Chapter 10 Ecosystems

CALIFORNIA Standards Preview

S 6.2 Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:

d. Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

S 6.5 Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept:

a. Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs.

b. Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.

c. Students know populations of organisms can be categorized by the functions they serve in an ecosystem.

e. Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

This population of monarch butterflies is made up of thousands of individual butterflies. ▶

Video Preview
Discovery Channel School
Populations and Communities

Focus on the
BIG Idea

S 6.5.c.

What relationships exist between living things and the environment?

Check What You Know

A tidepool at the seashore is home to a small community of organisms. In the shallow, salty water of the tidepool is seaweed called kelp. The kelp requires sunlight to grow. The tidepool also contains small crabs that eat kelp, and an octopus that eats crabs. What is the source of energy for this community? What would happen to the octopus if the kelp were removed from the tidepool? Explain.

©

Build Science Vocabulary

The images shown here represent some of the key terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some key terms in this chapter.

Vocabulary Skill

Identify Related Word Forms

You can increase your vocabulary by learning related forms of a word. If you know that the verb *collect* means "to gather together," then you can figure out the meaning of the noun *collection* and the adjective *collective*.

Example Students will *collect* (verb) cans and take the *collection* (noun) to a recycling center.

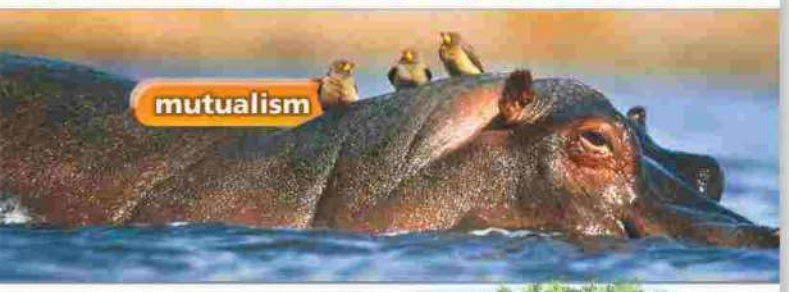
Verb	Noun	Adjective
inhabit To live in	**habitat** The place where an organism lives	**habitable** Fit to be lived in
limit To keep within or below a certain amount	**limit** An amount that is within or below a certain level or number	**limited** Kept within a certain amount
prey To hunt or kill for food	**predator** An organism that hunts or kills	**predatory** Living by hunting or killing
produce To make one's own food	**producer** An organism that can make its own food	**productive** Capable of making its own food

Apply It!

Review the words related to *prey*. Complete the following sentences with the correct form of the word.

1. Owls _____ on mice, moles, and rabbits.
2. How could a rabbit avoid being killed by a _____?
3. Eagles, hawks, and owls are _____ animals.

Chapter 10 Vocabulary



Section 1 (page 392)

organism
habitat
biotic factor
abiotic factor
photosynthesis
species
population
community
ecosystem
ecology

Section 2 (page 399)

birth rate
death rate
immigration
emigration
limiting factor
carrying capacity

Section 3 (page 404)

producer
consumer
herbivore
carnivore
omnivore
scavenger
decomposer
food chain
food web
energy pyramid

Section 4 (page 410)

natural selection
adaptations
niche
competition
predation
predator
prey
symbiosis
mutualism
commensalism
parasitism
parasite
host

Section 5 (page 417)

nitrogen fixation

Section 6 (page 422)

succession
primary succession
pioneer species
secondary succession

Interactive Textbook

Build Science Vocabulary *Online*

Use interactive flashcards

How to Read Science

Reading Skill

Sequence

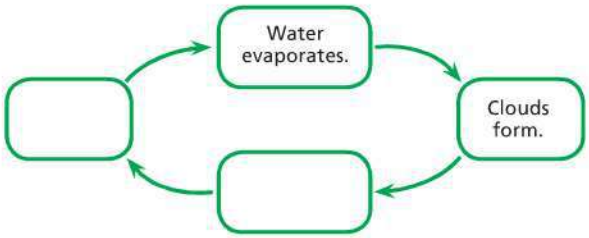
Sequence is the order in which a series of events occurs. In Chapter 3, you used a flowchart to show events in a process that has a beginning and an end. Sequence can also be a continuous process, or cycle, that does not have an end. The paragraph below shows a continuous sequence. As you read, look for signal words, such as *first*, *next*, and *then*, that indicate sequence.

The Water Cycle

The water cycle is a continuous process by which water moves from Earth's surface to the atmosphere and back. First, water evaporates from oceans, rivers and lakes. Next, water vapor in the atmosphere condenses, forming clouds. Then, water returns to Earth's surface as precipitation—rain or snow. Finally, streams flow back to the ocean.

Use a cycle diagram like this one to help you understand the text. In your notebook, write the first event in the circle at the top of the page. Then write each event in sequence, moving clockwise.

The Water Cycle



Apply It!

Review the water cycle diagram above.

1. Why is a cycle diagram a good way to explain what happens to water on Earth?
2. Fill in the sequence of the next two events in the water cycle.

After you read Section 5, prepare a cycle diagram showing the carbon cycle.

©

Lab zone

Standards Investigation

S 6.5.c, 6.7.c

What's a Crowd?

In this chapter, you will explore how living things obtain the things they need from their surroundings. You will also learn how living things interact with the living and nonliving things around them. As you work on this investigation, you will observe interactions among growing plants.

Your Goal

To design and conduct an experiment to determine the effect of crowding on plant growth

To complete this investigation, you must

- develop a planting plan
- develop a hypothesis relating the growth of plants in a container to the number of plants
- observe and collect data on the growing plants
- present your results in a written report and a graph
- follow the safety guidelines in Appendix A

Plan It!

With your group, brainstorm ideas for your plan. What conditions do plants need to grow? How will you arrange your seeds in their containers? What types of measurements will you make when the plants begin to grow? Submit your draft plan to your teacher. When your teacher has approved your plan, plant your seeds. Then collect and analyze the growth data and present your results.

Section 1

Living Things and the Environment

California Standards Focus

S 6.5.e Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

- What needs are met by an organism's environment?
- What are the two parts of an organism's habitat with which it interacts?
- What are the levels of organization within an ecosystem?

Key Terms

- organism
- habitat
- biotic factor
- abiotic factor
- photosynthesis
- species
- population
- community
- ecosystem
- ecology

Lab zone Standards Warm-Up

What Does It Depend On?

1. Choose a magazine picture of a nature scene. Paste the picture onto a sheet of paper, leaving space all around the picture.
2. Locate everything in the picture that is alive. Use a colored pencil to draw a line from each living thing. If you know its name, write it on the line.
3. Using a different colored pencil, label each nonliving thing.

Think It Over

Inferring How do the living things in the picture depend on the nonliving things? Using a third color, draw lines connecting the living things to the nonliving things they need.

As the sun rises on a warm summer morning, the Nebraska town is already bustling with activity. Some residents are hard at work building homes for their families. They are working underground, where it is dark and cool. Other inhabitants are collecting seeds for breakfast. Some of the town's younger residents are at play, chasing each other through the grass.

Suddenly, an adult spots a threatening shadow—an enemy has appeared in the sky! The adult cries out several times, warning the others. Within moments, the town's residents disappear into their underground homes. The town is silent and still, except for a single hawk circling overhead.

Have you guessed what kind of town this is? It is a prairie dog town on the Nebraska plains. As these prairie dogs dug their burrows, searched for food, and hid from the hawk, they interacted with their environment, or surroundings.

Black-Tailed Prairie Dog

FIGURE 1
Red-Tailed Hawk
This red-tailed hawk obtains food, water, and shelter from its habitat. Prairie dogs are a major source of food for red-tailed hawks.

Habitats

A prairie dog is one type of **organism,** or living thing. Different types of organisms must live in different types of environments. **An organism obtains food, water, shelter, and other things it needs to live, grow, and reproduce from its environment.** An environment that provides the things the organism needs to live, grow, and reproduce is called its **habitat.**

One area may contain many habitats. For example, in a forest, mushrooms grow in the damp soil, salamanders live on the forest floor, and woodpeckers build nests in tree trunks.

Organisms live in different habitats because they have different requirements for survival. A prairie dog obtains the food and shelter it needs from its habitat. It could not survive in a tropical rain forest or on the rocky ocean shore. Likewise, the prairie would not meet the needs of a spider monkey or hermit crab.

Reading Checkpoint **Why do different organisms live in different habitats?**

Biotic Factors

To meet its needs, a prairie dog must interact with more than just the other prairie dogs around it. **An organism interacts with both the living and nonliving parts of its habitat.** The living parts of a habitat are called **biotic factors** (by AHT ik). Biotic factors in the prairie dogs' habitat include the grass and plants that provide seeds and berries. The hawks, ferrets, badgers, and eagles that hunt the prairie dogs are also biotic factors. In addition, worms, fungi, and bacteria are biotic factors that live in the soil underneath the prairie grass.

Reading Checkpoint **Name a biotic factor in your environment.**

Lab zone **Try This Activity**

Observing a Habitat

1. With your teacher's permission, visit an area such as a schoolyard or park that contains habitats for a variety of organisms.
2. Select appropriate tools, such as binoculars or a hand lens. Use them to observe a particular organism and the biotic factors in its habitat.
3. Record your observations. To display your data, make a poster showing your organism and the biotic factors you identified.

Predicting How do you think the organism interacts with the habitat's biotic factors?

FIGURE 2
Abiotic Factors
The nonliving things in an organism's habitat are abiotic factors. **Applying Concepts** *Name three abiotic factors you interact with each day.*

▲ This orangutan is enjoying a drink of water.

▲ Sunlight enables this plant to make its own food.

▲ This banjo frog burrows in the soil to stay cool.

Abiotic Factors

Abiotic factors (ay by AHT ik) are the nonliving parts of an organism's habitat. They include water, sunlight, oxygen, temperature, and soil.

Water All living things require water to carry out their life processes. Water also makes up a large part of the bodies of most organisms. Your body, for example, is about 65 percent water. Plants and algae need water, along with sunlight and carbon dioxide, to make their own food in a process called **photosynthesis** (foh toh SIN thuh sis). Other living things depend on plants and algae for food.

Sunlight Because sunlight is needed for photosynthesis, it is an important abiotic factor for most living things. In places that do not receive sunlight, such as dark caves, plants and algae cannot grow. Because there are no plants or algae to provide food, few other organisms can live in such places.

Oxygen Most living things require oxygen to carry out their life processes. Oxygen is so important to the functioning of the human body that you can live only a few minutes without it. Organisms that live on land obtain oxygen from air, which is about 20 percent oxygen. Fish and other water organisms obtain oxygen that is dissolved in the water around them.

Temperature The typical range of temperatures in an area determines the types of organisms that can live there. For example, if you took a trip to a warm tropical island, you might see colorful orchid flowers and tiny lizards. These organisms could not survive on the frozen plains of Siberia.

Some animals alter their environments so they can survive very hot or very cold temperatures. Prairie dogs, for example, dig underground dens to find shelter from the hot summer sun and cold winter winds.

Soil Soil is a mixture of rock fragments, nutrients, air, water, and the decaying remains of living things. Soil in different areas consists of varying amounts of these materials. The composition of soil in an area influences the kinds of plants that can grow there. Many animals, such as the prairie dogs, use the soil itself as a home. Billions of microscopic organisms such as bacteria also live in the soil.

Reading Checkpoint **How do abiotic factors differ from biotic factors?**

Levels of Organization

Of course, organisms do not live all alone in their habitat. Instead, organisms live together in populations and communities, and with abiotic factors in their ecosystems.

Populations In 1900, travelers saw a prairie dog town in Texas that covered an area twice the size of the city of Dallas. The town contained more than 400 million prairie dogs! These prairie dogs were all members of one species, or single kind, of organism. A **species** (SPEE sheez) is a group of organisms that are physically similar and can mate with each other and produce offspring that can also mate and reproduce.

All the members of one species in a particular area are referred to as a **population.** The 400 million prairie dogs in the Texas town are one example of a population. All the pigeons in New York City make up a population, as do all the bees that live in a hive. In contrast, all the trees in a forest do not make up a population, because they do not all belong to the same species. There may be pines, maples, birches, and many other tree species in the forest.

Communities A particular area usually contains more than one species of organism. The prairie, for instance, includes prairie dogs, hawks, grasses, badgers, and snakes, along with many other organisms. All the different populations that live together in an area make up a **community.**

To be considered a community, the different populations must live close enough together to interact. One way the populations in a community may interact is by using the same resources, such as food and shelter. For example, the tunnels dug by prairie dogs also serve as homes for burrowing owls and black-footed ferrets. The prairie dogs share the grass with other animals. Meanwhile, prairie dogs themselves serve as food for many species.

Lab zone **Try This Activity**

With or Without Salt?

In this activity you will explore salt as an abiotic factor.

1. Label four 600-mL beakers A, B, C, and D. Fill each with 500 mL of room-temperature spring water.
2. Set beaker A aside. Add 2.5 grams of noniodized salt to beaker B, 7.5 grams of salt to beaker C, and 15 grams of salt to beaker D. Stir each beaker.
3. Add $\frac{1}{8}$ spoonful of brine shrimp eggs to each beaker.
4. Cover each beaker with a square of paper. Keep them away from direct light or heat. Wash your hands.
5. Observe the beakers daily for three days.

Drawing Conclusions In which beakers did the eggs hatch? What can you conclude about the amount of salt in the shrimps' natural habitat?

FIGURE 3
A Population
All these zebras make up a population.

Go Online
SCILINKS NSTA
For: Links on biotic and abiotic factors
Visit: www.SciLinks.org
Web Code: scn-0511

Ecosystems The community of organisms that live in a particular area, along with their nonliving surroundings, make up an **ecosystem.** A prairie is just one of the many different ecosystems found on Earth. Other ecosystems in which living things make their homes include mountain streams, deep oceans, and evergreen forests.

