthetics Things pertaining to beauty.

biodegradable Materials that decomposers can break down fairly easily.

biological community All the organisms living together in a specific area.

biological diversity The variety of life at all levels of organization that exists in an area.

biotic Those things that are alive or were recently alive.

birth rate The number of children born each year.

calorie The amount of energy it takes to raise the temperature of one gram of water one degree Celsius. (The calories used to describe food are actually k calories or 1,000 calories.)

camouflage The color, markings, body shape, or behavior that helps an animal or plant hide in its surroundings.

carbonification The process by which dead plants and/or animals are turned into coal, oil, or natural gas.

carnivores Animals that eat only other animals. Some plants are also considered carnivores because they "eat" insects.

carrying capacity The number of organisms that a habitat can support indefinitely.

CFCs (chlorinated fluorocarbons) Gases formerly used in air conditioners and refrigerators that are also being released into the atmosphere.

community A group of organisms that live in the same place.

competition What happens when one organism uses a resource in a way that prevents other organisms from using it.

consumers Organisms that get energy by eating other organisms.

cycle A chain of events that happens regularly and has no distinct beginning or end.

decomposers Organisms that break down dead matter.

dehydrate To dry up.

demographers Ecologists who study human populations.

diversity variety

doubling time The amount of time it takes for a population to double in size.

ecological pyramid A snapshot of the amount of energy or number of individuals at different levels of a food web in a specific location.

ecologists Scientists who study the distribution and abundance of organisms in-the environment.

emigration Moving away from an area.

endangered A species that is threatened with becoming extinct.

environment The physical, chemical, and biotic (living) factors that you affect and that affect you.

ethics A set of moral principles or values.

evaporate Change into water vapor.

extinct A species of which all members have died.

food chain A description of the path by which energy moves from the sun to plants and animals.

food web A diagram that shows how food chains in a community are related and interlinked.

fossil fuels Coal, oil, and gas that are made up of the remains of ancient plants and animals.

genes Structures in almost every living cell that carry genetic information from one generation to the next.

giga A prefix meaning one billion.

gigajoule A unit used to measure energy.

global change Any worldwide change in the environment.

global warming A warming trend around the world that is caused by an increase of greenhouse gases such as carbon dioxide in the atmosphere.

greenhouse effect The trapping of heat in Earth's atmosphere due to the presence of gases such as carbon dioxide.

greenhouse gas Gases that trap heat from the sun in the atmosphere, much like glass traps the heat of the sun in a greenhouse.

groundwater Water within the earth that supplies wells and springs.

habitat The physical place where a plant or animal usually lives.

herbivores Organisms that eat only plants.

host organism An organism that is used as food by a parasitic organism without the host being killed.

human community All of the people who live around you and help you live where you do.

immigration Moving into an area.

joule 0.24 calories.

melanin A pigment that gives color to hair, skin, and eyes.

mimicry A method of protection in which one species or organism looks like another species.

mortality rate death rate

mutualism Two species helping each other out.

nature reserves Protected areas for wildlife and plants.

niche The full range of biotic and abiotic conditions under which a particular species can live and reproduce.

omnivores Organisms that eat both plants and animals.

open water Water on the surface of Earth.

organism A complete and whole living thing.

parasite An organism that feeds off another organism without killing it immediately.

photosynthesis A process in which a plant uses sunlight, water, and carbon dioxide to produce sugar and release oxygen.

population All of the individuals of a species living in a certain area at a certain time.

precipitation rain, snow, sleet, hail

predation An interaction in which one organism kills and eats another.

producers Organisms that make sugars through photosynthesis.

proximate cause An action that happens right before an event and that causes the event to happen.

recycle Use materials over again, thus saving resources and energy.

resource A substance, object, or space needed by an organism to live, grow, and reproduce.

species A group of organisms that are so much alike that they can reproduce and make others like themselves.

terrestrial net primary productivity A name for all of the sun's energy that is trapped and stored by all of the plants on Earth's land surfaces during photosynthesis.

ultimate cause An action that starts a series of events.

watershed The area of land drained by a stream or river.