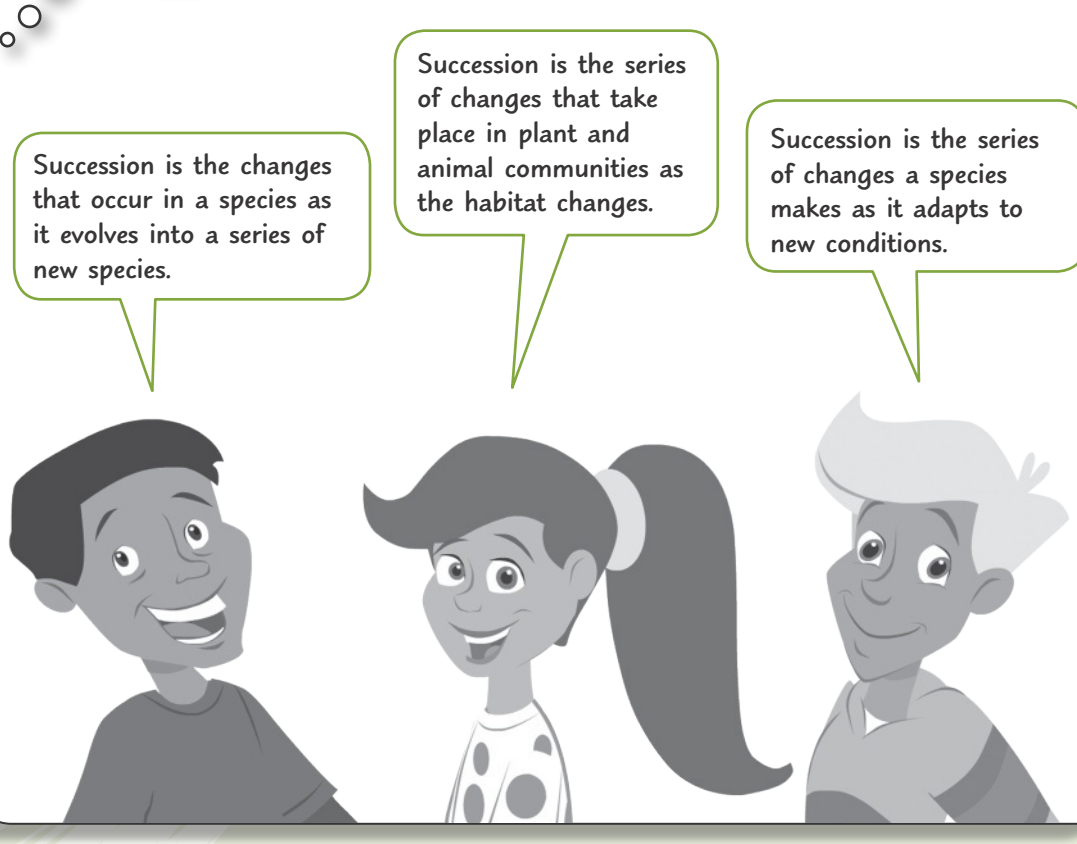
# Ecology

TOPIC 6

## What do You Think?

## Succession



TOPIC 6

# Ecology

## Vocabulary

abiotic
autotroph
biodiversity
biosphere
biotic
carnivore
carrying capacity
community
competition
consumer
decomposer
ecological niche
ecological succession
ecology
ecosystem
energy pyramid
environment
finite
food chain
food web
habitat
herbivore
heterotroph
host
limiting factors
parasite
population
predator
prey
producer
scavenger

## Topic Overview

Our Earth is home to trillions of different organisms. None of these organisms can survive alone. All organisms—including humans—must interact with both the living and nonliving things around them. **Ecology** is the study of how organisms interact with the living and nonliving things that surround them.

## Organisms and Their Environment

As you read this book, you are surrounded by your environment, which includes this book and perhaps your chair, light streaming through the window, a dog barking outside, and a pretzel on the table. If you're in class, your environment may include other students reading nearby, your teacher pacing the aisles, the drone of an airplane, the smell of the lunchroom, sunlight coming in the window, and the unseen mite picking skin flakes off your arm. In short, the **environment** is every living and nonliving thing that surrounds an organism.

### Parts of an Ecosystem

**Ecosystem** is a short way of saying "ecological system." Scientists use the term to describe any portion of the environment. An ecosystem is made up of all the living things, such as bacteria, plants, and animals, that interact with one another. These interacting living things are termed **biotic** factors. When scientists study ecosystems, they also study the nonliving things, such as soil, water, physical space, and energy, that influence the organisms. Nonliving influences are termed **abiotic** factors.