Figure 4 shows the levels of organization in an ecosystem. **The smallest level of organization is a single organism, which belongs to a population that includes other members of its species. The population belongs to a community of different species. The community and abiotic factors together form an ecosystem.**

Because the populations in an ecosystem interact with one another, any change affects all the different populations that live there. The study of how living things interact with each other and with their environment is called **ecology.** Ecologists are scientists who study ecology. As part of their work, ecologists study how organisms react to changes in their environment. An ecologist, for example, may look at how a fire affects a prairie ecosystem.

Reading Checkpoint **What is ecology?**

Section 1 Assessment

S 6.5.e; E-LA: Writing 6.2.0

Vocabulary Skill Use Related Words
Complete the sentence by using the correct form of *habitat* or *inhabit.* An organism must live in a _____ that meets its needs for survival.

Reviewing Key Concepts

HINT **1. a. Listing** What basic needs are provided by an organism's habitat?

HINT **b. Predicting** What might happen to an organism if its habitat could not meet one of its needs?

HINT **2. a. Defining** Define the terms *biotic factors* and *abiotic factors.*

HINT **b. Interpreting Illustrations** List all the biotic and abiotic factors in Figure 4.

HINT **c. Making Generalizations** Explain why water and sunlight are two abiotic factors that are important to most organisms.

HINT **3. a. Sequencing** List these terms in order from the smallest level to the largest: *population, organism, ecosystem, community.*

HINT **b. Classifying** Would all the different kinds of organisms in a forest be considered a population or a community? Explain.

HINT **c. Relating Cause and Effect** How might a change in one population affect other populations in a community?

Writing in Science

Descriptive Paragraph What habitat do you live in? Write a one-paragraph description of your habitat. Describe how you obtain the food, water, and shelter you need from your habitat. How does this habitat meet your needs in ways that another would not?

FIGURE 4

Ecological Organization

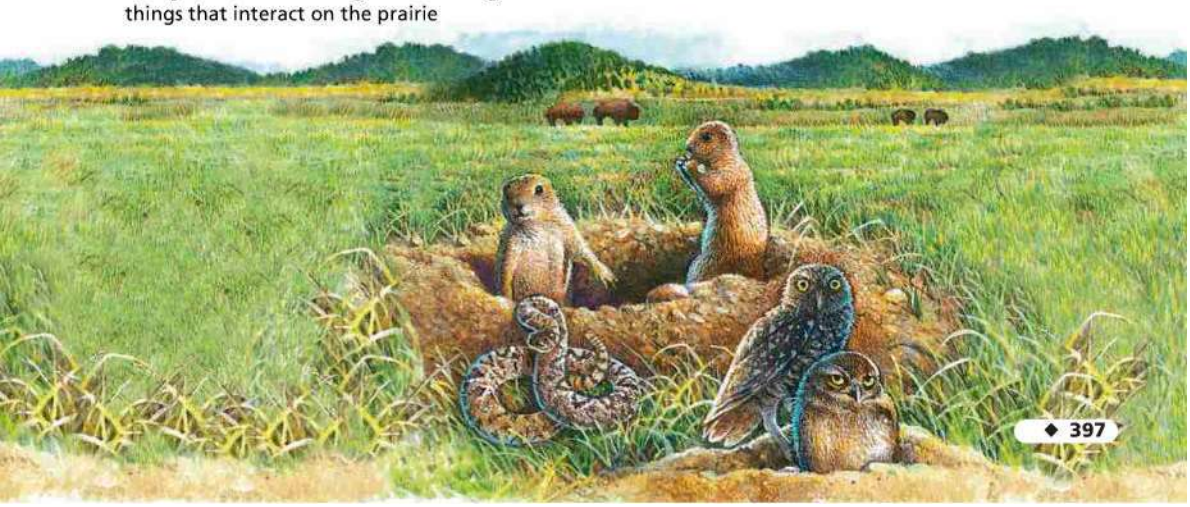
The smallest level of organization is the organism. The largest is the entire ecosystem.

Organism: Prairie dog

Population: Prairie dog town

Community: All the living things that interact on the prairie

Ecosystem: All the living and nonliving things that interact on the prairie



Lab zone **Skills Lab**
Directed Inquiry

S 6.5.e

A World in a Bottle

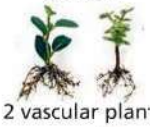
Materials

pre-cut, clear plastic bottle


gravel and soil


plastic spoon and large rubber band


charcoal


2 vascular plants


spray bottle


moss plants


clear plastic wrap

Problem How do organisms survive in a closed ecosystem?

Skills Focus Making models, observing

Procedure

1. In this lab, you will place plants in moist soil in a bottle that then will be sealed. This setup is called a terrarium. Predict whether the plants can survive in this habitat.
2. Spread about 2.5 cm of gravel on the bottom of a pre-cut bottle. Then sprinkle a spoonful or two of charcoal over the gravel.
3. Use the spoon to layer about 8 cm of soil over the gravel and charcoal. After you add the soil, tap it down to pack it.
4. Scoop out two holes in the soil. Remove the vascular plants from their pots. Gently place their roots in the holes. Then pack the loose soil firmly around the plants' stems.
5. Fill the spray bottle with water. Spray the soil until you see water collecting in the gravel.
6. Cover the soil with the moss plants, including the areas around the stems of the vascular plants. Lightly spray the mosses with water.
7. Tightly cover your terrarium with plastic wrap. Secure the cover with a rubber band. Place the terrarium in bright, indirect light.
8. Observe your terrarium daily for two weeks. Record your observations in your notebook. If its sides fog, move the terrarium to an area with a different amount of light. You may need to move it a few times. Note any changes you make in your terrarium's location.

Analyze and Conclude

1. **Making Models** List all of the biotic factors and abiotic factors that are part of your ecosystem model.
2. **Observing** Are any biotic or abiotic factors able to enter the terrarium? If so, which ones?
3. **Predicting** Suppose a plant-eating insect were added to the terrarium. Predict whether it would be able to survive. Explain your prediction.
4. **Communicating** Write a paragraph that explains how the plant depends on each of the abiotic factors you listed in Question 1. Are there any factors the plant could survive without? Explain.

Design an Experiment

Plan an experiment that would model a freshwater ecosystem. How would this model be different from the land ecosystem? *Obtain your teacher's approval before carrying out your plan.*

Section 2

Populations

California Standards Focus

S 6.5.e Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

- What causes populations to change in size?
- What factors limit population growth?

Key Terms

- birth rate
- death rate
- immigration
- emigration
- limiting factor
- carrying capacity

Lab zone Standards Warm-Up

How Can Population Size Change?

A population of 30 deer lives in a forest. In your notebook, calculate how the population size changes during the five years listed below.

1. In the first year, 10 deer are born and 5 die.
2. In the second year, 8 deer are born and none die.
3. In the third year, 7 deer are born and 2 die.
4. In the fourth year, 12 deer are born, 8 die, and 10 leave the forest.
5. In the fifth year, 6 deer are born, 10 die, and 12 leave the forest.
6. Make a graph of the changes in population size.

Think It Over

Interpreting Graphs Describe how the population size of the deer herd changed over time. Did the overall population size increase, stay the same, or decrease?

How would you like to be an ecologist today? Your assignment is to study the albatross population on an island. One question you might ask is how the size of the albatross population is changing. Is the number of albatrosses on the island increasing, decreasing, or remaining about the same? To answer this question, an ecologist must observe how the size of the albatross population changes over several years.

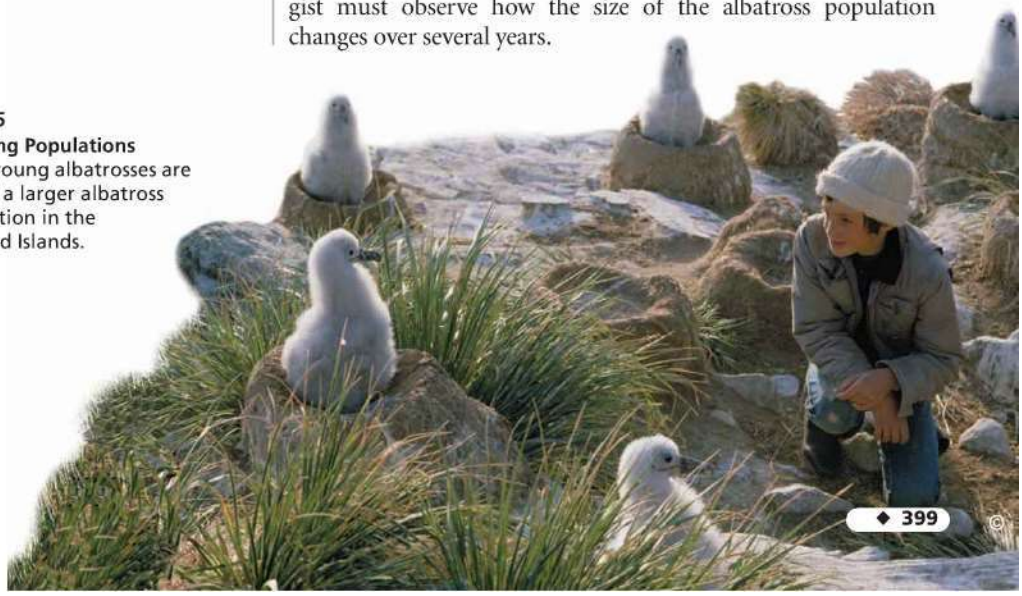


FIGURE 5
Studying Populations
These young albatrosses are part of a larger albatross population in the Falkland Islands.

Changes in Population Size

The size of any population does not remain the same for very long. **Populations can change in size when new members join the population or when members leave the population.**

Births and Deaths The main way in which new individuals join a population is by being born into it. The **birth rate** of a population is the number of births in a population in a certain amount of time. For example, suppose that a population of 100 rabbits produces 600 young in a year. The birth rate in this population would be 600 young per year.

The main way that individuals leave a population is by dying. The **death rate** is the number of deaths in a population in a certain amount of time. If 400 rabbits die in a year in the population, the death rate would be 400 rabbits per year.

The Population Statement When the birth rate in a population is greater than the death rate, the population will generally increase. This can be written as a mathematical statement using the "is greater than" sign:

If birth rate > death rate, population size increases.

However, if the death rate in a population is greater than the birth rate, the population size will generally decrease. This can also be written as a mathematical statement:

If death rate > birth rate, population size decreases.

Immigration and Emigration The size of a population also can change when individuals move into or out of the population. **Immigration** (im ih GRAY shun) means moving into a population. **Emigration** (em ih GRAY shun) means leaving a population. For instance, if food is scarce, some members of an antelope herd may wander off in search of better grassland. If they become permanently separated from the original herd, they will no longer be part of that population.

Graphing Changes in Population Changes in a population's size can be displayed on a line graph. Figure 6 shows a graph of the changes in a rabbit population. The vertical axis shows the numbers of rabbits in the population, while the horizontal axis shows time. The graph shows the size of the population over a ten-year period.

Reading Checkpoint **How does emigration affect population size?**

Math Skills

Inequalities

The population statement is an example of an inequality. An inequality is a mathematical statement that compares two expressions. Two signs that represent inequalities are

< (is less than)

> (is greater than)

For example, an inequality comparing the fraction $\frac{1}{2}$ to the decimal 0.75 would be written

$$\frac{1}{2} < 0.75$$

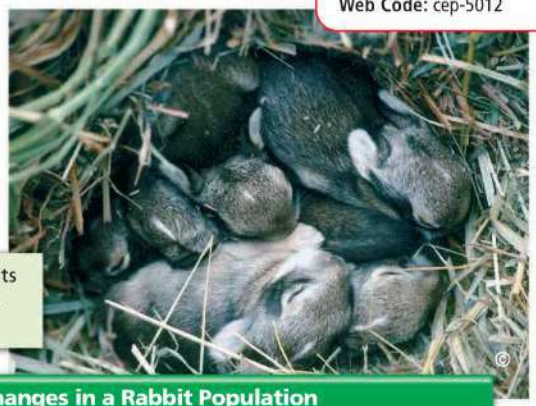
Practice Problems Write an inequality comparing each pair of expressions below.

1. $5 \blacksquare -6$
2. $0.4 \blacksquare \frac{3}{5}$
3. $-2 - (-8) \blacksquare 7 - 1.5$

FIGURE 6
This line graph shows how the size of a rabbit population changed over a ten-year period. **Interpreting Graphs** *In what year did the rabbit population reach its highest point? What was the size of the population in that year?*

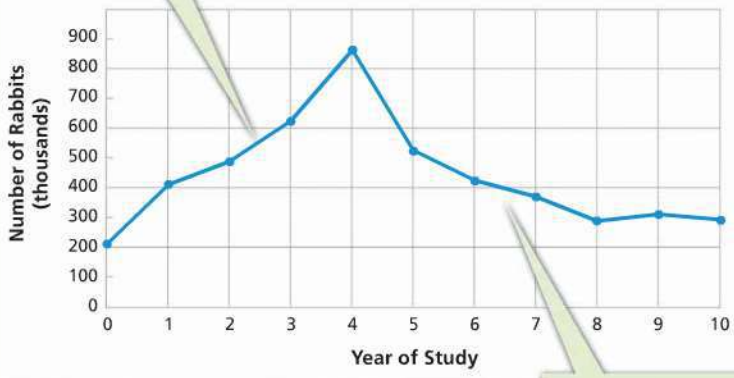
Go Online
active art
For: Changes in Population activity
Visit: PHSchool.com
Web Code: cep-5012

▼ Young rabbits in a nest



From Year 0 to Year 4, more rabbits joined the population than left it, so the population increased.

