Overview
Tell students that this chapter introduces the concept of ecosystems. In ecosystems, the biotic (living) and abiotic (non-living) components interact to form an interconnected system. Species adapt to their environment through the process of evolution by natural selection. The six-kingdom system of organization helps scientists to classify organisms and study their differences.

Using the Figure — General
In a coral reef ecosystem, reef-building coral combine with algae to produce a colony that gathers energy from the sun, and creates shelter for many organisms. Ask students to identify ways that this ecosystem is organized and to identify some of the possible interactions between organisms in the photo. (sponges grow on coral, animals hide in coral, water provides nutrients) Animals that use coral reefs include sponges, sea worms, crustaceans, mollusks, sea urchins, jellyfish, turtles, sea anemones, and many varieties of fish. Unfortunately, coral reefs are very sensitive to changing environmental conditions, and pollution, fishing, and boating can damage coral reef ecosystems.

Pre-reading Activity
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.

Chapter Correlations
National Science Education Standards
LS 4c Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years. (Section 1)
LS 3a Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring. (Section 2)
LS 3b The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms. (Section 2 and Section 3)
LS 3e Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification. (Section 3)
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 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 carry parasitic insects called 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 are connected—mice, acorns, ticks, and a human disease—can be linked to each other in a complex web.

**Defining an Ecosystem**

The mice, moths, oak trees, deer, and ticks in the previous example are all part of the same ecosystem. An **ecosystem** (EE koh sys 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.

![Figure 1](image-url) This vacant lot is actually a small ecosystem. It includes various organisms, including plants and insects, as well as soil, air, and sunlight.

**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

**REAL-LIFE CONNECTION**

**Complex Systems** Use the following example to illustrate the complexity and interconnectedness of the components within an ecosystem. In San Diego, California, a marsh habitat, home to two endangered bird species, was destroyed to build a freeway. To get a permit to build the freeway, the city had to agree to “rebuild” the ecosystem for the birds. After five years and $500,000, scientists and officials found that replacing an ecosystem is something that we do not know much about.

For example, when the endangered birds were released into their re-created ecosystem, they would not nest because the marsh grass was not tall enough. The grass was shorter because a tiny predator beetle that fed on marsh-grass-eating insects was not present in the new ecosystem. Without the beetle to control the insect population, the marsh grass could not grow to its full height. This was only one of many problems that the city faced in its ecosystem re-creation project.
Bring in some magazines that have photos of natural systems. Pick out three pictures that represent different ecosystems. Show each picture to the class, and have them brainstorm all the components of each ecosystem. Write the components of each system in its own section on the board. After the class is finished naming the components, compare the systems. Identify the components that are common to all systems. Discuss why some of the components are needed in all ecosystems.

**Activity**

**Ecosystem Connections** In this exercise, students will learn how forest and stream ecosystems are linked. Bring in some pre-assembled wooden frames and some window screen. Have students staple the screen to the frames to form a frame that will catch and hold leaves. Take these materials out to a stream area with trees next to it. (Make sure the area is somewhat isolated, so the materials are not disturbed.) Have students tie the screens to vegetation that is close to the stream edge. Tell them to try to keep the screens flat. Also have them attach a note to the screens identifying them as a science project. Take students out to the stream every week to collect any material that has been caught in the screens. Have students bring the material back to the classroom to identify and weigh it.

**Teach**

**Demonstration**

**Identifying Ecosystem Components** Bring in some magazines that have photos of natural systems. Pick out three pictures that represent different ecosystems. Show each picture to the class, and have them brainstorm all the components of each ecosystem. Write the components of each system in its own section on the board. After the class is finished naming the components, compare the systems. Identify the components that are common to all systems. Discuss why some of the components are needed in all ecosystems.

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**Answer to Reading Check**

Biotic factors are the living or once-living parts of an ecosystem. Abiotic factors are the nonliving parts of an ecosystem.

**Notable Quotes**

“...when we try to pick out anything by itself, we find it hitched to everything else in the universe.”

—John Muir (naturalist, writer, and founder of the Sierra Club)

Ask students to explain what they think John Muir might have meant. Ask students to what extent humans are “hitched to everything else.” (Humans rely on natural systems to provide all of the necessities for survival.)

**BRAIN FOOD**

**Diverse Temperate Forests** The soil of a temperate forest has a biological diversity that rivals the soil found in tropical rain forests. In fact, invertebrates in forest soils may be the most important factor in determining the long-term productivity of a forest. Soil arthropods include beetles, centipedes, pseudoscorpions, springtails, and mites. Have students collect several 20 cm³ soil samples and use a microscope to examine the samples for soil arthropods.
**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 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.

