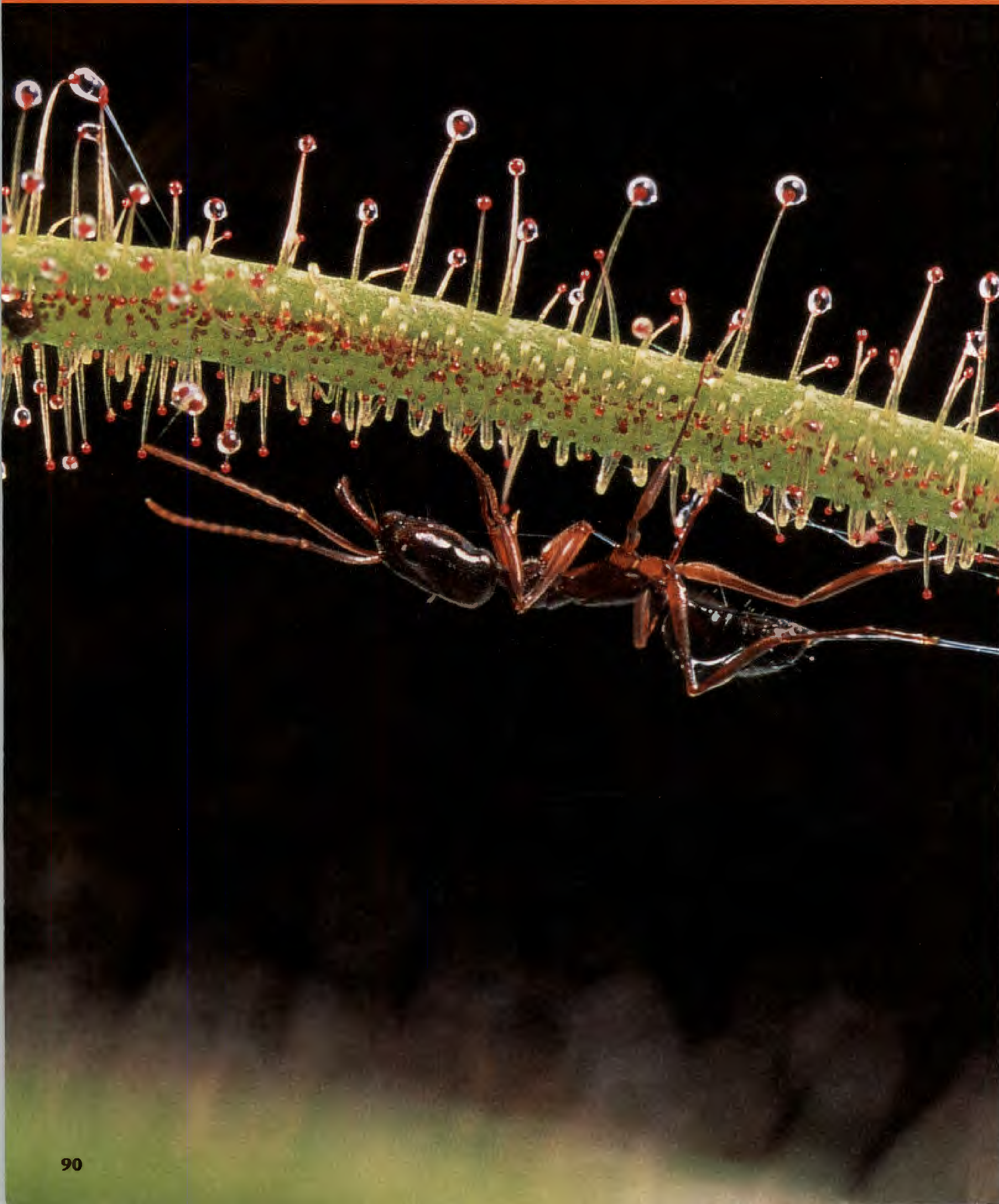
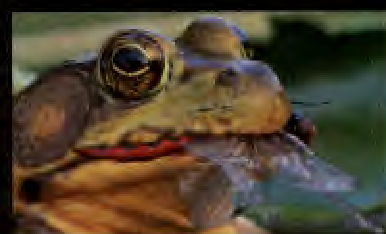
# ECOLOGY



# UNIT 2

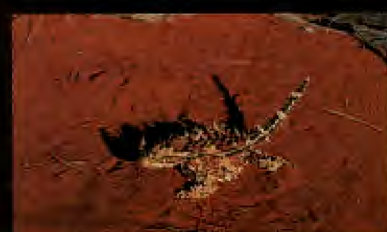
CHAPTER 4

## The Organization of Life



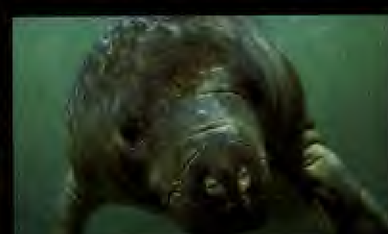
CHAPTER 5

## How Ecosystems Work



CHAPTER 6

## Biomes



CHAPTER 7

## Aquatic Ecosystems

This Australian plant called the *fork-leafed sundew* gets the nutrients that it needs to survive by dissolving insects that get stuck on its sticky tips.

# The Organization of Life

CHAPTER 4



## PRE-READING ACTIVITY

FOLDNOTES

**Layered Book** Before you read this chapter, create the **FoldNote** entitled "Layered Book" described in the Reading and Study Skills section of the Appendix. Label the tabs of the layered book with "Ecosystem," "Population," "Community," and "Habitat." As you read the chapter, write information you learn about each category under the appropriate flap.

A coral reef is an ecosystem that contains a wide variety of species. How many different species can you find in this photograph?

SECTION 1

# Ecosystems: Everything Is Connected

You may have heard the concept that in nature everything is connected. What does this mean? Consider the following example. In 1995, scientists interested in controlling gypsy moths, which kill oak trees, performed an experiment. The scientists removed most mice, which eat young gypsy moths, from selected plots of oak forest. The number of young gypsy moth eggs and young increased dramatically. The scientists then added acorns to the plots. Mice eat acorns. The number of mice soon increased, and the number of gypsy moths declined as the mice ate them as well.

This result showed that large acorn crops can suppress gypsy moth outbreaks. Interestingly, the acorns also attracted deer, which carried ticks. Young ticks soon infested the mice. Wild mice carry the organism that causes Lyme disease. Ticks can pick up the organism when they bite mice. Then the ticks can bite and infect humans. This example shows that in nature, things that we would never think were connected—mice, acorns, ticks, and humans—can be linked to each other in a complex web.

## Objectives

- Distinguish between the biotic and abiotic factors in an ecosystem.
- Describe how a population differs from a species.
- Explain how habitats are important for organisms.

## Key Terms

**ecosystem**
**biotic factor**
**abiotic factor**
**organism**
**species**
**population**
**community**
**habitat**

## Defining an Ecosystem

The mice, deer, moths, oak trees, and ticks in the previous example are all part of the same ecosystem. An **ecosystem** (EE koh SIS tuhm) is all of the organisms living in an area together with their physical environment. An oak forest is an ecosystem. The coral reef on the opposite page is an ecosystem. Even a vacant lot, as shown in **Figure 1**, is an ecosystem.

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**Figure 1** ▶ This vacant lot is actually a small ecosystem. It includes various organisms, including plants and insects, as well as soil, air, and sunlight.

**Figure 2** ▶ Like all ecosystems, this desert in France contains certain basic components. What components can you identify?

**Geofact**

**The Living Soil** Soil, which is part of nearly all ecosystems on land, is formed in part by living organisms, which break down dead leaves and organisms. Small, plantlike organisms even help break down rocks!

**Ecosystems Are Connected** People often think of ecosystems as isolated from each other, but ecosystems do not have clear boundaries. Things move from one ecosystem into another. Soil washes from a mountain into a lake, birds migrate from Michigan to Mexico, and pollen blows from a forest into a field.