Changes in a Rabbit Population



From Year 4 to Year 8, more rabbits left the population than joined it, so the population decreased.

◀ Rabbit caught by a fox

Limiting Factors

When the living conditions in an area are good, a population will generally grow. But eventually some environmental factor will cause the population to stop growing. The number of organisms an ecosystem can support depends on the amount of resources available and on abiotic factors. A **limiting factor** is an environmental factor that causes a population to stop growing. **Some limiting factors for populations are food and water, space, light, soil composition, and weather conditions.**

Food and Water Organisms require food and water to survive. Since food and water are often in limited supply, they are often limiting factors. Suppose a giraffe must eat 10 kilograms of leaves each day to survive. The trees in an area can provide 100 kilograms of leaves a day while remaining healthy. Five giraffes could live easily in this area, since they would only require a total of 50 kilograms of food. But 15 giraffes could not all survive—there would not be enough food. No matter how much shelter, water, and other resources there were, the population would not grow much larger than 10 giraffes.

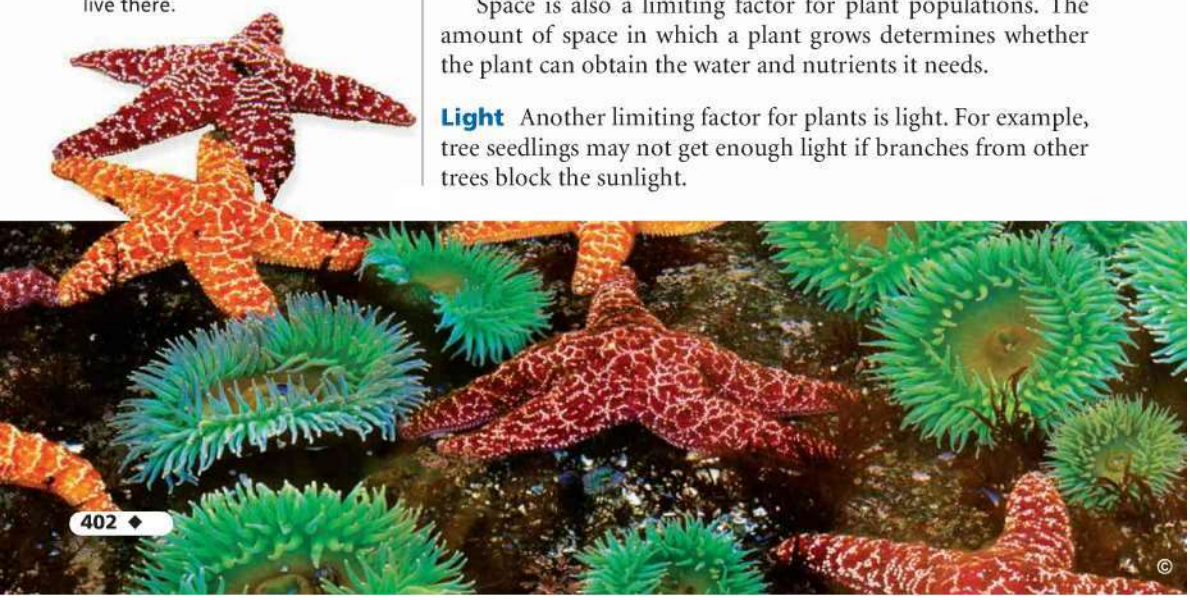
The largest population that an area can support is called its **carrying capacity.** The carrying capacity of this giraffe habitat would be 10 giraffes. A population usually stays near its carrying capacity because of the limiting factors in its habitat.

Space Space is also a limiting factor. For example, nesting space is a limiting factor for seabirds such as gannets. The rocky shores where gannets nest get very crowded. If a pair does not find space to nest, they will not be able to add to the population.

Space is also a limiting factor for plant populations. The amount of space in which a plant grows determines whether the plant can obtain the water and nutrients it needs.

Light Another limiting factor for plants is light. For example, tree seedlings may not get enough light if branches from other trees block the sunlight.

FIGURE 7
Space as a Limiting Factor
The amount of space available in this tidepool limits the number of sea stars and anemones that can live there.



Soil Composition The composition of the soil is also a limiting factor that affects plant growth. To support vigorous plant growth, soils must contain sufficient nitrogen and minerals, including phosphorus and potassium. The soil must also contain enough humus without excess acidity or alkalinity.

Weather Weather conditions can limit population growth. Many types of organisms require a particular range of temperatures and amount of rainfall to live and reproduce. For example, the saguaro cactus can withstand the heat and dryness of the Arizona desert. But the saguaro will not grow where winter temperatures fall much below freezing.

The number of organisms that an ecosystem can support varies from season to season. For example, more organisms thrive during temperate summers than can survive icy winters.

Unusual weather events can also affect population size. A cold snap in late spring can kill the young of many species of birds and mammals. A hurricane or flood can wash away nests and burrows.

Reading Checkpoint **How can unusual weather affect population size?**

FIGURE 8
Weather as a Limiting Factor
A snowstorm can limit the size of an orange crop.
Applying Concepts *What other weather conditions can limit population growth?*

Section 2 Assessment

S 6.5.e, Math: 6 NS 2.3

Vocabulary Skill **Use Related Words** Complete the sentence by using the correct form of *limit* and *limiting*. A _____ factor will stop the growth of an animal population because it may _____ food, water, or space for that population.

Reviewing Key Concepts

1. a. **Identifying** Name two ways organisms join a population and two ways organisms leave a population.
   b. **Calculating** Suppose a population of 100 mice has produced 600 young. If 200 mice have died, how many mice are in the population now? (Assume for this question that no mice have moved into or out of the population for other reasons.)
   c. **Drawing Conclusions** Suppose that you discovered that there were actually 750 mice in the population. How could you account for the difference?
2. a. **Reviewing** Name five limiting factors for populations.
   b. **Describing** Choose one of the limiting factors and describe how it limits population growth.
   c. **Inferring** How might the limiting factor you chose affect the pigeon population in your town?

HINT HINT HINT HINT HINT

Math Practice

3. **Inequalities** Complete the following inequality showing the relationship between carrying capacity and population size. Then explain why the inequality is true.

If population size ■ carrying capacity, then population size will decrease.

Section 3

Energy Flow in Ecosystems

California Standards Focus

S 6.5.a Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs.

S 6.5.c Students know populations of organisms can be categorized by the functions they serve in an ecosystem.

- What energy roles do organisms play in an ecosystem?
- How does energy move through an ecosystem?
- How much energy is available at each level of an energy pyramid?

Key Terms

- producer
- consumer
- herbivore
- carnivore
- omnivore
- scavenger
- decomposer
- food chain
- food web
- energy pyramid

Lab zone Standards Warm-Up

Where Did Your Dinner Come From?

1. Across the top of a sheet of paper, list the different types of foods you ate for dinner last night.
2. Under each item, write the name of the plant, animal, or other organism that was the source of that food. Some foods have more than one source. For example, macaroni and cheese contains flour (which is made from a plant such as wheat) and cheese (which comes from an animal).

Think It Over

Classifying How many of your food sources were plants? How many were animals?

Do you play an instrument in your school band? If so, you know that each instrument has a role in a piece of music. For instance, the flute may provide the melody while the drum provides the beat.

Just like the instruments in a band, each organism has a role in the movement of energy through its ecosystem. A bluebird's role, for example, is different from that of the giant oak tree where it is perched. But all parts of the ecosystem, like all parts of a band, are necessary for the ecosystem to work.

Energy Roles

An organism's energy role, or ecological function, is determined by how it obtains energy and how it interacts with other organisms. **Each of the organisms in an ecosystem fills the energy role of producer, consumer, or decomposer.**

Producers Energy enters most ecosystems as sunlight. Some organisms, such as plants, algae, and some bacteria, capture the energy of sunlight and store it as food energy. These organisms use the sun's energy to turn water and carbon dioxide into chemical energy in a process called photosynthesis. This chemical energy is stored as food within the organism.

©

An organism that can make its own food is a **producer.** Producers, such as plants, algae, and some bacteria, are the source of all the food in an ecosystem. In a few ecosystems, producers obtain energy from a source other than sunlight. One such ecosystem is found in rocks deep beneath the ground. How is energy brought into this ecosystem? Certain bacteria in this ecosystem produce their own food using the energy in a gas, hydrogen sulfide, that is found in their environment.

Consumers Some members of an ecosystem cannot make their own food. An organism that obtains energy by feeding on other organisms is a **consumer.**

Consumers are classified by what they eat. Consumers that eat only plants are **herbivores.** Familiar herbivores are caterpillars and deer. Consumers that eat only animals are **carnivores.** Lions and spiders are some examples of carnivores. Consumers that eat both plants and animals are **omnivores.** Crows, bears, and most humans are omnivores.

Some carnivores are scavengers. A **scavenger** is a carnivore that feeds on the bodies of dead organisms. Scavengers include catfish and vultures.

Decomposers If an ecosystem had only producers and consumers, the raw materials of life would stay locked up in wastes and the bodies of dead organisms. Luckily, there are organisms in ecosystems that prevent this problem. **Decomposers** break down wastes and dead organisms and return the raw materials to the ecosystem.

You can think of decomposers as nature's recyclers. While obtaining energy for their own needs, decomposers return simple molecules to the environment. These molecules can be used again by other organisms. Mushrooms and bacteria are common decomposers.

Reading Checkpoint **What do herbivores and carnivores have in common?**

FIGURE 9
Energy Roles
Producers, such as oak trees, obtain energy by making their own food. Consumers, such as luna moth larvae and eastern bluebirds, obtain energy by feeding on other organisms. **Classifying** *What role do decomposers play in ecosystems?*

Go Online
SCILINKS NSTA
For: Links on food chains and food webs
Visit: www.SciLinks.org
Web Code: scn-0521

Food Chains and Food Webs

As you have read, energy enters most ecosystems as sunlight and is converted into chemical energy by producers. This energy is transferred to each organism that eats a producer, and then to other organisms that feed on these consumers. **The transfer of energy from organism to organism in an ecosystem can be shown in diagrams called food chains and food webs.**

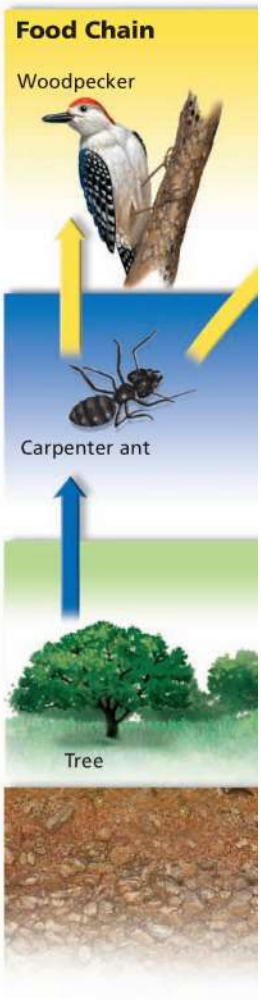
Food Chains A **food chain** is a series of events in which one organism eats another and obtains energy. You can follow one food chain in Figure 10. The first organism in a food chain is always a producer, such as the tree. The second organism feeds on the producer and is called the first-level consumer. The carpenter ant is a first-level consumer. Next, a second-level consumer eats the first-level consumer. The second-level consumer in this example is the woodpecker.

Food Webs A food chain shows only one possible path along which energy can move through an ecosystem food web. But just as you do not eat the same thing every day, neither do most other organisms. Most producers and consumers are part of many food chains. A more realistic way to show the flow of energy through an ecosystem is a food web. As shown in Figure 10, a **food web** consists of the many overlapping food chains in an ecosystem.

In Figure 10, you can trace the many food chains in a woodland ecosystem food web. Note that an organism may play more than one role in an ecosystem. For example, an omnivore such as the mouse is a first-level consumer when it eats grass. But when the mouse eats a grasshopper, it is a second-level consumer.

Just as food chains overlap and connect, food webs interconnect as well. While a gull might eat a fish at the ocean, it might also eat a mouse at a landfill. The gull, then, is part of two food webs—an ocean food web and a land food web. All the world's food webs interconnect in what can be thought of as a global food web.

Reading Checkpoint **What energy role is filled by the first organism in a food chain?**



Lab zone Try This Activity

Weaving a Food Web

This activity shows how the organisms in a food web are interconnected.