**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.

**Using the Figure** — **GENERAL**

Connecting Ecosystem Levels
Have students analyze Figure 4 and explain the connection of each level to the preceding one. Then have students look at a series of pictures or slides, and ask them to classify the images using the terms organism, population, community, ecosystem, and biosphere. [The illustration shows a wildebeest (organism); a herd of wildebeest (population); a closeup of several species: wildebeest, lion, giraffe, elephant, rhino, and vulture (community); a scene of the African savanna showing many animals (ecosystem); and the Earth (biosphere)]

**Group Activity** — **ADVANCED**

Golf Course Impacts Ask students to imagine that they are on a committee that has the task of deciding whether a golf course can be built without damaging the environment. Tell students to pick a specific location in their community for their proposed golf course, and to describe the ecosystem at that location. Take a field trip out to that location to better understand all the organisms that use the site. Back in the classroom, have students analyze and describe all of the possible repercussions of the golf course on the ecosystem. Finally, ask students to determine if the golf course should be built. If not, they should explain why. If they decide that the golf course is a good idea, have them develop a plan showing how the course could be designed so that it has little impact on the environment. If a golf-course scenario isn't appropriate for your region, suggest a highway, parking garage, shopping center, or other development.

**Self-sustaining Colonies** Have groups research the reasons for Biosphere II, including its failure as a self-contained ecosystem and its current use as an ecological laboratory. Once students have learned something about running a self-sustaining colony, have groups design their own colony for Mars, Antarctica, a desert, the moon, or under the sea. Students can create models, scale drawings, or blueprints on the recycling of air, water, and waste, and descriptions of how different populations would be managed. **Interpersonal**

**Linnaeus** Swedish naturalist, Carolus Linnaeus (1707–1778), was the father of the binomial system used to identify species today. A species has a two-part Latin name: the first part is its genus, and the second part names the specific organism. For example, the Norway rat is classified in the genus *Rattus*. Its full scientific name, which is unique among all organisms, is *Rattus norvegicus*. Have students look up the scientific name of some common plants and animals. Also ask them to find out who named these species and when they were named. **Interpersonal**
Describe Logical a population not mentioned in this section.

Think of your favorite animal. Each species has evolved to occupy a certain habitat that allow it to survive. How could soil and a mouse interact in an ecosystem? (Possible interactions include: honeybees pollinate sunflowers, which produce seeds for blackbirds; earthworms process soil for sunflowers; moles eat earthworms; sunflowers use water, air, and soil.)

The squirrels mentioned above live 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 and a cactus’s habitat is a desert. The salamander shown in Figure 6 is in its natural habitat, the damp forest floor.

Every habitat has specific biotic and abiotic factors that the organisms living 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 cannot usually survive for long periods of time away from their natural habitats. For example, a fish that lives in the crevices of a coral reef will die if the coral reef is destroyed.

Why is an organism’s habitat important for that organism? (See the Appendix for answers to Reading Checks.)

SECTION 1 Review

1. List the abiotic and biotic factors 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.
6. Understanding Concepts Why might a scientist say that an animal is becoming rare because of habitat destruction?

Answers to Section Review

1. Biotic components include: caribou, plants (higher plants, lichen, moss). Abiotic components include air, water, rock, and light. Students could also include soil in both the biotic and abiotic lists.
2. Answers may vary. A population is a group of individuals of one species living in an area at a given time.
3. The abiotic factors, including water, air, rocks, and sunlight, are not part of a community.
4. A species is a group of organisms whose members can mate to produce fertile offspring. A population is a subset of a species; it consists of members of the same species that also live in the same vicinity.
5. Answers may vary. Students should understand that only biotic factors are part of a community.
6. Each species has evolved to occupy a certain type of habitat. If that habitat is destroyed, the species may become rare because its members cannot get all the things they need to survive.

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

**Evolution by Natural Selection**

In 1859, English naturalist Charles 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 ee 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 survival and reproduction of organisms with 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.

**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

**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 come 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.

**Focus**

**Overview**

Before beginning this section, review with your students the Objectives in the Student Edition. In this section, students learn how organisms become adapted to their environments through the process of evolution by natural selection.

**Bellringer**

Have students look at Figure 7 and write down the characteristics they think help the chameleon when it hunts. Ask them to compare their thoughts to the information in the first paragraph of the section.

**Group Activity**

**Natural Variety** Members of a population naturally vary from one another. Have pairs measure each other’s shoe size in centimeters. On the board, create a table to record the data for each student. Then, have students construct a bar graph using the results. Ask students if they think a bigger or smaller shoe size could be a more suitable trait in a human population. Ask them to think of characteristics that might have been advantageous to the survival of early humans. (Sample answers: problem-solving capabilities, the ability to cooperate with other humans, or the ability to recognize enemies)

**Answer to Reading Check**

How is natural selection related to the process of evolution?
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. For example, lions that have the trait of sharper claws can kill their prey more easily than lions with duller claws. Thus, lions with sharper claws are more likely to survive and reproduce. Over time, the lion population includes a greater and greater proportion of lions with sharper claws. As the populations of a given species change, so does the species. Table 1 summarizes the premises of Darwin’s theory of evolution by natural selection. Darwin proposed his theory after drawing a conclusion based on these premises.