A decaying log, a pond, a field of corn, and even a fish tank are ecosystems. In each of these ecosystems, organisms interact with both the biotic and

abiotic parts of their environment. For example, frogs in a pond ecosystem may interact with insects, fish, hawks, and children chasing them with nets. They are also affected by abiotic factors, such as rainfall, the acidity of their pond, temperature, and the amount of light. Some biotic and abiotic parts of an ecosystem are shown in Figure 6-1.

Because the world contains a wide variety of physical conditions, many different kinds of environments are available to organisms. Some are shown in Figure 6-2. Most species, however, have a specific environment that is their "home." That specific environment is known as the species' **habitat.** Familiar habitats include fields, forests, oceans, streams, and deserts.

All the organisms of a species that live in the same area make up a **population.** Ants in a single anthill would be one population. All the different populations are combined to form a community.

Collectively, all of Earth's ecosystems make up the **biosphere**—the biologically inhabited portions of the planet. Earth's biosphere extends from the deepest ocean troughs to high above the surface of the planet. It includes all the water, land, and air in which organisms live. Throughout the biosphere, organisms interact and compete for vital resources, such as food, space, and shelter.

The fundamental concept of ecology is that all living organisms are interdependent, and they interact with one another and with the physical environment. These interactions result in a flow of energy and a cycling of materials essential for life.

## Environmental Limits on Population Size

In any ecosystem, the growth and survival of organisms depends on the physical conditions and on the resources available to the organism. If they had unlimited resources, living things could produce populations of infinite (unlimited) size. Within any ecosystem, however, resources, such as oxygen and carbon dioxide, water, nutrients, space, and sunlight, are

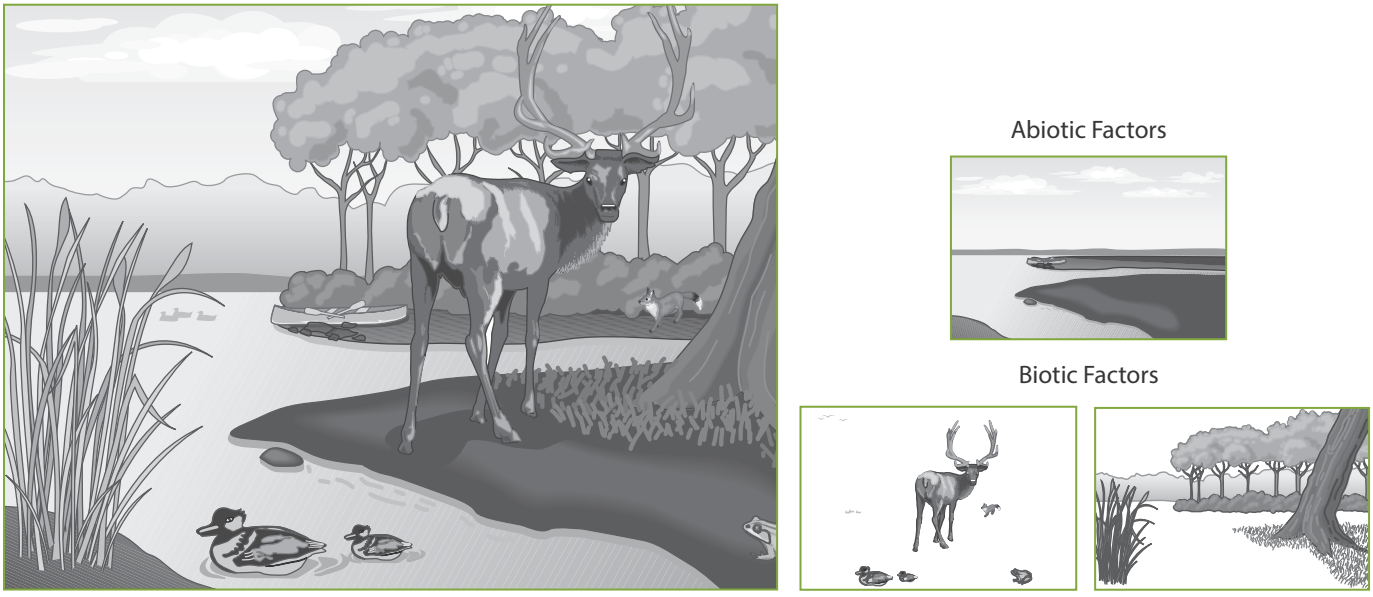



**Figure 6-1. Parts of an ecosystem:** The biotic part of the ecosystem includes all the living things that make up the community.

