History & Biology

16 000 B.C. The glaciers of the last ice age reach their greatest extent.

1800

1830 The lawn mower is invented.

1850

1851 One hundred house sparrows are introduced in the United States.

1859 The first oil well in the U.S. is drilled in Titusville, PA.

Unit 2

Ecology

What You'll Learn

Chapter 2
Principles of Ecology

Chapter 3
Communities and Biomes

Chapter 4
Population Biology

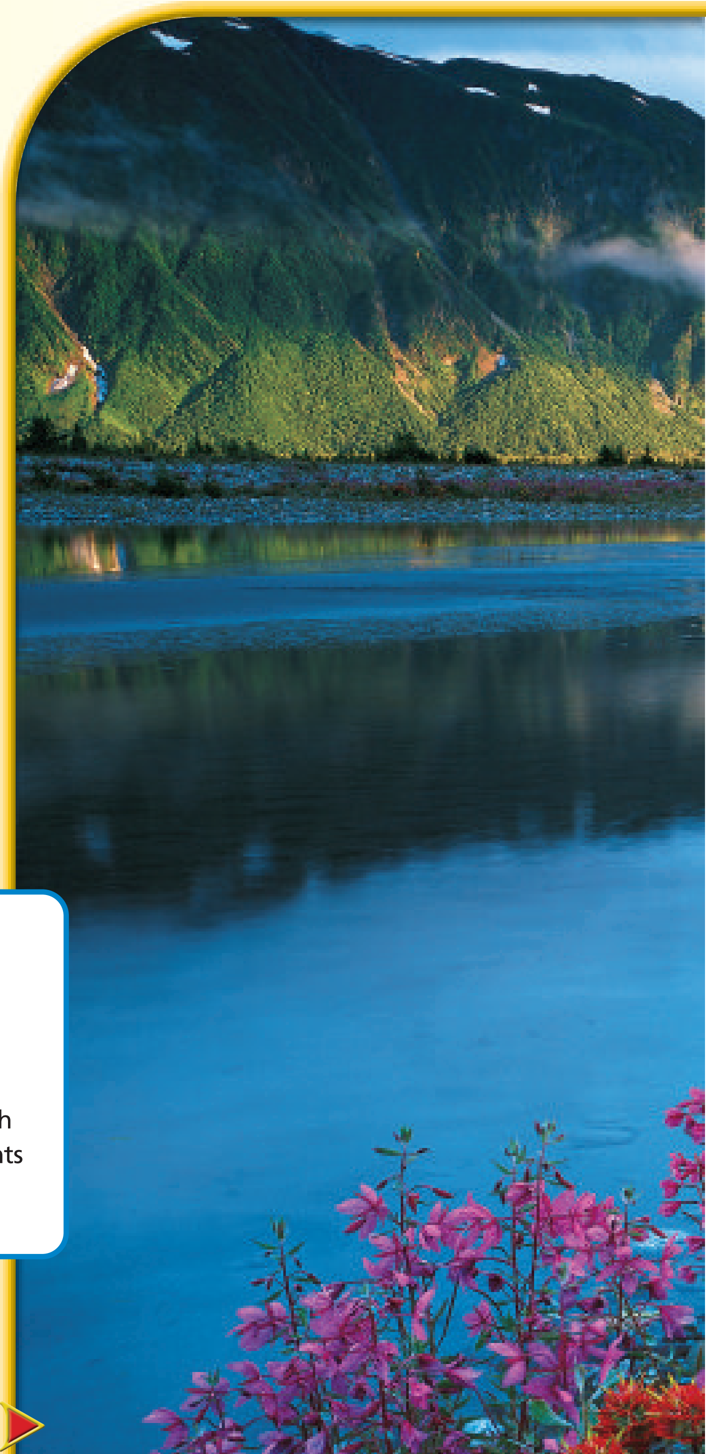
Chapter 5
Biological Diversity and Conservation

Unit 2 Review
BioDigest & Standardized Test Practice

Why It's Important

Everything on Earth—air, land, water, plants, and animals—is connected. Understanding these connections helps us keep our environment clean, healthy, and safe.

California Standards
The following standards are covered in Unit 2:
Investigation and Experimentation: 1a, 1c, 1d, 1e, 1i, 1j, 1l
Biology/Life Sciences: 6a, 6b, 6c, 6d, 6e, 6f



Understanding the Photo

At the foot of the Elias Mountains in Glacier Bay National Park and Preserve in Alaska, a cold, clear stream moves silently past brilliant purple dwarf fireweed and red and yellow Indian paintbrush plants growing out of a rocky beach. The clouds are so low, it looks as if they could touch the stream. Ecology is the study of the interactions of plants and animals, where they live, how they survive, and sometimes, what causes their demise.

ca.bdol.glencoe.com/webquest

Carr Clifton/Minden Pictures

1872
Yellowstone becomes the world's first national park.

1888
The first use of a large windmill to generate electricity takes place in Cleveland, OH.

1900

1901
The modern oil industry begins in Spindletop,TX, with the Lucas Gusher.

1916
The National Park Service is formed.

1934
Federal Duck Stamp sales begin. The funds raised conserve wetlands.

U.S. Fish and Wildlife Service/Joseph Hautman

1950

1957
American Bandstand airs nationally.

1967
The first list of endangered species is issued.

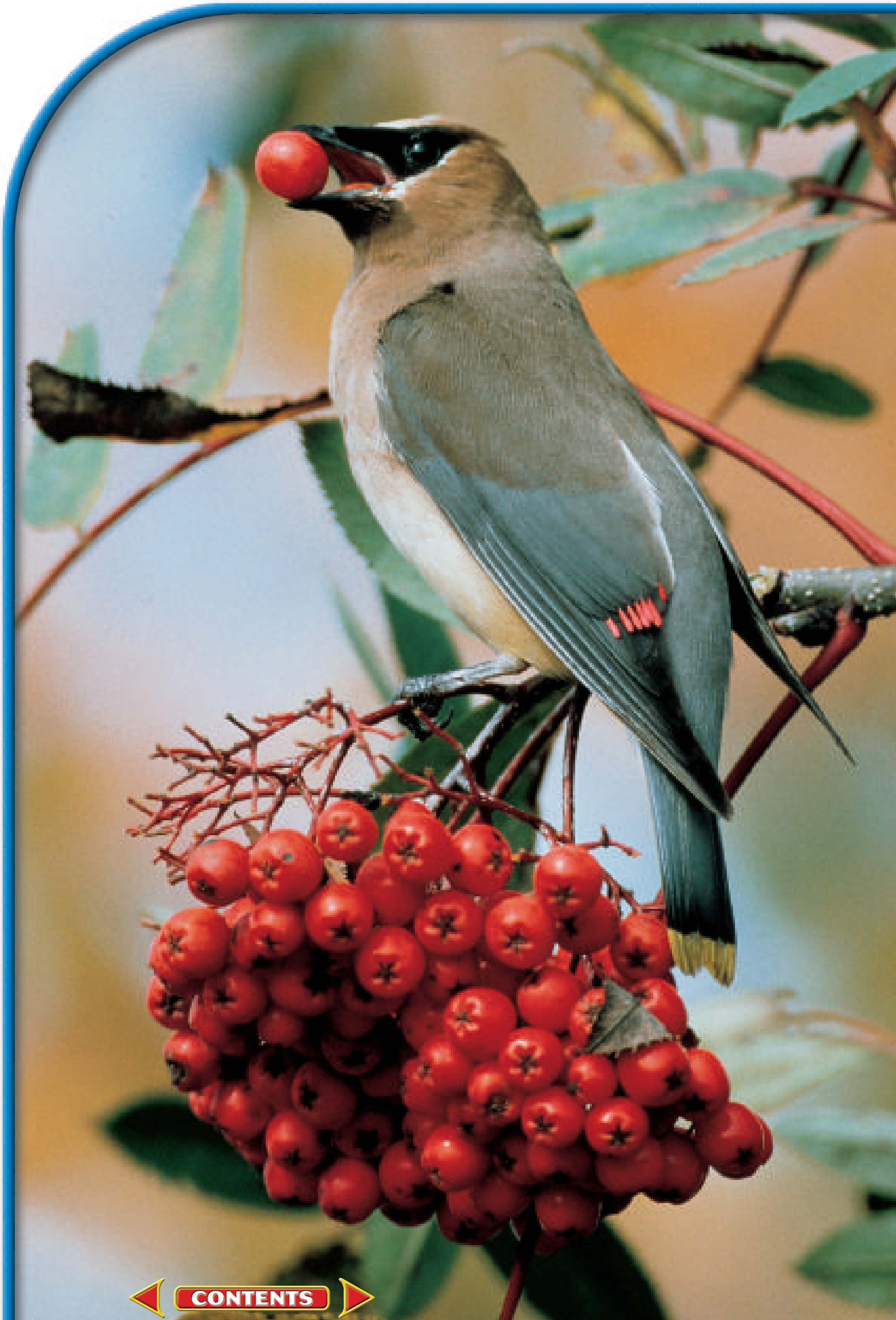
1999
The world population reaches 6 billion.

2000
One hundred fifty million house sparrows live in the United State

2000

Chapter 2

Principles of Ecology



What You'll Learn

- You will describe ecology and the work of ecologists.
- You will identify important aspects of an organism's environment.
- You will trace the flow of energy and nutrients in the living and nonliving worlds.

Why It's Important

Organisms get what they need to survive from their immediate environment. There they find food and shelter, reproduce and interact with other organisms. It is important to understand how living things depend on their environments.

Understanding the Photo

If you have a sweet tooth and lots of friends, you have a lot in common with the cedar waxwing *(Bombycilla cedrorum)* shown here. These handsome birds are known for traveling in flocks and for their fruit-eating habits. They can be found wherever fruit is ripening and so their range is extensive throughout the year. In winter, flocks of up to 100 birds can be found from southern Canada to Central America.

Biology Online

Visit ca.bdol.glencoe.com to
- study the entire chapter online
- access Web Links for more information and activities on ecology
- review content with the Interactive Tutor and self-check quizzes

Gregory K. Scott/Photo Researchers

Section 2.1

SECTION PREVIEW

Objectives

Distinguish between the biotic and abiotic factors in the environment.

Compare the different levels of biological organization and living relationships important in ecology.

Explain the difference between a niche and a habitat.

Review Vocabulary

species: a group of organisms that can interbreed and produce fertile offspring in nature (p. 7)

New Vocabulary

ecology
biosphere
abiotic factor
biotic factor
population
biological community
ecosystem
habitat
niche
symbiosis
commensalism
mutualism
parasitism

Organisms and Their Environment

California Standards Standard 6b Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Where in the world am I?

Finding the Main Idea When you start to study a new topic in depth, it is sometimes difficult to see the big ideas and make the connections that you need to make. Learning about ecology is more than memorizing the vocabulary. Of all the subjects that you might study in biology, ecology makes you stand back to get the big picture—of how individual organisms interact with each other and with their environment, because it is your environment, too.

Organize Information *As you study this chapter, use the red and blue titles throughout the chapter to organize information or outline the main ideas of ecology.*

Sharing the World

How much do you know about the environment and the organisms that share your life? As cities and suburbs expand, and humans move into territories previously occupied by fields and wildlife, animals such as raccoons and deer are tipping over garbage cans and meandering through backyards. Every day, you also interact with houseflies, mosquitoes, billions of dust mites, and other organisms that you cannot even see. What affects their environment also affects you. Understanding what affects the environment is important because it is where you live.

Studying nature

People have always shown an interest in their natural surroundings. You may know someone who can identify every animal, plant, and rock they see. Other people keep records of rainfall and temperature. The study of plants and animals, including where they grow and live, what they eat, or what eats them, is called natural history. Collecting data like these is similar to taking the pulse of an individual. These data reflect the status or health of the world in which you live.

