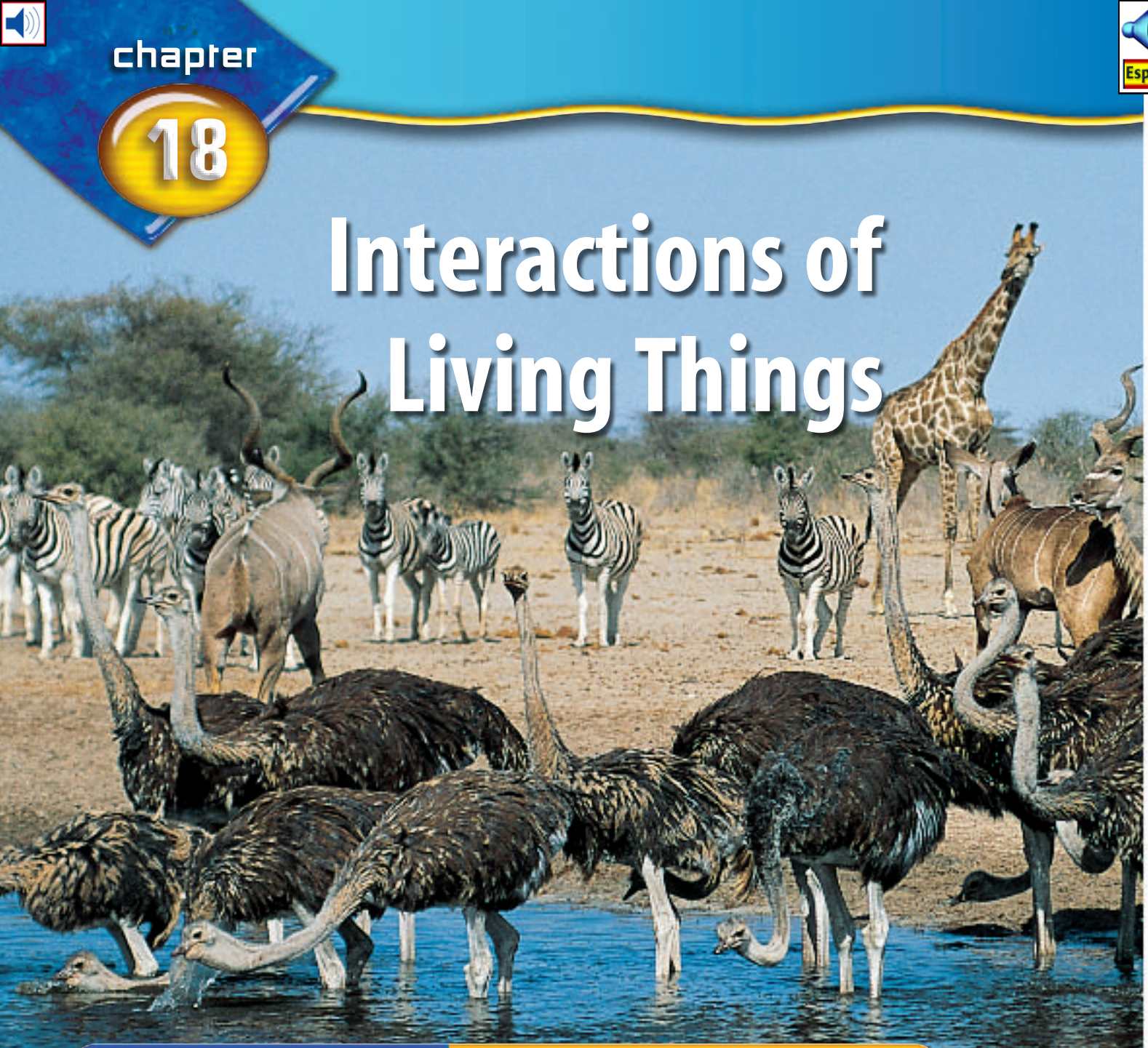
chapter 18

Interactions of Living Things



Clem Haagner/A.B.P.L./Photo Researchers

chapter preview

sections

Interactions at a Waterhole

How many different kinds of animals can you see in the photo? How are the animals interacting with each other? Animals and other organisms in an area not only interact with each other, but with the nonliving factors of the area as well. What non-living factors can you identify?

Science Journal Write a list of things you interact with each day.

Start-Up Activities

Launch Lab

Space and Interactions

Imagine that you are in a crowded elevator. Everyone jostles and bumps each other. The temperature increases and ordinary noises seem louder. Like people in an elevator, plants and animals in an area interact. How does the amount of space available to each organism affect its interaction with other organisms?

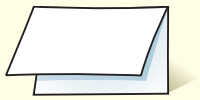
1. Use a meterstick to measure the length and width of the classroom.
2. Multiply the length by the width to find the area of the room in square meters.
3. Count the number of individuals in your class. Divide the area of the classroom by the number of individuals. In your Science Journal, record how much space each person has.
4. **Think Critically** Write a prediction in your Science Journal about what might happen if the number of students in your classroom doubled.

Science Online | Preview this chapter's content and activities at green.msscience.com

Foldables Study Organizer

Biotic and Abiotic Make the following Foldable to help you understand the cause and effect relationship of biotic and abiotic things.

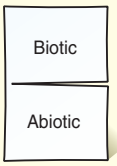
STEP 1 **Fold** a vertical sheet of paper in half from top to bottom.



STEP 2 **Fold** in half from side to side with the fold at the top.

STEP 3 **Unfold** the paper once. **Cut** only the fold of the top flap to make two tabs.

STEP 4 **Turn** the paper vertically and **label** the front tabs as shown.



Illustrate and Label Before you read the chapter, list examples of biotic and abiotic things around you on the tabs. As you read, write about each.

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section 1

The Environment

as you read

What You'll Learn

- **Identify** biotic and abiotic factors in an ecosystem.
- **Describe** the different levels of biological organization.
- **Explain** how ecology and the environment are related.

Why It's Important

Abiotic and biotic factors interact to make up your ecosystem. The quality of your ecosystem can affect your health. Your actions can affect the health of the ecosystem.

Review Vocabulary

climate: the average weather conditions of an area over time

New Vocabulary

- ecology
- abiotic factor
- biotic factor
- population
- community
- ecosystem
- biosphere

Ecology

All organisms, from the smallest bacteria to a blue whale, interact with their environment. **Ecology** is the study of the interactions among organisms and their environment. Ecologists, such as the one in **Figure 1,** are scientists who study these relationships. Ecologists organize the environmental factors that influence organisms into two groups—nonliving and living or once-living. **Abiotic** (ay bi AH tihk) **factors** are the nonliving parts of the environment. Living or once-living organisms in the environment are called **biotic** (bi AH tihk) **factors.**

Reading Check *Why is a rotting log considered a biotic factor in the environment?*

Abiotic Factors

In any environment, birds, insects, and other living things, including humans, depend on one another for food and shelter. They also depend on the abiotic factors that surround them, such as water, sunlight, temperature, air, and soil. All of these factors and others are important in determining which organisms are able to live in a particular environment.

Figure 1 Ecologists study biotic and abiotic factors in an environment and the relationships among them. Many times, ecologists must travel to specific environments to examine the organisms that live there.

WM. J. Jahoda/Photo Researchers

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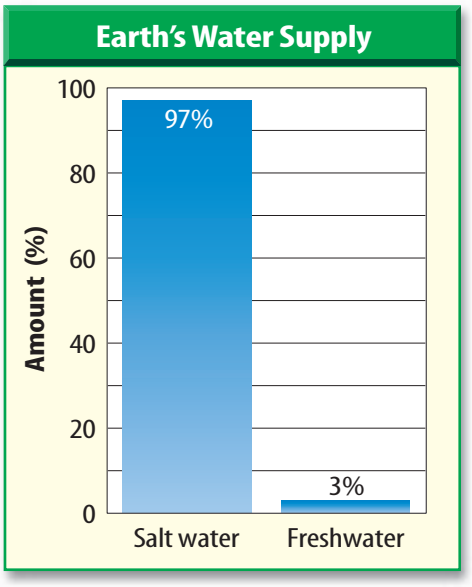

The seas and oceans are home to thousands of different species.

This stream is a freshwater environment. It is home to many species of plants and animals.

Figure 2 Salt water accounts for 97 percent of the water on Earth. It is found in the seas and oceans. Only three percent of Earth's water is freshwater.

Water All living organisms need water to survive. The bodies of most organisms are 50 percent to 95 percent water. Water is an important part of the cytoplasm in cells and the fluid that surrounds cells. Respiration, photosynthesis, digestion, and other important life processes can only occur in the presence of water.