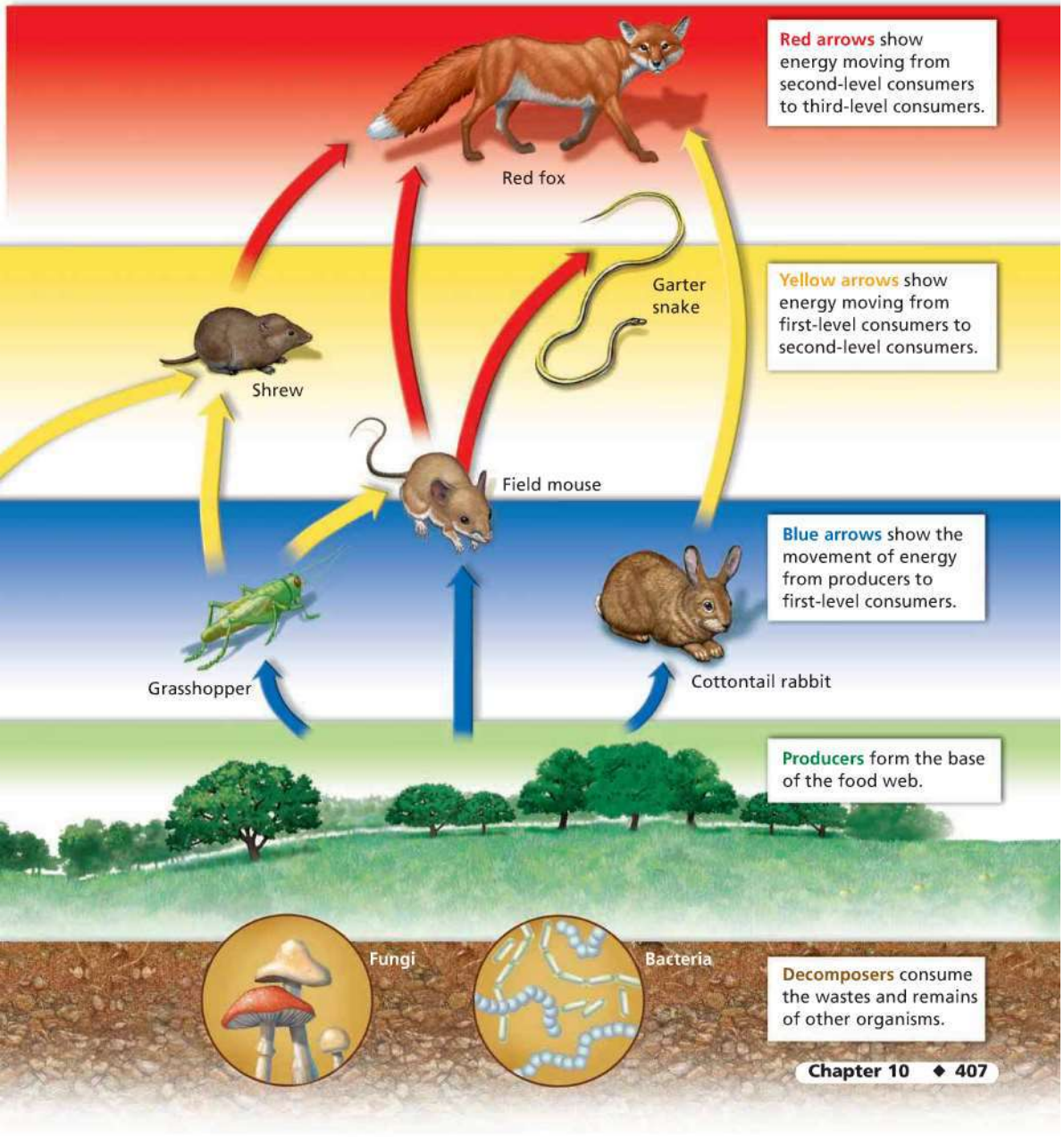
1. Your teacher will assign you a role in the food web.
2. Hold one end of each of several pieces of yarn in your hand. Give the other ends of your yarn to the other organisms to which your organism is linked.
3. Your teacher will now eliminate an organism. All the organisms connected to the missing organism should drop the yarn that connects them.

Making Models How many organisms were affected by the removal of just one organism? What does this activity show about the importance of each organism in a food web?

FIGURE 10

A Food Web

A food web consists of many interconnected food chains. Trace the path of energy through the producers, consumers, and decomposers.
Interpreting Diagrams *Which organisms in the food web are acting as herbivores? Which are carnivores?*



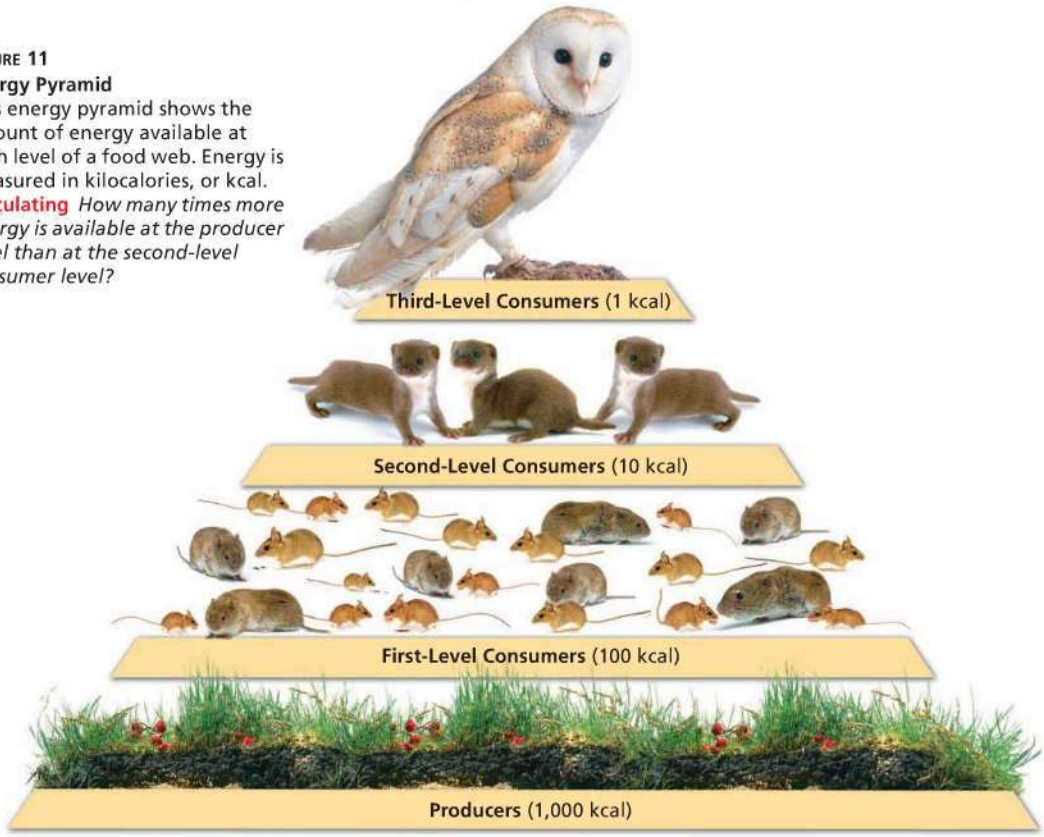


FIGURE 11
Energy Pyramid
This energy pyramid shows the amount of energy available at each level of a food web. Energy is measured in kilocalories, or kcal.
Calculating *How many times more energy is available at the producer level than at the second-level consumer level?*

Energy Pyramids

When an organism in an ecosystem eats, it obtains energy. The organism uses some of this energy to move, feed, grow, and reproduce. This means that only some of the energy it obtains will be available to the next organism in the food web.

A diagram called an **energy pyramid** shows the amount of energy that moves from one feeding level to another in a food web. You can see an energy pyramid in Figure 11. **The most energy is available at the producer level of the pyramid. As you move up the pyramid, each level has less energy available than the level below.** An energy pyramid is wider at the base and narrower at the top.

Energy Flow in Ecosystems The wide base of the pyramid represents the ecosystem's producers—in this case, plants. The richness of plant growth controls the number of organisms that can be supported at higher feeding levels in the ecosystem. In turn, abiotic factors control the richness of plant growth.

In general, only about 10 percent of the chemical energy at one level of a food web is transferred to the next higher level. The other 90 percent of the energy is used for the organism's life processes or is lost to the environment as heat. Since about 90 percent of the energy is lost at each step, there is not enough energy to support many feeding levels in an ecosystem.

The organisms at higher feeding levels of an energy pyramid do not necessarily require less energy to live than do the organisms at lower levels. Since so much energy is lost at each level, the amount of energy available at the producer level limits the number of consumers that the ecosystem is able to support. As a result, there are usually few organisms at the highest level in a food web.

Scavengers and Decomposers Scavengers and decomposers are also part of an energy pyramid. They feed on the remains or wastes of organisms at each level of the pyramid.

FIGURE 12
Energy Flow
This barn owl will soon use the energy contained in the rat to carry out its own life processes.

Section 3 Assessment

S 6.5.a, 6.5.c

Vocabulary Skill **Use Related Words** Complete the sentence by using the correct form of *produce* or *producers*. Organism called _____, which include plants, algae, and some bacteria, _____ all the food in an ecosystem.

Reviewing Key Concepts

1. a. **Identifying** Name the three energy roles that organisms fill in an ecosystem.
   b. **Explaining** How do organisms in each of the three energy roles obtain chemical energy?
   c. **Classifying** Identify the energy roles of the following organisms in a pond ecosystem: tadpole, algae, heron.
2. a. **Defining** What is a food chain? What is a food web?
   b. **Comparing and Contrasting** Why is a food web a more realistic model of an ecosystem than is a food chain?
3. a. **Reviewing** What does an energy pyramid show?
   b. **Describing** How does the amount of chemical energy available at one level of an energy pyramid compare to the amount of energy available at the next level up?
   c. **Relating Cause and Effect** Why are there usually few organisms at the top of an energy pyramid?

HINT HINT HINT HINT HINT HINT HINT HINT

Lab zone At-Home Activity

Energy-Role Walk Take a short walk outdoors with a family member to look for producers, consumers, and decomposers. Create a list of the organisms and their energy roles. For each consumer, try to classify it further according to what it eats and its level. Then explain to your family member how energy flows in ecosystems.

Section 4

Interactions Among Living Things

California Standards Focus

S 6.5.c Students know populations of organisms can be categorized by the functions they serve in an ecosystem.

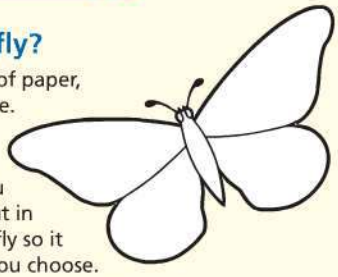
- How do an organism's adaptations help it to survive?
- What are the major ways in which organisms in an ecosystem interact?
- What are the three types of symbiotic relationships?

Key Terms

- natural selection
- adaptations
- niche
- competition
- predation
- predator
- prey
- symbiosis
- mutualism
- commensalism
- parasitism
- parasite
- host

Lab zone Standards Warm-Up

Can You Hide a Butterfly?



1. Trace a butterfly on a piece of paper, using the outline shown here.
2. Look around the classroom and pick a spot where you will place your butterfly. You must place your butterfly out in the open. Color your butterfly so it will blend in with the spot you choose.
3. Tape your butterfly down. Someone will now have one minute to find the butterflies. Will your butterfly be found?

Think It Over

Predicting Over time, do you think the population size of butterflies that blend in with their surroundings would increase or decrease?

Can you imagine living in a cactus like the one in Figure 13? Ouch! You probably wouldn't want to live in a house covered with sharp spines. But many species live in, on, and around saguaro cactuses.

As day breaks, a twittering sound comes from a nest tucked in one of the saguaro's arms. Two young red-tailed hawks are preparing to fly for the first time. Farther down the stem, a tiny elf owl peeks out of its nest in a small hole. This owl is so small it could fit in your palm! A rattlesnake slithers around the base of the saguaro, looking for lunch. Spying a shrew, the snake strikes it with its needle-like fangs. The shrew dies instantly.

Activity around the saguaro continues after sunset. Long-nosed bats come out to feed on the nectar from the saguaro's blossoms. The bats stick their faces into the flowers to feed, dusting their long snouts with white pollen. As they move from plant to plant, they carry the pollen to other saguaros. This enables the cactuses to reproduce.

Adapting to the Environment

Each organism in the saguaro community has unique characteristics. These characteristics affect the individual's ability to survive in its environment.

Natural Selection A characteristic that makes an individual better suited to its environment may eventually become common in that species through a process called **natural selection.** Natural selection works like this: Individuals whose unique characteristics are best suited for their environment tend to survive and produce offspring. Offspring that inherit these characteristics also live to reproduce. In this way, natural selection results in **adaptations,** the behaviors and physical characteristics that allow organisms to live successfully in their environments.

Individuals with characteristics that are poorly suited to the environment are less likely to survive and reproduce. Over time, poorly suited characteristics may disappear from the species.

Niche **Every organism has a variety of adaptations that are suited to its specific living conditions.** The organisms in the saguaro community have adaptations that result in specific ecological roles. For example, the organism may be a producer, consumer, or decomposer. The role of an organism in its habitat, or how it makes its living, is called its **niche.** A niche includes the type of food the organism eats, how it obtains this food, and which other organisms use the organism as food. A niche also includes when and how the organism reproduces and the physical conditions it requires to survive.