<table>
<thead>
<tr>
<th>Premises</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Individuals in a population vary in each generation.</td>
<td>Based on these four premises, individuals with genetic traits that make them more likely to grow up and reproduce in the existing environment will become more common in the population from one generation to the next.</td>
</tr>
<tr>
<td>2. Some of these variations are genetic, or inherited.</td>
<td></td>
</tr>
<tr>
<td>3. More individuals are produced than live to grow up and reproduce.</td>
<td></td>
</tr>
<tr>
<td>4. Individuals with some genes are more likely to survive and reproduce than individuals with other genes.</td>
<td></td>
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</tbody>
</table>

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 different species have differently specialized bills adapted to eating different types 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 the finches that survived were those able to eat what they found on their island.

Notice the beaks in the two species of Darwin’s finches. What do you think these 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

Survival of the Fittest  Ask students what the term “survival of the fittest” means to them. They may say that when two organisms fight each other to survive, the “fittest” one will win the contest. This is not the correct meaning of the term. The “fittest” individual, the one that survives to pass its genes on, is the one most adapted to its current or changing environment. This individual may belong to a species of birds with small bills that can only crack small seeds. If smaller seeds become less available, and a few individuals have slightly larger bills that allow them to crack bigger seeds, those individuals are more likely to survive and pass their genes on to future generations. This example involves no fighting. Instead, it involves the spread of advantageous characteristics through a population.
Figure 8 shows an example of evolution in which a population of deer become isolated in a cold area. Many die, but some have genes for thicker, warmer fur. These deer are more likely to survive, and their young with thick fur are also more likely to survive and 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.

These deer live in a warm climate. Some have thicker fur than others.

Some deer become separated from the rest of the group.

As years pass, each generation has a greater proportion of deer with thick fur. After many generations, most deer have thick fur.

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. Divide the class into four groups that represent populations of a species of finch that have four different types of beak: thin, medium, small and powerful, and large and powerful. Have students write their bill type on a nametag or index card. Assign a food to the four suits in a deck of cards, and then assign a bill type to that food type (e.g., if you assigned nectar to spades, the corresponding finch would have a thin bill). Write the suits (foods) and their corresponding bill types on the board. Tell students that there is an abundance of two food types, so you are stacking the deck to include more of two of the suits. Shuffle the deck, and have each student draw one card. If the student draws the suit that corresponds to her or his bill, then that student stays in the game (i.e., passes genes on to the next generation). In following rounds, have each remaining student draw three cards for each successful match in the previous round (successful individuals have three successful offspring each round). Keep stacking the deck to simulate patterns of environmental change. At the end of the game, ask students if the surviving offspring match the most abundant food sources.

**Critical Thinking**

1. Analyzing Relationships

Could the finches that evolved bigger beaks in this study evolve smaller beaks some day?

**Crop Origins in the New World**

Teosinte, a wild grass, was domesticated in Mexico more than 7,000 years ago, and eventually became our modern corn. Other important crops that were probably first cultivated in Mexico include cotton, tomatoes, chili peppers, tobacco, cacao, pineapple, squash, and avocados. Potatoes, tomatoes, and peanuts may have originated in Peru and were brought to Mexico by human travelers.
Coevolution  Organisms evolve adaptations to other organisms and 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 possible 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 cause the bird to get pollen on its head as it sips the nectar. When the bird moves to another flower, some of the pollen rubs off. In this way, the bird helps lobelia plants reproduce. The honeycreeper’s adaptation for obtaining more nectar is a long, curved beak. The plant has two adaptations for greater pollination. 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 the nectar.

**Gardens and Artificial Selection**

Bring in some flower and vegetable seed catalogs. Have students each pick a flower or vegetable and research the plant from which it originated. Ask them to print a picture of the original plant, if it is available, and to compare the differences between the artificially-selected plant and the original. Ask students what characteristic was selected for in each case. (It is usually the size of the fruit or flower.) As an extension, grow a few heirloom plants for students to observe during the school year.

**Answer to Reading Check**

Humans use artificial selection to breed organisms with traits that humans want those organisms to have. Natural selection is not guided by human decisions but by an organism’s chance of survival and reproduction in its environment.