**Figure 3** ▶ This caribou is a biotic factor in a cold, northern ecosystem in Denali National Park, Alaska.

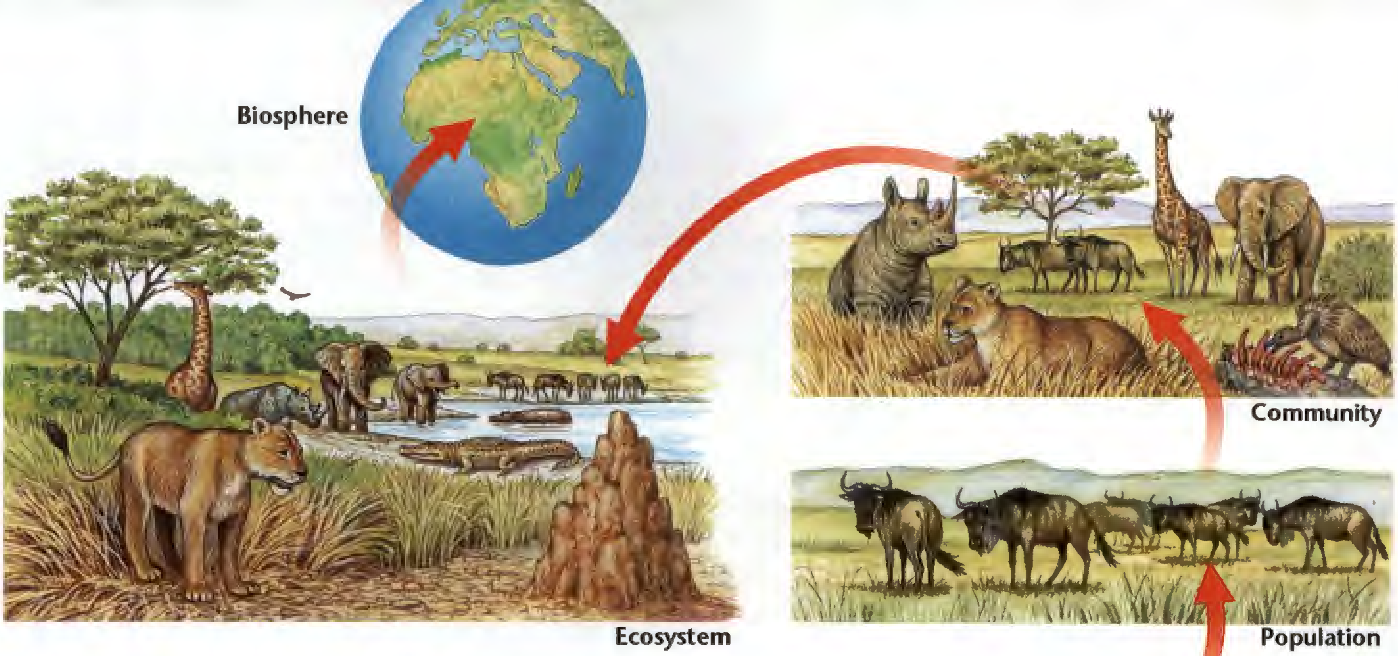
## The Components of an Ecosystem

In order to survive, ecosystems need five basic components. These are energy, mineral nutrients, water, oxygen, and living organisms. As shown in **Figure 2**, plants and rock are two of the most obvious components of most land ecosystems. The energy in most ecosystems comes from the sun.

To appreciate how all of the things in an ecosystem are connected, think about how a car works. The engine alone is made up of hundreds of parts that all work together. If even one part breaks, the car might not run. Likewise, if one part of an ecosystem is destroyed or changes, the entire system may be affected.

**Biotic and Abiotic Factors** An ecosystem is made up of both living and nonliving things. **Biotic factors** are the living and once living parts of an ecosystem, including all of the plants and animals. Biotic factors include dead organisms, dead parts of organisms, such as leaves, and the organisms' waste products. The biotic parts of an ecosystem interact with each other in various ways. They also interact with the **abiotic** (ay bie AHT ik) **factors,** the nonliving parts of the ecosystem. Abiotic factors include air, water, rocks, sand, light, and temperature. **Figure 3** shows several biotic and abiotic factors in an Alaskan ecosystem.

Scientists organize living things into various levels. **Figure 4** shows how an ecosystem fits into the organization of living things. The illustration shows the different levels of ecological organization, from the individual organism to the biosphere.





**Organisms** An organism is an individual living thing. You are an organism, as is an ant crawling across the floor, an ivy plant on the windowsill, and a bacterium in your intestines.

A species is a group of organisms that are closely related and that can mate to produce fertile offspring. All humans, for example, are members of the species *Homo sapiens*, while all black widow spiders are members of the species *Latrodectus mactans*. Every organism is a member of a species.

**Figure 4** ▶ An individual organism is part of a population, a community, an ecosystem, and the biosphere.

**Populations** Members of a species may not all live in the same place. Field mice in Maine and field mice in Florida will never interact even though they are members of the same species. An organism lives as part of a population. A population is all the members of the same species that live in the same place at the same time. For example, all the field mice in a corn field make up one population of field mice.

An important characteristic of a population is that its members usually breed with one another rather than with members of other populations. The bison in **Figure 5** (right) will usually mate with another member of the same herd, just as the wildflowers (left) will usually be pollinated by other flowers in the same field.

**Figure 5** ▶ The two populations shown here are a population of purple-flowered musk thistle (left) and a herd of bison (right).

**Communities** An organism does not live alone and neither does a population. Every population is part of a **community,** a group of various species that live in the same place and interact with each other. A pond community, for example, includes all of the populations of plants, fish, and insects that live in and around the pond. All of the living things in an ecosystem belong to one or more communities.

The most obvious difference between communities is the types of species they have. Land communities are often dominated by a few species of plants. In turn, these plants determine what other organisms live in that community. For example, the most obvious feature of a Colorado forest might be its ponderosa pine trees. This pine community will have animals, such as squirrels, that live in and feed on these trees.

**Figure 6 ▶** Salamanders, such as this red backed salamander, live in habitats that are moist and shaded.

## Habitat

The squirrel discussed above lives in a pine forest. All organisms live in particular places. The place an organism lives is called its **habitat.** A howler monkey's habitat is the rain forest, a cactus's habitat is a desert, and a waterlily's habitat is a pond. The salamander shown in **Figure 6** is in its natural habitat, the damp forest floor. An organism's habitat may be thought of as its "address."

Every habitat has specific characteristics that the organisms that live there need to survive. A coral reef contains sea water, coral, sunlight, and a wide variety of other organisms. If any of these factors change, then the habitat changes.

Organisms tend to be very well suited to their natural habitats. Indeed, animals and plants usually cannot survive for long periods of time away from their natural habitat. For example, a fish that lives in the crevices of a coral reef will die if the coral reef is destroyed.

## SECTION 1 Review

1. **List** the abiotic and biotic components you see in the northern ecosystem in Figure 3.
2. **Describe** a population not mentioned in this section.
3. **Describe** which factors of an ecosystem are not part of a community.
4. **Explain** the difference between a population and a species.

### CRITICAL THINKING

5. **Analyzing Relationships** Write your own definition of the term *community,* using the terms *biotic factors* and *abiotic factors.* WRITING SKILLS
6. **Understanding Concepts** Why might a scientist say that an animal is becoming rare because of habitat destruction?

SECTION 2
# Evolution

Organisms tend to be well suited to where they live and what they do. **Figure** 7 shows a chameleon (kuh MEEL ee uhn) capturing an insect. Insects are not easy to catch, so how does the chameleon do it? Chameleons can change the color and pattern of their skin, and then blend into their backgrounds. Their eyes are raised on little, mobile turrets that enable the lizards to look around without moving. An insect is unlikely to notice such an animal sitting motionless on a branch. When the insect moves within range, the chameleon shoots out an amazingly long tongue to grab the insect, while the chameleon's big hind feet hold it securely to the branch.

## Objectives

- Explain the process of evolution by natural selection.
- Explain the concept of adaptation.
- Describe the steps by which a population of insects becomes resistant to a pesticide.