More than 95 percent of Earth's surface water is found in the oceans. The saltwater environment in the oceans is home to a vast number of species. Freshwater environments, like the one in **Figure 2,** also support thousands of types of organisms.

Light and Temperature The abiotic factors of light and temperature also affect the environment. The availability of sunlight is a major factor in determining where green plants and other photosynthetic organisms live, as shown in **Figure 3.** By the process of photosynthesis, energy from the Sun is changed into chemical energy that is used for life processes. Most green algae live near the water's surface where sunlight can penetrate. In dense forests where little sunlight penetrates through to the forest floor, very few photosynthetic plants grow.

The temperature of a region also determines which plants and animals can live there. Some areas of the world have a fairly consistent temperature year round, but other areas have seasons during which temperatures vary. Water environments throughout the world also have widely varied temperatures. Living organisms are found in the freezing cold Arctic, in the extremely hot water near ocean vents, and at almost every temperature in between.

Figure 3 Flowers that grow on the forest floor, such as these bluebells, grow during the spring when they receive the most sunlight. **Infer** *why there is little sunlight on the forest floor during the summer.*

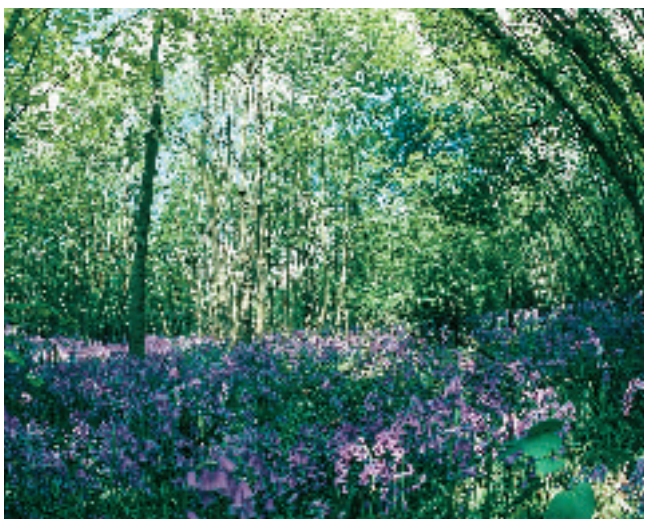

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Figure 4 Air pollution can come from many different sources. Air quality in an area affects the health and survival of the species that live there.

INTEGRATE Career

Air Pollution Engineer
Have you ever wondered who monitors the air you breathe? Air pollution engineers are people who make sure air quality standards are being met. They also design new technologies to reduce air pollution, such as improved machinery, filters, and ventilation systems, to try and solve problems like "sick building syndrome".

Air Although you can't see the air that surrounds you, it has an impact on the lives of most species. Air is composed of a mixture of gases including nitrogen, oxygen, and carbon dioxide. Most plants and animals depend on the gases in air for respiration. The atmosphere is the layer of gases and airborne particles that surrounds Earth. Polluted air, like the air in **Figure 4,** can cause the species in an area to change, move, or die off.

Clouds and weather occur in the bottom 8 km to 16 km of the atmosphere. All species are affected by the weather in the area where they live. The ozone layer is 20 km to 50 km above Earth's surface and protects organisms from harmful radiation from the Sun. Air pressure, which is the weight of air pressing down on Earth, changes depending on altitude. Higher altitudes have less air pressure. Few organisms live at extreme air pressures.

Reading Check *How does pollution in the atmosphere affect the species in an area?*

Figure 5 Soil provides a home for many species of animals and other organisms.

Soil From one enviroment to another, soil, as shown in **Figure 5,** can vary greatly. Soil type is determined by the amounts of sand, silt, and clay it contains. Various kinds of soil contain different amounts of nutrients, minerals, and moisture. Different plants need different kinds of soil. Because the types of plants in an area help determine which other organisms can survive in that area, soil affects every organism in an environment.

Biotic Factors

Abiotic factors do not provide everything an organism needs for survival. Organisms depend on other organisms for food, shelter, protection, and reproduction. How organisms interact with one another and with abiotic factors can be described in an organized way.

Francis Lepine/Earth Scenes
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Levels of Organization The living world is highly organized. Atoms are arranged into molecules, which in turn might be organized into cells. Cells form tissues, tissues form organs, and organs form organ systems. Together, organ systems form organisms. Biotic and abiotic factors also can be arranged into levels of biological organization, as shown in **Figure 6.**

Figure 6 The living world is organized in levels.

An organism is one individual from a population.

All of the individuals of one species that live in the same area at the same time make up a population.

The populations of different species that interact in some way are called a community.

All of the communities in an area and the abiotic factors they interact with make up an ecosystem.

A biome is a large region with plants and animals well adapted to the soil and climate of the region.

The level of biological organization that is made up of all the ecosystems on Earth is the biosphere.

Figure 7 Members of a penguin population compete for resources. **Infer** *what resources these penguins might be using.*

Populations All the members of one species that live together make up a **population.** For example, all of the humans living on Earth at the same time make up a population. Part of a population of penguins is shown in **Figure 7.** Members of a population compete for food, water, mates, and space. The resources of the environment and the ways the organisms use these resources determine how large a population can become.

Communities Most populations of organisms do not live alone. They live and interact with populations of other types of organisms. Groups of populations that interact with each other in a given area form a **community.** For example, a population of penguins and all of the species that they interact with form a community. Populations of organisms in a community depend on each other for food, shelter, and other needs.

Ecosystems In addition to interactions among populations, ecologists also study interactions among populations and their physical surroundings. An **ecosystem** is made up of a biotic community and the abiotic factors that affect it. Examples of ecosystems include coral reefs, forests, and ponds. You will learn more about the interactions that occur in ecosystems later in this chapter.

Biomes Scientists divide Earth into different regions called biomes. A biome (BI ohm) is a large region with plant and animal groups that are well adapted to the soil and climate of the region. Many different ecosystems are found in a biome. Examples of biomes include tundra, as shown in **Figure 8,** tropical rain forests, and grasslands.

Science Online

Topic: Earth's Biomes

Visit green.msscience.com for Web links to information about Earth's different biomes.

Activity Select one of Earth's biomes and research what plants, animals, and other organisms live there. Prepare a display that includes pictures and text about your selected biome.

Figure 8 Biomes contain many different ecosystems. This mountaintop ecosystem is part of the alpine tundra biome.

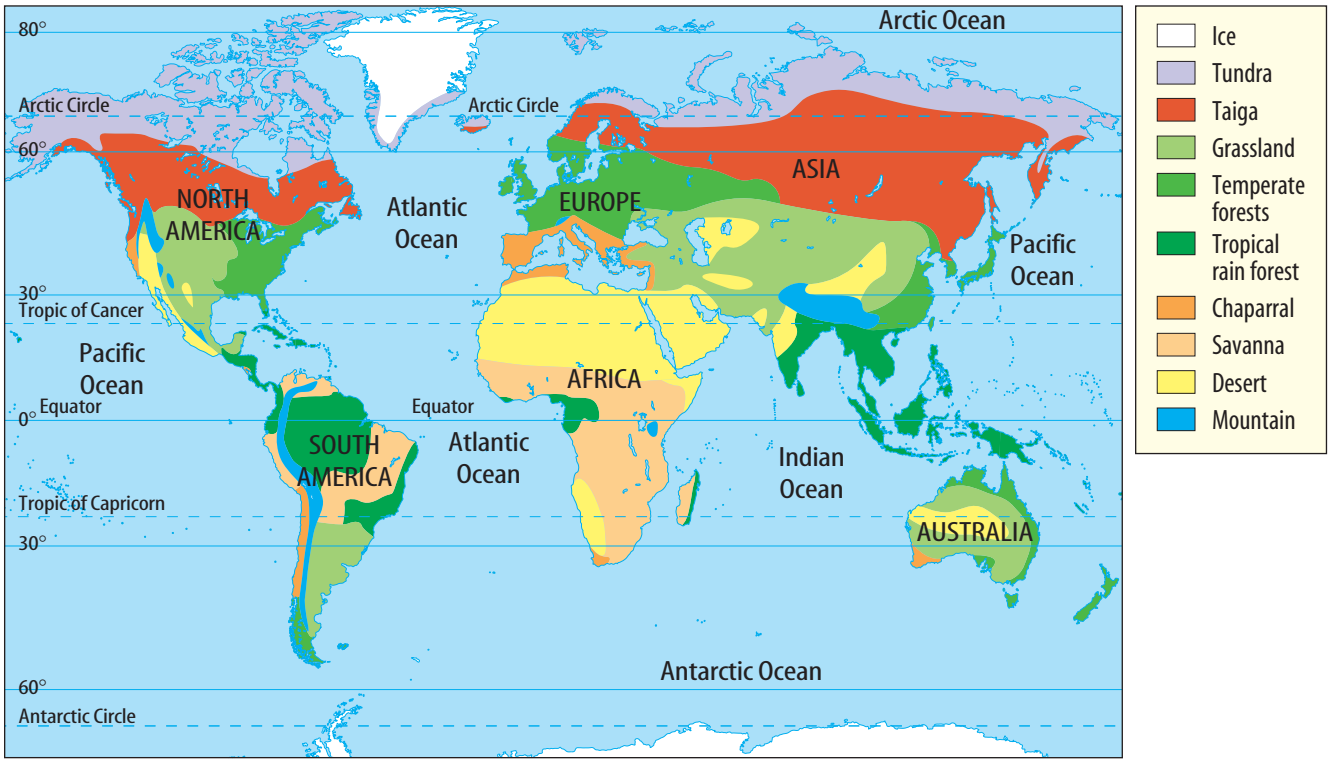

Figure 9 This map shows some of the major biomes of the world. **Determine** *what biome you live in.*