**Wasp and Fig Coevolution**

Figs and tiny wasps called **fig wasps** are thought to have coevolved a unique relationship. Fig flowers are completely enclosed in a structure called a **syconium**. Fig wasp eggs hatch in a syconium, the wasp eats the ovule on which the egg hatches, and the wasp matures to mate there. The male fig wasp lives and dies within the structure, but the female wasp chews its way out. A female, covered with pollen after mating, enters another syconium through a pore in the structure. Once inside, the female spreads pollen on some of the flowers, lays eggs, and dies, thereby continuing the cycle.
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 version of a gene that protects them from the pesticide. The surviving insects pass on the gene to their offspring. Each time the corn is sprayed, insects that are resistant to the pesticide will have a greater chance of survival and reproduction. As a result, the insect population will evolve to include more and more resistant members.

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.
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.

Answers to Section Review

1. An adaptation is an inherited trait that increases an organism’s chances of survival and reproduction, such as thick fur, sharp claws, or a sticky tongue.
2. Organisms within populations differ in their traits. These differences make some organisms more likely to survive and reproduce in their environment than others in their population are. The genetic characteristics of populations change over time in response to these likelihoods, which is a process called evolution.
3. Answers may vary. Sample answer: Artificially selecting the most nutritious rice can help nourish more people.
4. When a pesticide is sprayed on insects, many of them die. But the insects that survive have traits that allow them to resist the pesticide. Those resistant insects produce offspring that are resistant, so the population becomes resistant.
5. If the environment contains limited resources, organisms that have certain characteristics or traits may be more likely to survive and reproduce in the environment than other organisms in the same environment.
6. No. This is an adaptation to the physical environment, so it is natural selection. Coevolution involves two organisms that have evolved mutually beneficial traits.
**Chapter 4 • The Organization of Life**

**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**
- Archaebacteria
- Eubacteria
- Protist
- Gymnosperm
- Angiosperm
- Invertebrate
- Vertebrate

**Classification of Life** This textbook classifies organisms into six kingdoms. Other scientists use three superkingdoms: Bacteria, Archaea, and Eucarya. Still others use a five-kingdom system. Who is right? All of them are, in a way. Scientists use the best data they have to organize species in a way that reflects how the species relate to each other. But each classification system focuses on different characteristics. It is difficult to determine how all organisms evolved, so it is difficult to find the "right" way to classify them. Alternate systems enliven the debate and inspire scientists to find the closest underlying relationships. Ask students to give examples of how things may be classified differently but still logically. (One example is the way grade levels are organized. One school district may divide its schools into Primary (1–6), Jr. High (7–8) and High School (9–12). Other districts may have a Middle School that encompasses grades 6–9. Neither way is right or wrong, and each way reflects logical relationships between the grades.)

**Archaebacteria and Eubacteria**
Organisms in the kingdoms Archaebacteria and Eubacteria share a lot of features, even though they are not closely related. They are microscopic, single-celled organisms that usually have cell walls and reproduce by dividing in half. Unlike all other organisms, members of Archaebacteria and Eubacteria lack nuclei. Archaebacteria are often found in extreme places, such as hot springs. Eubacteria are very common and can be found in soil and animal bodies. Many types of eubacteria are commonly referred to as bacteria.

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archaebacteria</td>
<td>single celled; lack cell nuclei; reproduce by dividing in half; often found in harsh environments</td>
<td>methanogens (live in swamps and produce methane gas and extreme thermophiles (live in hot springs)</td>
</tr>
<tr>
<td>Eubacteria</td>
<td>single celled; lack cell nuclei; reproduce by dividing in half; incredibly common</td>
<td>proteobacteria (common in soils and in animal intestines) and cyanobacteria (also called blue-green algae)</td>
</tr>
<tr>
<td>Fungi</td>
<td>absorb their food through their body surface; have cell walls; most live on land</td>
<td>yeasts, mushrooms, molds, mildews, and rusts</td>
</tr>
<tr>
<td>Protists</td>
<td>most single celled but some have many cells; most live in water</td>
<td>diatoms, dinoflagellates (red tide), amoebas, trypanosomes, paramecia, and Euglena</td>
</tr>
<tr>
<td>Plants</td>
<td>many cells; make their own food by photosynthesis; have cell walls</td>
<td>ferns, mosses, trees, herbs, and grasses</td>
</tr>
<tr>
<td>Animals</td>
<td>many cells; no cell walls; ingest their food; live on land and in water</td>
<td>corals, sponges, worms, insects, fish, reptiles, birds, and mammals</td>
</tr>
</tbody>
</table>
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. A different form of E. coli can cause severe food poisoning.

Fungi  A fungus (plural, fungi) is an organism whose cells have nuclei and cell walls. 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.

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.

Reading Check  Name one way that bacteria and fungi are similar and one way that they are different.

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

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.