## Key Terms

**natural selection**
**evolution**
**adaptation**
**artificial selection**
**resistance**

## Evolution by Natural Selection

How do organisms become so well suited to their environments? In 1859, English naturalist Charles Darwin proposed an answer. Darwin observed that organisms in a population differ slightly from each other in form, function, and behavior. Some of these differences are *hereditary* (huh RED i TER ee)—that is, passed from parent to offspring. Darwin proposed that the environment exerts a strong influence over which individuals survive to produce offspring. Some individuals, because of certain traits, are more likely to survive and reproduce than other individuals. Darwin used the term **natural selection** to describe the unequal survival and reproduction that results from the presence or absence of particular traits.

Darwin proposed that over many generations natural selection causes the characteristics of populations to change. A change in the genetic characteristics of a population from one generation to the next is known as **evolution.**

**Connection to Geology**

**Darwin and Fossils** In the 1800s, fossil hunting was a popular hobby. The many fossils that people found started arguments about where fossils came from. Darwin's theory of evolution proposed that fossils are the remains of extinct species from which modern species evolved. When his book on the theory of evolution was first published in 1859, it became an immediate bestseller.

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**Figure 7** ▶ A chameleon catches an unsuspecting insect that has strayed within range of the lizard's long, fast-moving tongue.

**Nature Selects** Darwin thought that nature selects for certain traits, such as sharper claws or lighter feathers, because organisms with these traits are more likely to survive and reproduce. Over time, the population includes a greater and greater proportion of organisms with the beneficial trait. As the populations of a given species change, so does the species. **Table 1** summarizes Darwin's

**Table 1** ▼

| Evolution by Natural Selection | |
|---|---|
| **1. Organisms produce more offspring than can survive.** | In nature, organisms have the ability to produce more offspring than can survive to become adults. |
| **2. The environment is hostile and contains limited resources.** | The environment contains things and situations that kill organisms, and the resources needed to live, such as food and water, are limited. |
| **3. Organisms differ in the traits they have.** | The organisms in a population may differ in size, coloration, resistance to disease, and so on. Much of this variation is inherited. |
| **4. Some inherited traits provide organisms with an advantage.** | Some inherited traits give organisms an advantage in coping with environmental challenges. These organisms are more likely to survive longer and produce more offspring; they are "naturally selected for." |
| **5. Each generation contains proportionately more organisms with advantageous traits.** | Because organisms with more advantageous traits have more offspring, each generation contains a greater proportion of offspring with these traits than the previous generation did. |

CASE STUDY

## Darwin's Finches

Before Charles Darwin formulated his theory of evolution, he sailed around the coast of South America. The plants and animals he saw had a great effect on his thinking about how modern organisms had originated. He was surprised by the organisms he saw on islands because they were often unusual species found nowhere else.

He was particularly impressed by the organisms in the Galápagos Islands, an isolated group of volcanic islands in the Pacific Ocean west of Ecuador. The islands contain 13 unique species of birds, which have become known as Darwin's finches. All the species look generally similar, but each species has a specialized bill adapted to eating a different type of food. Some species have large, parrotlike bills adapted to cracking big seeds, some species have slim bills that are used to sip nectar from flowers, and some species have even become insect eaters. Darwin speculated that all the Galápagos finches had evolved from a single species of seed-eating finch that found its way to the islands from the South American mainland. Populations of the finches became established on the various islands, and those finches were able to eat what they found on their island in order to survive.

▶ Notice the beaks in the two species of Darwin's finches. What do you think the finches eat?

Princeton University biologists Peter and Rosemary Grant have spent 25 years studying Darwin's finches on Daphne Major, one of the Galápagos Islands. Here, one theory of evolution by natural selection. An example of evolution is shown in **Figure 8**, in which a population of deer became isolated in a cold area. Many died, but some had genes for thicker, warmer fur. These deer were more likely to survive, and their young with thick fur were also more likely to survive to reproduce. The deer's thick fur is an **adaptation,** an inherited trait that increases an organism's chance of survival and reproduction in a certain environment.

**Figure 8** ▶ These steps show the evolution of thicker fur in a population of deer.


species, the medium ground finch, has a short, stubby beak and eats seeds as well as a few insects. The ground finches have few predators. The Grants found that the main factor that determined whether a finch lived or died was how much food was available. During a long drought in 1977, many plants died and the small seeds that the finches eat became scarce. Only finches that had large beaks survived. Large beaks allowed them to eat larger seeds from the larger plants that had survived the drought.

The finches that survived the drought passed their genes for large beaks to their offspring. Two years later, the Grants found that the beaks of medium ground finches on Daphne Major were nearly 4 percent larger, on average, than they were before the drought. The Grants had observed evolution occurring in birds over a short period of time, something that had seldom been seen before.

The Galápagos Islands are well suited for research on evolution because the islands are strongly influenced by El Niño and La Niña weather patterns.

These weather patterns produce alternating periods of very wet and dry weather in a relatively short period of time. The weather determines which plants live and which plants die. Then, this effect exerts selective pressure on the animals that depend on particular plants for food or for places to reproduce.

## CRITICAL THINKING

**1. Making Inferences** What is the shortest period in which a population of Darwin's finches can evolve?

**2. Analyzing Relationships** Would you expect that the finches that evolved bigger beaks in this study might one day evolve smaller beaks?

**Figure 9 ▶** This Hawaiian honey-creeper is using its curved beak to sip nectar from a lobelia flower.

**Coevolution** Organisms evolve adaptations to other organisms as well as to their physical environment. The process of two species evolving in response to long-term interactions with each other is called *coevolution* (koh EV uh LOO shuhn). One example is shown in **Figure 9.** The honeycreeper's beak is long and curved, which lets it reach the nectar at the base of the long, curved flower. The flower has evolved structures that ensure that the bird gets pollen from the flower on its head as it sips nectar. When the bird moves to another flower, some of the pollen will rub off. In this way, the bird helps lobelia plants reproduce. The honeycreeper's adaptation is a long, curved beak. The plant has two adaptations. One is sweet nectar, which attracts the birds. The other is a flower structure that forces pollen onto a bird's head when the bird sips nectar.

## Evolution by Artificial Selection

Many populations of plants and animals do not live in the wild but instead are cared for by humans. People control how these plants and animals reproduce and therefore how they evolve. The wolf and the Chihuahua in **Figure 10** are closely related. Over thousands of years, humans bred the ancestors of today's wolves to produce the variety of dog breeds we now have. The selective breeding of organisms by humans for specific characteristics is called **artificial selection.**

The fruits, grains, and vegetables we eat were also produced by artificial selection. Humans saved the seeds from the largest, sweetest fruits and most nutritious grains. By selecting for these traits, farmers directed the evolution of crop plants. As a result, crops produce fruits, grains, and roots that are larger, sweeter, and often more nutritious than their wild relatives do. Native Americans cultivated the ancestor of today's corn from a grasslike plant in the mountains of Mexico. Modern corn is very different from the wild plant that was its ancestor.

**MATHPRACTICE**

**Plumper Pumpkins**

Each year a farmer saves and plants only the seeds from his largest pumpkins. If he starts with pumpkins that average 5 kg and each year grows pumpkins 3 percent more massive, on average, than those he grew the year before, what will be the average mass of his pumpkins after 10 years?

**Figure 10 ▶** As a result of artificial selection, the Chihuahua on the right looks very different from its wolf ancestor on the left.


**Figure 11** ▶ The evolution of resistance to a pesticide starts when the pesticide is sprayed on the corn. Most of the insects are killed, but a few resistant ones survive. After each spraying, the insect population contains a larger proportion of resistant organisms.

## Evolution of Resistance

Sometimes humans cause populations of organisms to evolve unwanted adaptations. You may have heard about insect pests that are resistant to pesticides and about bacteria that are resistant to antibiotics. What is resistance, and what does it have to do with evolution?

**Resistance** is the ability of one or more organisms to tolerate a particular chemical designed to kill it. An organism may be resistant to a chemical when it contains a gene that allows it to break the chemical down into harmless substances. By trying to control pests and bacteria with chemicals, humans promote the evolution of resistant populations.