The Biosphere Where do all of Earth's organisms live? Living things can be found 11,000 m deep in the ocean, 9,000 m high on mountains, and 4.5 km high in Earth's atmosphere. The part of Earth that supports life is the **biosphere** (BI uh sfihr). It includes the top part of Earth's crust, all the waters that cover Earth's surface, the surrounding atmosphere, and all biomes, including those in **Figure 9.**

section 1 review

Summary

Abiotic Factors

- Organisms interact with and depend on factors in their environments.
- More than 95 percent of Earth's surface is water.
- The amount of sunlight determines where green plants can grow.
- Temperature determines which organisms can live in a region.
- Air is needed by most organisms. Polluted air can harm organisms.
- Soil can determine organisms in an area.

Biotic Factors

- Organisms depend on other organisms for food, shelter, protection, and reproduction.
- The living world is organized into levels.

Self Check

1. **Compare and contrast** abiotic factors and biotic factors. Give five examples of each that are in your ecosystem.
2. **Describe** a population and a community.
3. **Define** the term *ecosystem.*
4. **Explain** how the terms *ecology* and *environment* are related.
5. **Think Critically** Explain how biotic factors change in an ecosystem that has flooded.

Applying Skills

6. **Record Observations** Each person lives in a population as part of a community. Describe your population and community.
7. **Use a database** to research biomes. Find the name of the biome that best describes where you live.

LAB

Delicately Balanced Ecosystems

Each year you might visit the same park, but notice little change. However, ecosystems are delicately balanced, and small changes can upset this balance. In this lab, you will observe how small amounts of fertilizer can disrupt an ecosystem.

Real-World Question

How do manufactured fertilizers affect pond systems?

Goals

- **Observe** the effects of manufactured fertilizer on water plants.
- **Predict** the effects of fertilizers on pond and stream ecosystems.

Materials

large glass jars of equal size (4)
clear plastic wrap
stalks of *Elodea* (8)
**another aquatic plant*
garden fertilizer
**houseplant fertilizer*
rubber bands (4)
pond water
triple-beam balance
**electronic scale*
weighing paper
spoon
metric ruler
**Alternate materials*

Safety Precautions

Procedure

1. Working in a group, label four jars *A, B, C,* and *D.*
2. **Measure** eight *Elodea* stalks to be certain that they are all about equal in length.
3. Fill the jars with equal volumes of pond water and place two stalks of *Elodea* in each jar.
4. Add 5 g of fertilizer to jar B, 10 g to jar C, and 30 g to jar D. Put no fertilizer in jar A.
5. Cover each jar with plastic wrap and secure it with a rubber band. Use your pencil to punch three small holes through the plastic wrap.
6. Place all jars in a well-lit area.
7. **Observe** the jars daily for three weeks. Record your observations in your Science Journal.
8. **Measure and record** the length of each *Elodea* stalk in your Science Journal.

Conclude and Apply

1. **List** the control and variables you used in this experiment.
2. **Compare** the growth of *Elodea* in each jar.
3. **Predict** what might happen to jar A if you added 5 g of fertilizer to it each week.
4. **Infer** what effects manufactured fertilizers might have on pond and stream ecosystems.

Communicating Your Data

Compare your results with the results of other students. Research how fertilizer runoff from farms and lawns has affected aquatic ecosystems in your area.

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section 2

Interactions Among Living Organisms

Characteristics of Populations

You, the person sitting next to you, everyone in your class, and every other organism on Earth is a member of a specific population. Populations can be described by their characteristics such as spacing and density.

Population Size The number of individuals in the population is the population's size, as shown in **Figure 10.** Population size can be difficult to measure. If a population is small and made up of organisms that do not move, the size can be determined by counting the individuals. Usually individuals are too widespread or move around too much to be counted. The population size then is estimated. The number of organisms of one species in a small section is counted and this value is used to estimate the population of the larger area.

Suppose you spent several months observing a population of field mice that live in a pasture. You probably would observe changes in the size of the population. Older mice die. Mice are born. Some are eaten by predators, and some mice move away to new nests. The size of a population is always changing. The rate of change in population size varies from population to population. In contrast to a mouse population, the number of pine trees in a mature forest changes slowly, but a forest fire or disease could reduce the pine tree population quickly.

as you read

What You'll Learn

- **Identify** the characteristics that describe populations.
- **Examine** the different types of relationships that occur among populations in a community.
- **Determine** the habitat and niche of a species in a community.

Why It's Important

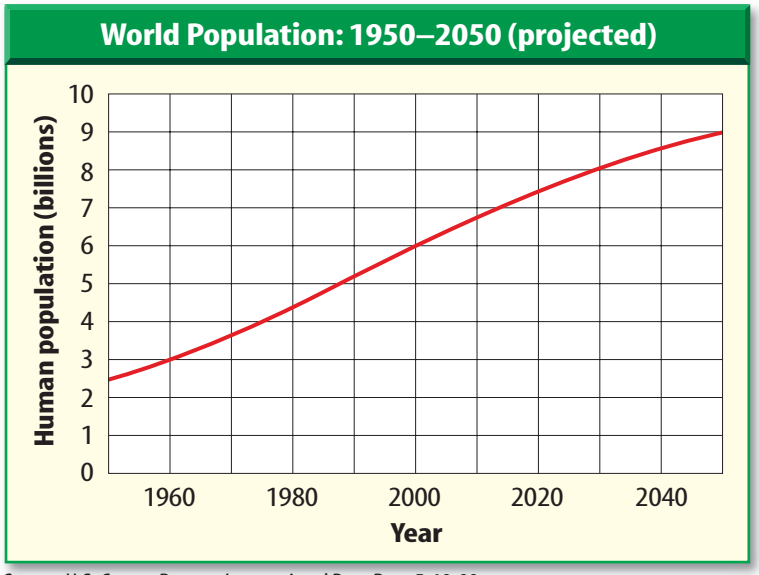
You must interact with other organisms to survive.

Review Vocabulary

coexistence: living together in the same place at the same time

New Vocabulary

- population density
- limiting factor
- symbiosis
- niche
- habitat



Source: U.S. Census Bureau, International Data Base 5-10-00.

Figure 10 The size of the human population is increasing each year. By the year 2050, the human population is projected to be more than 9 billion.

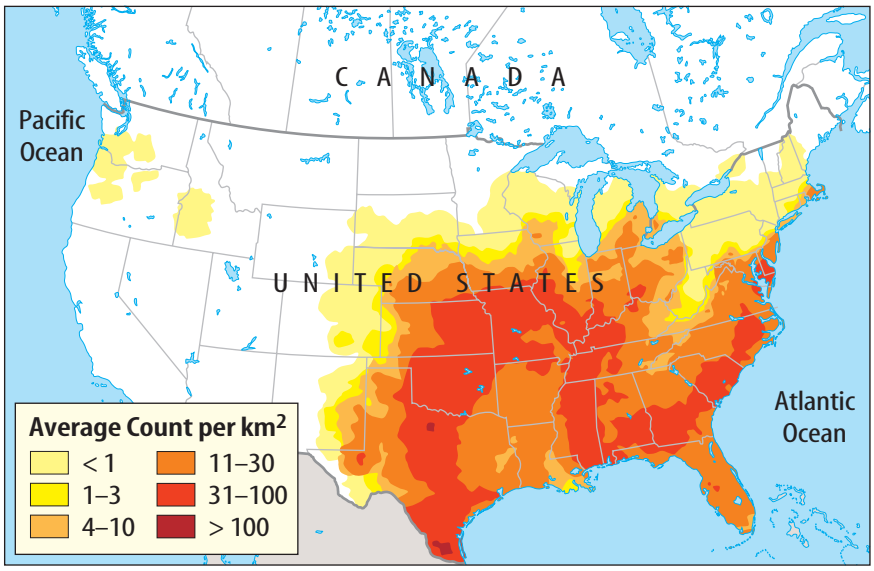


Figure 11 Population density can be shown on a map. This map uses different colors to show varying densities of a population of northern bobwhites, a type of bird.