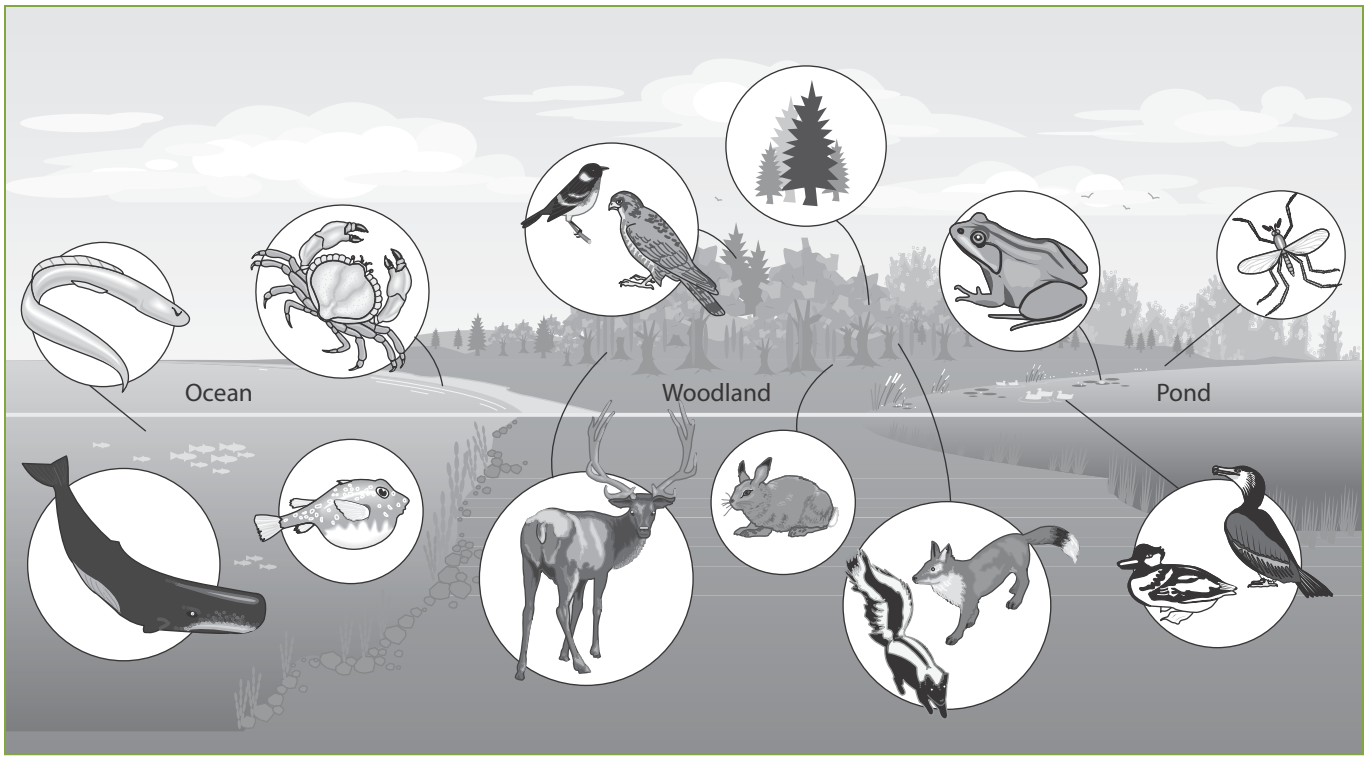



**Figure 6-2. Some ecosystems in Earth's biosphere:** In each ecosystem, the organisms interact with one another and with their environment. The degree to which each abiotic factor is present determines the types of organisms that can live there.

**finite** (limited). This has a profound effect on the interactions among organisms: Because the resources are finite, organisms must compete with one another to survive.

**Competition** is the struggle for resources among organisms. Within any one species, competition keeps the size of that species' population in check. In established ecosystems, populations tend to increase or decrease depending on the resources that are available at the time. This variation in population size tends to follow a predictable cycle. Many populations, for example, vary with the seasons. Over time, however, the size of the population remains stable.