CONTENTS

MiniLab 2.1

Experiment

Salt Tolerance of Seeds Salinity, the amount of salt dissolved in water, is a nonliving factor. Might salt water affect how certain seeds sprout or germinate? Experiment to find out.

Salt marsh

Freshwater pond

Procedure

1. Obtain 40 seeds of one species of plant. Soak 20 of them in a freshwater solution and soak 20 seeds in a 10 percent saltwater solution overnight.
2. The next day, wrap the seeds in two different paper towels moistened with their soaking solutions. Slide each towel into its own self-sealing plastic bag.
3. Label the bags *Fresh* and *Salt.*
4. Examine all seeds two days later. Count the number of seeds in each treatment that show signs of root growth or sprouting, which is called germination. Record your data. **CAUTION:** ***Be sure to wash your hands after handling seeds and seedlings. Make wise choices about disposal.***

Analysis

1. **Observe and Infer** Did the germination rates differ between the two treatments? If yes, how?
2. **Conclude** What nonliving factor was tested in this experiment? What living factor was affected?
3. **Infer** Would all seeds respond to the presence or absence of salt in a similar manner? How could you find out?

What is ecology?

The branch of biology that developed from natural history is called ecology. **Ecology** is the study of interactions that take place between organisms and their environment.

Ecological research

Scientific research includes using descriptive and quantitative methods. Ecological research combines information and techniques from many scientific fields, including mathematics, chemistry, physics, geology, and other branches of biology. Most ecologists use both descriptive and quantitative research. They obtain descriptive information by observing organisms. They obtain quantitative data by making measurements and carrying out experiments in the field and in the laboratory. Ecologists may ask what a coyote eats, how day length influences plants or migrating birds, or why tiny shrimp help rid ocean fishes of parasites.

The Biosphere

On Earth, living things are found in the air, on land, and in both fresh- and salt water. The **biosphere** (BI uh sfihr) is the portion of Earth that supports living things. It extends from high in the atmosphere to the bottom of the oceans. This may seem extensive, but if you could shrink Earth to the size of an apple, the biosphere would be thinner than the apple's peel.

Although it is thin, the biosphere supports a diverse group of organisms in a wide range of climates. The climate, soils, plants, and animals in one part of the world can be very different from those same factors in other parts of the world. Living things are affected by both the physical or nonliving environment and by other living things.

(l)David Sieren/Visuals Unlimited, (r)Marc Epstein/DRK Photo

CONTENTS

Ecologists study how organisms survive and reproduce under different physical and biological conditions in Earth's biosphere.

The nonliving environment: Abiotic factors

The nonliving parts of an organism's environment are the **abiotic** (ay bi AH tihk) **factors**. Examples of abiotic factors include air currents, temperature, moisture, light, and soil. Ecology includes the study of features of the environment that are not living because these features are part of an organism's life. For example, a complete study of the ecology of moles would include an examination of the types of soil in which these animals dig their tunnels. Similarly, a thorough investigation of the life cycle of trout would need to include whether they need to lay their eggs on rocky or sandy stream bottoms.

Abiotic factors have obvious effects on living things and often determine which species survive in a particular environment. For example, extended lack of rainfall in the grassland shown in ***Figure 2.1*** can cause drought. What changes in a grassland might result from a drought? Grasses would grow more slowly. They might produce fewer seeds, and the animals that depend on seeds for food would find it harder to survive. Examine other ways that abiotic factors affect living things in the *MiniLab* and *Problem-Solving Lab* shown on these pages.

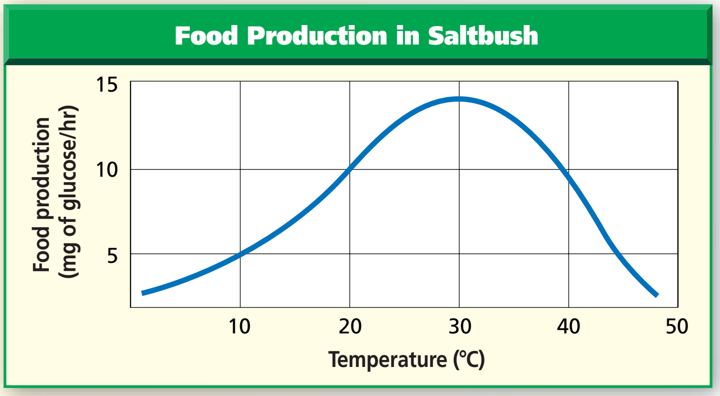
Problem-Solving Lab 2.1

Interpret Data

How does an abiotic factor affect food production? Green plants carry out the process of photosynthesis. Glucose, a sugar, is the food product made during this process. Glucose production can be used as a means for measuring the rate at which the process of photosynthesis is occurring.

Solve the Problem

Examine the following graph of a plant called saltbush *(Atriplex).* The graph shows how the plant's glucose (food) production is affected by temperature.



Thinking Critically

1. **Observe and Infer** What is the abiotic factor influencing photosynthesis? How does this factor affect photosynthesis?
2. **Analyze** How much glucose is being produced at 20°C?
3. **Analyze** Based on the graph, at what temperature is glucose production greatest?
4. **Make and Use Graphs** Does the graph tell you how the rate of photosynthesis might vary for plants other than saltbush? Explain your answer.
5. **Analyze** What happens to the formation of glucose after the temperature reaches 30°C?

Figure 2.1
Drought is an abiotic condition common in grasslands that is the result of lack of moisture. As the grasses dry out, they turn yellow and appear to be dead, but new shoots grow from the bases of the plants soon after it rains. Some species, such as these grasses and prairie dogs, thrive in grasslands even though they experience periodic drought.

Jim Brandenburg/Minden Pictures

The living environment: Biotic factors

In addition to abiotic factors, a key consideration of ecology is that living organisms affect other living organisms. All the living organisms that inhabit an environment are called **biotic** (by AH tihk) **factors.**

Think about a goldfish in a bowl. Now consider its relationships with other organisms. Does the fish live alone or with other fishes? Are there live plants in the bowl? The fish may depend on other living things for food, or it may be food for other life. The goldfish needs members of the same species to reproduce. To meet its needs, the goldfish may compete with organisms of the same or different species that share the bowl.

Reading Check **Compare** biotic and abiotic factors.

CAREERS IN BIOLOGY

Science Reporter

Does science fascinate you? Can you explain complex ideas and issues in a clear and interesting way? If so, you might consider a career as a science reporter.

Skills for the Job

As a science reporter, you are a writer first and a scientist second. A degree in journalism and/or a scientific field is usually necessary, but curiosity and good writing skills are also essential. You might work for newspapers, national magazines, medical or scientific publications, television networks, or internet news services. You could work as a full-time employee or a freelance writer. You must read daily to stay up-to-date. Many science reporters attend scientific conventions and events to find news of interest to the public. Then they relate what's new in science so that nonscientists can understand it.

For more careers in related fields, visit ca.bdol.glencoe.com/careers

All organisms depend on others directly or indirectly for food, shelter, reproduction, or protection. If you study an individual organism, such as a male white-tailed deer, you might find out what food it prefers, how often it eats, and how far it roams to search for food. However, studying a single individual won't tell you all there is to know about white-tailed deer. In fact, white tails are social animals. They live in small groups or a herd in which there is a strong social structure built around visual and vocal communications that keep the herd safe.

So you can see that the study of a single individual provides only part of the story of its life.

Levels of Organization

Ecologists study individual organisms, interactions among organisms of the same species, and interactions among organisms of different species, as well as the effects of abiotic factors on interacting species.

To help them understand the interactions of the biotic and abiotic parts of the world, ecologists have organized the living world into levels—the organism by itself, populations, communities, and ecosystems.

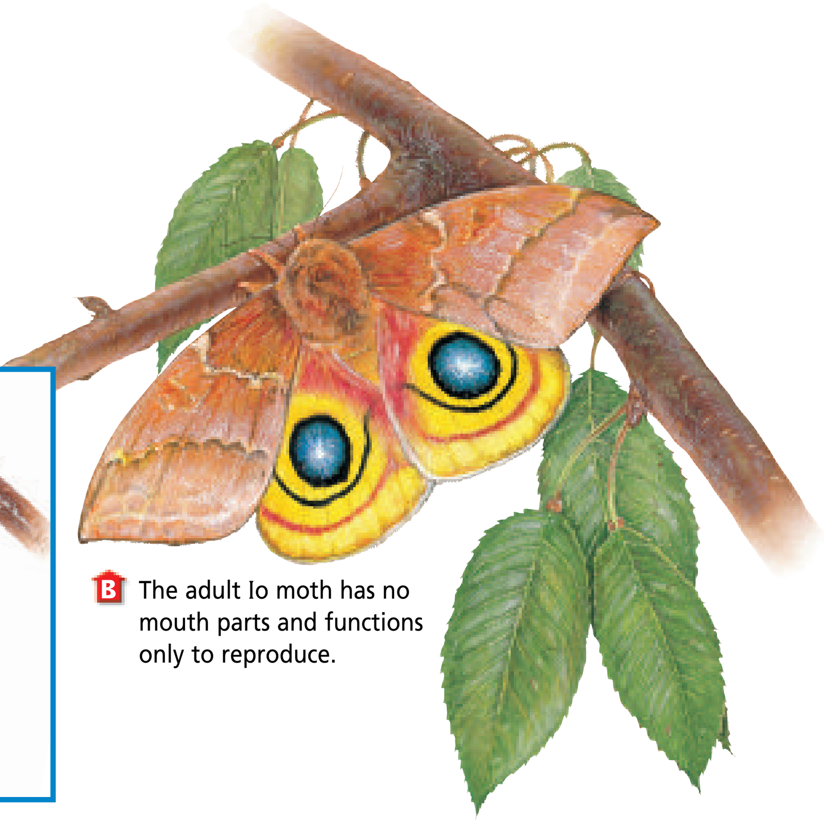
Interactions within populations

A **population** is a group of organisms, all of the same species, which interbreed and live in the same area at the same time.

How the organisms in a population share the resources of their environment may determine how far apart the organisms live and how large the populations become. Members of the same population may compete with each other for food, water, mates, or other resources. Competition increases when resources are in short supply.

Figure 2.2
Some adult insects and their young have different food requirements. These differences limit competition for food resources between members of the same species.

A The Io moth larva hatches on leaves on which it begins to feed immediately.



B The adult Io moth has no mouth parts and functions only to reproduce.

Some species have adaptations that reduce competition within a population. An example is the life cycle of a frog. The juvenile stage of the frog, called the tadpole, looks very different from the adult and has different food requirements. As you can see in ***Figure 2.2,*** many species of insects, including butterflies and moths, also produce juveniles that differ from the adult in body form and food requirements.

Interactions within communities

No species lives independently. Just as a population is made up of individuals, several different populations make up a biological community. A **biological community** is made up of interacting populations in a certain area at a certain time. An example of a community is shown in ***Figure 2.3.***

A change in one population in a community may cause changes in the other populations. Some of these changes can be minor, such as when a small increase in the number of individuals of one population causes a small decrease in the size of another population. For example, if the population of mouse-eating hawks increases slightly, the population of mice will, as a result, decrease slightly. Other changes might be more extreme, as when the size of one population grows so large it begins affecting the food supply for another species in the community. ***Figure 2.4*** on the next page is a visual summary of the ecological levels of organization.

Figure 2.3
This community of flowers is made up of populations of different species of flowers.

Larry Ulrich

Figure 2.4

Levels of Organization

Ecology is the study of relationships on several levels of biological organization, including individual organisms, populations, communities, ecosystems, biomes, and the biosphere.