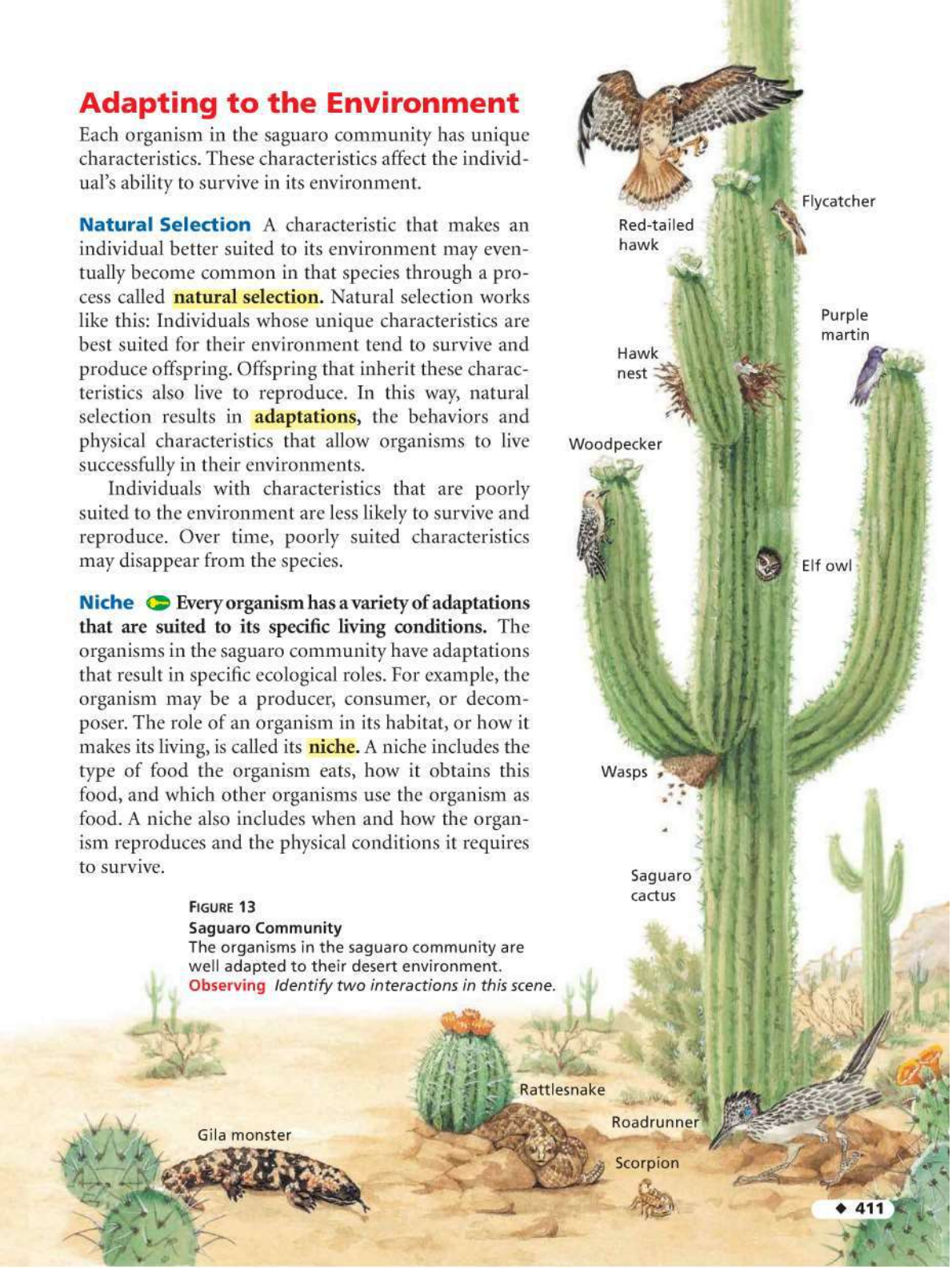


FIGURE 13
Saguaro Community
The organisms in the saguaro community are well adapted to their desert environment.
Observing *Identify two interactions in this scene.*

FIGURE 14
Niche and Competition
Each of these warblers occupies a different niche in its spruce tree habitat. By feeding in different areas of the tree, the birds avoid competing for food.
Comparing and Contrasting
How do the niches of these three warblers differ?

Competition

During a typical day in the saguaro community, a range of interactions takes place among organisms. **There are three major types of interactions among organisms: competition, predation, and symbiosis.**

Different species can share the same habitat and food requirements. For example, the roadrunner and the elf owl both live on the saguaro and eat insects. However, these two species do not occupy exactly the same niche. The roadrunner is active during the day, while the owl is active mostly at night. If two species occupy the same niche, one of the species will eventually die off. The reason for this is **competition,** the struggle between organisms to survive as they attempt to use the same limited resource.

In any ecosystem, there is a limited amount of food, water, and shelter. Organisms that survive have adaptations that enable them to reduce competition. For example, the three species of warblers in Figure 14 live in the same spruce forest habitat. They all eat insects that live in the spruce trees. How do these birds avoid competing for the limited insect supply? Each warbler "specializes" in feeding in a certain part of a spruce tree. This is how the three species coexist.

Reading Checkpoint **Why can't two species occupy the same niche?**

Go Online
PHSchool.com
For: More on population interactions
Visit: PHSchool.com
Web Code: ced-5013

Predation

A tiger shark lurks below the surface of the clear blue water, looking for shadows of albatross chicks floating above. The shark spots a chick and silently swims closer. Suddenly, the shark bursts through the water and seizes the albatross with one snap of its powerful jaw. This interaction between two organisms has an unfortunate ending for the albatross.

An interaction in which one organism kills another for food is called **predation.** The organism that does the killing, in this case the tiger shark, is the **predator.** The organism that is killed, in this case the albatross, is the **prey.**

The Effect of Predation on Population Size Predation can have a major effect on the size of a population. Recall from Section 2 that when the death rate exceeds the birth rate in a population, the size of that population usually decreases. So if there are many predators, the result is often a decrease in the size of the population of their prey. But a decrease in the number of prey results in less food for their predators. Without adequate food, the predator population starts to decline. So, generally, populations of predators and their prey rise and fall in related cycles.

FIGURE 15
Predation
This green tree python and mouse are involved in a predator-prey interaction.

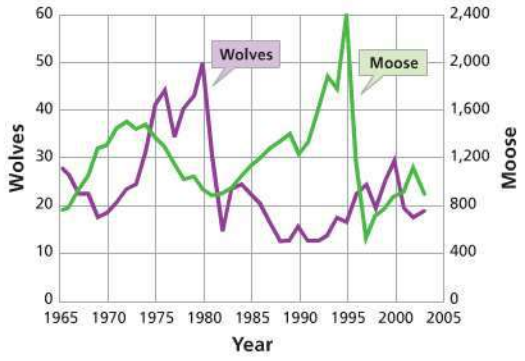
Math: Statistics, Data Analysis, and Probability 6.3.2

Math Analyzing Data

Predator-Prey Interactions

On Isle Royale, an island in Lake Superior, the populations of wolves (the predator) and moose (the prey) rise and fall in cycles. Use the graph to answer the questions.

Wolf and Moose Populations on Isle Royale

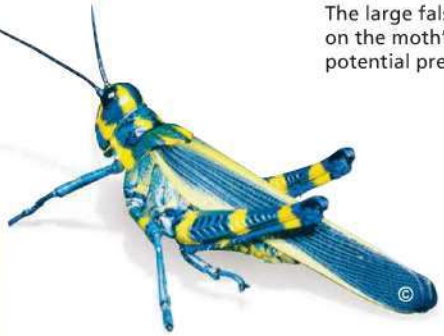


1. **Reading Graphs** What variable is plotted on the *x*-axis? What two variables are plotted on the *y*-axis?
2. **Interpreting Data** How did the moose population change between 1965 and 1972? What happened to the wolf population from 1973 through 1976?
3. **Inferring** How might the change in the moose population have led to the change in the wolf population?
4. **Drawing Conclusions** What is one likely cause of the dip in the moose population between 1974 and 1981?
5. **Predicting** How might a disease in the wolf population one year affect the moose population the next year?

◀ Mimicry
If you're afraid of snakes, you'd probably be terrified to see this organism staring at you. Because this caterpillar looks like a snake, it can trick would-be predators into staying away.

False Coloring ▲
The large false eyespots on the moth's wings scare potential predators away.

▼ Camouflage
This insect might fool a predator into looking elsewhere for a meal.



◀ Warning Coloring
Like many brightly colored animals, this grasshopper is poisonous. Its bright blue and yellow colors warn predators not to eat it.

FIGURE 16
Defense Strategies
Organisms display a wide array of adaptations that help them avoid becoming prey. **Inferring** *What other adaptations might contribute to the grasshopper's ability to escape a predator?*

Predator Adaptations Predators have adaptations that help them catch and kill their prey. For example, a cheetah can run very fast for a short time, enabling it to catch its prey. A jellyfish's tentacles contain a poisonous substance that paralyzes tiny water animals. Some plants, too, have adaptations for catching prey. The sundew is covered with sticky bulbs on stalks—when a fly lands on the plant, it remains snared in the sticky goo while the plant digests it.

Some predators have adaptations that enable them to hunt at night. For example, the big eyes of an owl let in as much light as possible to help it see in the dark. Insect-eating bats can hunt without seeing at all. Instead, they locate their prey by producing pulses of sound and listening for the echoes. This precise method enables a bat to catch a flying moth in complete darkness.

Prey Adaptations How do organisms avoid being killed by such effective predators? Organisms have many kinds of adaptations that help them avoid becoming prey. The alertness and speed of an antelope help protect it from its predators. And you're probably not surprised that the smelly spray of a skunk helps keep its predators at a distance. As you can see in Figure 16, other organisms also have some very effective ways to avoid becoming a predator's next meal.

Video Field Trip
Discovery Channel School
Populations and Communities

Reading Checkpoint **What are two predator adaptations?**

Symbiosis

Many of the interactions in the saguaro community you read about are examples of symbiosis. **Symbiosis** (sim bee OH sis) is a close relationship between two species that benefits at least one of the species. **The three types of symbiotic relationships are mutualism, commensalism, and parasitism.**

Mutualism A relationship in which both species benefit is called **mutualism** (MYOO choo uh liz um). The relationship between the saguaro and the long-eared bats is an example of mutualism. The bats benefit because the cactus flowers provide them with food. The saguaro benefits as its pollen is carried to another plant on the bat's nose.

In some cases of mutualism, two species are so dependent on each other that neither could live without the other. This is true for some species of acacia trees and stinging ants in Central and South America. The stinging ants nest only in the acacia tree, whose thorns discourage the ants' predators. The tree also provides the ants' only food. The ants, in turn, attack other animals that approach the tree and clear competing plants away from the base of the tree. To survive, each species needs the other.

Commensalism A relationship in which one species benefits and the other species is neither helped nor harmed is called **commensalism** (kuh MEN suh liz um). The red-tailed hawks' interaction with the saguaro is an example of commensalism. The hawks benefit by having a place to build their nest, while the cactus is not affected by the hawks.

Commensalism is not very common in nature because two species are usually either helped or harmed a little by any interaction. For example, by creating a small hole for its nest in the cactus stem, the elf owl slightly damages the cactus.

Lab zone Skills Activity

Classifying

Classify each interaction as an example of mutualism, commensalism, or parasitism. Explain your answers.

- A remora fish attaches itself to the underside of a shark without harming the shark, and eats leftover bits of food from the shark's meals.
- A vampire bat drinks the blood of horses.
- Bacteria living in cows' stomachs help to break down the cellulose in grass.

FIGURE 17
Mutualism
Three yellow-billed oxpeckers get a cruise and a snack aboard an obliging hippopotamus. The oxpeckers eat ticks living on the hippo's skin. Since both the birds and the hippo benefit from this interaction, it is an example of mutualism.

FIGURE 18
Parasitism
Ticks feed on the blood of certain animals. **Predicting** *How will the tick affect its host?*

Parasitism **Parasitism** (PA ruh sit iz um) involves one organism living on or inside another organism and harming it. The organism that benefits is called a **parasite,** and the organism it lives on or in is called a **host.** The parasite is usually smaller than the host. In a parasitic relationship, the parasite benefits from the interaction while the host is harmed.

Some common parasites are fleas, ticks, and leeches. These parasites have adaptations that enable them to attach to their host and feed on its blood. Other parasites live inside the host's body, such as tapeworms that live inside the digestive systems of dogs, wolves, and some other mammals.

Unlike a predator, a parasite does not usually kill the organism it feeds on. If the host dies, the parasite loses its source of food. An interesting example of this rule is shown by a species of mite that lives in the ears of moths. The mites almost always live in just one of the moth's ears. If they live in both ears, the moth's hearing is so badly affected that it is likely to be quickly caught and eaten by its predator, a bat.

Reading Checkpoint **Why doesn't a parasite usually kill its host?**

Section 4 Assessment

S 6.5.c

Vocabulary Skill **Use Related Words** Complete the sentence by using the correct form of *prey* or *predation.* _____ affects the population size of owls, mice, rabbits, and other animals.

Reviewing Key Concepts

HINT 1. a. **Defining** What are adaptations?

HINT b. **Explaining** How are a snake's sharp fangs an adaptation that helps it survive in the saguaro community?

HINT c. **Developing Hypotheses** Explain how natural selection in snakes might have led to adaptations such as sharp fangs.

HINT 2. a. **Reviewing** What are three main ways in which organisms interact?

HINT b. **Classifying** Give one example of each type of interaction.

HINT 3. a. **Listing** List the three types of symbiotic relationships.

HINT b. **Comparing and Contrasting** For each type of symbiotic relationship, explain how the two organisms are affected.

HINT c. **Applying Concepts** Some of your classroom plants are dying. Others that you planted at the same time and cared for in the same way are growing well. When you look closely at the dying plants, you see tiny mites on them. Which symbiotic relationship is likely occurring between the plants and mites? Explain.

Lab zone At-Home Activity

Feeding Frenzy You and your family can observe interactions among organisms at a bird feeder. Fill a clean, dry, 2-liter bottle with birdseed. With paper clips, attach a plastic plate to the neck of the bottle. Then hang your feeder outside where you can see it easily. Observe the feeder at different times of the day, using binoculars if available. Keep a log of all the organisms you see near it and of how they interact.

Section 5

Cycles of Matter

California Standards Focus

S 6.5.b Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.

- What processes are involved in the water cycle?
- How are carbon and oxygen recycled in ecosystems?
- What is the nitrogen cycle?

Key Term

- nitrogen fixation

Lab zone Standards Warm-Up

What's the Matter?

1. Hold a small mirror a few centimeters from your mouth.
2. Exhale onto the mirror.
3. Observe the surface of the mirror.

Think It Over

Inferring What is the substance that forms on the mirror? Where did this substance come from?

A pile of crumpled cars is ready for loading into a giant compactor. The aluminum and copper pieces have already been removed so that they can be recycled, or used again. Now the steel will be reclaimed at a recycling plant. Earth has a limited supply of aluminum, copper, and the iron used in steel. Recycling old cars is one way to ensure a steady supply of these materials.

Like the supply of metal for building cars, the supply of matter in an ecosystem is limited. Matter in an ecosystem includes water, carbon, oxygen, nitrogen, and many other substances. Matter is transferred from one organism to another in the food web and between organisms and the environment. If matter could not be recycled in this way, ecosystems would quickly run out of the raw materials necessary for life. In this section, you will learn about some cycles of matter: the water cycle, the carbon and oxygen cycles, and the nitrogen cycle.