**Pesticide Resistance** Consider the evolution of pesticide resistance among corn pests, as shown in **Figure 11.** A pesticide is sprayed on corn to kill grasshoppers. Most of the grasshoppers die, but a few survive. The survivors happen to have a gene that protects them from the pesticide. The surviving insects pass on the gene to their offspring. Each time the corn is sprayed, the insect population changes to include more and more resistant members. After many sprayings, the entire population may be resistant, making the pesticide useless. The faster an organism reproduces, the faster its populations can evolve.

### FIELD ACTIVITY

**Artificial Selection** Look around your school grounds and the area around your home for possible examples of artificial selection. Observe and report on any examples you can find.

Dogs are one example of artificial selction mentioned in this chapter, but you will probably find many more plant examples. Record your observations in your ***EcoLog.***

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## SECTION 2 Review

1. **Explain** what an adaptation is, and provide three examples.
2. **Explain** the process of evolution by natural selection.
3. **Describe** one way in which artificial selection can benefit humans.
4. **Explain** how a population of insects could become resistant to a pesticide.

**CRITICAL THINKING**

5. **Understanding Concepts** Read the description of evolution by natural selection in this section and describe the role that the environment plays in the theory. READING SKILLS
6. **Identifying Relationships** A population of rabbits evolves thicker fur in response to a colder climate. Is this an example of coevolution? Explain your answer.

SECTION 3
# The Diversity of Living Things

## Objectives

- Name the six kingdoms of organisms and identify two characteristics of each.
- Explain the importance of bacteria and fungi in the environment.
- Describe the importance of protists in the ocean environment.
- Describe how angiosperms and animals depend on each other.
- Explain why insects are such successful animals.

## Key Terms

**bacteria**
**fungus**
**protist**
**gymnosperm**
**angiosperm**
**invertebrate**
**vertebrate**

Life on Earth is incredibly diverse. Take a walk in a park, and you will see trees, birds, insects, and maybe fish in a stream. All of these organisms are living, but they are all very different from one another. How do scientists organize this variety into categories they can understand?

Most scientists classify organisms into six *kingdoms*, as described in **Table 2,** based on different characteristics. Members of the six kingdoms get their food in different ways and are made up of different types of *cells,* the smallest unit of biological organization. The cells of animals, plants, fungi, and protists contain a *nucleus* (NOO klee uhs), which consists of a membrane that surrounds a cell's genetic material. A characteristic shared by bacteria, fungi, and plants is the *cell wall,* a structure that surrounds a cell and provides it with rigid support.

## Bacteria

**Bacteria** are microscopic, single-celled organisms that usually have cell walls and reproduce by dividing in half. Bacteria also lack nuclei, unlike all other organisms. Scientists have found two main kinds of bacteria, archaebacteria (AHR kee bak TIR ee uh) and eubacteria (YOO bak TIR ee uh). Most bacteria, including the kinds that cause disease and those found in garden soil, are eubacteria. Bacteria live in every habitat on Earth, from hot springs to the bodies of animals.

**Table 2 ▼**

**The Kingdoms of Life**

| Kingdom | Characteristics | Examples |
|---|---|---|
| Archaebacteria | single celled; lack cell nuclei; reproduce by dividing in half; found in harsh environments | methanogens (live in swamps and produce methane gas) and extreme thermophiles (live in hot springs) |
| Eubacteria | single celled; lack cell nuclei; reproduce by dividing in half; incredibly common | proteobacteria (common in soils and in animal intestines) and cyanobacteria (also called *blue-green algae*) |
| Fungi | absorb their food through their body surface; have cell walls; most live on land | yeasts, mushrooms, molds, mildews, and rusts |
| Protists | most single celled but some have many cells; most live in water | diatoms, dinoflagellates (red tide), amoeba, trypanosomes, paramecia, and *Euglena* |
| Plants | many cells; make their own food by photosynthesis; have cell walls | ferns, mosses, trees, herbs, and grasses |
| Animals | many cells; no cell walls; ingest their food; live on land and in water | corals, sponges, worms, insects, fish, reptiles, birds, and mammals |

**Bacteria and the Environment** Bacteria play many important roles in the environment. Some kinds of bacteria break down the remains and wastes of other organisms and return nutrients to the soil. Others recycle mineral nutrients, such as nitrogen and phosphorous. For example, certain kinds of bacteria play a very important role by converting nitrogen in the air into a form that plants can use. Nitrogen is important because it is a main component of proteins and genetic material.

Bacteria also allow many organisms, including humans, to extract certain nutrients from their food. The bacteria in **Figure 12** are *Escherichia coli,* or *E. coli,* a bacterium found in the intestines of humans and other animals. Here, *E. coli* helps digest food and release vitamins that humans need.

**Figure 12** ▶ The long, orange objects in the image above are *E. coli* bacteria as they appear under a microscope.

## Fungi

A **fungus** (plural, *fungi*) is an organism whose cells have nuclei, cell walls, and no chlorophyll (the pigment that makes plants green). Cell walls act like miniature skeletons that allow fungi, such as the mushrooms in **Figure 13**, to stand upright. A mushroom is the reproductive structure of a fungus. The rest of the fungus is an underground network of fibers. These fibers absorb food from decaying organisms in the soil.

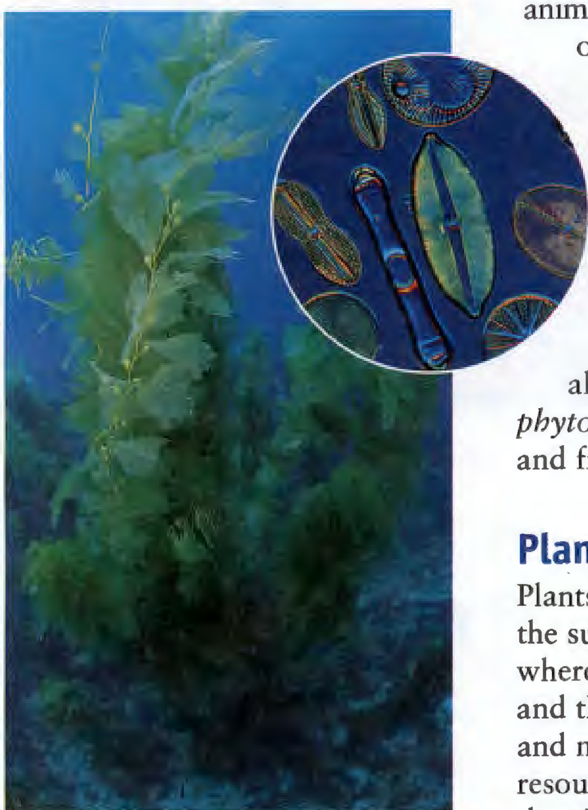
Indeed, all fungi absorb their food from their surroundings. Fungi get their food by releasing chemicals that help break down organic matter, and then absorbing the nutrients. The bodies of most fungi are a huge network of threads that grow through the soil, dead wood, or other material on which the fungi are feeding. Like bacteria, fungi play an important role in the environment by breaking down the bodies and body parts of dead organisms.

Like bacteria, some fungi cause diseases, such as athlete's foot. Other fungi add flavor to food. The fungus in blue cheese, shown in **Figure 13**, gives the cheese its strong flavor. And fungi called *yeasts* produce the gas that makes bread rise.

**Graphic Organizer** **Spider Map** Create the **Graphic Organizer** entitled "Spider Map" described in the Appendix. Label the circle "Kingdoms." Create a leg for each kingdom. Then, fill in the map with details about the organisms in each kingdom.

**Figure 13** ▶ A mushroom (left) is the reproductive structure of a fungus that lives in the soil. The cheese (above) gets its taste and its blue color from a fungus.

**Figure 14 ▶** Kelp (left) are huge protists with many cells that live attached to the ocean floor. The microscopic diatoms (right) are protists that live in the plankton.