Teach  Group Activity — GENERAL

Mushroom Walk  Take your class on a walk in the woods to find the fungal structures commonly known as mushrooms. Have students study the fungi they find. CAUTION: Warn students not to eat any of the fungi, as some may be poisonous. Use a mushroom identification guide, and work with students to make spore prints and identify the types of fungi. Have students wear gloves while making spore prints. Also have students identify where each fungus fits into its woodland ecosystem. Ask, “Does it decompose dead wood or attack other fungi?” Have students draw the different types of fungi and include those drawings in their Portfolio. L Kinesthetic/Visual

BRAIN FOOD  Humongous Fungus  The world’s largest individual organism is a fungus! One particular honey mushroom, Armillaria ostoyae, has been growing for about 2,400 years and now covers 2,200 acres in the Malheur National Forest in eastern Oregon. That makes it 3.5 miles across and as big as 1,665 football fields. This giant fungus was determined to be one organism by a Forest Service scientist, Catherine Parks, who tested its DNA at various locations.

Answer to Reading Check  Both bacteria and fungi cause diseases. Bacteria do not have nuclei, while fungi do have nuclei.

Chapter 4 • The Organization of Life

Homework — GENERAL

Ruminant Animals  Bring in a diagram of a cow’s digestive system. Show students how the stomachs are arranged, and tell them that each stomach contains microbes that help the cow process its food. Ask students to research how the microbes help the cow derive nutrients from grass and hay. (Microbes that can break down cellulose, which is found in the tough cell walls of plants, ferment grass and hay. This process releases fatty acids from the plant matter that can be absorbed and used by the cow.) L Intrapersonal
Teach, continued

Activity

Pond Protists

Gather 2 or 3 plastic lab bottles with lids, some microscopes, glass slides, cover slips, medicine droppers, and a book on protist identification. Then visit a local pond where it is easy to get a water sample. Have students fill the bottles with pond water. Back in class have students prepare slides using drops of pond water. Have students look for protists and other organisms under the microscope. Ask students to draw what they see and to include those drawings in their Portfolio.

Teaching Tip

Pond Creatures

The following protists are likely to be found in pond water: diatoms—one-celled organisms with geometric shapes, they are made of silica and are usually yellow-brown in color; amoebas—one-celled organisms that “ooze” or travel by cytoplasmic movement; ciliates—single-celled protozoans with hair-like structures (cilia) around their entire cell margin; volvox: colonial green algae that look like spiky golfballs; euglenas: single-celled protozoans with a tail called a flagellum; dinoflagellates: tiny algae with two flagella, one extending like a tail and one running in a groove around the center of the organism; other types of green algae: these can be various shapes and sizes.

Protists

Most people have some idea what bacteria and fungi are, but few could define a protist. Protists are a diverse group of one-celled organisms and their many-celled relatives. Some, such as amoebas, are animal-like. Others, such as the kelp in Figure 14, are plant-like.

Still others are more like fungi. Most protists are one-celled microscopic organisms. This group includes amoebas and diatoms (DI uh TAHM). 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 plant-like protists that can make their own food using the sun’s energy. Green pond “scum” and seaweed are examples of algae. Algae 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 have cell walls and that make their own food using the sun’s energy. 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 access water and nutrients in the soil and leaves that collect 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. Tree ferns still live in the tropics and in New Zealand today. Some examples of lower plants are shown in Figure 15.
Gymnosperms  Pine trees and other evergreens with needle-like leaves are gymnosperms (JIM noh SPUHRMZ). Gymnosperms are woody plants that produce seeds, but their seeds are not enclosed in fruits. Gymnosperms such as pine trees are also called conifers because their seeds are inside 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 could not survive without 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.

**Reading Check**  How do angiosperms depend on animals, and how do animals depend on angiosperms?

---

**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.

---

**Group Activity**

**Angiosperms in the Classroom**

Place students in groups of three or four. Give them three minutes to write down everything that is a product of an angiosperm. Then ask each group to name their objects. Disqualify any objects that are not produced from a flowering plant. Award small prizes made of angiosperm products to the winning group. Prizes could include dried fruit, nuts, pencils made of birch or maple, and something made of cotton.

**Discussion**

**Do All Fruiting Trees Flower?**

Some trees, such as magnolias and plums, have fragrant flowers that are hard to miss. But what about maple or birch trees? Have students think about the types of flowers they might have seen on trees that are not well known for their flowers. Bring in a tree identification guide for your area, and show students the different flowers. If it is spring, tell them to watch for these flowers, and report back to the class when they see each tree blooming.

---

**Teaching Tip**

**Transport of Materials in Plants**

The vascular tissue of higher plants is made up of **phloem**, which transports sugars (food) throughout the plant and **xylem**, which transports water. Xylem usually has larger cells and is located closer to the center of the stem. Lower plants, such as moss, lack xylem but contain elongated conducting cells that move water through the plant. Food-conducting cells exist in some mosses, to take the place of phloem.