A Organism
An individual living thing that is made of cells, uses energy, reproduces, responds, grows, and develops

B Population
A group of organisms, all of one species, which interbreed and live in the same place at the same time

C Biological Community
All the populations of different species that live in the same place at the same time

D Ecosystem
Populations of plants and animals that interact with each other in a given area and with the abiotic components of that area

E Biosphere
The portion of Earth that supports life

(tl tr)Barbara Gerlach/DRK Photo, (cl)IFA/Peter Arnold, Inc., (bl)Earth Satellite Corporation/Science Photo Library/Photo Researchers, (br)Frans Lanting/Minden Pictures

Biotic and abiotic factors form ecosystems

In a healthy forest community, interacting populations might include birds eating insects, squirrels eating nuts from trees, mushrooms growing from decaying leaves or bark, and raccoons fishing in a stream. In addition to how individuals in a population interact with each other, ecologists also study interactions between separate populations and their physical surroundings. An **ecosystem** is made up of interacting populations in a biological community and the community's abiotic factors. Because animals and plants in an area can change, and because abiotic factors can change, ecosystems are subject to change.

There are two major kinds of ecosystems—terrestrial ecosystems and aquatic ecosystems. Terrestrial ecosystems are those located on land. Examples include forests, meadows, and rotting logs. Aquatic ecosystems occur in both fresh- and saltwater forms. Freshwater ecosystems include ponds, lakes, and streams. Saltwater ecosystems, also called marine ecosystems, make up approximately 70 percent of Earth's surface. ***Figure 2.5*** shows a freshwater and a marine ecosystem. Examples of ecosystems are given in ***Table 2.1.***

Table 2.1 Examples of Ecosystems

Terrestrial Ecosystems	Aquatic Ecosystems	Other Sites for Ecosystems
• Forest	Freshwater	Human body
• Old farm field	• Pond	• Skin
• Meadow	• Lake	• Intestine
• Yard	• Stream	• Mouth
• Garden plot	• Estuary	Buildings
• Empty lot	Salt water (marine)	• Mold in walls, floors, or basement
• Compost heap	• Ocean	• Ventilation systems
• Volcano site	• Estuary	• Bathrooms
• Rotting log	• Aquarium	Food
		• Any moldy food
		• Refrigerator

Figure 2.5
There may be hundreds of populations interacting in a pond or in areas where tides move in and out.
Infer ***What abiotic factors in these environments affect the biotic factors?***

A Ponds are made up of many populations of plants and animals. Water in a pond is usually calm or stationary.

B Daily, organisms living in tidal areas must survive measurable changes in abiotic factors. When the tide is high, ocean waves replenish the water containing dissolved nutrients and food sources. When the tide is low, water moves out and what remains evaporates, raising the concentration of nutrients.

(l)Michael P. Gadomski/Photo Researchers, (r)Carolina Biological Supply/Phototake, NYC

CONTENTS

Organisms in Ecosystems

A prairie dog living in a grassland makes its home in burrows that it digs underground. Some species of birds make their homes in the trees of a beech-maple forest. In these areas, they find food, avoid enemies, and reproduce. A **habitat** (HA buh tat) is the place where an organism lives out its life. A lawn, the bottom of a stream, and beech-maple forests are examples of habitats. Other habitats could be a wetland, a specific species of tree, a city lot or park, a pond, or a specific area in the ocean. Habitats can change, and even disappear. Habitats can change due to both natural and human causes. Examples of habitat changes are presented in *Biology and Society* at the end of this chapter.

Reading Check **Compare** habitats and ecosystems.

Niche

Although several species may share a habitat, the food, shelter, and other essential resources of that habitat are often used in different ways. For example, if you turn over a log like the one shown in ***Figure 2.6***, you will find a community of millipedes, centipedes, insects, slugs, and earthworms. In addition, there are billions of fungi and bacteria at work breaking down the log, the leaves, and wastes produced by these animals. At first, it looks like members of this community are competing for the same food because they all live in the same habitat. But close inspection reveals that each population feeds in different ways, on different materials, and at different times. These differences lead to reduced competition. Each species is unique in satisfying all its needs. Each species occupies a niche (neesh).

Figure 2.6
This series of photographs shows how a habitat can be seen as a collection of several niches. As you can see, each species uses the available resources in a different way.

A A centipede is a predator that captures and eats beetles and other animals.

B A worm obtains nourishment from the organic material it eats as it burrows through the soil.

(tl)John D. Cunningham/Visuals Unlimited, (bl)Breck P. Kent/Animals Animals, (crossover)Matt Meadows

A **niche** is all strategies and adaptations a species uses in its environment—how it meets its specific needs for food and shelter, how and where it survives, and where it reproduces. A species' niche, therefore, includes all its interactions with the biotic and abiotic parts of its habitat.

It is an advantage for a species to occupy a niche different from those of other species in the same habitat, although a species' niche may change during its life cycle. It is thought that two species can't exist for long in the same community if their niches are the same. In time, one of the species will gain control of the resources both need. The other will become extinct in that area, move elsewhere, or, over time, become adapted in the way its species uses that particular habitat's resources.

Organisms of different species use a variety of strategies to live and reproduce in their habitats. Life may be harsh in the polar regions, but the polar bear, with its thick coat, flourishes there. Nectar may be deep in the flower, inaccessible to most species, but the hummingbird, with its long beak and long tongue is adapted to retrieve it. Unique adaptations and structures are important to a species' niche and important because they reduce competition with other species in the same habitat.

D These ants eat dead insects.

C A millipede eats decaying leaves near the log.

Figure 2.7
These ants and acacia trees both benefit from living in close association. This mutualistic relationship is so strong that in nature, the trees and ants are never found apart.

Survival Relationships

A predator is a type of consumer. Predators seek out and eat other organisms. Predation is found in all ecosystems and includes organisms that eat plants and animals. Predators may be animals such as lions and insect-eating birds. The animals that predators eat are called prey. Predator-prey relationships such as the one between cats and mice involve a fight for survival. Use the *BioLab* at the end of this chapter to examine a predator-prey relationship.

Not all organisms living in the same environment are in a continuous battle for survival. However, studies have shown that most species survive because of the relationships they have with other species.

These relationships help maintain survival in many species. The relationship in which there is a close and permanent association between organisms of different species is called **symbiosis** (sihm bee OH sus). Symbiosis means living together. Three kinds of symbiosis are recognized: mutualism, commensalism, and parasitism.

Mutualism

Sometimes, two species of organisms benefit from living in close association. A symbiotic relationship in which both species benefit is called **mutualism** (MYEW chuh wuh lih zum). Ants and acacia trees living in the subtropical regions of the world illustrate mutualism, as shown in ***Figure 2.7.*** The ants protect the acacia tree by attacking any animal that tries to feed on the tree. The tree provides nectar and a home for the ants. In an experiment, ecologists removed the ants from some acacia trees. Results showed that the trees with ants grew faster and survived longer than trees without ants.

Commensalism

Commensalism (kuh MEN suh lih zum) is a symbiotic relationship in which one species benefits and the other species is neither harmed nor benefited.

Commensal relationships occur among animals and in plant species, too. Spanish moss is a kind of flowering plant that drapes itself on the branches of trees, as shown in ***Figure 2.8.*** Orchids, ferns, mosses, and other plants sometimes grow on the branches of larger plants. The larger plants are not harmed, but the smaller plants benefit from the habitat.

Parasitism

Some interactions are harmful to one species, yet beneficial to another. Have you ever owned a dog or cat that was attacked by ticks or fleas? Ticks, like the one shown in ***Figure 2.9,*** are examples of parasites. A symbiotic

Michael Fogden/DRK Photo

Figure 2.8
Spanish moss grows on and hangs from the limbs of trees but does not obtain any nutrients or cause any harm to the trees.

relationship in which a member of one species derives benefit at the expense of another species (the host) is called **parasitism** (PER uh suh tih zum). Parasites have evolved in such a way that they harm, but usually do not kill the host species. If the host were to die, the parasite also would die unless it can quickly find another host. Some parasites, such as certain bacteria, tapeworms, and roundworms, live in or on other organisms.

Brown-headed cowbirds, in a behavior called brood parasitism, lay their eggs in the nests of songbirds, often at the expense of the host bird's eggs. The cowbird is about the size of an American Robin. It is not uncommon to see a much smaller bird species, such as a chipping sparrow, in the act of feeding a much larger, but younger, cowbird. Brown-headed cowbirds are known to parasitize about 200 other species of birds in North America.

Figure 2.9
Ticks are blood-sucking parasites. Some transmit disease as they obtain nutrients from their host.

Section Assessment

Understanding Main Ideas

1. Compare and give several examples of biotic and abiotic factors in a forest ecosystem.
2. Compare and contrast the characteristics of populations and communities. Provide examples of populations in a community.
3. Give examples that would demonstrate the differences between the terms *niche* and *habitat.*
4. Interpret the interaction between a cowbird and a chipping sparrow as the sparrow raises the young of a brown-headed cowbird.

Thinking Critically

5. Clownfish are small, tropical marine fish often found swimming among the stinging tentacles of sea anemones without being harmed. Interpret and describe this type of relationship.

Skill Review

6. **Get the Big Picture** Analyze and interpret the effect of an increasing population of brown-headed cowbirds on the forest community it inhabits. For more help, refer to *Get the Big Picture* in the **Skill Handbook.**

ca.bdol.glencoe.com/self_check_quiz

Section 2.2

Nutrition and Energy Flow

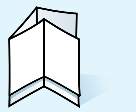
California Standards **Standard 6d Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem** and how oxygen cycles through photosynthesis and respiration.

FOLDABLES Study Organizer

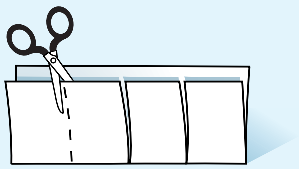
Cycles of Matter Make the following Foldable to help you understand the cycles of water, carbon, nitrogen, and phosphorus.

STEP 1 **Fold** a sheet of paper in half lengthwise. Make the back edge about 2.5 cm longer than the front edge.

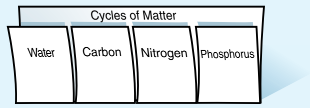
STEP 2 **Fold** in half, then fold in half again to make three folds.



STEP 3 **Unfold and cut** only the top layer along the three folds to make four tabs.



STEP 4 **Label** the Foldable as shown.



Use Models As you read Section 2.2, draw the cycle of each type of matter and describe the process of the cycle below it.

SECTION PREVIEW

Objectives

Compare how organisms satisfy their nutritional needs.

Trace the path of energy and matter in an ecosystem.

Analyze how matter is cycled in the abiotic and biotic parts of the biosphere.

Review Vocabulary

energy: the ability to cause change (p. 9)

New Vocabulary

autotroph
heterotroph
decomposer
food chain
trophic level
food web
biomass

How Organisms Obtain Energy

The mosquito in ***Figure 2.10*** takes in a blood meal. This is one means by which the female mosquito obtains nutrients. Mosquitoes also feed on nectar as a source of energy. An important characteristic of a species' niche is how it obtains energy. Ecologists trace the flow of energy through communities to discover nutritional relationships between organisms.

Figure 2.10
Female mosquitoes obtain protein for egg development from blood.

The producers: Autotrophs

The ultimate source of the energy for life is the sun. Plants use the sun's energy to manufacture food in a process called photosynthesis. An organism that uses light energy or energy stored in chemical compounds to make energy-rich compounds is a producer, or **autotroph** (AW tuh trohf). Grass and trees in ***Figure 2.11*** are autotrophs. Although plants are the most familiar autotrophs, some unicellular organisms such as green algae, also make their own nutrients. Other organisms in the biosphere depend on autotrophs for nutrients and energy. These dependent organisms are called consumers.