## Protists

Most people have some idea what bacteria and fungi are, but few could define a protist. Protists are a diverse group of organisms that belong to the kingdom Protista. Some, such as amoebas, are animallike. Others, such as the kelp in **Figure 14,** are plantlike. Still others are more like fungi. Most protists are one-celled microscopic organisms. This group includes amoebas and *diatoms* (DIE uh TAHMS). Diatoms, shown in **Figure 14,** float on the ocean surface. The most infamous protist is *Plasmodium,* the one-celled organism that causes the disease malaria.

From an environmental standpoint, the most important protists are probably algae. Algae are plantlike protists that can make their own food using the sun's energy. Green pond "scum" and seaweed are examples of algae. They range in size from the giant kelp to the one-celled *phytoplankton,* which are the initial source of food in most ocean and freshwater ecosystems.

## Plants

Plants are many-celled organisms that make their own food using the sun's energy and have cell walls. Most plants live on land, where the resources a plant needs are separated between the air and the soil. Sunlight, oxygen, and carbon dioxide are in the air, and minerals and water are in the soil. Plants have roots that tap resources underground and leaves that intercept light and gases in the air. Leaves and roots are connected by *vascular tissue,* a system of tubes that carries water and food. Vascular tissue has thick cell walls, so a wheat plant or a tree is like a building supported by its plumbing.

**Lower Plants** The first land plants had no vascular tissue, and they also had swimming sperm. As a result, these early plants could not grow very large and had to live in damp places. Their descendants alive today are small plants such as mosses. Ferns and club mosses were the first vascular plants. Some of the first ferns were as large as small trees, and some of these tree ferns live in the tropics and in New Zealand today. Some examples of lower plants are shown in **Figure 15.**

**Connection to Physics**

**Cell Size** Every cell must exchange substances with its environment across its surface. The larger the cell, the smaller its surface is compared with its volume. So the larger the cell, the more slowly substances move from outside the cell to its interior. This relationship limits most cells to microscopic sizes.

**Figure 15 ▶** Lower plants, such as these mosses and ferns, live in damp places.

**Gymnosperms** Pine trees and other evergreens are common examples of gymnosperms (JIM noh SPUHRMZ). **Gymnosperms** are woody plants whose seeds are not enclosed in fruits. Gymnosperms such as pine trees are also called *conifers* because they bear cones, as shown in **Figure 16.**

Gymnosperms have several adaptations that allow them to live in drier conditions than lower plants can. Gymnosperms produce *pollen,* which protects and moves sperm between plants. These plants also produce *seeds,* which protect developing plants from drying out. And a conifer's needle-like leaves lose little water. Much of our lumber and paper comes from gymnosperms.

**Angiosperms** Most land plants today are **angiosperms** (AN jee oh SPUHRMZ), flowering plants that produce seeds in fruit. All of the plants in **Figure 17** are angiosperms. The flower is the reproductive structure of the plant. Some angiosperms, such as grasses, have small flowers that produce pollen that is carried by the wind. Other angiosperms have large flowers that attract insects or birds to carry their pollen to other plants. Many flowering plants depend on animals to disperse their seeds and carry their pollen. For example, a bird that eats a fruit will drop the seeds elsewhere, where they may grow into new plants.

Most land animals are dependent on flowering plants. Most of the food we eat, such as wheat, rice, beans, oranges, and lettuce, comes from flowering plants. Building materials and fibers, such as oak and cotton, also come from flowering plants.

**Figure 16 ▶** This gymnosperm has male and female reproductive structures called *cones.*

## QuickLAB

### Pollen and Flower Diversity

**Procedure**

1. Use a **cotton swab** to collect pollen from a common **flowering plant.**
2. Tap the cotton swab on a **microscope slide** and cover the slide with a **cover slip.**
3. Examine the slide under a **microscope**, and draw the pollen grains in your ***EcoLog.***
4. Repeat this exercise with a **grass plant in bloom.**

**Analysis**

1. Based on the structure of the flower and the pollen grains, explain which plant is pollinated by insects and which is pollinated by wind.

**Figure 17 ▶** This meadow contains a wide array of angiosperms, including grasses, trees, and wildflowers.

## Animals

Animals cannot make their own food like plants can. They have to take in food from their environment. In addition, animal cells have no cell walls, so animals' bodies are soft and flexible. Some animals have evolved hard skeletons against which their muscles can pull to move the body. As a result, animals are much more mobile than plants and all animals move around in their environments during at least one stage in their lives.

**Invertebrates** Animals that lack backbones are **invertebrates** (in VUHR tuh brits). Many invertebrates live attached to hard surfaces in the ocean and filter their food out of the water. These organisms move around only when they are larvae. At this early stage of life, they are part of the ocean's plankton. Filter feeders include corals, various worms, and mollusks such as clams and oysters. **Figure 18** shows a variety of invertebrates. Other invertebrates, including squid in the ocean and insects on land, move around actively in search of food.

More insects exist on Earth than any other type of animal. They are successful for several reasons. Insects have a waterproof external skeleton, they move quickly, and they reproduce quickly. Also, most insects can fly. Their small size allows them to live on little food and to hide from enemies in small spaces, such as a seed or in the hair of a mammal.

Many insects and plants have evolved together and depend on each other to survive. Insects carry pollen from male parts of flowers to fertilize a plant's egg, which develops into a fruit. Without insect pollinators, we would not have tomatoes, cucumbers, apples, and many other crops. Insects are also valuable because they eat other insects that we consider to be pests. But, humans and insects are often enemies. Bloodsucking insects transmit human diseases, such as malaria, sleeping sickness, and West Nile virus. Insects probably do more damage indirectly, however, by eating our crops.

### MATHPRACTICE

**Insect Survival** Most invertebrates produce large numbers of offspring. Most of these offspring die before reaching adulthood. Suppose an insect lays 80 eggs on a plant. If 70 percent of the eggs hatch and 80 percent of those that hatch die before reaching adulthood, how many insects will reach adulthood?



**Figure 18** ▶ Examples of invertebrates include a banana slug (left), a leaf-footed bug (middle), and a cuttlefish (right).

**Figure 19 ▶** Examples of vertebrates include the toco toucan (left), the blue-spotted stingray (middle), and the snow leopard (right).

**Vertebrates** Animals that have backbones are called **vertebrates.** Members of three vertebrate groups are shown in **Figure 19.** The first vertebrates were fish, but today most vertebrates live on land. Amphibians, which include toads, frogs, and salamanders, are partially aquatic. Nearly all amphibians must return to water to lay their eggs.

The first land vertebrates were the reptiles, which today include turtles, lizards, snakes, and crocodiles. These animals were successful because they have an almost waterproof egg, which allows the egg to hatch on land, away from predators in the water.

Birds are warm-blooded vertebrates with feathers. Bird eggs have hard shells. Adult birds keep their eggs and young warm until they develop insulating layers of fat and feathers. *Mammals* are warm-blooded vertebrates that have fur and feed their young milk. The ability to maintain a high body temperature allows birds and mammals to live in cold areas, where other animals cannot survive.

**Ecofact**

**Conserving Water** Arthropods and vertebrates are the only two groups of animals that have adaptations that prevent dehydration so effectively that some of them can move about freely on land on a dry, sunny day.

## SECTION 3 Review

1. **Describe** how animals and angiosperms depend on each other. Write a short paragraph to explain your answer. WRITING SKILLS
2. **Describe** the importance of protists in the ocean.
3. **Name** the six kingdoms of life, and give two characteristics of each.
4. **Explain** the importance of bacteria and fungi in the environment.

### CRITICAL THINKING

5. **Analyzing Relationships** Explain how the large number and wide distribution of angiosperm species is related to the success of insects.
6. **Understanding Concepts** Write a short paragraph that compares the reproductive structures of gymnosperms and angiosperms. WRITING SKILLS

CHAPTER 4

# Highlights

## 1 Ecosystems: Everything Is Connected

### Key Terms

ecosystem, 93
biotic factor, 94
abiotic factor, 94
organism, 95
species, 95
population, 95
community, 96
habitat, 96

### Main Ideas

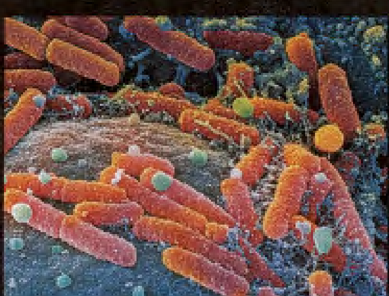
- Ecosystems are composed of many interconnected parts that often interact in complex ways.
- An ecosystem is the community of all the different organisms living in an area and their physical environment.
- An ecosystem contains biotic (living) and abiotic (nonliving) components.
- Organisms live as populations of one species in communities with other species. Each species has its own habitat, or type of place that it lives.