Science Online

Topic: Human Population

Visit green.msscience.com for Web links to information about human population and densities.

Activity Select at least three different areas of the world and prepare a bar graph to compare population density of each area. Compare the population density of where you live to the three areas of the world you select.

Population Density

At the beginning of this chapter, when you figured out how much space is available to each student in your classroom, you were measuring another population characteristic. The number of individuals in a population that occupy a definite area is called **population density.** For example, if 100 mice live in an area of one square kilometer, the population density is 100 mice per square kilometer. When more individuals live in a given amount of space, as seen in **Figure 11,** the population is more dense.

Population Spacing

Another characteristic of populations is spacing, or how the organisms are arranged in a given area. They can be evenly spaced, randomly spaced, or clumped together. If organisms have a fairly consistent distance between them, as shown in **Figure 12,** they are evenly spaced. In random spacing, each organism's location is independent of the locations of other organisms in the population. Random spacing of plants usually results when wind or birds disperse seeds. Clumped spacing occurs when resources such as food or living space are clumped. Clumping results when animals gather in groups or plants grow near each other in groups.

Figure 12 Some populations, such as creosote bushes in the desert, are evenly spaced throughout an area.

Dan Suzio/Photo Researchers

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Limiting Factors Populations, such as the antelopes in **Figure 13,** cannot continue to grow larger forever. All ecosystems have a limited amount of food, water, living space, mates, nesting sites, and other resources. A **limiting factor** is any biotic or abiotic factor that limits the number of individuals in a population. A limiting factor also can affect other populations in the community indirectly. For example, a drought might reduce the number of seed-producing plants in a forest clearing. Fewer plants means that food can become a limiting factor for deer that eat the plants and for a songbird population that feeds on the seeds of these plants. Food also could become a limiting factor for animals that feed on the songbirds.

Reading Check *What is an example of a limiting factor?*

Competition is the struggle among organisms to obtain the same resources needed to survive and reproduce, as shown in **Figure 14.** As population density increases, so does competition among individuals for the resources in their environment.

Figure 13 These antelope and zebra populations live in the grasslands of Africa.
Infer *what limiting factors might affect the plant and animal populations shown here.*

Carrying Capacity Suppose a population increases in size year after year. At some point, food, nesting space, or other resources become so scarce that some individuals are not able to survive or reproduce. When this happens, the environment has reached its carrying capacity. Carrying capacity is the largest number of individuals of a species that an environment can support and maintain for a long period of time. If a population gets bigger than the carrying capacity of the environment, some individuals are left without adequate resources. They will die or be forced to move elsewhere.

Figure 14 During dry summers, the populations of animals at existing watering holes increase because some watering holes have dried up. This creates competition for water, a valuable resource.

Biotic Potential What would happen if a population's environment had no limiting factors? The size of the population would continue to increase. The maximum rate at which a population increases when plenty of food and water are available, the weather is ideal, and no diseases or enemies exist, is its biotic potential. Most populations never reach their biotic potential, or they do so for only a short period of time. Eventually, the carrying capacity of the environment is reached and the population stops increasing.

Symbiosis and Other Interactions

In ecosystems, many species of organisms have close relationships that are necessary for their survival. **Symbiosis** (sihm bee OH sus) is any close interaction between two or more different species. Symbiotic relationships can be identified by the type of interaction between organisms. Mutualism is a symbiotic relationship in which two different species of organisms cooperate and both benefit. **Figure 15** shows one example of mutualism.

Commensalism is a form of symbiosis that benefits one organism without affecting the other organism. For example, a species of flatworm benefits by living in the gills of horseshoe crabs, eating scraps of the horseshoe crab's meals. The horseshoe crab is unaffected by the flatworms.

Parasitism is a symbiotic relationship between two species in which one species benefits and the other species is harmed. Some species of mistletoe are parasites because their roots grow into a tree's tissue and take nutrients from the tree.

Reading Check *What form of symbiosis exists between a bee and a flower?*

Mini LAB

Observing Symbiosis

Procedure

1. Carefully wash and examine the roots of a **legume plant** and a **nonlegume plant.**
2. Use a **magnifying lens** to examine the roots of the legume plant.

Analysis

1. What differences do you observe in the roots of the two plants?
2. Bacteria and legume plants help one another thrive. What type of symbiotic relationship is this?

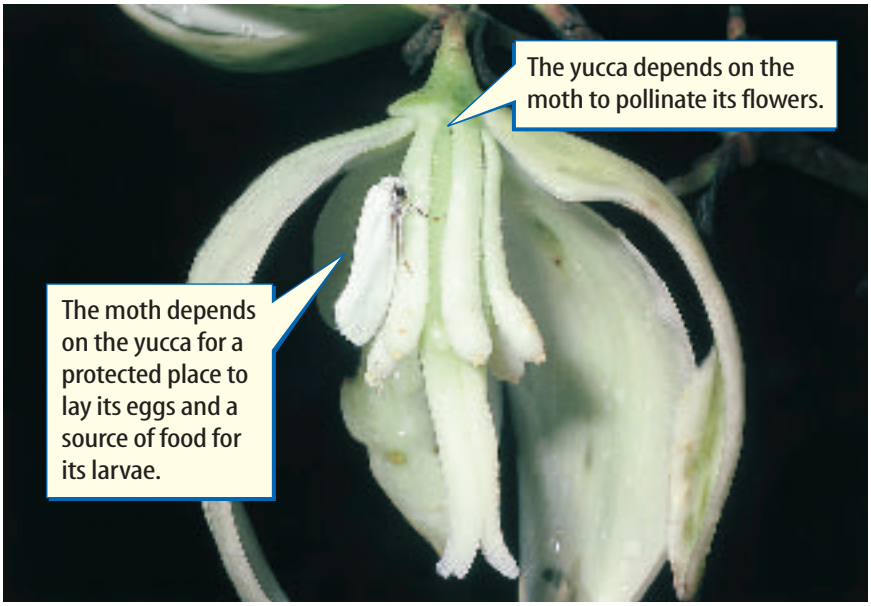

Figure 15 The partnership between the desert yucca plant and the yucca moth is an example of mutualism.

Predation One way that population size is regulated is by predation (prih DAY shun). Predation is the act of one organism hunting, killing, and feeding on another organism. Owls are predators of mice, as shown in **Figure 16.** Mice are their prey. Predators are biotic factors that limit the size of the prey population. Availability of prey is a biotic factor that can limit the size of the predator population. Because predators are more likely to capture old, ill, or young prey, the strongest individuals in the prey population are the ones that manage to reproduce. This improves the prey population over several generations.

Figure 16 Owls use their keen senses of sight and hearing to hunt for mice in the dark.

Habitats and Niches In a community, every species plays a particular role. For example, some are producers and some are consumers. Each also has a particular place to live. The role, or job, of an organism in the ecosystem is called its **niche** (NICH). What a species eats, how it gets its food, and how it interacts with other organisms are all parts of its niche. The place where an organism lives is called its **habitat.** For example, an earthworm's habitat is soil. An earthworm's niche includes loosening, aerating, and enriching the soil.

section 2 review

Summary

Characteristics of Populations

- Populations can be described by size, density, and spacing.
- Limiting factors affect population size.
- The number of individuals an environment can support and maintain over time is called the carrying capacity.
- The biotic potential is the rate a population would increase without limiting factors.

Symbiosis and Other Interactions

- A close interaction between two or more different species is called symbiosis.
- Mutualism, commensalism, and parasitism are types of symbiotic relationships that can exist between organisms.
- Predators are biotic limiting factors of prey.
- The role an organism plays is called its niche.

Self Check

1. **Determine** the population of students in your classroom.
2. **Describe** how limiting factors can affect a population.
3. **Explain** the difference between a habitat and a niche.
4. **Describe** and give an example of two symbiotic relationships that occur among populations in a community.
5. **Explain** how sound could be used to relate the size of the cricket population in one field to the cricket population in another field.
6. **Think Critically** A parasite obtains food from its host. Most parasites weaken but do not kill their hosts. Why?

Applying Math

7. **Solve One-Step Equations** A 15-m^2 wooded area has the following: 30 ferns, 150 grass plants, and 6 oak trees. What is the population density per m^2 of each of the above species?

section 3

Matter and Energy

Michael P. Gadomski/Photo Researchers

as you read

What You'll Learn

- **Explain** the difference between a food chain and a food web.
- **Describe** how energy flows through ecosystems.
- **Examine** how materials such as water, carbon, and nitrogen are used repeatedly.