Figure 2.11
Many kinds of organisms live in the savanna of East Africa. **Identify** ***What are some of the autotrophs and heterotrophs in this photograph?***

The consumers: Heterotrophs

A deer nibbles the leaves of a clover plant; a bison eats grass; an owl swallows a mouse. The deer, bison, and owl are consumers, incapable of producing their own food. They obtain nutrients by eating other organisms. An organism that cannot make its own food and feeds on other organisms is called a **heterotroph** (HE tuh ruh trohf). Heterotrophs include organisms that feed only on autotrophs, organisms that feed only on other heterotrophs, and organisms that feed on both autotrophs and heterotrophs.

Some heterotrophs, such as grazing, seed-eating, and algae-eating animals, feed directly on autotrophs. Heterotrophs display a variety of feeding relationships.

1. A heterotroph that feeds only on plants is an herbivore. Herbivores include rabbits, grasshoppers, beavers, squirrels, bees, elephants, fruit-eating bats, and some humans.
2. Some heterotrophs eat other heterotrophs. Animals such as lions that kill and eat only other animals are carnivores.
3. Some heterotrophs, called scavengers, do not kill for food. Instead, scavengers eat animals that have already died. Scavengers, such as black vultures, feed on dead animals and garbage and play a beneficial role in the ecosystem. Imagine for a moment what the environment would be like if there were no vultures to devour animals killed on the African plains, no buzzards to clean up dead animals along roads, and no ants and beetles to remove dead insects and small animals from sidewalks and basements.

Humans are an example of a third type of heterotroph. Most people eat a variety of foods that include both animal and plant materials. They are omnivores. Raccoons, opossums, and bears are other examples of omnivores.

Some organisms, such as bacteria and fungi, are decomposers. They break down and release nutrients from dead organisms. **Decomposers** break down the complex compounds of dead and decaying plants and animals into simpler molecules that can be more easily absorbed. Some protozoans, many bacteria, and most fungi carry out this essential process of nutrient recycling.

Word Origin

herbivore from the Latin words *herba,* meaning "grass," and *vorare,* meaning "to devour"; Herbivores feed on grass and other plants.

carnivore from the Latin word *caro,* meaning "flesh"; Carnivores eat animals.

omnivore from the Latin word *omnis,* meaning "all"; Omnivores eat both plants and animals.

Figure 2.12
In order for a temperate forest ecosystem to function, its organisms depend on each other for a supply of energy.

Autotrophs The first level in all food chains is made up of producers. In this forest community, grasses, shrubs, trees, and some aquatic, photosynthetic plants are autotrophs.

First-order heterotrophs Herbivores, such as the deer, cardinal, turtle, and fish, make up the second level in a food chain. They obtain food from photosynthetic organisms.

Third-order heterotrophs Carnivores are animals that feed on second-order heterotrophs. Some bears may attack other animals, such as the deer. Bears also rely on a large diet of berries and so are termed omnivores.

Flow of Matter and Energy in Ecosystems

When you eat food, such as an apple, you consume matter. Matter, in the form of carbon, nitrogen, and other elements, flows through the levels of an ecosystem from producers to consumers. In doing so, the matter is cycled. The apple also contains energy from sunlight that was trapped in the plant during the process of photosynthesis. As you cycle the matter of the apple, some trapped energy is transferred from one level to the next. At each level, a certain amount of energy is also transferred to the environment as heat.

How do matter and energy flow through ecosystems? You have already learned that feeding relationships and symbiotic relationships describe the ways in which organisms interact. Ecologists study these interactions and make models to trace how matter and energy flow through ecosystems. The simplest models are called food chains.

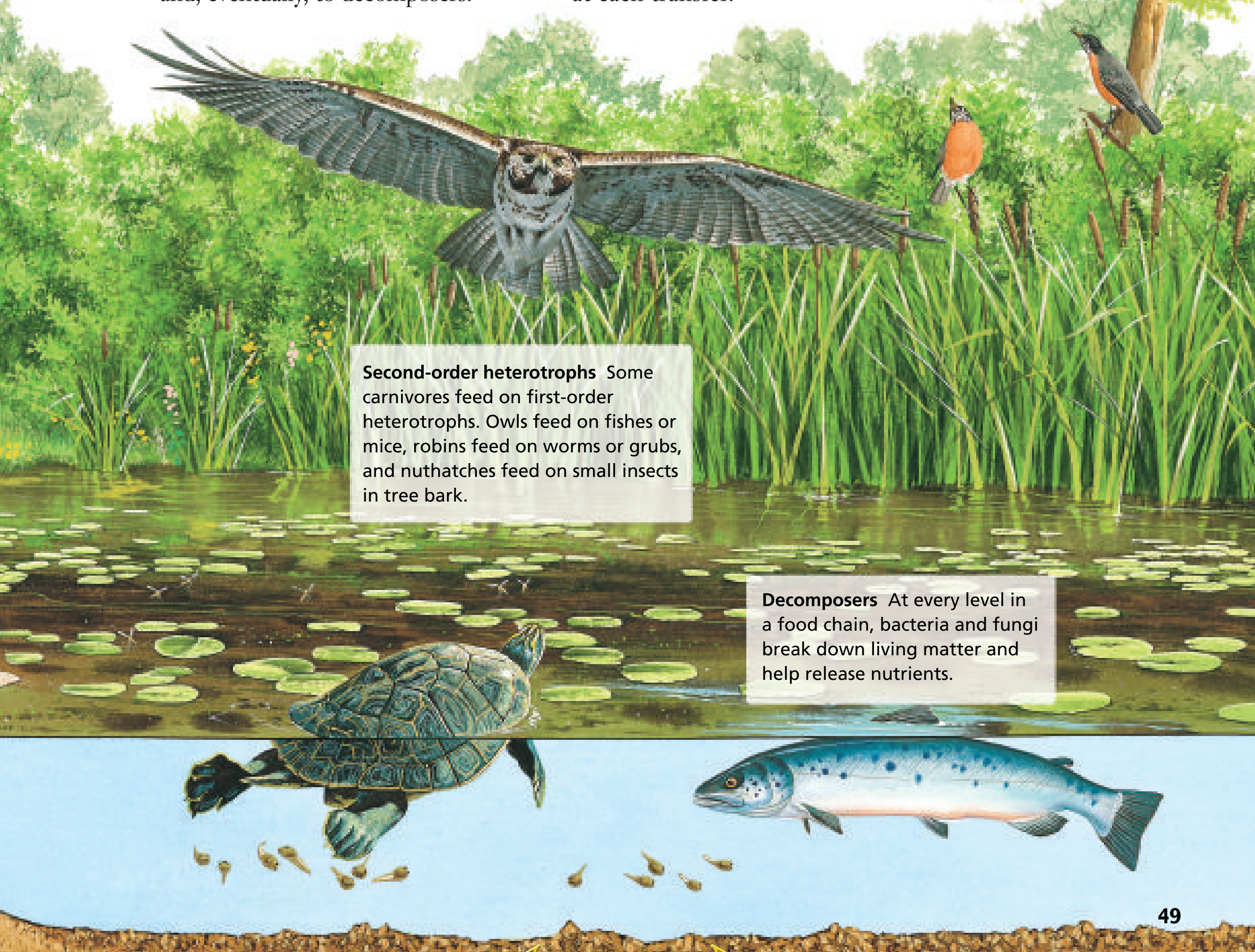
Food chains: Pathways for matter and energy

A **food chain** is a simple model that scientists use to show how matter and energy move through an ecosystem. In a food chain, nutrients and energy move from autotrophs to heterotrophs and, eventually, to decomposers.

The forest community pictured in ***Figure 2.12*** illustrates examples of food chains. A food chain is drawn using arrows to indicate the direction in which energy is transferred from one organism to the next. One simple food chain on this page would be shown as:

berries → mice → black bear

Most food chains consist of two, three, or four transfers. The amount of energy remaining in the final transfer is only a portion of what was available at the first transfer. A portion of the energy is given off as heat at each transfer.



Second-order heterotrophs Some carnivores feed on first-order heterotrophs. Owls feed on fishes or mice, robins feed on worms or grubs, and nuthatches feed on small insects in tree bark.

Decomposers At every level in a food chain, bacteria and fungi break down living matter and help release nutrients.

Trophic levels represent links in the chain

Each organism in a food chain represents a feeding step, or **trophic** (TROH fihk) **level,** in the passage of energy and materials. A first order heterotroph is an organism that feeds on plants, such as a grasshopper. A second order heterotroph is an organism that feeds on a first order heterotroph. An example of this would be a bird that feeds on a grasshopper. Examine how energy flows through trophic levels in the *Problem-Solving Lab* shown here.

A food chain represents only one possible route for the transfer of matter and energy through an ecosystem. Many other routes may exist. As ***Figure 2.12*** showed, many different species can occupy each trophic level in a forest ecosystem. In addition, many different kinds of organisms eat a variety of foods, so a single species may feed at several trophic levels. For example, the North American black bear may eat the mouse, but it also eats berries. The hawk may feed on the fish, or a mouse.

Food webs

A simple food chain such as

grass → mouse → hawk

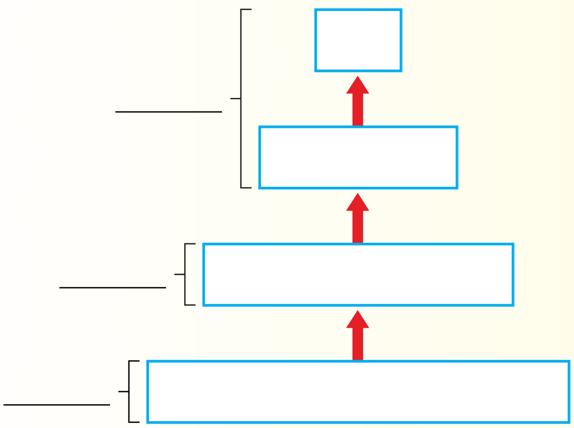
is easy to study, but it does not indicate the complex relationships that exist for organisms that feed on more than one species. Ecologists interested in energy flow in an ecosystem may set up experiments with as many organisms in the community as they can. The model they create, called a **food web,** shows all the possible feeding relationships at each trophic level in a community. A food web is a more realistic model than a food chain because most organisms depend on more than one other species for food. The food web of the desert ecosystem shown in ***Figure 2.13*** represents a network of interconnected food chains formed by herbivores and carnivores.

Reading Check **Compare** food chains and food webs.

Problem-Solving Lab 2.2

Apply Concepts

How can you organize trophic level information?
Diagrams help to summarize information or concepts in a logical and simple manner. This is the case with information that shows relationships among trophic levels.



Solve the Problem

Copy the diagram above. Use it to investigate the various relationships in a food chain.

Each box represents a trophic level. Write the name for each trophic level in the proper box. Use these choices: 1st-order heterotroph; autotroph; 2nd-order heterotroph; 3rd-order heterotroph.

Each bracket identifies one or more traits of the trophic levels. Use the following labels to identify them in their proper order: herbivore, carnivore, producer.