## 2 Evolution

natural selection, 97
evolution, 97
adaptation, 99
artificial selection, 100
resistance, 101

- The naturalist Charles Darwin used the term natural selection to describe the unequal survival and reproduction that results from the presence or absence of particular traits.
- Darwin proposed that natural selection is responsible for evolution—a change in the genetic characteristics of a population from one generation to the next.
- By selecting which domesticated animals and plants breed, humans cause evolution by artificial selection.
- We have unintentionally selected for pests that are resistant to pesticides and for bacteria that are resistant to antibiotics.

## 3 The Diversity of Living Things



bacteria, 102
fungus, 103
protist, 104
gymnosperm, 105
angiosperm, 105
invertebrate, 106
vertebrate, 107

- Organisms can be divided into six kingdoms, which are distinguished by the types of cells they possess and how they obtain their food.
- Bacteria and fungi play the important environmental roles of breaking down dead organisms and recycling nutrients.
- Gymnosperms are evergreen plants, many of which bear cones, while angiosperms produce flowers and bear seeds in fruit.
- Insects, invertebrates that are the most successful animals on Earth, affect humans in both positive and negative ways.
- Vertebrates, or animals with backbones, include fish, amphibians, reptiles, birds, and mammals.

# CHAPTER 4 Review

## Using Key Terms

Use each of the following terms in a separate sentence.

1. *adaptation*
2. *invertebrate*
3. *abiotic factor*
4. *habitat*
5. *species*

For each pair of terms, explain how the meanings of the terms differ.

6. *community* and *population*
7. *evolution* and *natural selection*
8. *gymnosperm* and *angiosperm*
9. *bacteria* and *protists*

**STUDY TIP**

**Make an Outline** After reading each section, summarize the main ideas into a short outline, leaving space between each entry. Then write the key terms under the subsection in which they are introduced, followed by a short definition for each.

## Understanding Key Ideas

10. Which of the following pairs of organisms belong to the same population?
    a. a dog and a cat
    b. a marigold and a geranium
    c. a human mother and her child
    d. a spider and a cockroach
11. Which of these phrases does *not* describe part of the process of evolution by natural selection?
    a. the environment contains limited resources
    b. organisms produce more offspring than will survive to reproduce
    c. communities include populations of several species
    d. organisms in a population differ in their traits
12. Which of the following components of an ecosystem are *not* abiotic factors?
    a. wind
    b. small rocks
    c. sunlight
    d. tree branches
13. Some snakes produce a powerful poison that paralyzes their prey. This poison is an example of
    a. coevolution.
    b. an adaptation.
    c. a reptile.
    d. a biotic factor.
14. Angiosperms called roses come in a variety of shapes and colors as a result of
    a. natural selection.
    b. coevolution.
    c. different ecosystems.
    d. artificial selection.
15. Single-celled organisms that live in swamps and produce methane gas are
    a. protists.
    b. archaebacteria.
    c. fungi.
    d. eubacteria.
16. Which of the following statements about protists is *not* true?
    a. Most of them live in water.
    b. Some of them cause diseases in humans.
    c. They contain genetic material.
    d. Their cells have no nucleus.
17. Which of the following statements about plants is *not* true?
    a. They make their food from carbon dioxide and water through photosynthesis.
    b. Land plants have cell walls that help hold their stems upright.
    c. They have adaptations that help prevent water loss.
    d. Plants absorb food through their roots.

# CHAPTER 4 Review

## Short Answer

**18.** List the five components that an ecosystem must contain to survive indefinitely.

**19.** What is the difference between biotic and abiotic factors in an ecosystem?

**20.** What is the difference between adaptation and evolution?

**21.** Describe the three steps by which a population of insects becomes resistant to a pesticide.

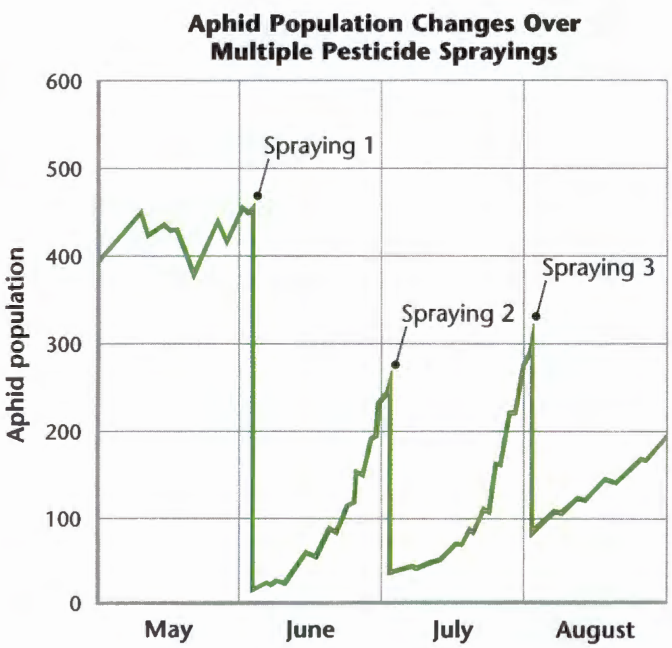
**22.** List the six kingdoms of organisms and the characteristics of each kingdom.

## Interpreting Graphics

Below is a graph that shows the number of aphids on a rose bush during one summer. The roses were sprayed with a pesticide three times, as shown. Use the graph below to answer questions 23 and 24.

**23.** What evidence is there that the pesticide killed aphids?

**24.** Aphids have a generation time of about 10 days. Is there any evidence that the aphids evolved resistance to the pesticide during the summer? Explain your answer.




## Concept Mapping

**25.** Use the following terms to create a concept map: *ecosystem, abiotic factor, biotic factor, population, species, community,* and *habitat.*

## Critical Thinking

**26. Analyzing Ideas** Can a person evolve? Read the description of evolution in this chapter and explain why or why not. READING SKILLS

**27. Making Inferences** A scientist applies a strong fungicide, a chemical that kills fungi, to an area of forest soil every week during October and November. How might this area look different from the surrounding ground at the end of the experiment?

**28. Drawing Conclusions** In what building in your community do you think bacteria are evolving resistance to antibiotics most rapidly? Explain your answer.

**29. Evaluating Assumptions** Many people assume that the human population is no longer evolving. Do you think these people are right? Explain your answer.

## Cross-Disciplinary Connection

**30. Geography** Find out how the isolation of populations on islands has affected their evolution. Research a well-known example, such as the animals and plants of Madagascar, the Galápagos Islands, and the Hawaiian Islands. Write a short report on your findings. WRITING SKILLS

## Portfolio Project

**31. Study an Ecosystem** Observe an ecosystem near you, such as a pond or a field. Identify biotic and abiotic factors and as many populations of organisms as you can. Do not try to identify the organisms precisely. Just list them, for example, as spiders, ants, grass, not as a specific type. Make a poster showing the different populations. Put the organisms into columns to show which of the kingdoms they belong to.