FIGURE 19
Water Cycle
This cheetah is drinking from a pool of fresh water that formed as part of the water cycle.

The Water Cycle

Water is essential for life. To ensure a steady supply, Earth's water must be recycled. Recall that the water cycle is the continuous process by which water moves from Earth's surface to the atmosphere and back. **The processes of evaporation, condensation, and precipitation make up the water cycle.** The heat of the sun provides the energy for the water cycle.

Living things are also involved in the water cycle. For example, plants absorb water from the soil through their roots and then release water vapor into the air through pores in their leaves. You release liquid water in your wastes and water vapor when you exhale.

Lab zone Try This Activity

Carbon and Oxygen Blues

This activity explores the role of producers in the carbon and oxygen cycles.

1. Your teacher will provide you with two plastic cups containing bromthymol blue solution. Bromthymol blue solution appears blue in the absence of carbon dioxide and appears yellow in the presence of carbon dioxide. Note the color of the solution.
2. Place two sprigs of an *Elodea* plant into one of the cups. Do not put any *Elodea* into the second cup. Cover both cups with plastic wrap. Wash your hands.
3. Place the cups where they will not be disturbed. Observe the two cups over the next few days. Note any color changes.

Inferring What do your observations indicate about the role of producers in the carbon and oxygen cycles?

The Carbon and Oxygen Cycles

Two other substances necessary for life are carbon and oxygen. Carbon is a major building block in the bodies of living things. Most organisms use oxygen for their life processes. **In ecosystems, the processes by which carbon and oxygen are recycled are linked. Producers, consumers, and decomposers play roles in recycling carbon and oxygen.**

The Carbon Cycle Producers take in carbon dioxide gas from the air during photosynthesis. They use carbon from the carbon dioxide to make food molecules—carbon-containing molecules such as sugars and starches. When consumers eat producers, they take in the carbon-containing food molecules. When consumers break down these food molecules to obtain energy, they release carbon dioxide and water as waste products. When producers and consumers die, decomposers break down their remains and return carbon compounds to the soil. Some decomposers also release carbon dioxide as a waste product.

The Oxygen Cycle Like carbon, oxygen cycles through ecosystems. Producers release oxygen as a result of photosynthesis. Most organisms take in oxygen from the air or water and use it to carry out their life processes.

Human Impact Human activities also affect the levels of carbon and oxygen in the atmosphere. When humans burn oil and other fuels, carbon dioxide is released into the atmosphere. When humans clear forests for lumber, fuel, and farmland, carbon dioxide levels also rise. As you know, producers take in carbon dioxide during photosynthesis. When trees are removed from the ecosystem, there are fewer producers to absorb carbon dioxide. There is a greater effect if trees are burned down to clear a forest. If trees are burned down to clear a forest, additional carbon dioxide is released in the burning process.

Reading Checkpoint **What role do producers play in the carbon and oxygen cycles?**

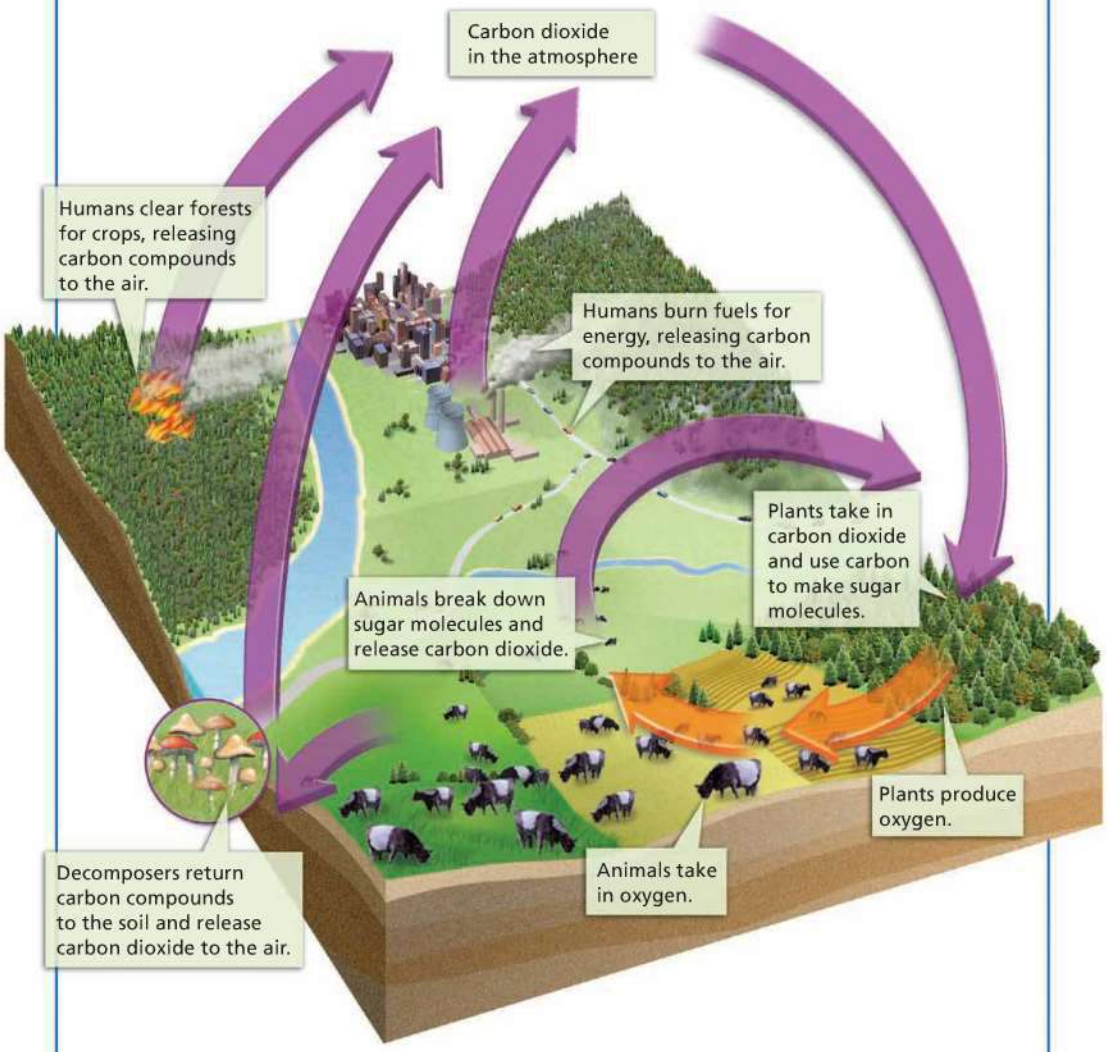
FIGURE 20
Rising Carbon Dioxide Levels
When forests burn, large amounts of carbon dioxide are released into the air. In addition, there are fewer trees available to absorb carbon dioxide from the air.

FIGURE 21

Carbon and Oxygen Cycles

This scene shows how the carbon and oxygen cycles are linked. Producers, consumers, and decomposers all play a role in recycling these two substances.

Interpreting Diagrams *How do human activities affect the carbon and oxygen cycles?*



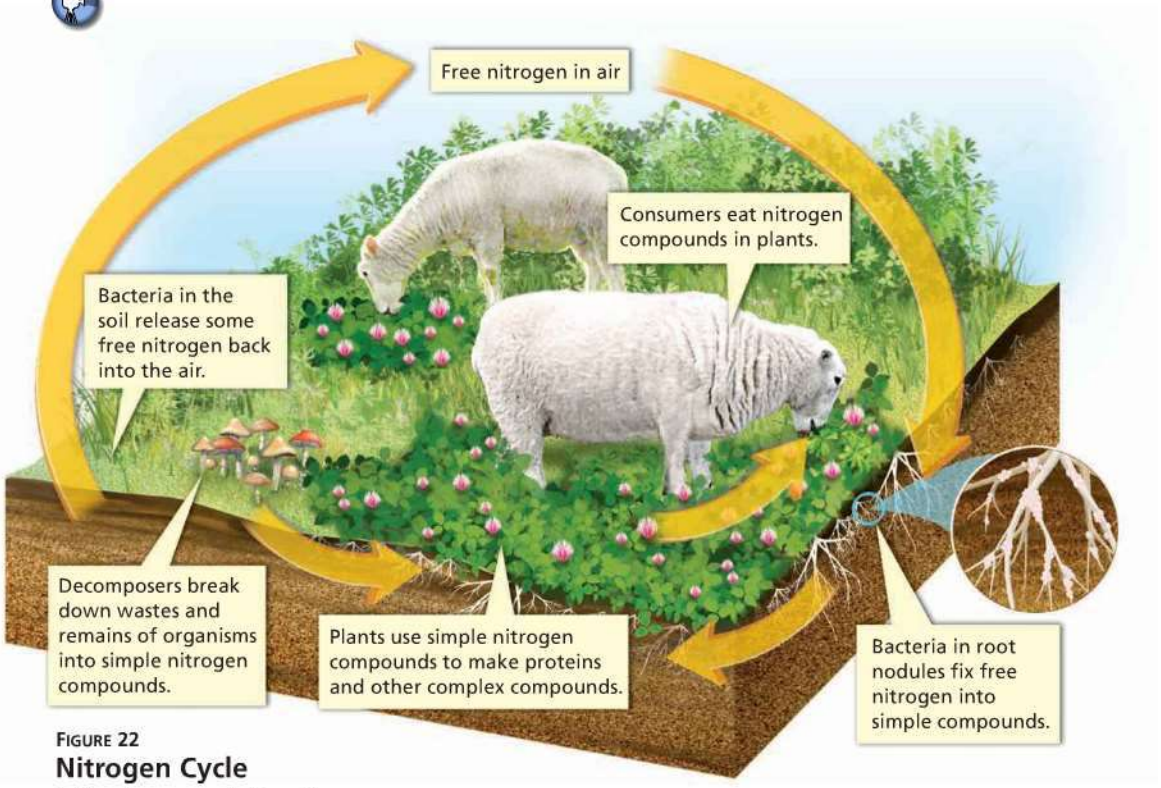


FIGURE 22
Nitrogen Cycle
In the nitrogen cycle, free nitrogen from the air is fixed into compounds. Plants can then use these nitrogen compounds in carrying out their life processes. **Relating Cause and Effect** *How does nitrogen get returned to the environment?*

The Nitrogen Cycle

Like carbon, nitrogen is a necessary building block in the matter that makes up living things. **In the nitrogen cycle, nitrogen moves from the air to the soil, into living things, and back into the air.** You can follow this process in Figure 22.

Since the air around you is about 78 percent nitrogen gas, you might think that it would be easy for living things to obtain nitrogen. However, most organisms cannot use nitrogen gas. Nitrogen gas is called "free" nitrogen because it is not combined with other kinds of atoms.

Nitrogen Fixation Most organisms can use nitrogen only once it has been "fixed," or combined with other elements to form nitrogen-containing compounds. The process of changing free nitrogen into a usable form of nitrogen is called **nitrogen fixation.** Most nitrogen fixation is performed by certain kinds of bacteria. Some of these bacteria live in bumps called nodules (NAHJ oolz) on the roots of certain plants. These plants, known as legumes, include clover, beans, peas, alfalfa, and peanuts.

The relationship between the bacteria and the legumes is an example of mutualism. Both the bacteria and the plant benefit from this relationship: The bacteria feed on the plant's sugars, and the plant is supplied with nitrogen in a usable form.

Return of Nitrogen to the Environment

Once nitrogen has been fixed, producers can use it to build proteins and other complex compounds. Decomposers, in turn, break down these complex compounds in animal wastes and the bodies of dead organisms. Decomposition returns simple nitrogen compounds to the soil. Nitrogen can cycle from the soil to producers and then to consumers many times. At some point, however, bacteria break down the nitrogen compounds completely. These bacteria then release free nitrogen back into the air. The cycle continues from there.

Reading Checkpoint **Where do some nitrogen-fixing bacteria live?**

FIGURE 23
Growth in Nitrogen-Poor Soil
Pitcher plants can grow in nitrogen-poor soil because they have another way of obtaining nitrogen. Insects become trapped in the plant's tube-shaped leaves. The plant then digests the insects and uses their nitrogen compounds for its functions.

Section 5 Assessment

S 6.5.b; E-LA: Reading 6.2.0, Writing 6.2.1

Target Reading Skill **Sequence** Review the text that follows the blue heading The Carbon Cycle on page 418. Create a diagram of the cycle.

Reviewing Key Concepts

1. a. **Defining** Define the three major processes that occur during the water cycle.
   b. **Making Generalizations** Defend this statement: The sun is the driving force behind the water cycle.
2. a. **Reviewing** Which two substances are linked in one recycling process?
   b. **Comparing and Contrasting** What role do producers play in the carbon and oxygen cycles? What role do consumers play in these cycles?
   c. **Developing Hypotheses** How might the death of all the producers in a community affect the carbon and oxygen cycles?
3. a. **Reviewing** Why do organisms need nitrogen?
   b. **Sequencing** Outline the major steps in the nitrogen cycle.
   c. **Predicting** What might happen in a community if all the nitrogen-fixing bacteria died?

HINT HINT HINT HINT HINT HINT HINT

Writing in Science

Comic Strip Choose one of the cycles discussed in this section. Then draw a comic strip with five panels that depicts the important events in the cycle. Remember that the last panel must end with the same event that begins the first panel.

Section 6

Changes in Communities

CALIFORNIA Standards Focus

S 6.2.d Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

S 6.5.e Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

How do primary and secondary succession differ?

Key Terms

- succession
- primary succession
- pioneer species
- secondary succession

Lab zone Standards Warm-Up

What Happened Here?