Why It's Important

You are dependent upon the recycling of matter and the transfer of energy for survival.

Review Vocabulary

consumer: organism that obtains energy by eating other organisms

New Vocabulary

- food chain
- food web
- water cycle

Energy Flow Through Ecosystems

Life on Earth is not simply a collection of independent organisms. Even organisms that seem to spend most of their time alone interact with other members of their species. They also interact with members of other species. Most of the interactions among members of different species occur when one organism feeds on another. Food contains nutrients and energy needed for survival. When one organism is food for another organism, some of the energy in the first organism (the food) is transferred to the second organism (the eater).

Producers are organisms that take in and use energy from the Sun or some other source to produce food. Some use the Sun's energy for photosynthesis to produce carbohydrates. For example, plants, algae, and some one-celled, photosynthetic organisms are producers. Consumers are organisms that take in energy when they feed on producers or other consumers. The transfer of energy does not end there. When organisms die, other organisms called decomposers, as shown in **Figure 17,** take in energy as they break down the remains of organisms. This movement of energy through a community can be diagrammed as a food chain or a food web.

Food Chains

A **food chain,** as shown in **Figure 18,** is a model, a simple way of showing how energy, in the form of food, passes from one organism to another. When drawing a food chain, arrows between organisms indicate the direction of energy transfer. An example of a pond food chain follows.

aquatic plants → insects → bluegill → bass → humans

Food chains usually have only three or four links. This is because the available energy decreases from one link to the next link. At each transfer of energy, a portion of the energy is lost as heat due to the activities of the organisms. In a food chain, the amount of energy left for the last link is only a small portion of the energy in the first link.

Figure 17 These mushrooms are decomposers. They obtain needed energy for life when they break down organic material.

NATIONAL GEOGRAPHIC

VISUALIZING A FOOD CHAIN

Figure 18

In nature, energy in food passes from one organism to another in a sequence known as a food chain. All living things are linked in food chains, and there are millions of different chains in the world. Each chain is made up of organisms in a community. The photographs here show a food chain in a North American meadow community.

E The last link in many food chains is a top carnivore, an animal that feeds on other animals, including other carnivores. This great horned owl is a top carnivore.

D The fourth link of this food chain is a garter snake, which feeds on toads.

A The first link in any food chain is a producer—in this case, grass. Grass gets its energy from sunlight.

B The second link of a food chain is usually an herbivore like this grasshopper. Herbivores are animals that feed only on producers.

C The third link of this food chain is a carnivore, an animal that feeds on other animals. This woodhouse toad feeds on grasshoppers.

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Food Webs Food chains are too simple to describe the many interactions among organisms in an ecosystem. A **food web** is a series of overlapping food chains that exist in an ecosystem. A food web provides a more complete model of the way energy moves through an ecosystem. They also are more accurate models because food webs show how many organisms, including humans, are part of more than one food chain in an ecosystem.

Humans are a part of many land and aquatic food webs. Most people eat foods from several different levels of a food chain. Every time you eat a hamburger, an apple, or other food, you have become a link in a food web. Can you picture the steps in the food web that led to the food in your lunch?

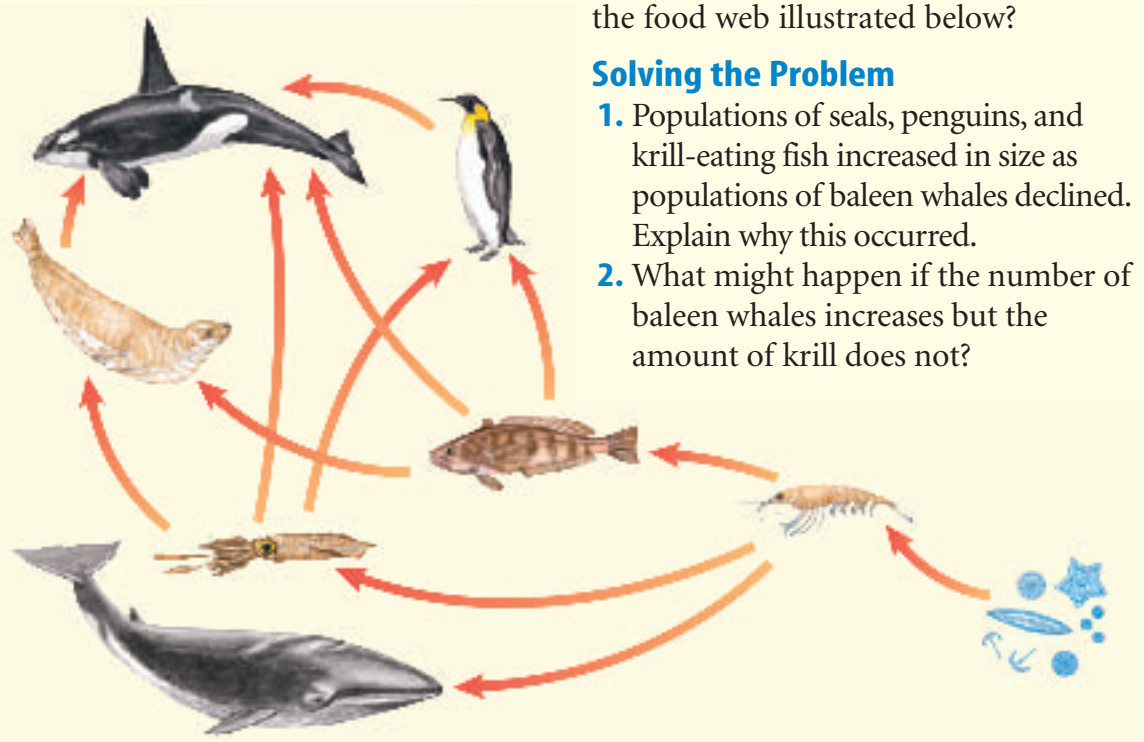
Applying Science

How do changes in Antarctic food webs affect populations?

The food webs in the icy Antarctic Ocean are based on phytoplankton, which are microscopic algae that float near the water's surface. The algae are eaten by tiny, shrimplike krill, which are consumed by baleen whales, squid, and fish. Toothed whales, seals, and penguins eat the fish and squid. How would changes in any of these populations affect the other populations?

Identifying the Problem

Worldwide, the hunting of most baleen whales has been illegal since 1986. It is hoped that the baleen whale population will increase. How will an increase in the whale population affect the food web illustrated below?



Solving the Problem

1. Populations of seals, penguins, and krill-eating fish increased in size as populations of baleen whales declined. Explain why this occurred.
2. What might happen if the number of baleen whales increases but the amount of krill does not?

CLICK HERE

Ecological Pyramids Most of the energy in the biosphere comes from the Sun. Producers take in and transform only a small part of the energy that reaches Earth's surface. When an herbivore eats a plant, some of the energy in the plant passes to the herbivore. However, most of it is given off into the atmosphere as heat. The same thing happens when a carnivore eats an herbivore. An ecological pyramid models the number of organisms at each level of a food chain. The bottom of an ecological pyramid represents the producers of an ecosystem. The rest of the levels represent successive consumers.

Reading Check *What is an ecological pyramid?*

Energy Pyramid The flow of energy from grass to the hawk in **Figure 19** can be illustrated by an energy pyramid. An energy pyramid compares the energy available at each level of the food chain in an ecosystem. Just as most food chains have three or four links, a pyramid of energy usually has three or four levels. Only about ten percent of the energy at each level of the pyramid is available to the next level. By the time the top level is reached, the amount of energy available is greatly reduced.

INTEGRATE Chemistry

Chemosynthesis Certain bacteria take in energy through a process called chemosynthesis. In chemosynthesis, the bacteria produce food using the energy in chemical compounds instead of light energy. In your Science Journal, predict where these bacteria are found.