Thinking Critically

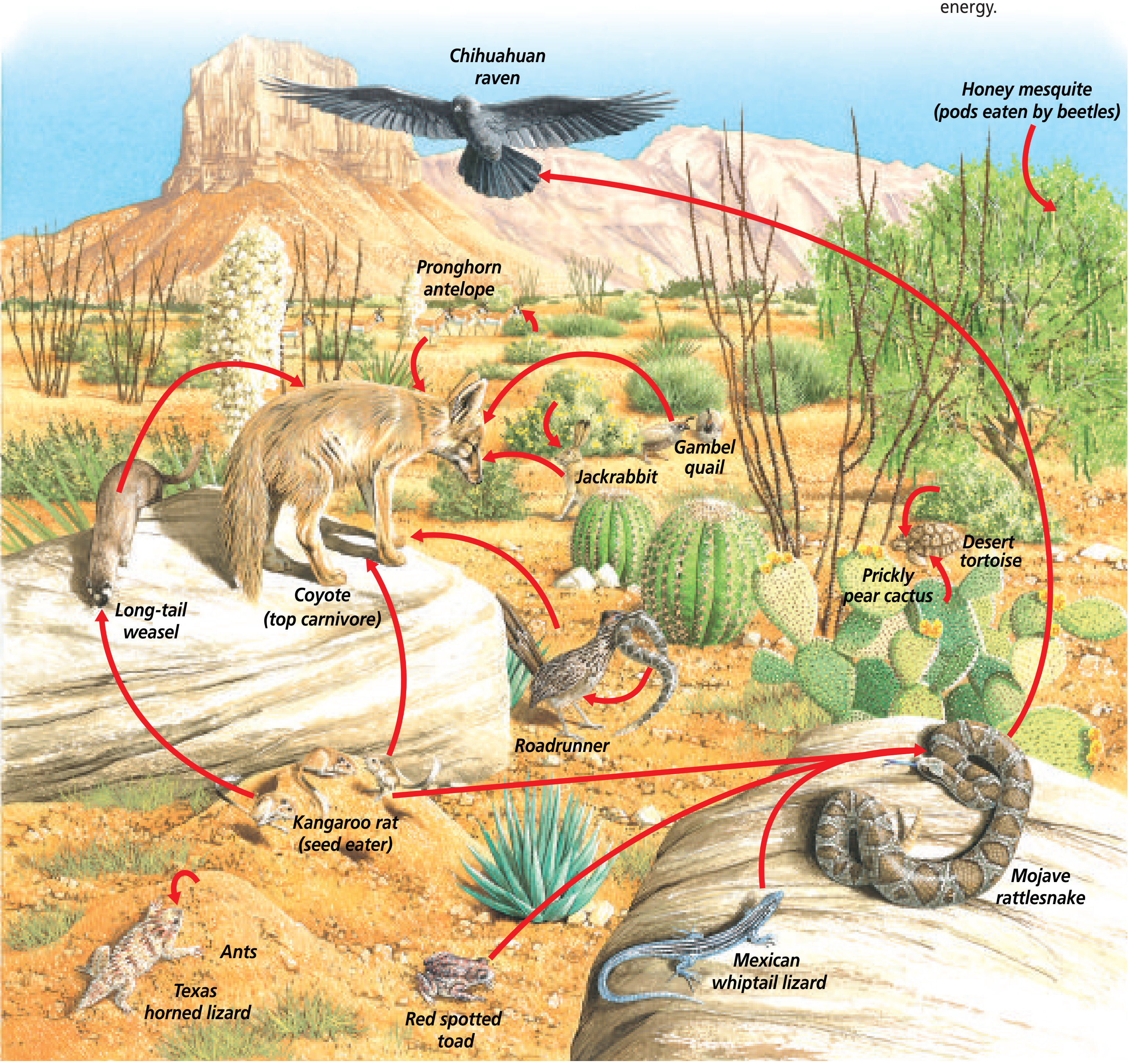
Infer What is represented by the small arrows connecting trophic levels? What does the decreasing width of each box mean in terms of available matter and energy at each level?

Energy and trophic levels: Ecological pyramids

Ecologists use food chains and food webs to model the distribution of matter and energy within an ecosystem. They also use another kind of model called an ecological pyramid. An ecological pyramid can show how energy flows through an ecosystem.

The base of the ecological pyramid on the next page represents the autotrophs, or first trophic level. Higher trophic levels are layered on top of one another. Examine each of the three types of ecological pyramids on the following pages.

Figure 2.13
A desert community food web includes many organisms at each trophic level. Arrows indicate the flow of materials and energy.



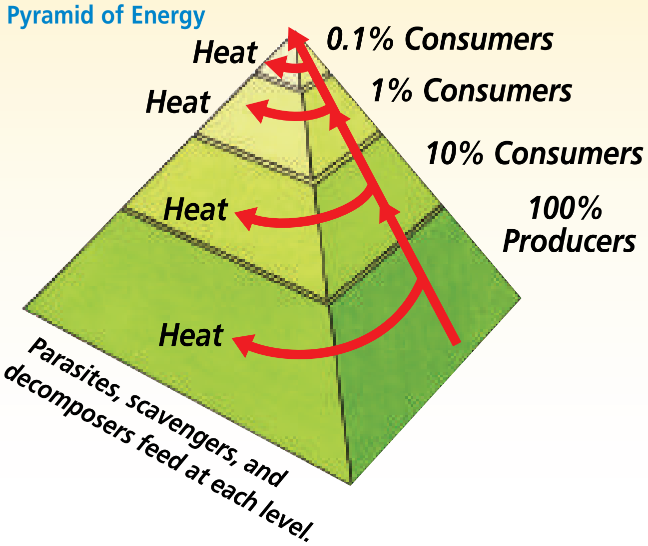


Figure 2.14
Each level in an energy pyramid represents the energy that is available within that trophic level. With each step up, only 10 percent of the energy is available for the next trophic level.

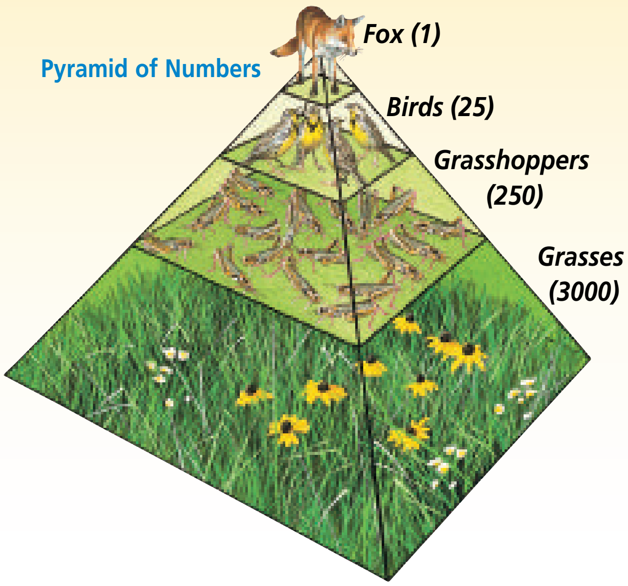


Figure 2.15
In a pyramid of numbers, each level represents the number of organisms consumed by the level above it.

Physical Science Connection

Conservation of energy The energy contained in food is in the form of chemical energy. When an organism consumes food, chemical energy in the food is converted into other forms of energy, such as heat and energy of motion. The law of conservation of energy—energy cannot be created or destroyed—always applies to all processes.

Each type of pyramid shown in ***Figures 2.14, 2.15,*** and ***2.16*** gives different information about an ecosystem.

The pyramid of energy illustrates that the amount of available energy decreases at each succeeding trophic level. The total energy transfer from one trophic level to the next is only about ten percent because organisms fail to capture and eat all the food energy available at the trophic level below them. When an organism consumes food, it uses some of the energy in the food for its metabolism—some for building body tissues, and some is given off as heat. When that organism is eaten, the energy that was used to build body tissue is again available as energy to be used by the organism that consumed it. According to the law of conservation of energy, energy is neither lost nor gained. Some of the energy transferred at each successive trophic level enters the environment as heat, but the total amount of energy remains the same.

A pyramid of numbers shows that population sizes decrease at each higher trophic level. This is not always true. For example, one tree can be food for thousands of insects. In this case, the pyramid would be inverted.

Biomass is the total weight of living matter at each trophic level. A pyramid of biomass represents the total dry weight of living material available at each trophic level.

Cycles in Nature

Food chains, food webs, and ecological pyramids are all models that show how energy moves in only one direction through the trophic levels of an ecosystem. Some of the energy also is transferred to the environment as heat generated by the body processes of organisms. Sunlight is the primary source of all this energy, and is always being replenished by the sun.

Matter, in the form of nutrients, also moves through, or is part of, all organisms at each trophic level. But matter is cycled and is not replenished like the energy from sunlight. There is a finite amount of matter. The atoms of

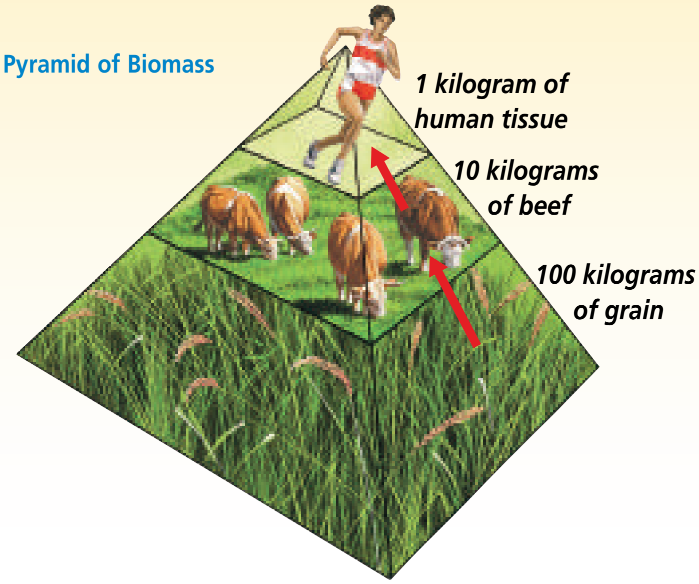


Figure 2.16
Each level in a pyramid of biomass represents the amount that the level above needs to consume to meet its needs.

carbon, nitrogen, and other elements that make up the bodies of organisms alive today are the same atoms that have been on Earth since life began. Matter is constantly recycled. It is never lost.

The water cycle

Life on Earth depends on water. Even before there was life on Earth, water cycled through stages. Have you ever left a glass of water out and a few days later observed there was less water in the glass? This is the result of evaporation. Just as the water evaporated from the glass, water evaporates from lakes and oceans and becomes water vapor in the air, as shown in *Figure 2.17.*

Physical Science Connection

Conservation of mass A number of physical and chemical reactions occur in natural cycles, such as the water cycle and carbon cycle. These reactions alter the physical and chemical properties of the substances involved. However, in all of these reactions, mass is neither created nor destroyed. This is the law of conservation of mass.