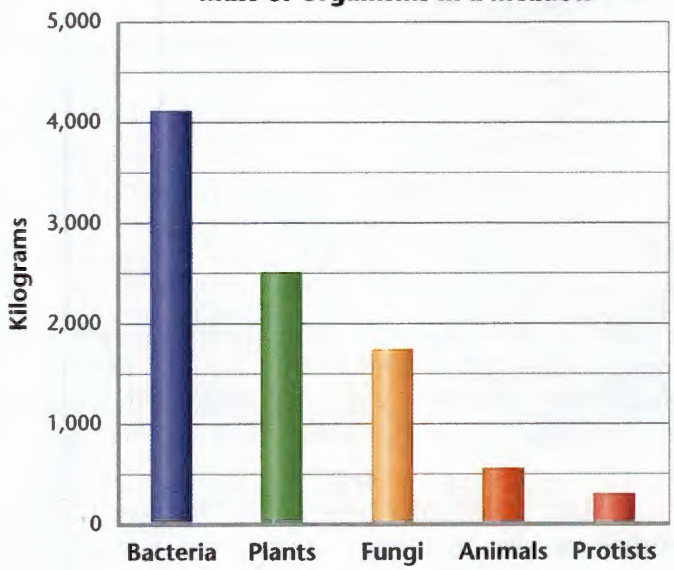
## MATH SKILLS

Use the graph below to answer questions 32–33.

32. **Analyzing Data** The graph below shows the mass of different types of organisms found in a meadow. How much greater is the mass of the plants than that of the animals?

33. **Analyzing Data** What is the ratio of the mass of the bacteria to the mass of the fungi?

**Mass of Organisms in a Meadow**




## WRITING SKILLS

34. **Communicating Main Ideas** Why is evolution considered to be such an important idea in biology?

35. **Outlining Topics** Outline the essential steps in the evolution of pesticide resistance in insects.

## STANDARDIZED TEST PREP

For extra practice with questions formatted to represent the standardized test you may be asked to take at the end of your school year, turn to the sample test for this chapter in the Appendix.

## READING SKILLS

**Read the passage below, and then answer the questions that follow.**

Some Central American acacia trees, called *ant acacias*, have a mutually beneficial relationship with ants that live on them. The trees have several structures that benefit the ants. The trees have hollow thorns in which the ants live, glands that produce sugary nectar, and swollen leaf tips, which the ants remove and feed to their larvae.

The ants reduce the damage that other organisms do to the tree. They remove dust, fungus spores, and spider webs. They destroy seedlings of other plants that sprout under the tree, so that the tree can obtain water and nutrients without competition from other plants. The ants sting animals that try to eat the tree.

Proof that the ants are valuable to the acacia tree comes from studies in which the ants are removed. Fungi invade the tree, it is eaten by herbivores, and it grows more slowly. When ants are removed from the tree, it usually dies in a few months.

1. According to the passage, which of the following statements is not true?
   - **a.** Ants and ant acacias have evolved a relationship beneficial to both of them.
   - **b.** The ants prevent fungi from growing on the acacia.
   - **c.** The tree would benefit from not having ants.
   - **d.** The ants benefit from living on the tree.

2. What is the advantage to an acacia of not having other plants grow nearby?
   - **a.** Ants cannot crawl onto the acacia from the other plants.
   - **b.** The acacia keeps more ants for itself.
   - **c.** This reduces competition for water and nutrients.
   - **d.** This reduces competition for fungi.

CHAPTER 4

# Inquiry Lab: DESIGN YOUR OWN

## Objectives

- USING SCIENTIFIC METHODS **Observe** the behavior of brine shrimp.
- USING SCIENTIFIC METHODS **Identify** a variable, and design an experiment to test the effect of the variable on habitat selection by brine shrimp.

## Materials

**aluminum foil**
**brine shrimp culture**
**corks sized to fit tubing**
**Detain™ or methyl cellulose**
**fluorescent lamp or grow light**
**funnel**
**graduated cylinder or beaker**
**hot-water bag**
**ice bag**
**metric ruler**
**Petri dish**
**pipet**
**plastic tubing, 40cm × 1cm, clear, flexible**
**screen, pieces**
**screw clamps**
**tape**
**test-tube rack**
**test tubes with stoppers**

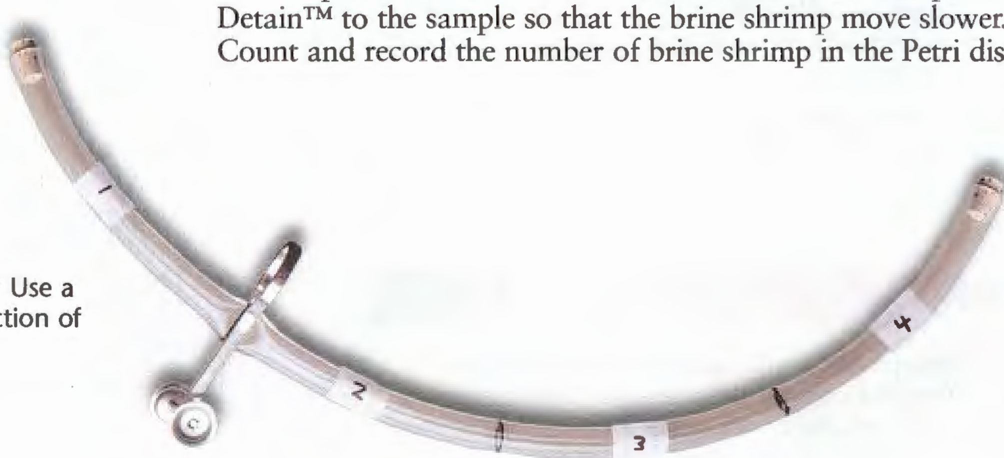
## How Do Brine Shrimp Select a Habitat?

Different organisms are adapted for life in different habitats. For example, brine shrimp are small crustaceans that live in saltwater lakes. Organisms select habitats that provide the conditions, such as a specific temperature range and amount of light, to which they are best adapted. In this investigation, you will explore habitat selection by brine shrimp and determine which environmental conditions they prefer.

## Procedure

### Establish a Control Group

1. To make a test chamber and to establish a control group, divide a piece of plastic tubing into four sections by making a mark at 10 cm, 20 cm, and 30 cm from one end. Label the sections "1", "2", "3", and "4".
2. Place a cork in one end of the tubing. Then transfer 50 mL of brine shrimp culture to the tubing. Place a cork in the other end of the tubing. Set the tube aside, and let the brine shrimp move about the tube for 30 min.
3. After 30 min, divide the tubing into four sections by placing a screw clamp at each mark on the tubing. While someone in your group holds the corks firmly in place, tighten the middle clamp at 20 cm and then tighten the other two clamps.
4. Remove the cork from the end of section 1 and pour the contents of section 1 into a test tube labeled "1." Repeat this step for the other sections by loosening the screw clamps and pouring the contents of each section into their corresponding test tubes.
5. To get an accurate count for the number of brine shrimp in each test tube, place a stopper on test tube 1, and invert the tube gently to distribute the shrimp. Use a pipet to transfer a 1 mL sample of the culture to a Petri dish. Add a few drops of Detain™ to the sample so that the brine shrimp move slower. Count and record the number of brine shrimp in the Petri dish.




▶ **Making a Test Chamber** Use a screw clamp to divide one section of tubing from another.

6. Empty the Petri dish, and take two more 1 mL samples of brine shrimp from test tube 1. Calculate the average of the three samples recorded for test tube 1.
7. Repeat steps 5 and 6 for each of the remaining test tubes to count the number of brine shrimp in each section of tubing.

### Ask a Question

8. Write a question you would like to explore about brine shrimp habitat selection. For example, you can explore how temperature or light affects brine shrimp. To explore the question, design an experiment that uses the materials listed for this lab.
9. Write a procedure and a list of safety precautions for your group's experiment. Have your teacher approve your procedure and precautions before you begin the experiment.
10. Set up and conduct your group's experiment.

▶ **Brine Shrimp** These crustaceans have specific habitat preferences.

## Analysis

1. **Constructing Graphs** Make a bar graph of your data. Plot the environmental variable on the *x*-axis and the number of brine shrimp on the *y*-axis.
2. **Evaluating Results** How did the brine shrimp react to changes in the environment?
3. **Evaluating Methods** Why did you have to have a control in your experiment?
4. **Evaluating Methods** Why did you record the average of three samples to count the number of brine shrimp in each test tube in step 6?

## Conclusions

5. **Drawing Conclusions** What can you conclude from your results about the types of habitat that brine shrimp prefer?