1. The two photographs at the bottom of this page show the same area in Yellowstone National Park in Wyoming. The photograph on the left was taken soon after a major fire. The photograph on the right was taken a few years later. Observe the photographs carefully.
2. Make a list of all the differences you notice between the two scenes.

Think It Over

Posing Questions How would you describe what happened during the time between the two photographs? What questions do you have about this process?

In 1988, huge fires raged through the forests of Yellowstone National Park. The fires were so hot that they jumped from tree to tree without burning along the ground. It took months for the fires to burn out. All that remained were thousands of blackened tree trunks sticking out of the ground like charred toothpicks.

Could a forest community recover from such disastrous fires? It might seem unlikely. But within just a few months, signs of life had returned. First, tiny green shoots of new grass poked through the sooty ground. Then, small tree seedlings began to grow. The forest was coming back! After 15 years, young forests were flourishing in many areas.

Fires, earthquakes, volcanic eruptions, landslides, floods, and other natural disasters can change human and wildlife habitats very quickly. But even without such disasters, communities change. The series of predictable changes that occur in a community over time is called **succession.**

Changes in a Yellowstone community ▼

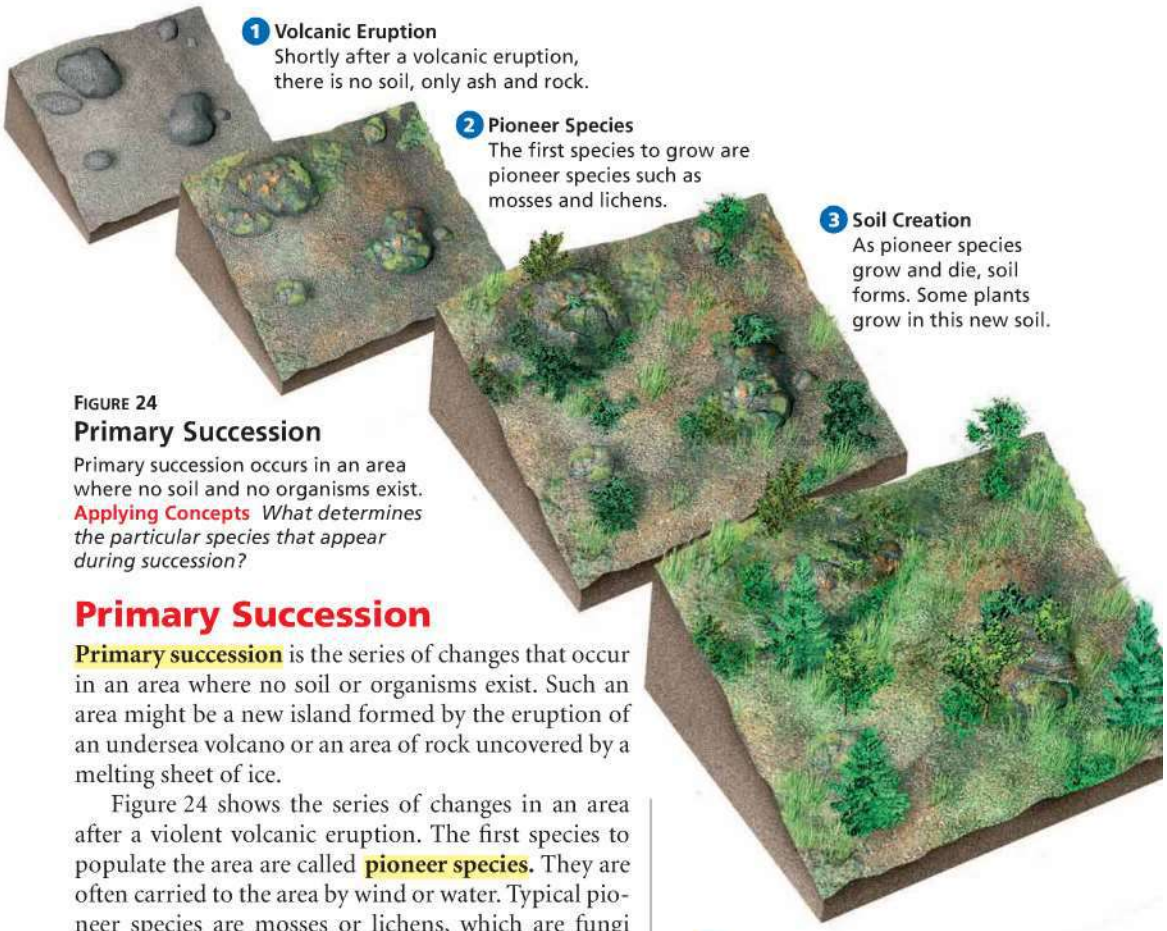


FIGURE 24
Primary Succession
Primary succession occurs in an area where no soil and no organisms exist. **Applying Concepts** *What determines the particular species that appear during succession?*

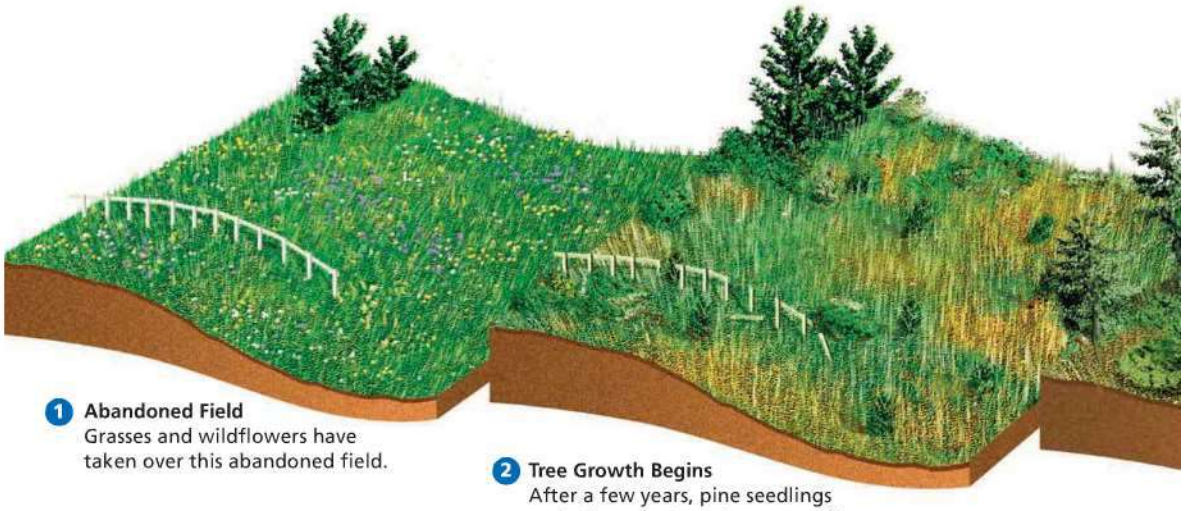
Primary Succession

Primary succession is the series of changes that occur in an area where no soil or organisms exist. Such an area might be a new island formed by the eruption of an undersea volcano or an area of rock uncovered by a melting sheet of ice.

Figure 24 shows the series of changes in an area after a violent volcanic eruption. The first species to populate the area are called **pioneer species.** They are often carried to the area by wind or water. Typical pioneer species are mosses or lichens, which are fungi and algae growing in a symbiotic relationship. As pioneer species grow, they help break up the rocks and form soil. When the organisms die, they provide nutrients that enrich the thin layer of soil that is forming on the rocks.

Over time, plant seeds land in the new soil and begin to grow. The specific plants that grow depend on the climate of the area. For example, in a cool, northern area, early seedlings might include alder and cottonwood trees. Eventually, succession may lead to a community of organisms that does not change unless the ecosystem is disturbed. Reaching this mature community can take centuries.

Reading Checkpoint **What are some pioneer species?**



1 Abandoned Field
Grasses and wildflowers have taken over this abandoned field.

2 Tree Growth Begins
After a few years, pine seedlings and other plants replace some of the grasses and wildflowers.

FIGURE 25
Secondary Succession
Secondary succession occurs following a disturbance to an ecosystem, such as clearing a forest for farmland.

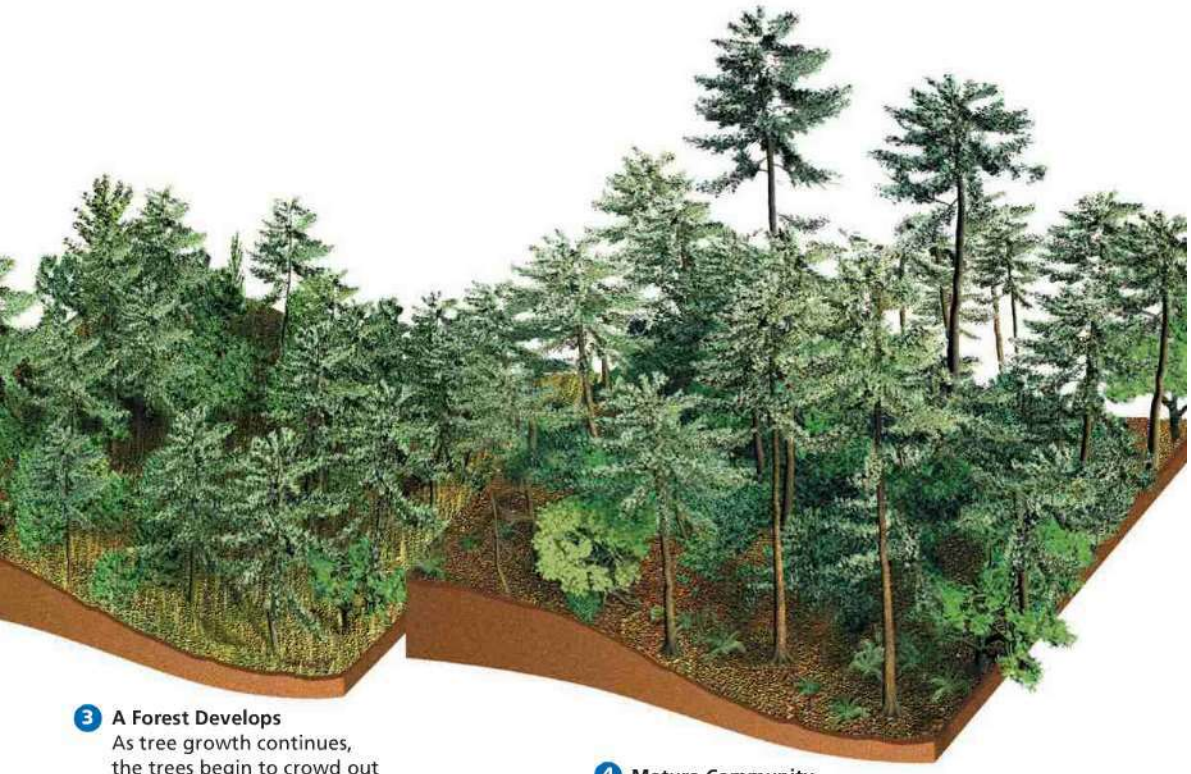
Secondary Succession

The changes following the Yellowstone fire were an example of secondary succession. **Secondary succession** is the series of changes that occur in an area where the ecosystem has been disturbed, but where soil and organisms still exist. Natural disturbances that have this effect include fires, hurricanes, and tornadoes. Human activities, such as farming, logging, or mining, may also disturb an ecosystem. **Unlike primary succession, secondary succession occurs in a place where an ecosystem currently exists.**

Secondary succession usually occurs more rapidly than primary succession. Consider, for example, an abandoned field in the southeastern United States. You can follow the process of succession in such a field in Figure 25. After a century, a hardwood forest is developing. This forest community may remain for a long time.

Reading Checkpoint **What are two natural events that can disturb an ecosystem?**

Go Online
SCILINKS NSTA
For: Links on succession
Visit: www.SciLinks.org
Web Code: scn-0514



3 A Forest Develops
As tree growth continues, the trees begin to crowd out the grasses and wildflowers.

4 Mature Community
Eventually, a mixed forest of pine, oak, and hickory dominates the landscape.

Section 6 Assessment

S 6.2.d, 6.5.e

Target Reading Skill **Sequence** Review the steps in Figure 25 Secondary Succession. Would you use a cycle diagram or a flowchart to show this proccess. Why?

Reviewing Key Concepts

HINT
1. a. **Defining** What is primary succession? What is secondary succession?

HINT
b. **Comparing and Contrasting** How do primary succession and secondary succession differ?

HINT
c. **Classifying** Grass poking through a crack in a sidewalk is an example of succession. Is it primary succession or secondary succession? Explain.

Lab zone At-Home Activity

Community Changes Interview a family member or neighbor who has lived in your neighborhood for a long time. Ask the person to describe how the neighborhood has changed over time. Have areas that were formerly grassy been paved or developed? Have any farms, parks, or lots returned to a wild state? Write a summary of your interview. Can you classify any of the changes as examples of succession?

Lab zone **Skills Lab**
Guided Inquiry

S 6.5.b, 6.5.c, 6.7.h

Change in a Tiny Community

Materials


small baby-food jar


wax pencil


hay solution


pond water


plastic dropper

microscope slide

coverslip


microscope

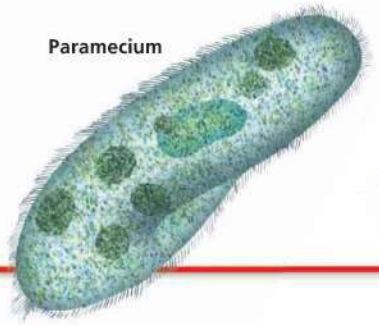
Problem How can you observe energy roles in a pond community?