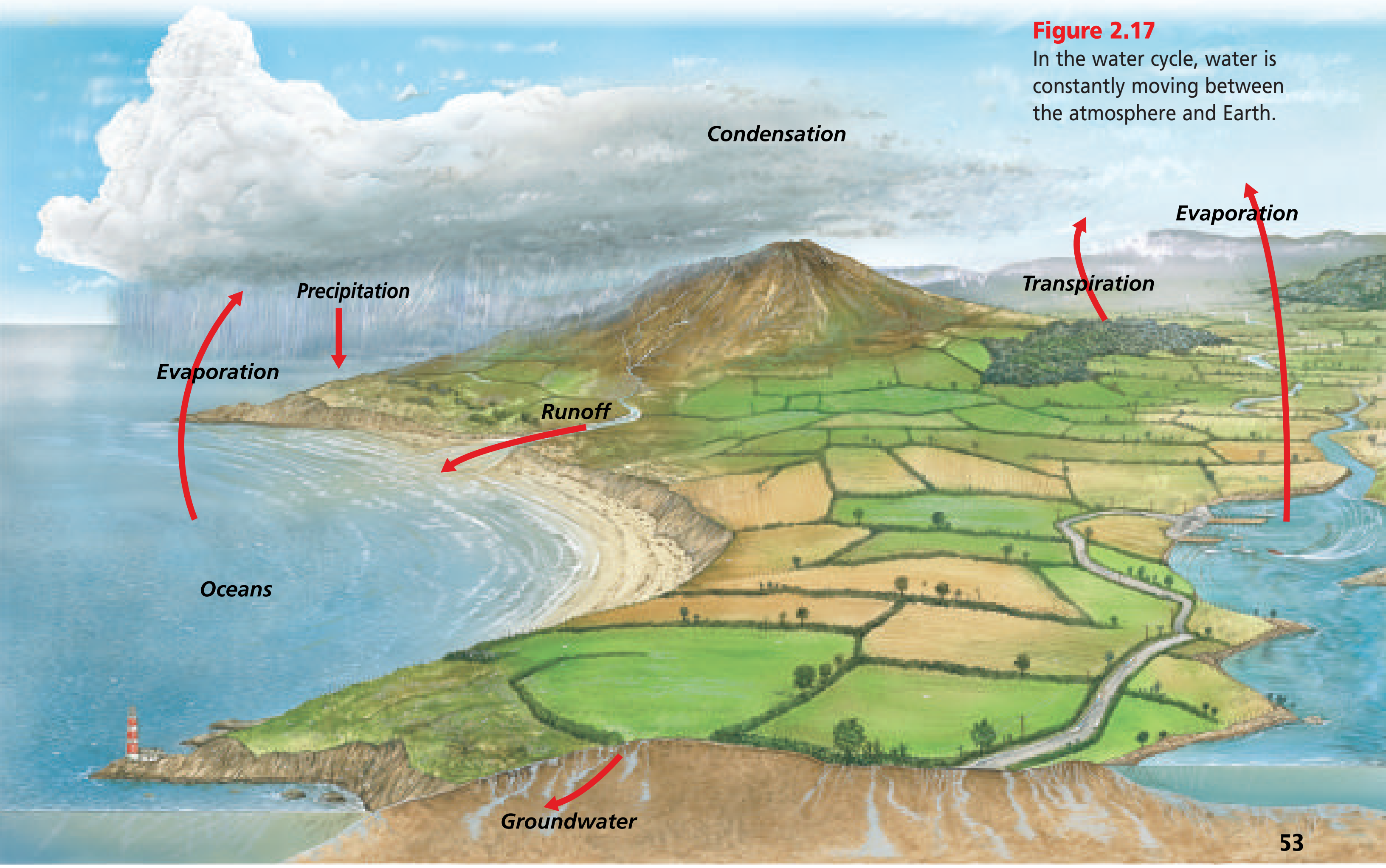


Figure 2.17
In the water cycle, water is constantly moving between the atmosphere and Earth.

MiniLab 2.2

Observe and Infer

Detecting Carbon Dioxide Cellular respiration is the chemical process whereby food is broken down, energy is released, and carbon dioxide is given off. When carbon dioxide dissolves in water, an acid forms. Certain chemicals called indicators can be used to detect acids. One indicator, called bromothymol blue, will change from its normal blue color to green or yellow if an acid is present.

Procedure

1. Half fill a test tube with bromothymol blue solution.
2. Add a quarter of an effervescent antacid tablet to the tube and note any color change.
3. Half fill a second test tube with bromothymol blue solution. Using a straw, exhale into the bromothymol blue at least 30 times. Record any color change that occurs in the test tube. **CAUTION:** ***DO NOT inhale the bromothymol blue.***

Analysis

1. **Observe** Describe the color change that occurs when sufficient carbon dioxide is added to bromothymol blue.
2. **Infer** What was the chemical composition of the bubbles seen in the tube with the antacid tablet?
3. **Conclude** Does exhaled air contain carbon dioxide? Explain how you can determine this.

Where do the drops of water that form on a cold can of soda come from? The water vapor in the air condenses on the surface of the can because the can is colder than the surrounding air. What takes place in the glass of water and on the cold soda can is similar to the global water cycle on the previous page. Water vapor also condenses on dust in the air and forms clouds. Further condensation makes small drops that build in size until they fall from the clouds as precipitation in the form of rain, ice, or snow. The water falls to Earth and accumulates in oceans and lakes where evaporation continues. Plants and animals need water to live. Natural processes constantly recycle water throughout the environment. Plants pull water from the ground and lose water from their leaves through the process of transpiration. This activity puts water vapor into the air. Animals breathe out water vapor in every breath. When they perspire or urinate, water also is returned to the environment.

The carbon cycle

All life on Earth is based on carbon molecules. Atoms of carbon form the framework for proteins, carbohydrates, fats, and other important molecules. More than any other element, carbon is the molecule of life. It is an important part of all living organisms.

The carbon cycle described in ***Figure 2.18*** on the next page starts with an autotroph. During photosynthesis, energy from the sun is used by autotrophic organisms to convert carbon dioxide gas into energy-rich carbon molecules that many organisms use for food and a source of energy. Autotrophs use these molecules for growth and energy. Heterotrophs, which feed either directly or indirectly on the autotrophs, use these carbon molecules for growth and energy. When the autotrophs and heterotrophs use the carbon-containing molecules and release energy, carbon dioxide is released and returned to the atmosphere. As the term implies, carbon *cycles* again and again through this system. How rapidly it cycles depends upon whether it is in soil, leaves, roots, tied up in a forest, in oil or coal, in animal fossils, or in the world's vast calcium carbonate reserves. Learn how to detect the presence of carbon dioxide in the *MiniLab* shown here.

Matt Meadows

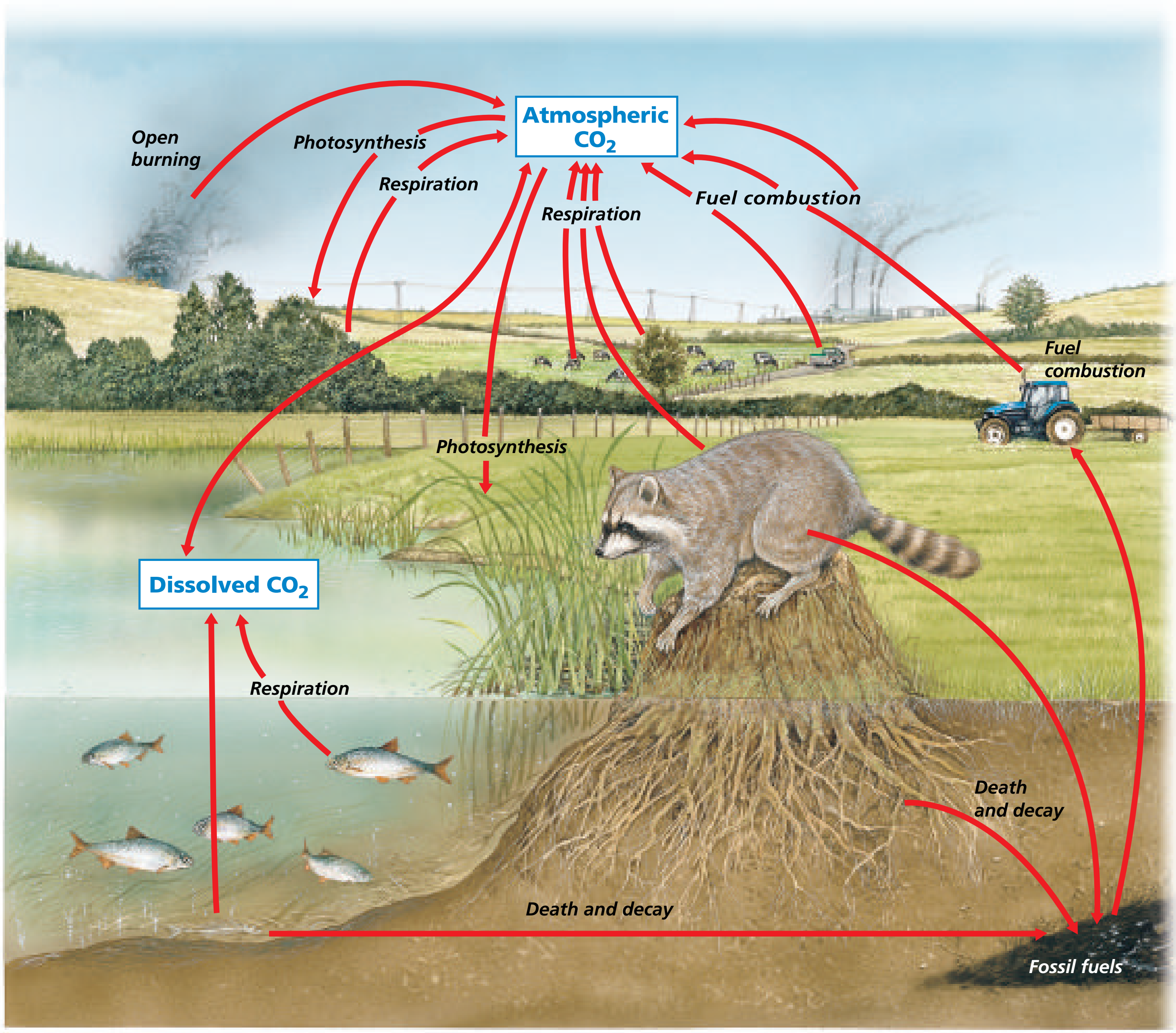
INSIDE STORY

The Carbon Cycle

Figure 2.18

From proteins to sugars, carbon is the building block of the molecules of life. Linked carbon atoms form the frame for molecules produced by plants and other living things. Organisms use these carbon molecules for growth and energy. **Critical Thinking** ***How is carbon released from the bodies of organisms?***

Forests use carbon dioxide.



Michael P. Gadomski/Photo Researchers

The nitrogen cycle

If you add nitrogen fertilizer to a lawn, houseplants, or garden, you may see that they become greener, bushier, and taller. Even though the air is 78 percent nitrogen, plants seem to do better when they receive nitrogen fertilizer. This is because most plants cannot use the nitrogen in the air. They use nitrogen in the soil that has been converted into more usable forms.

As ***Figure 2.19*** shows, certain bacteria convert the nitrogen from air into these more usable forms. Chemical fertilizers also give plants nitrogen in a form they can use.