### Extension

1. **Formulating Hypotheses** Now that you have observed brine shrimp, write a hypothesis about how brine shrimp select a habitat that could be explored with another experiment, other than the one you performed in this lab. Formulate a prediction based on your hypothesis.
2. **Evaluating Hypotheses** Conduct an experiment to test your prediction. Write a short explanation of your results. Did your results support your prediction? Explain your answer.

# Making a difference

## BUTTERFLY ECOLOGIST

Imagine millions of butterflies swirling through the air like autumn leaves, clinging in tightly packed masses to tree trunks and branches, and covering low-lying forest vegetation like a luxurious, moving carpet. According to Alfonso Alonso-Mejía, this is quite a sight to see.

Every winter Alfonso climbs up to the few remote sites in central Mexico where about 150 million monarch butterflies spend the winter. He is researching the monarchs because he wants to help preserve their habitat and the butterflies themselves. His work helped him earn a Ph.D. in ecology from the University of Florida.

Monarchs are famous for their long-distance migration. The butterflies that eventually find their way to Mexico come from as far away as the northeastern United States and southern Canada. Some of them travel an amazing 3,200 km before reaching central Mexico.

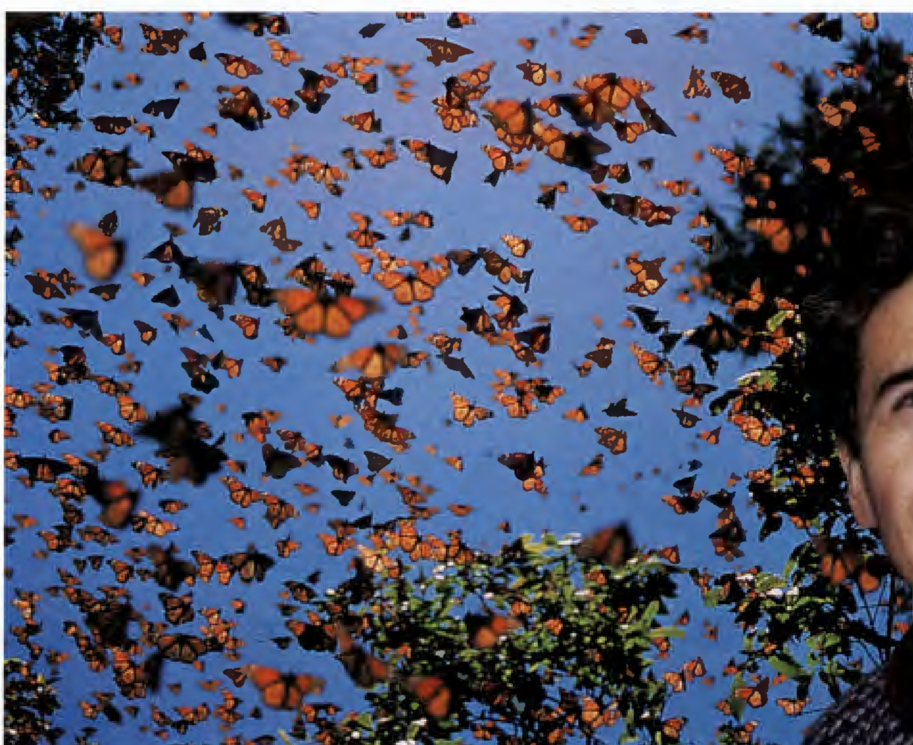
### Wintering Habitat at Risk

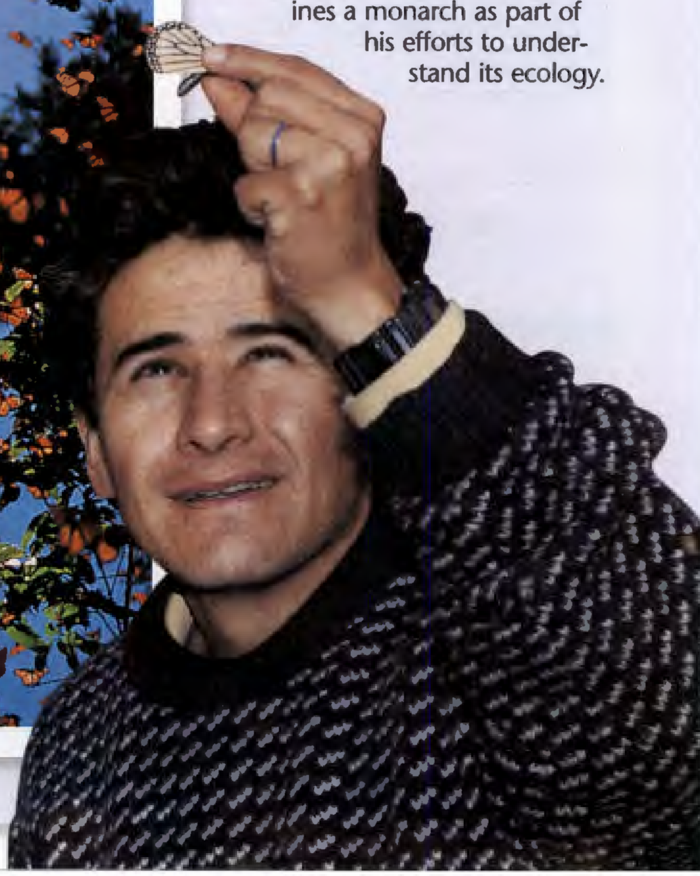
Unfortunately, the habitat that the monarchs travel long distances to reach is increasingly threatened by logging and other human activities. Only 9 to 11 of the monarchs' wintering sites remain (monarchs colonize more sites in some years than in others). Five of those sites are set aside as sanctuaries for the butterflies, but even these sanctuaries are endangered by people who cut down fir trees for firewood or for commercial purposes.

Alfonso's work is helping Mexican conservationists better understand and protect monarch butterflies. Especially important is Alfonso's discovery that monarchs depend on bushlike vegetation, called *understory vegetation,* that grows beneath the fir trees.

### Keeping Warm

Alfonso's research showed that when the temperature falls below freezing, as it often does in the mountains where the monarchs winter, understory vegetation can mean the difference between life and death for some monarchs. These conditions are life threatening to monarchs because low temperatures (–1°C to 4°C, or 30°F to 40°F) limit their movement. In fact, the butterflies are not even able to fly at such low temperatures. At extremely cold temperatures (–7°C to –1°C, or 20°F to 30°F), monarchs resting on the forest floor are in danger of freezing to death. But if the forest has understory vegetation, the monarchs can slowly climb the vegetation until they are at least 10 cm above the ground. This tiny difference in elevation can provide a microclimate that is warm enough to ensure the monarchs' survival.





▶ **Butterfly Man** Alfonso examines a monarch as part of his efforts to understand its ecology.


▶ **Monarch Sanctuaries** Monarch butterflies spend the winter at forested sites just above Mexico City.

The importance of understory vegetation was not known before Alfonso did his research. Now, thanks to Alfonso's work, Mexican conservationists will better protect the understory vegetation. And the Mexican government has passed a new decree that protects monarchs in areas the butterflies are known to use.

### The Need for Conservation

Although the monarchs continue to enjoy the forests where they overwinter, those forests are still threatened. There is little forest left in this area, and the need for wood increases each year. Alfonso hopes his efforts will help protect the monarch both now and in the future.

Now that he has completed his Ph.D., Alfonso is devoting himself to preserving monarchs and other organisms. He works as director for conservation and development for the Smithsonian Institutions Monitoring and Assessment of Biodiversity (MAB) program.

▶ **A Sea of Orange** At their overwintering sites in Mexico, millions of monarchs cover trees and bushes in a fluttering carpet of orange and black.

### Information...

If you are interested in learning more about monarchs, including their spectacular migration, visit the Website for Monarch Watch. Monarch Watch is an organization based at the University of Kansas that is dedicated to educating people about the monarch and promoting its conservation.

### What Do You Think?

As a migrating species, monarchs spend part of their lives in the United States and part in Mexico. Should the U.S. and Mexico cooperate in their efforts to understand and manage the monarch? Should nations set up panels to manage other migrating species, such as many songbirds?