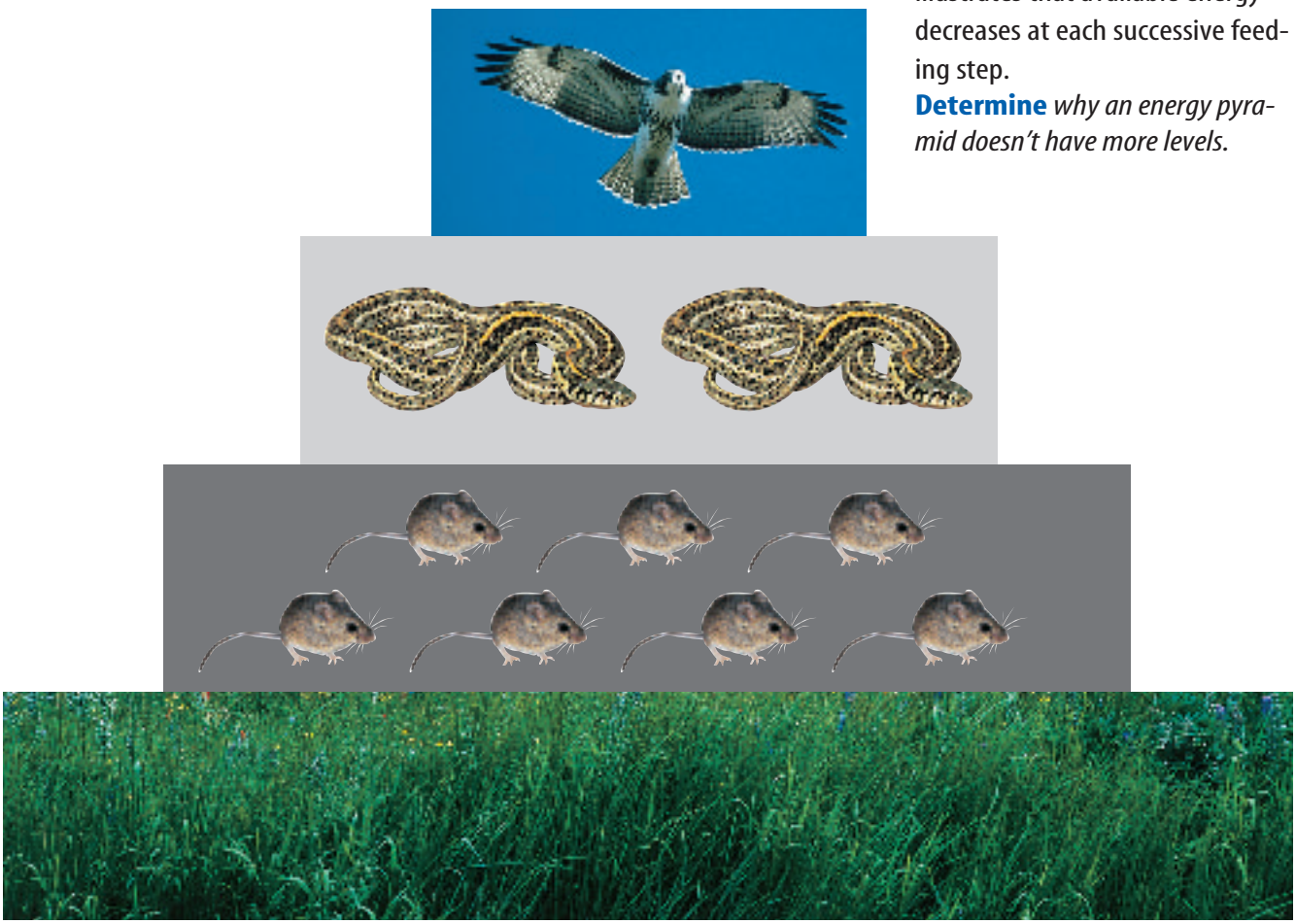


Figure 19 An energy pyramid illustrates that available energy decreases at each successive feeding step.
Determine *why an energy pyramid doesn't have more levels.*

Mini LAB

Modeling the Water Cycle

Procedure

1. With a **marker,** make a line halfway up on a **plastic cup.** Fill the cup to the mark with water.
2. Cover the top with **plastic wrap** and secure it with a **rubber band or tape.**
3. Put the cup in direct sunlight. Observe the cup for three days. Record your observations.
4. Remove the plastic wrap and observe the cup for seven more days.

Analysis

1. What parts of the water cycle did you observe during this activity?
2. How did the water level in the cup change after the plastic wrap was removed?

Try at Home

The Cycles of Matter

The energy available as food is constantly renewed by plants using sunlight. However, think about the matter that makes up the bodies of living organisms. The law of conservation of mass states that matter on Earth is never lost or gained. It is used over and over again. In other words, it is recycled. The carbon atoms in your body might have been on Earth since the planet formed billions of years ago. They have been recycled billions of times. Many important materials that make up your body cycle through the environment. Some of these materials are water, carbon, and nitrogen.

INTEGRATE Chemistry

Water Cycle Water molecules on Earth constantly rise into the atmosphere, fall to Earth, and soak into the ground or flow into rivers and oceans. The **water cycle** involves the processes of evaporation, condensation, and precipitation.

Heat from the Sun causes water on Earth's surface to evaporate, or change from a liquid to a gas, and rise into the atmosphere as water vapor. As the water vapor rises, it encounters colder and colder air and the molecules of water vapor slow down. Eventually, the water vapor changes back into tiny droplets of water. It condenses, or changes from a gas to a liquid. These water droplets clump together to form clouds. When the droplets become large and heavy enough, they fall back to Earth as rain or other precipitation. This process is illustrated in **Figure 20.**

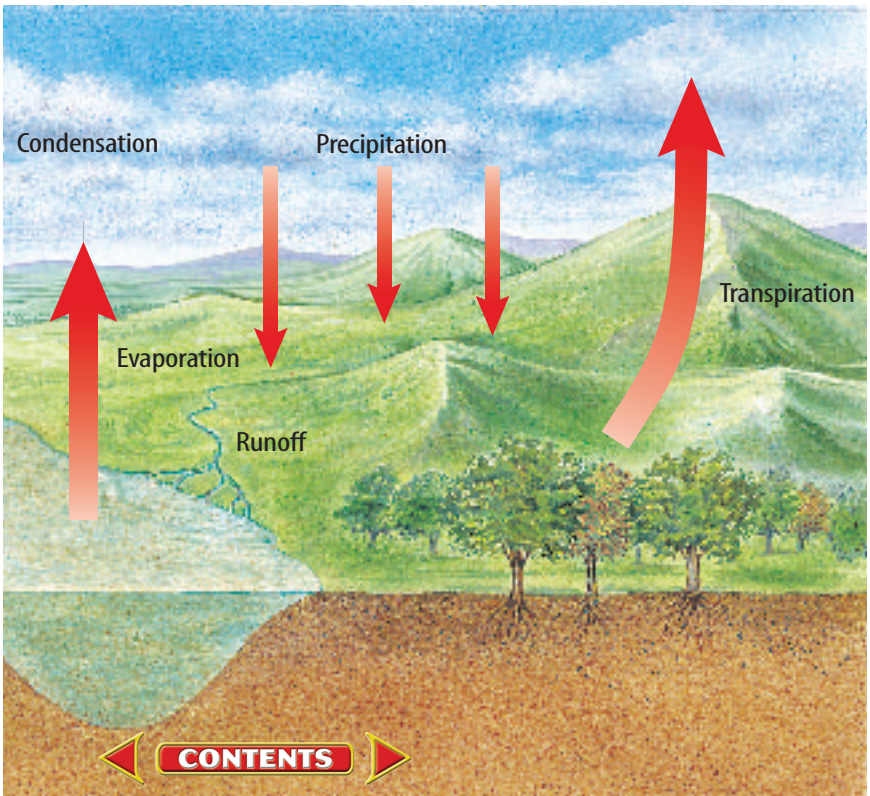


Figure 20 A water molecule that falls as rain can follow several paths through the water cycle. **Identify** *these paths in this diagram.*

Other Cycles in Nature You and all organisms contain carbon. Earth's atmosphere contains about 0.03 percent carbon in the form of carbon dioxide gas. The movement of carbon through Earth's biosphere is called the carbon cycle, as shown in **Figure 21.**

Nitrogen is an element found in proteins and nucleic acids. The nitrogen cycle begins with the transfer of nitrogen from the atmosphere to producers then to consumers. The nitrogen then moves back to the atmosphere or directly into producers again.

Phosphorus, sulfur, and other elements needed by living organisms also are used and returned to the environment. Just as you recycle aluminum, glass, and paper products, the matter that organisms need to live is recycled continuously in the biosphere.