---

**Skill Builder**

**Vocabulary**  Gymnosperms and angiosperms share the base *-sperm*, derived from the Greek *sperma*, or “seed.” Since gymnosperms have seeds that are not covered by fruit, their seeds are gymnos, which is Greek for “naked.” An angiosperm has a seed covered by an angion, or “vessel,” which is the fruit. For extra credit, ask students if they can figure out the generic (genus) name for the ground squirrel. Give them the hint that it is a “seed lover.”

---

**Answer to Reading Check**

Angiosperms depend on animals for pollination and dispersal of seeds. Animals depend on angiosperms for food, building materials, and fibers.
Animals that lack backbones are invertebrates. 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?

**Answers**

\[ 80 \text{ eggs} \times 0.7 = 56 \text{ hatchlings} \\
56 \times (1 - 0.8) = 11 \text{ survive to reach adulthood} \]

**Group Activity**

**Pollinator Game** Organize the class into two groups, and give each group a pile of blank index cards. Have students conduct research to find names of specific plants that have insect pollinators. Ask the students to write the name of each plant on one side of each card and that of the pollinator on the other. Tell the groups not to share information. After the groups have each created six pollination pairs, have each group take turns trying to identify the pollinator associated with the plants the other group has researched. The group that identifies the most correct pairs wins the game. (You may want to give flowers as a prize.)

**Writing** Ask students to write an essay about their favorite animal. Have them include information about where the animal lives, what it eats, if it is a vertebrate or invertebrate, how it reproduces, if it is solitary or social, and information on its other traits. Ask students to include information about how the animal may have adapted to its current environment.

**Inclusion Strategies**

- **Learning Disabled**
- **Developmentally Delayed**
- **Attention Deficit Disorder**

Ask students to create a chart to compare invertebrates and vertebrates. Ask students to fold a piece of lined paper in half vertically. Have students label one half “Invertebrates” and the other half “Vertebrates.” Students can fill in the characteristics of these animals using the textbook as a reference. Have students list at least three examples for each type of animal. The charts can be displayed or presented to groups of students.
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 vertebrates to complete their entire life cycle on land were the reptiles, which today include turtles, lizards, snakes, and crocodiles. These animals 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.

**SECTION 3 Review**

1. **Describe** how animals and angiosperms depend on each other. Write a short paragraph to explain your answer.  
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.  

**ANSWERS TO SECTION REVIEW**

1. Many animals use the components of angiosperms for food. Many angiosperms depend on animals to pollinate them and to spread their seeds.  
2. Algae make their own food using the sun’s energy and in turn are the initial source of food for most ocean animals.  
3. **Archaebacteria**: single-celled, lack nuclei, live in extreme environments; **eubacteria**: single-celled, lack nuclei; **fungi**: have cell walls, absorb food through body surface; **protists**: mostly single-celled, most live in water; **plants**: multi-celled, photosynthesize food, have cell walls; **animals**: multi-celled, ingest their food  
4. Fungi and some bacteria break down the remains of organisms and return the nutrients from the remains to the soil. Some bacteria also convert nitrogen to a form plants can use.  
5. Many insects have evolved together with angiosperms. The success of angiosperms spurred the success of insects.  
6. **Angiosperms** produce flowers as reproductive structures, while gymnosperms called **conifers** produce cones. Unlike the seeds of gymnosperms, the seeds of angiosperms are enclosed in fruit.

**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.  

**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 in a dry, sunny day.
Evolution of long-necked giraffes.) More than others did, causing the animals survived and reproduced longer necks. Generations of longer-necked giraffes were able to reach more food and were selected with slightly longer necks were more likely to pass their long neck as their parents. Necks lengthen over generations without a genetic basis.) Would not lengthen over generations; the neck of the giraffe became giraffe’s long neck.

Clarifying Natural Selection

Lamarck was a famous scientist who suggested (incorrectly) that the neck of the giraffe became longer because it was stretching to reach high leaves. Ask students to discuss why Lamarck was wrong. (If the parents lengthened their necks slightly by reaching for food, the offspring would still start with the same length neck as their parents. Necks would not lengthen over generations without a genetic basis.) Have students use Darwin’s theory of evolution by natural selection to devise a possible explanation for the giraffe’s long neck. (Giraffe ancestors with slightly longer necks were able to reach more food and were able to survive and reproduce better than their counterparts with shorter necks. Generations of longer-necked animals survived and reproduced more than others did, causing the evolution of long-necked giraffes.)

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, which include the conifers, are the earliest plants with seeds. Angiosperms are flowering plants. 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.

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.

The naturalist Charles Darwin used the term natural selection to describe the survival and reproduction of organisms with particular traits.

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.

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Using Key Terms

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

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. resistance.
   b. an adaptation.
   c. a reptile.
   d. an abiotic 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. archaeabacteria.
   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 oxygen 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 nutrients through their roots.