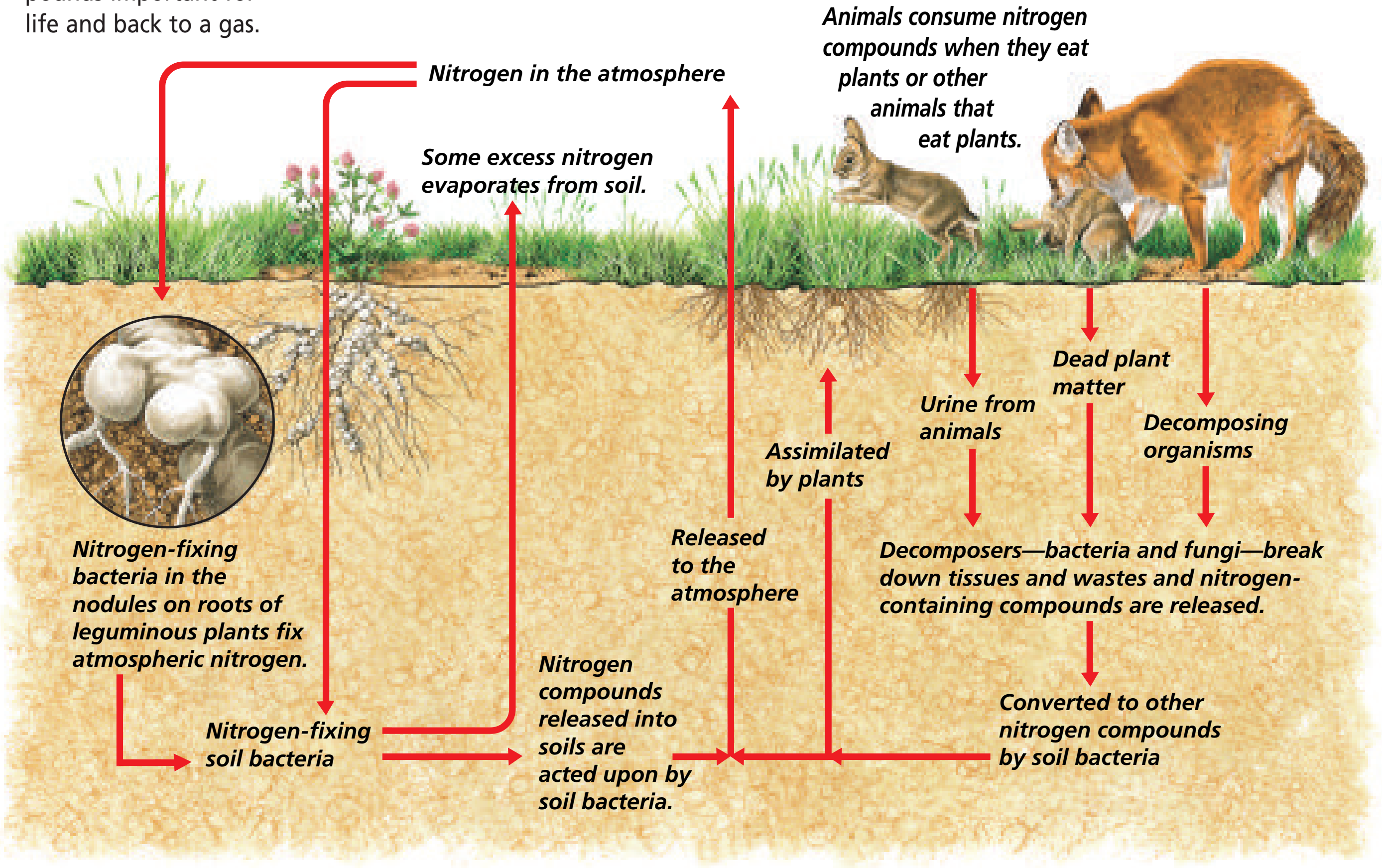
Plants use the nitrogen to make important molecules such as proteins. Herbivores eat plants and convert nitrogen-containing plant proteins into nitrogen-containing animal proteins. After you eat your food, you convert the protein components in food into human proteins in the form of muscle cells, blood cells, enzymes, and urine. Urine, an animal waste, contains nitrogen compounds. When an animal urinates, nitrogen returns to the water or soil. When organisms die and decay, nitrogen returns to the soil and eventually to the atmosphere. Plants reuse this nitrogen. Soil bacteria also act on these molecules and put nitrogen back into the air.

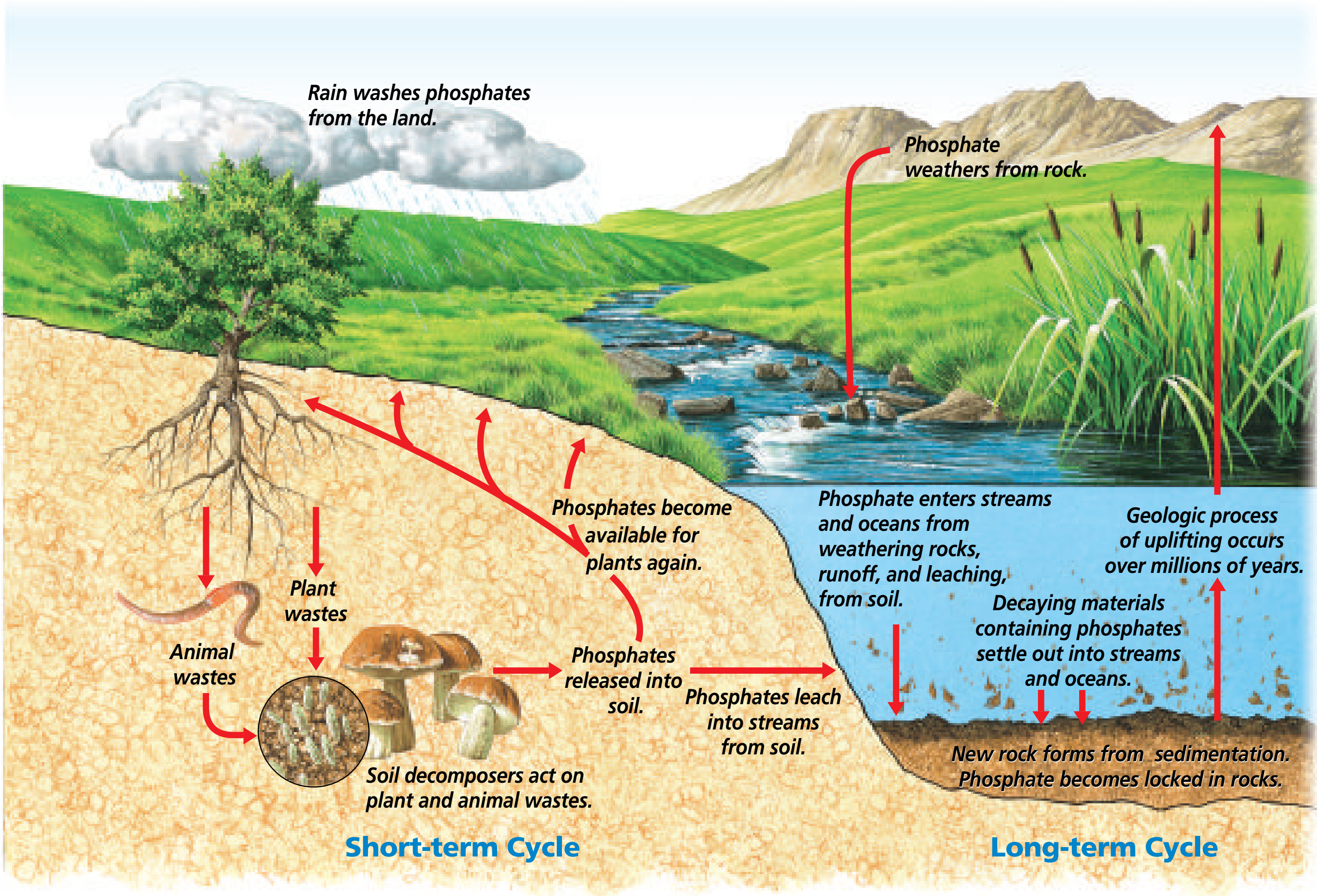
The phosphorus cycle

Materials other than water, carbon, and nitrogen cycle through ecosystems. Substances such as sulfur, calcium, and phosphorus, as well as others, must also cycle through an ecosystem. One essential element, phosphorus, cycles in two ways.

All organisms require phosphorus for growth and development. Plants

Figure 2.19
In the nitrogen cycle, nitrogen is converted from a gas to compounds important for life and back to a gas.





obtain phosphorus from the soil. Animals obtain phosphorus by eating plants. When these animals die, they decompose and the phosphorus is returned to the soil to be used again. This is the short-term phosphorus cycle in ***Figure 2.20.*** Phosphorus also has a long-term cycle, where phosphates washed into water become incorporated into rock as insoluble compounds. Millions of years later, as the environment changes, the rock containing phosphorus is exposed. As the rock erodes, the phosphorus again becomes part of the local ecological system.

Figure 2.20
In the phosphorus cycle, phosphorus moves between the living and nonliving parts of the environment.
Explain ***What is the function of mountains in the phosphorus cycle?***

Section Assessment

Understanding Main Ideas

1. What is the difference between an autotroph and a heterotroph?
2. Why do autotrophs always occupy the lowest level of ecological pyramids?
3. Give two examples of how nitrogen cycles from the abiotic portion of the environment into living things and back.
4. Explain the interactions among organisms in pyramids of energy, numbers, and biomass.

Thinking Critically

5. Evaluate the adequacy of the pyramid model to explain energy and matter transfer in an ecosystem.

Skill Review

6. **Design an Experiment** Suppose there is a fertilizer called GrowFast. It contains extra nitrogen and phosphorus. Design an experiment to see if GrowFast increases the growth rate of plants. For more help, refer to *Design an Experiment* in the **Skill Handbook.**

DESIGN YOUR OWN

BioLab

How can one population affect another?

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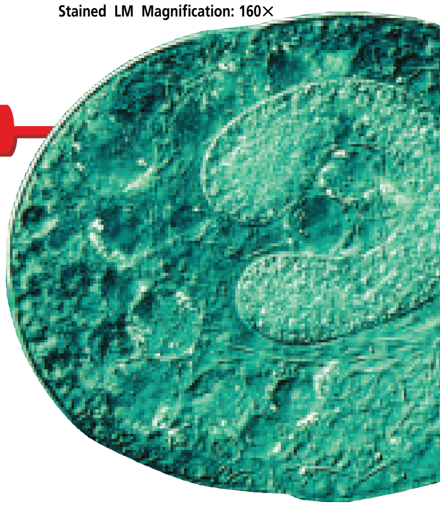


Didinium

INQUIRY

Before You Begin

Why don't prey populations disappear when predators are present? Prey species have evolved a variety of defenses to avoid being eaten. Just as prey have evolved defenses to avoid predators, predators have evolved mechanisms to overcome those defenses.

Didinium is a unicellular protist that attacks and devours *Paramecium* larger than itself. Do populations of *Paramecium* change when a population of *Didinium* is present?

PREPARATION

Problem

How does a population of *Paramecium* react to a population of *Didinium?*

Hypotheses

Have your group agree on an hypothesis to be tested. Record your hypothesis.

Objectives

In this BioLab, you will:

- **Design** an experiment to establish the relationships between *Paramecium* and *Didinium.*
- **Use** appropriate variables, constants, and controls in experimental design.

Possible Materials

microscope	culture of *Paramecium*
microscope slides	beakers or jars
coverslips	eyedroppers
culture of *Didinium*	sterile pond water

Safety Precautions

CAUTION: ***Take care when using electrical equipment. Always use goggles in the lab. Handle slides and coverslips carefully. Dispose of broken glass in a container provided by your teacher.***

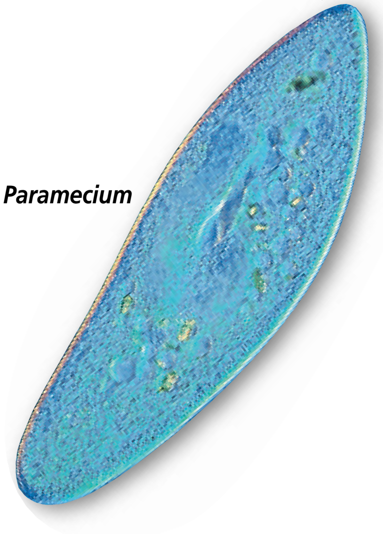
Skill Handbook

If you need help, with this lab, refer to the **Skill Handbook.**

PLAN THE EXPERIMENT

1. Review the discussion of feeding relationships in this chapter.
2. Select the materials you will use in your investigation. Record your list.
3. Be sure that your experimental plan contains a control, tests a single variable such as population size, and allows for the collection of quantitative data.
4. Prepare a list of numbered directions. Explain how you will use each of your materials.

Stained LM Magnification: 110×



Paramecium

M. Abbey/Visuals Unlimited

Check the Plan

Discuss the following points with other group members to decide final procedures. Make any needed changes to your plan.