Skills Focus observing, classifying

Procedure

1. Use a wax pencil to label a small jar with your name.
2. Fill the jar about three-fourths full with hay solution. Add pond water until the jar is nearly full. Examine the mixture and record your observations in your notebook.
3. Place the jar in a safe location out of direct sunlight where it will remain undisturbed. Always wash your hands thoroughly with soap after handling the jar or its contents.
4. After two days, examine the contents of the jar and record your observations.
5. Use a plastic dropper to collect a few drops from the surface of the solution in the jar. Make a slide following the procedures in the yellow box at the right. **CAUTION:** *Slides and coverslips are fragile, and their edges are sharp. Handle them carefully.*
6. Examine the slide under a microscope, using both low and high power and following the procedures in the box at the right. Draw each type of organism you observe. Estimate the number of each type in your sample. The illustration below shows some of the organisms you might see.
7. Repeat Steps 5 and 6 with a drop of solution taken from the side of the jar beneath the surface.
8. Repeat Steps 5 and 6 with a drop of solution taken from the bottom of the jar. When you are finished, follow your teacher's directions about cleaning up.
9. After 3 days, repeat Steps 5 through 8.
10. After 3 more days, repeat Steps 5 through 8 again. Then follow your teacher's directions for returning the solution.

Paramecium



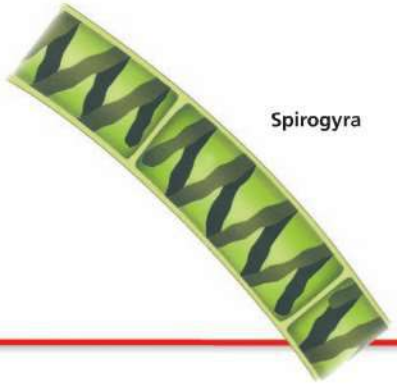
Daphnia

Analyze and Conclude

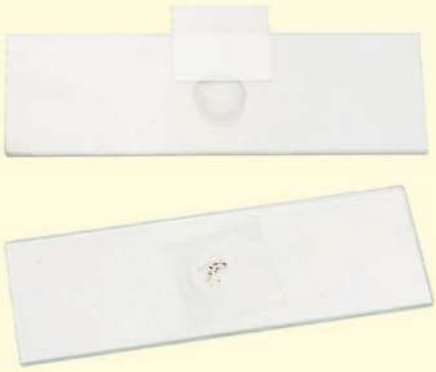
1. **Classifying** Identify as many of the organisms you observed as possible. Use the diagrams on the facing page and any other resources your teacher provides.
2. **Observing** Producers usually contain chlorophyll, a substance that helps them capture sunlight for photosynthesis. Chlorophyll makes an organism look green. Which organisms appear to be producers?
3. **Inferring** Which organisms appear to be consumers? Explain your answer.
4. **Observing** How did the community change over the period of time that you made your observations?
5. **Inferring** What biotic factors may have influenced the changes in this community? Explain.
6. **Communicating** Based on what you have observed in this lab, draw a simple food chain from this community.

More to Explore

Use library materials to research the organisms you observed in your sample of pond water. Based on your research, draw a food web showing how food energy is transferred from organism to organism in the pond community. Classify the organisms in your food web as producers and consumers (herbivores, omnivores, or carnivores).



Spirogyra



Making and Viewing a Slide

A. Place one drop of the solution to be examined in the middle of a microscope slide. Place one edge of a coverslip at the edge of the drop, as shown in the photo. Gently lower the coverslip over the drop. Try not to trap any air bubbles

B. Place the slide on the stage of a microscope so the drop is over the opening in the stage. Adjust the stage clips to hold the slide.

C. Look from the side of the microscope, and use the coarse adjustment knob to move the low-power objective close to, but not touching, the coverslip.

D. Look through the eyepiece and use the coarse adjustment knob to raise the body tube and bring the slide into view. Use the fine adjustment knob to bring the slide into focus.

E. To view the slide under high power, look from the side of the microscope and revolve the nosepiece until the high-power objective clicks into place just over, but not touching, the slide.

F. While you are looking through the eyepiece, use the fine adjustment knob to bring the slide into focus.

Chapter 10 Study Guide

The BIG Idea Organisms in ecosystems exchange energy and nutrients among themselves and with the environment.

1 Living Things and the Environment

Key Concepts S 6.5.e

- An organism obtains food, water, shelter, and other things it needs to live, grow, and reproduce from its environment.
- An organism interacts with both the living and nonliving parts of its habitat.
- The smallest unit of organization is a single organism, which belongs to a population of its species. The population belongs to a community of different species. The community and abiotic factors together form an ecosystem.

Key Terms

• organism • habitat • biotic factor
• abiotic factor • photosynthesis • species
• population • community • ecosystem
• ecology

2 Populations

Key Concepts S 6.5.e

- Populations can change in size when new members join the population or when members leave the population.
- Some limiting factors for populations are food and water, space, light, soil, and weather.

Key Terms

• birth rate • death rate • immigration
• emigration • limiting factor
• carrying capacity

3 Energy Flow in Ecosystems

Key Concepts S 6.5.a, c

- Each organism in an ecosystem fills the energy role of producer, consumer, or decomposer.
- The transfer of energy from organism to organism in an ecosystem can be shown in diagrams called food chains and food webs.
- The most energy is available at the producer level of an energy pyramid.

Key Terms

• producer • consumer • herbivore
• carnivore • omnivore • scavenger
• decomposer • food chain • food web
• energy pyramid

4 Interactions Among Living Things

Key Concepts S 6.5.c

- Every organism has a variety of adaptations that are suited to its specific living conditions.
- The major types of interactions among organisms are competition, predation, and symbiosis.
- The three types of symbiotic relationships are mutualism, commensalism, and parasitism.

Key Terms

• natural selection • adaptations • niche
• competition • predation • predator • prey
• symbiosis • mutualism • commensalism
• parasitism • parasite • host

5 Cycles of Matter

Key Concepts S 6.5.b

- The processes of evaporation, condensation, and precipitation make up the water cycle.
- In ecosystems, the processes by which carbon and oxygen are recycled are linked. Living things recycle carbon and oxygen.
- In the nitrogen cycle, nitrogen moves from the air to soil, to living things, and back to the air.

Key Term

• nitrogen fixation

6 Changes in Communities

Key Concept S 6.2.d; 6.5.e

- Unlike primary succession, secondary succession occurs in an existing ecosystem.

Key Terms

• succession • primary succession
• pioneer species • secondary succession

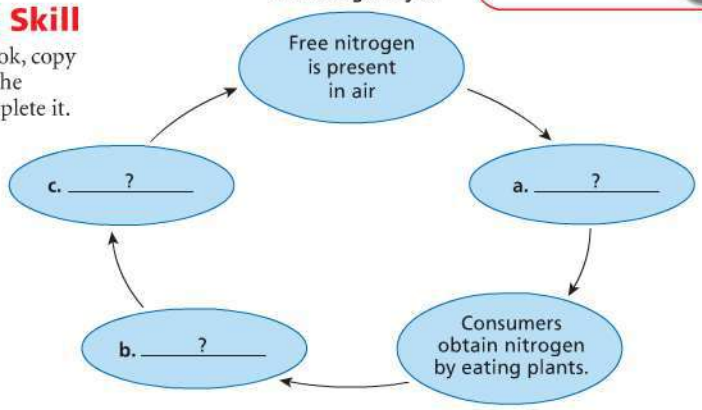
Review and Assessment

Go Online
PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cwa-4100

Target Reading Skill

Sequence In your notebook, copy the graphic organizer for the Nitrogen Cycle. Then complete it.

The Nitrogen Cycle



Reviewing Key Terms

Choose the letter of the best answer.

HINT
1. A prairie dog, a hawk, and a badger all are members of the same
   a. niche. b. community.
   c. species. d. population.

HINT
2. All of the following are examples of limiting factors for populations *except*
   a. space. b. food.
   c. time. d. weather.

HINT
3. In which type of interaction do both species benefit?
   a. predation b. mutualism
   c. commensalism d. parasitism

HINT
4. A diagram that shows how much energy is available at each feeding level in an ecosystem is a(n)
   a. food chain.
   b. food web.
   c. energy cycle.
   d. energy pyramid.

HINT
5. Which of these relationships is an example of parasitism?
   a. a bird building a nest on a tree branch
   b. a bat pollinating a saguaro cactus
   c. a flea living on a cat's blood
   d. ants protecting a tree that produces the ants' only food

Complete the following sentences so that your answers clearly explain the key terms.

HINT
6. You would expect to find an organism in its **habitat,** which is _____.

HINT
7. Any plants and animals in an organism's habitat are **biotic factors,** which are _____.

HINT
8. The flow of energy through an ecosystem can be shown in a **food web,** which is _____.

HINT
9. An organism's **niche,** or ecological role, can also be described as its _____.

HINT
10. One major type of interaction between organisms is **competition,** which is _____.

Writing in Science

Descriptive Paragraph Use what you have learned about predators and prey to write about an interaction between two organisms. For each organism, describe at least one adaptation that helps it either catch prey or fend off predators.

Video Assessment
Discovery Channel School
Populations and Communities

Review and Assessment

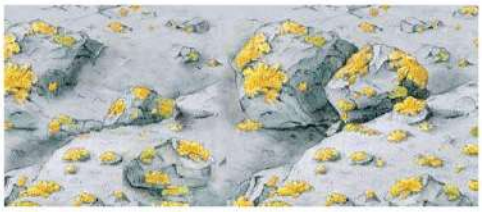
Checking Concepts

11. Name two biotic and two abiotic factors you might find in a forest ecosystem.
12. Explain how plants and algae use sunlight. How is this process important to other living things in an ecosystem?
13. Give an example showing how space can be a limiting factor for a population.
14. Describe two adaptations that prey organisms have developed to protect themselves. Tell how each adaptation protects the organism.
15. Name and describe each of the three energy roles organisms can play in an ecosystem.
16. How are food chains and food webs different?

Thinking Critically

17. **Classifying** Which organisms in the illustration at the right are producers? Consumers?

18. **Relating Cause and Effect** In the nitrogen cycle, how does free nitrogen become available for organisms to use?
19. **Inferring** What is the source of energy for most ecosystems? Explain.
20. **Classifying** Lichens and mosses have just begun to grow on the rocky area below. Which type of succession is occurring? Explain.

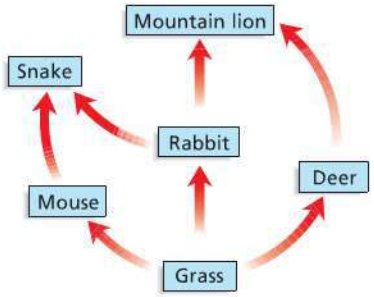


Math Practice

21. **Inequalities** Review the two inequalities about population size. Then revise each inequality to include immigration and emigration in addition to birth rate and death rate.

Applying Skills

Use the data in the food web below to answer Questions 22-25.



22. **Interpreting Diagrams** Which organism in this food web fills the role of producer?
23. **Classifying** Specify whether each consumer in this food web is a first-level, second-level, or third-level consumer.
24. **Inferring** Which level of the food web has the greatest amount of available energy?
25. **Predicting** If a disease were to kill most of the rabbits in this area, predict how the snakes, deer, and mountain lions would be affected?

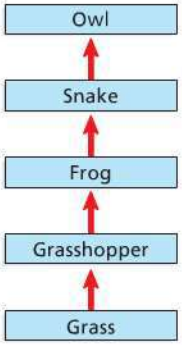
Lab zone Standards Investigation

Performance Assessment Review your report and graph to be sure that they clearly state your conclusion about the effects of crowding on plant growth. With your group, decide how you will present your results. After your presentation, list some improvements to your experimental plan.

Choose the letter of the best answer.

1. In the food chain shown in the diagram below, which of the following organisms obtains its energy directly from the frog?

A grass **B** grasshopper
C snake **D** owl



S 6.5.a

2. A freshwater lake has a muddy bottom, which is home to different types of algae and other organisms. Many species of fish feed on the algae. Which of the following is an abiotic factor in this ecosystem?

A the temperature of the water
B the color of the algae
C the number of species of fish
D the amount of food available to the fish

S 6.5.e

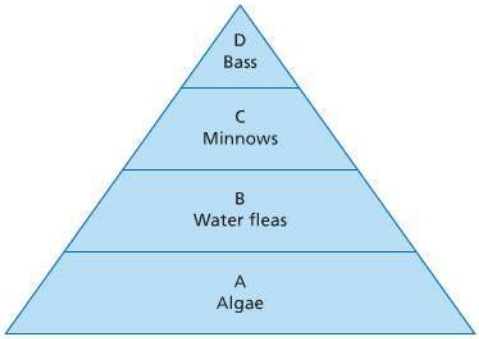
3. Although three different bird species all live in the same tree in an area, competition between the birds rarely occurs. The most likely explanation for this lack of competition is that these birds

A occupy different niches.
B eat the same food.
C have a limited supply of food.
D live in the same part of the trees. S 6.5.c

4. Which pair of terms could apply to the same organism?

A carnivore and producer
B omnivore and producer
C scavenger and herbivore
D carnivore and consumer S 6.5.c

Use the energy pyramid below and your to answer Questions 5 and 6.



5. Which organisms are the producers in this ecosystem?

A algae
B minnows
C water fleas
D bass S 6.5.c

6. At which level of this energy pyramid is the LEAST energy available?

A level A
B level B
C level C
D level D S 6.5.b

7. Which of the following events would most likely lead to primary succession?

A a hurricane
B a volcanic eruption
C a fire
D abandonment of a farm field S 6.2.d

Apply the BIG Idea

8. Describe the path of carbon as it travels through the carbon cycle. Begin with the atmosphere. Include the role of producers, consumers, and decomposers in the carbon cycle.

S 6.5.b