Assignment Guide

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Understanding Key Ideas

10. c
11. c
12. d
13. b
14. d
15. b
16. d
17. a
**Short Answer**

18. Energy, mineral nutrients, water, oxygen, and living organisms are all necessary to maintain an ecosystem.

19. Biotic factors are the living or once-living factors, and abiotic factors are the non-living factors.

20. An adaptation is an inherited trait that increases an organism’s chance of survival. Evolution is a change in the genetic characteristics of a population from one generation to the next. Populations evolve adaptations.

21. Step 1: The pesticide kills most of the insects, but some are not killed; Step 2: The surviving insects pass the trait for resistance to their offspring; Step 3: Each time the pesticide is used, the resistant insects become a larger portion of the population, which is evolution.

22. Archaebacteria are single-celled, lack nuclei, and live in extreme environments. Eubacteria are single-celled, lack nuclei, and live in everyday environments. Fungi absorb food through their surfaces and have cell walls. Protists are mostly single-celled, and most live in water. Plants are multicelled, produce food through photosynthesis, and have cell walls. Animals are multicelled and ingest their food.

**Interpreting Graphics**

23. The population dropped in size after each spraying.

24. Yes. The population still alive after each spraying steadily increased during the summer indicating that a larger and larger proportion of the population is resistant.

25. **Concept Mapping**

   Answers to the concept mapping questions are on pages pp. 715–720.

26. **Critical Thinking**

   Answers may vary. Leaf litter may accumulate because fungi are not there to help break it down. Plants that have fungal associations may not grow there.

27. **Cross-Disciplinary Connection**

   Answers may vary. Many antibiotics are used in a hospital, so hospitals could be an area where bacteria evolve antibiotic resistance.

28. **Critical Thinking**

   Answers may vary. Yes. The population still alive after each spraying steadily increased during the summer indicating that a larger and larger proportion of the population is resistant.

29. **Critical Thinking**

   Answers may vary. Natural selection may not be taking place in most modern human populations because we are protected from most environmental factors.

30. **Critical Thinking**

   Answers may vary.
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.

Math Skills

32. Total plant mass is 2500 kg and total animal mass is approximately 500 kg. Therefore, the mass of the plants is about 5 times the mass of the animals.

33. \(4,100 \div 1,700 = 2.4\); The ratio of bacteria to fungi is about 2.4 to 1.

Writing Skills

34. Answers may vary. Evolution provides a simple mechanism (natural selection) that explains why organisms are well suited to their environments, why populations change over time, and why and how new species develop.

35. Answers may vary. Insects are treated with a pesticide; most die, but some are not harmed; over generations, insects that can survive the pesticide become a dominant part of the population; the pesticide eventually becomes ineffective because the insect population has evolved to be resistant to it.

Reading Skills

1. c
2. c
Understanding Concepts

Directions (1–4): For each question, write on a separate sheet of paper the letter of the correct answer.

1. What is the term for the area where organisms live together with their physical environment?
   A. biome
   B. biosphere
   C. ecosystem
   D. population

2. Which of the following describes the theory of natural selection?
   F. Organisms with desired traits are selected for reproduction.
   G. Heredity determines which organisms will survive in their environment.
   H. Traits are developed in organisms in response to interaction with other organisms.
   I. Organisms with strong survival traits are more likely to pass on the traits in reproduction.

3. What inherited trait increases an organism’s chance of survival and reproduction in a certain environment?
   A. adaptation
   B. characteristic
   C. evolution
   D. natural selection

4. What are the six kingdoms of life?
   F. Archaeabacteria, Eubacteria, Fungi, Protists, Plants, Animals
   G. Eubacteria, Fungi, Protists, Plants, Land Animals, Marine Animals
   H. Archaeabacteria, Fungi, Plantlike Protists, Animal-like Protists, Plants, Animals
   I. Bacteria, Fungi, Protists, Flowering Plants, Non-Flowering Plants, Animals

Directions (5–6): For each question, write a short response.

5. Everything in nature is connected. Use the concept of interdependence to analyze how an ecosystem works.

6. Describe one of the important roles of bacteria.

Reading Skills

Directions (7–9): Read the passage below. Then answer the questions.

Ecosystems are composed of many interconnected parts that often interact in complex ways. People often think of ecosystems as isolated from each other, but ecosystems do not have clear boundaries. Things move from one ecosystem into another.

Ecosystems are made up of both living and nonliving things. Biotic factors are the living and once-living parts of an ecosystem, including all the plants and animals. Biotic factors include dead organisms, dead parts of organisms, such as leaves, and the organisms’ waste products. The nonliving parts of an ecosystem interact with the abiotic factors, the non-living parts of the ecosystem. There are different levels in the ecological organization, from the individual organism to the biosphere.