1. What will you measure to determine the effect of the *Didinium* on *Paramecium?* If you count *Paramecia*, will you count all you can see in the field of vision of the microscope at a certain power? Will you have multiple trials? If so, how many?
2. What single factor will you vary? For example, will you put no *Didinium* in one culture of *Paramecium* and 5 mL of *Didinium* culture in another culture of *Paramecium?*
3. How long will you observe the populations?
4. How will you estimate the changes in the populations of *Paramecium* and *Didinium* during the experiment?
5. ***Make sure your teacher has approved your experimental plan before you proceed further.***
6. Carry out your experiment.
7. Make a data table that has Date, Number of *Paramecium*, and Number of *Didinium* across the top. Place the data obtained for each culture in rows. Design and complete a graph of your data.
8. **CLEANUP AND DISPOSAL** Make wise choices as to how the organisms will be reused or disposed of at the end of your experiment. Always wash your hands with soap or detergent after handling these organisms.

Color-enhanced SEM Magnification: 1400×

A *Didinium* captures a *Paramecium.*

ANALYZE AND CONCLUDE

1. **Analyze Data** What differences did you observe among the experimental groups? Were these differences due to the presence of *Didinium?* Explain.
2. **Draw Conclusions** Did the *Paramecium* die out in any culture? Why or why not?
3. **Check Your Hypothesis** Was your hypothesis supported by your data? If not, suggest a new hypothesis.
4. **ERROR ANALYSIS** List several ways that your methods may have affected the outcome of the experiment and describe how you would change the experiment.

Apply Your Skill

Project Based on this lab experience, design another experiment that would help you answer any questions that arose from your work. What factors might you allow to vary if you kept the number of *Didinium* constant?

Web Links To find out more about population biology, visit ca.bdol.glencoe.com/population_biology

Biology and Society

The Everglades—Restoring an Ecosystem

The Florida Everglades ecosystem covers the southern portion of the Florida peninsula. As with any wetlands, water is the critical factor.

Each year, during the rainy season from May to October, the subtropical region of southern Florida receives between 100 and 165 cm (40–65 inches) of rain. Before extensive development took place, the heavy rainfall caused shallow Lake Okeechobee to overflow and a wide, thin sheet of water spread out from the lake, creating an extensive marshy area.

Early in the twentieth century, while Florida was still mostly wilderness, the seasonal slow-moving river that flowed slowly out of Lake Okeechobee was about 80 km (50 miles) wide in some places, and only 15–90 cm (six inches to three feet) deep. This wetland teemed with fishes, amphibians, and other animals that fed millions of wading birds. Healthy populations of crocodiles, alligators, and other large animals also lived here. During the dry season, from December to April, water levels in the marshes gradually dropped. Fishes and other water dwellers moved into deeper pools that held water all year long.

The map shows the location of the Everglades.

The Changing Everglades Water from Lake Okeechobee no longer floods the countryside, however. Because of its beauty and resources, people and industries were attracted to Florida beginning in the late 1880s and early 1900s. Over time, the area changed. As much as 70 percent of Lake Okeechobee's water was diverted to create dry land. The area around the lake became surrounded by farms and towns and is now unable to adequately renew the Everglades. As a result, the ecology of the area has been measurably affected. Since 1950, the wading bird population alone has declined more than 90 percent. Almost 70 percent of other native wildlife is now listed as threatened or endangered. As for the water supply, nearly 1.7 billion gallons of freshwater, which would normally flow slowly through the Everglades from Lake Okeechobee and other streams, now flows directly into the ocean instead.

Perspectives Agriculture and industry are important to the area's economy. However, over the years, runoff containing large amounts of toxins and excess nutrients (particularly phosphorus) has made its way into the water that eventually reaches the Everglades.

In 1993, a plan was put forth for restoring the deteriorating Everglades. The goals of the plan being worked out by federal, state, and industry are:

1. to reduce the levels of phosphorus and mercury runoff from industry to safe levels,
2. to restore the natural flow of unpolluted water into the Everglades,
3. to recover native habitats and species, and to create a sustainable ecosystem.

Forming Your Opinion

Point of View When Everglades National Park was established, scientists and government officials intended that a portion of the Everglades ecosystem would be preserved from development. Research the current history of attempts to restore the Everglades ecosystems.

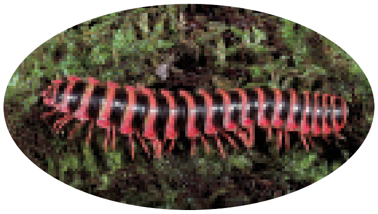
To find out more about the Everglades, visit ca.bdol.glencoe.com/biology_society

Chapter 2 Assessment

Study Guide

Section 2.1

Organisms and Their Environment



Key Concepts

- Natural history, the observation of how organisms live out their lives in nature, led to the development of the science of ecology—the study of the interactions of organisms with one another and with their environments.
- Ecologists classify and study the biological levels of organization from the individual to ecosystem. Ecologists study the abiotic and biotic factors that are a part of an organism's habitat. They investigate the strategies an organism is adapted with to exist in its niche.

Vocabulary

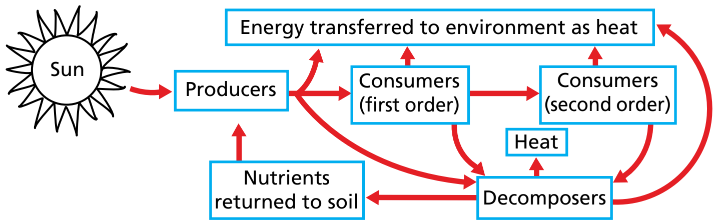
abiotic factor (p. 37)
biological community (p. 39)
biosphere (p. 36)
biotic factor (p. 38)
commensalism (p. 44)
ecology (p. 36)
ecosystem (p. 41)
habitat (p. 42)
mutualism (p. 44)
niche (p. 43)
parasitism (p. 44)
population (p. 38)
symbiosis (p. 44)

Section 2.2

Nutrition and Energy Flow

Key Concepts

- Autotrophs, such as plants, make nutrients that can be used by the plants and by heterotrophs. Heterotrophs include herbivores, carnivores, omnivores, and decomposers.



- Food chains are simple models that show how energy and materials move from autotrophs to heterotrophs and eventually to decomposers.
- Food webs represent many interconnected food chains and illustrate pathways in which energy and materials are transferred within an ecosystem. Energy is transferred through food webs. The materials of life, such as carbon and nitrogen, are used and reused as they cycle through the ecosystem.

Vocabulary

autotroph (p. 46)
biomass (p. 52)
decomposer (p. 47)
food chain (p. 49)
food web (p. 50)
heterotroph (p. 47)
trophic level (p. 50)

FOLDABLES Study Organizer To help you review the principles of ecology, use the Organizational Study Fold on page 46.

ca.bdol.glencoe.com/vocabulary_puzzlemaker

Chapter 2 Assessment

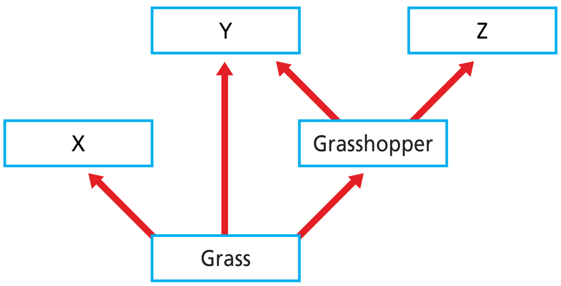
Vocabulary Review

Review the Chapter 2 vocabulary words listed in the Study Guide on page 61. Match the words with the definitions below.

1. any close and permanent association among organisms of different species
2. a simple model used to show how matter and energy move through an ecosystem
3. interactions among the populations in a community and the community's abiotic factors
4. organisms that use energy from the sun or energy stored in chemical compounds to manufacture their own nutrients
5. strategies and adaptations a species uses in its environment

Understanding Key Concepts

6. Which of the following would be abiotic factors for a polar bear?
   A. extreme cold, floating ice
   B. eating only live prey
   C. large body size
   D. paws with thick hair
7. In the food web below, which of the organisms—X, Y, or Z—is an herbivore?



   A. Z
   B. Y
   C. Both X and Y
   D. X
8. Which of the following would most decrease the amount of carbon dioxide in the air?
   A. a growing maple tree
   B. a running dog
   C. a person driving a car
   D. a burning forest
9. Which of the following describes energy and matter in ecosystems?
   A. Both energy and matter are completely recycled.
   B. Matter recycles, but some energy is transferred.
   C. Energy is recycled, but most matter is lost.
   D. Both matter and energy are completely lost.

Constructed Response

10. **Open Ended** Decomposers are all microorganisms. Review the role of decomposers in food chains and explain how they can both maintain and disrupt the equilibrium or balance of an ecosystem. Use a specific example in your explanation.
11. **Open Ended** Identify and describe an ecosystem in or around your home. List all the biotic and abiotic factors interacting there and explain how you think they affect each other.
12. **Open Ended** According to the law of conservation of matter, matter can neither be created nor destroyed. Make a relationship between this statement and the recycling of carbon in an ecosystem.

Thinking Critically

13. **Explain** In a food chain, explain what the arrows mean.
14. **Interpret Scientific Illustrations** Draw and label a pyramid of numbers that includes the components: deer, cougar, grass.
15. **Analyze** The three-toed sloth often is camouflaged by algae. Which type of symbiosis does this represent and why?
16. **REAL WORLD BIOCHALLENGE** Populations of amphibians are declining in areas worldwide. Visit ca.bdol.glencoe.com to investigate the reasons for the decline. What are some reasons amphibian populations may be decreasing? Suggest ways to reverse the decline to your class.

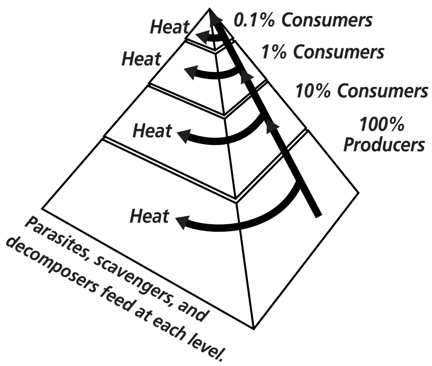
California Standards Practice

The assessed California standard appears next to the question.

All questions aligned and verified by The Princeton Review

Part 1 Multiple Choice

Use the picture of the food web shown here to answer questions 17 and 18.



17. In the pyramid of energy above, less energy is available in the second level because ________.
- **A.** there is more food than at the first level
- **B.** energy from the first level was given off as heat
- **C.** the organism at the top doesn't need very much
- **D.** producers don't use as much energy as consumers

18. The amount of energy at each level is about ________ of what it was on the level before.
- **A.** 50 percent
- **B.** 25 percent
- **C.** 20 percent
- **D.** 10 percent

19. All the abiotic and biotic factors in a small forest form a(n) ________.
- **A.** population
- **B.** community
- **C.** ecosystem
- **D.** biosphere

20. Because most humans consume both plant and animal products, they are described as ________.
- **A.** omnivores
- **B.** carnivores
- **C.** herbivores
- **D.** predators

21. The relationship of algae living in the fur of 3-toed sloths and helping camouflage the sloths, is called ________.
- **A.** parasitism
- **B.** commensalism
- **C.** mutualism
- **D.** symbiosis

22. Why is a jar of pond water an ecosystem?
- **A.** Depending on nonliving factors, many populations live in the jar.
- **B.** Only one population lives in the jar.
- **C.** Only the abiotic factors determine if algae can survive.
- **D.** Many different populations of microorganisms eat the algae.

Part 2 Constructed Response/Grid In

Use the flowchart of the phosphorus cycle below to answer question 23. Record your answers on your answer document.

23. Open Ended Phosphorus enters the cycle from sediments. Using evidence from the diagram, explain why and explain how the mountains in the diagram are related to the cycle.

24. 6d **Open Ended** Using information from the nitrogen cycle, explain the niche of nitrogen-fixing soil bacteria. Why are they important for life?