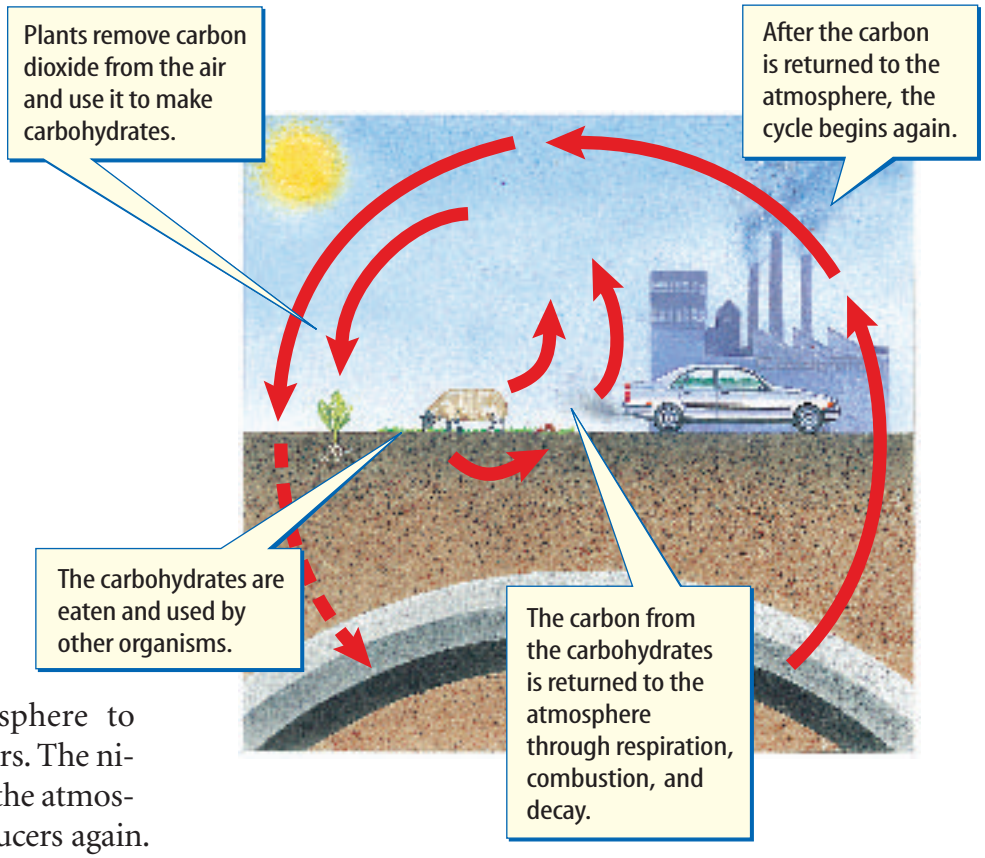


Figure 21 Carbon can follow several different paths through the carbon cycle. Some carbon is stored in Earth's biomass.

section 3 review

Summary

Energy Flow Through Ecosystems

- A food chain models one pathway of energy through an ecosystem, and a food web is made of many food chains.
- Humans are part of different food webs.
- Ecological pyramids model the number of organisms at each level of a food chain.
- Energy pyramids illustrate the available energy at each level of a food chain.

The Cycles of Matter

- Energy is constantly renewed by the Sun, but matter must be recycled.
- The water cycle involves evaporation, condensation, and precipitation.
- Other matter that cycles includes carbon, nitrogen, phosphorus, and sulfur.

Self Check

1. **Draw and label** a food web that includes you and what you've eaten today.
2. **Compare and contrast** producers, consumers, and decomposers.
3. **Explain** how carbon flows through ecosystems.
4. **Think Critically** Use your knowledge of food chains and the energy pyramid to explain why fewer lions than gazelles live on the African plains.

Applying Skills

5. **Classify** Look at the food chain in **Figure 18.** Classify each organism as a producer or a consumer.
6. **Communicate** In your Science Journal, write a short essay about how the water cycle, carbon cycle, and nitrogen cycle are important to living organisms.

LAB

Design Your Own

Identifying a Limiting Factor

Goals

- **Observe** the effects of an abiotic factor on the germination and growth of bean seedlings.
- **Design** an experiment that demonstrates whether or not a specific abiotic factor limits the germination of bean seeds.

Possible Materials

bean seeds
small planting containers
soil
water
label
trowel
**spoon*
aluminum foil
sunny window
**other light source*
refrigerator or oven
**Alternate materials*

Safety Precautions

Real-World Question

Organisms depend upon many biotic and abiotic factors in their environment to survive. When these factors are limited or are not available, it can affect an organism's survival. How do abiotic factors such as light, water, and temperature affect the germination of seeds?

Form a Hypothesis

Based on what you have learned about limiting factors, make a hypothesis about how one specific abiotic factor might affect the germination of a bean seed. Be sure to consider factors that you can change easily.

Test Your Hypothesis

Make a Plan

1. As a group, agree upon and write out a hypothesis statement.
2. **Decide** on a way to test your group's hypothesis. Keep available materials in mind as you plan your procedure. List your materials.
3. **Design** a data table in your Science Journal for recording data.
4. Remember to test only one variable at a time and use suitable controls.

CONTENTS

5. Read over your entire experiment to make sure that all steps are in logical order.
6. **Identify** any constants, variables, and controls in your experiment.
7. Be sure the factor that you will test is measurable.

Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. Carry out your approved plan.
3. While the experiment is going on, record any observations that you make and complete the data table in your Science Journal.

Analyze Your Data

1. **Compare** the results of this experiment with those of other groups in your class.
2. **Infer** how the abiotic factor you tested affected the germination of bean seeds.
3. **Graph** your results in a bar graph that compares the number of bean seeds that germinated in the experimental container with the number of seeds that germinated in the control container.

Conclude and Apply

1. **Identify** which factor had the greatest effect on the germination of the seeds.
2. **Determine** whether or not you could change more than one factor in this experiment and still have germination of seeds.

Communicating Your Data

Write a set of instructions that could be included on a packet of this type of seeds. Describe the best conditions for seed germination.

The Solace of Open Spaces

a novel by Gretel Ehrlich

Animals give us their constant, unjaded[1] faces and we burden them with our bodies and civilized ordeals. We're both humbled by and imperious[2] with them. We're comrades who save each other's lives. The horse we pulled from a boghole this morning bucked someone off later in the day; one stock dog refuses to work sheep, while another brings back a calf we had overlooked. . . . What's stubborn, secretive, dumb, and keen[3] in us bumps up against those same qualities in them. . . .

Living with animals makes us redefine our ideas about intelligence. Horses are as mischievous as they are dependable. Stupid enough to let us use them, they are cunning enough to catch us off guard. . . .

We pay for their loyalty; They can be willful, hard to catch, dangerous to shoe and buck on frosty mornings. In turn, they'll work themselves into a lather cutting cows, not for the praise they'll get but for the simple glory of outdodging a calf or catching up with an errant steer. . . .

1 *Jaded* means "to be weary with fatigue," so *unjaded* means "not to be weary with fatigue."

2 domineering or overbearing

3 intellectually smart or sharp

Understanding Literature

Informative Writing This passage is informative because it describes the real relationship between people and animals on a ranch in Wyoming. The author speaks from her own point of view, not from the point of view of a disinterested party. How might this story have been different if it had been told from the point of view of a visiting journalist?

Respond to the Reading

1. Describe the relationship between people and animals in this passage.
2. What words does the author use to indicate that horses are intelligent?
3. **Linking Science and Writing** Write a short passage about an experience you have had with a pet. Put yourself in the passage without overusing the word "I".

INTEGRATE Life Science

Animals and ranchers are clearly dependent on each other. Ranchers provide nutrition and shelter for animals on the ranch and, in turn, animals provide food, companionship, and perform work for the ranchers. You might consider the relationship between horses and ranchers to be a symbiotic one. Symbiosis (sihm bee OH sus) is any close interaction among two or more different species.

Allen Russell/Index Stock

CONTENTS

Reviewing Main Ideas

Section 1 The Environment

1. Ecology is the study of interactions among organisms and their environment.
2. The nonliving features of the environment are abiotic factors, and the organisms in the environment are biotic factors.
3. Ecosystems include biotic and abiotic factors.
4. The region of Earth and its atmosphere in which all organisms live is the biosphere.

Section 2 Interactions Among Living Organisms

1. Characteristics that can describe populations include size, spacing, and density.
2. Any biotic or abiotic factor that limits the number of individuals in a population is a limiting factor.
3. A close relationship between two or more species is a symbiotic relationship.
4. The place where an organism lives is its habitat, and its role in the environment is its niche.

Section 3 Matter and Energy

1. Food chains and food webs are models that describe the flow of energy.
2. At each level of a food chain, organisms lose energy as heat. Energy on Earth is renewed constantly by sunlight.
3. Matter on Earth is never lost or gained. It is used over and over again, or recycled.

Visualizing Main Ideas

Copy and complete the following concept map on the biosphere.

chapter 18 Review

Using Vocabulary

abiotic factor p. 532
biosphere p. 537
biotic factor p. 532
community p. 536
ecology p. 532
ecosystem p. 536
food chain p. 544
food web p. 546
habitat p. 543
limiting factor p. 541
niche p. 543
population p. 536
population density p. 540
symbiosis p. 542
water cycle p. 548

Fill in the blanks with the correct vocabulary word or words.

1. A(n) _____ is any living thing in the environment.
2. A series of overlapping food chains makes up a(n) _____.
3. The size of a population that occupies an area of definite size is its _____.
4. Where an organism lives in an ecosystem is its _____.
5. The part of Earth that supports life is the _____.
6. Any close relationship between two or more species is _____.