7. What is one example of an abiotic factor?
   A. armadillo
   B. carnation
   C. robin
   D. rock

8. Why would it be incorrect to describe ecosystems as being isolated from each other?
   F. All ecosystems have different species.
   G. Things can move from one ecosystem into another because ecosystems do not have clear boundaries.
   H. Ecosystems have biotic and abiotic factors.
   I. Both ecosystems and communities have biotic and abiotic factors.

9. State the kinds of biotic factors that would be found in an ocean ecosystem.
Interpreting Graphics

**Directions (10–12):** For each question below, record the correct answer on a separate sheet of paper.

The map below shows changes in forest cover in Costa Rica over 40 years. Use this map to answer questions 10 through 12.

10. Approximately what percentage of Costa Rica was covered by forest in 1947?
   A. 25%
   B. 33%
   C. 50%
   D. 75%

11. What conclusion can be drawn about the forest cover of Costa Rica?
   F. Most of the remaining forests are near cities.
   G. The remaining forests are concentrated along the western coast.
   H. Costa Rica lost more than half of its forest cover in less than 50 years.
   I. Deforestation has accounted for little change in Costa Rica’s environment.

12. What can be inferred about organisms adapted to living in trees in Costa Rica?
   A. Organisms that are adapted for living in trees will continue to thrive across the country.
   B. Organisms that are adapted for living in trees will be eliminated from the country’s environment.
   C. Organisms that are adapted for living in trees will continue to thrive in areas that used to have forest.
   D. Organisms that are adapted for living in trees will thrive in forested areas but struggle in areas that no longer have trees.
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.

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, 40 cm × 1 cm, clear, flexible
- screen, pieces
- screw clamps
- tape
- test-tube rack
- test tubes with stoppers

Tips and Tricks

Students are asked to design the conditions for the brine shrimp themselves. Possible variables for this experiment include temperature and light. To test temperature, students can place a section of tubing on a hot water bag, place a section on an ice bag, and leave two sections at room temperature. (Caution: Do not use water with a temperature higher than 70°C.) Each of the room temperature sections should be right next to the cold or hot section so that shrimp don’t have to migrate through a habitat they do not like to get to one they prefer. To test light, shine a grow light on one section and cover another section with aluminum foil. Again leave two sections in natural light and put those on either side of the extremes. Be sure that students include a control in their experiment. Students should make sure other factors besides the one they are testing are not different across the test tube. If students do not keep all other factors the same, they will not be able to tell which environmental factors the brine shrimp selected.
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.

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 steps 6 and 7?

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.
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 illegal logging and other human activities. Logging reduced the size of the wintering region by approximately 90 percent over a 30-year period, from about 1970 to 2000. Mexico has set aside five of the known butterfly sites as sanctuaries, but even these are endangered by people who cut down fir trees for fuel or money.

Alfonso’s work is helping Mexican conservationists better understand and protect monarch butterflies. Especially important is Alfonso’s discovery that the 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 the 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. They can only crawl. At even colder temperatures (–7°C to –1°C, or 20°F to 30°F), monarchs resting on the forest floor may freeze 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, where it is warmer. This tiny difference in elevation can provide a microclimate that is warm enough to ensure the monarchs’ survival.

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**Annual Life Cycle of a Monarch**

There are four generations of monarchs in the United States each year. First generation butterflies emerge from eggs laid by females that overwintered in Mexico. Four days after they emerge, the first generation migrates north, laying eggs as it migrates. Eggs from this generation are only found in the southern United States. The second generation is then spread throughout the United States. When this second generation emerges, it migrates farther north to avoid hot temperatures. Females lay eggs as they migrate. Individuals of the third generation that emerge during the summer then lay eggs. Individuals in the third generation that emerge during early fall, as well as all of the fourth generation, migrate to Mexico. This generation of monarchs does not reproduce right away. They slip into a stage called diapause, which is a stage of delayed maturity. In March, generations three and four move into the southern United States to lay eggs, and the first generation of the next year emerges.
Animals that migrate between two countries need the habitat that exists in both countries to survive. If countries do not cooperate to understand and protect the animals, one of the countries may destroy critical habitat. Even if necessary habitat is ample in one country, a loss of habitat in the other country may cause the animal’s population to decline or disappear. Therefore, cooperation between governments is essential when managing threatened or endangered migratory species.

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?

Answers to What Do You Think?

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 Institution’s Monitoring and Assessment of Biodiversity (MAB) program.

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.

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.

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Monarch Sanctuaries

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BRAIN FOOD

Adaptive Delay

The migratory generations of monarchs are developmentally delayed due to the environmental conditions when they were caterpillars. Shorter days and cool nights keep the monarchs in a juvenile state, which allows them to delay reproduction until winter is over and food is available for the next generation.