Checking Concepts

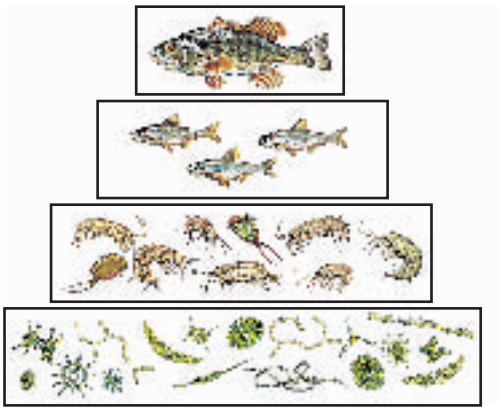
Choose the word or phrase that best answers the question.

7. Which of the following is a model that shows the amount of energy available as it flows through an ecosystem?
   A) niche
   B) energy pyramid
   C) carrying capacity
   D) food chain
8. Which of the following is a biotic factor?
   A) animals **C)** sunlight
   B) air **D)** soil
9. What is made up of all populations in an area?
   A) niche **C)** community
   B) habitat **D)** ecosystem
10. What is the term for the total number of individuals in a population occupying a certain area?
    A) clumping **C)** spacing
    B) size **D)** density
11. What is the tree to the right an example of?
    A) prey
    B) consumer
    C) producer
    D) predator

12. Which level of the food chain has the most energy?
    A) consumer **C)** decomposers
    B) herbivores **D)** producers
13. What is the symbitotc relationship called in which one organism is helped and the other organism is harmed?
    A) mutualism
    B) parasitism
    C) commensalism
    D) consumer
14. Which of the following is NOT cycled in the biosphere?
    A) nitrogen **C)** water
    B) soil **D)** carbon
15. What are coral reefs, forests, and ponds examples of?
    A) niches **C)** populations
    B) habitats **D)** ecosystems
16. What are all of the individuals of one species that live in the same area at the same time called?
    A) community **C)** biosphere
    B) population **D)** organism

Thinking Critically

Use the illustration below to answer question 17.



17. **Infer** why each level of the energy pyramid shown above is smaller than the one below it.

18. **Compare and contrast** the role of producers, consumers, and decomposers in an ecosystem.

19. **Explain** what carrying capacity has to do with whether or not a population reaches its biotic potential.

20. **Infer** why decomposers are vital to the cycling of matter in an ecosystem.

21. **Write** a paragraph that describes your own habitat and niche.

22. **Classify** the following as the result of either evaporation or condensation.
    - **a.** A puddle disappears after a rainstorm.
    - **b.** Rain falls.
    - **c.** A lake becomes shallower.
    - **d.** Clouds form.

23. **Concept Map** Use the following information to draw a food web of organisms living in a goldenrod field. *Aphids eat goldenrod sap, bees eat goldenrod nectar, beetles eat goldenrod pollen and goldenrod leaves, stinkbugs eat beetles, spiders eat aphids,* and *assassin bugs eat bees.*

24. **Record Observations** A home aquarium contains water, an air pump, a light, algae, a goldfish, and algae-eating snails. What are the abiotic factors in this environment?

25. **Determine** why viruses are considered parasites.

Performance Activities

26. **Poster** Use your own observations or the results of library research to develop a food web for a nearby park, pond, or other ecosystem. Make a poster display illustrating the food web.

27. **Oral Presentation** Research the steps in the phosphorous cycle. Find out what role phosphorus plays in the growth of algae in ponds and lakes. Present your findings to the class.

Applying Math

Use the table below to answer questions 28 and 29.

Arizona Deer Population

Year	Deer Per 400 Hectares
1905	5.7
1915	35.7
1920	142.9
1925	85.7
1935	25.7

28. **Deer Population** Use the data above to graph the population density of a deer population over the years. Plot the number of deer on the *y*-axis and years on the *x*-axis. Predict what might have happened to cause the changes in the size of the population.

29. **Population Trend** What might the population of deer be in 1940 if the trend continued?

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. Many of the processes necessary for life can only occur in the presence of water. Which of the following is not one of these necessary life processes?

A. photosynthesis **C.** digestion
B. respiration **D.** dehydration

Use the illustration below to answer questions 2 and 3.

2. Little light reaches the plants on the floor of this deciduous forest. Which season would let the bluebells pictured grow the best?

A. spring **C.** fall
B. summer **D.** winter

3. What process do these bluebells use to transform energy from the Sun into stored chemical energy for their life processes?

A. respiration **C.** photosynthesis
B. radiation **D.** desertification

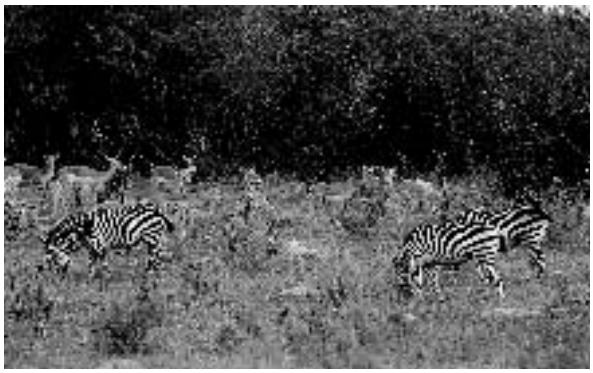
4. Soil that receives little rain can be changed and a desert can form. What is this process known as?

A. pollution **C.** desertification
B. radiation **D.** respiration

5. Which of the following is NOT considered when determining soil type?

A. amount of clay **C.** amount of sand
B. amount of silt **D.** amount of plant

Use the illustration below to answer questions 6 and 7.



6. Antelope and zebras interacting is an example of a(n)

A. community. **C.** ecosystem.
B. population. **D.** biome.

7. These two groups both eat plants, biotic factors that help determine the number of individuals that will survive in that area. This is known as a

A. carrying capacity.
B. limiting factor.
C. biotic potential.
D. population spacing.

8. The maximum rate at which a population increases when plenty of food and water are available is known as

A. carrying capacity.
B. limiting factor.
C. biotic potential.
D. population density.

9. A close interaction between two or more different species is known as

A. symbiosis. **C.** commensalism.
B. mutualism. **D.** botulism.

10. The job of an organism in the ecosystem is called its

A. habitat. **C.** niche.
B. ecosystem. **D.** community.

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Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

11. How do producers and consumers interact?

12. Give an example of an abiotic factor and explain how living organisms interact with it.

13. What is a limiting factor? Give a non-living limiting factor and show how it affects living organisms.

14. What is symbiosis? Name three types of symbiosis.

Use the illustration below to answer questions 15 and 16.

15. What is competition and how does it relate to population density? Use the illustration above as an example of competition. Explain the environment and how it impacts their survival.

16. Use the illustration to explain populations and communities.

17. What is biotic potential and how does it relate to limiting factors?

18. How is population size controlled by predators? Use the owl/mouse relationship as an example.

Part 3 Open Ended

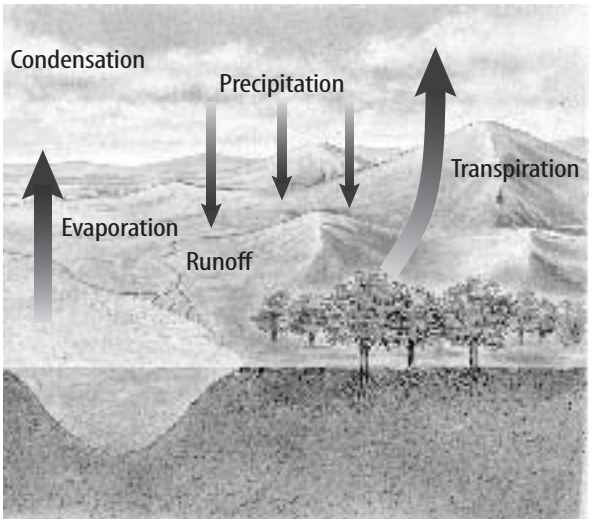
Record your answers on a sheet of paper.

19. How do humans interact with land and water food webs? What would happen to humans if these webs were destroyed?

20. Describe the carbon cycle.

21. Describe how better food production, sanitation, and disease prevention have contributed to the yearly increase in the human population.

Use the illustration below to answer questions 22 and 23.



22. Name the process shown in the illustration above.

23. Explain why this process is necessary for living organisms.

Test-Taking Tip

Answer All Parts of the Question Make sure each part of the question is answered when listing discussion points. For example, if the question asks you to compare and contrast, make sure you list both similarities and differences.

Question 21 Notice that this question asks you to describe how three things contribute to human population growth.