Factors in the environment that limit the size of populations are known as **limiting factors.** Some limiting factors are abiotic; others are biotic. For example, abiotic factors, such as the amount of dissolved oxygen in a pond, may limit the kinds and numbers of fish that can live there; the amount of sunlight filtering through a forest may limit the number of green plants living on the forest floor. Some other specific limiting factors include the intensity of light, the temperature range in the environment, minerals that are available in the water or soil, the type of rock or soil in the ecosystem, and the relative acidity (measured according to the pH scale).

An important biotic factor that limits population sizes is the relationship between **predators,** which kill and eat other organisms, and **prey,** which are killed for food. As predators kill and eat their prey, they limit the growth of the prey population. If too many prey animals are killed, predators begin to starve, and their population is reduced. With fewer predators, the size of the prey population begins to recover.

The number of organisms of any single species that an ecosystem can support is referred to as its **carrying capacity.** It is determined not only by the available energy, water, oxygen, and minerals (and the recycling of such minerals), but also by the interactions of its organisms. For example, a field's carrying capacity for a population of foxes is affected not only by the climate, but also by the number and kinds of other populations present. If there are many mice for the foxes to eat, the fox population may boom. If there are many viruses affecting the health of the foxes, their population may crash. Figure 6-3 shows the population increase that normally occurs until the carrying capacity is reached.

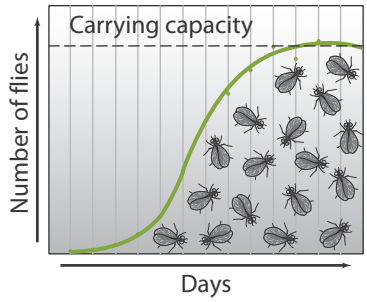



**Figure 6-3. Carrying capacity: This population of insects increased until it neared its carrying capacity. Then the population became approximately stable.**

## Review Questions

**Set 6.1**

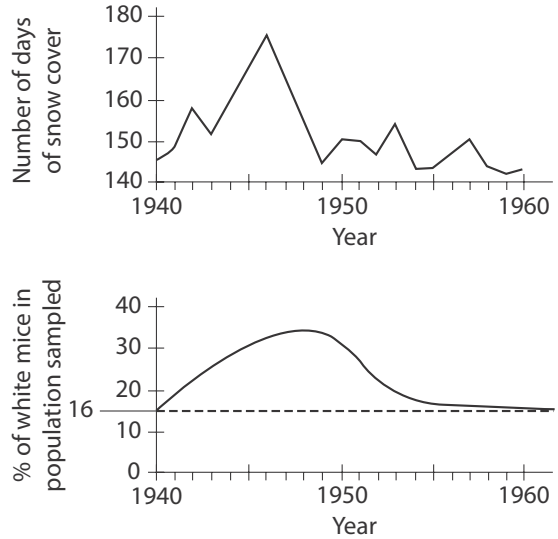
**1.** All of Earth's water, land, and atmosphere within which life exists is known as

(1) a population
(2) an ecosystem
(3) the biosphere
(4) a biotic community

**2.** In the biosphere, what are some of the major abiotic factors that determine the distribution and types of plant communities?

(1) temperature, sunlight, and rainfall
(2) humidity, location, and humans
(3) soil type, soil bacteria, and soil water
(4) insects, carbon dioxide, and nitrogen in the air

**Base your answers to questions 3 and 4 on the two graphs below and on your knowledge of biology. The first graph shows the number of days of snow cover from 1940–1960. The second graph shows the percentage of white mice in a population that was sampled during the same period.**




**3.** The appearance of the greatest percentage of white mice occurred

(1) before the maximum number of days of snow cover
(2) at the same time as the maximum number of days of snow cover
(3) after the maximum number of days of snow cover
(4) both before and after the maximum number of days of snow cover

**4.** Which statement is supported by the data in the graphs?

(1) The percentage of brown mice was greatest during the years of longest snow cover.
(2) The percentage of mice with white fur was greatest during the years of longest snow cover.
(3) The actual number of white mice was greatest during the years of least snow cover.
(4) The actual number of brown mice was greatest during the years of longest snow cover.

**5.** The fact that an organism cannot live without interacting with its surroundings is a basic concept in the field of study known as

(1) ecology
(2) evolution
(3) behavior
(4) technology

**6.** When two different species live in the same area and use the same limited resources, which of the following will occur?

(1) competition
(2) succession
(3) parasitism
(4) industrialization

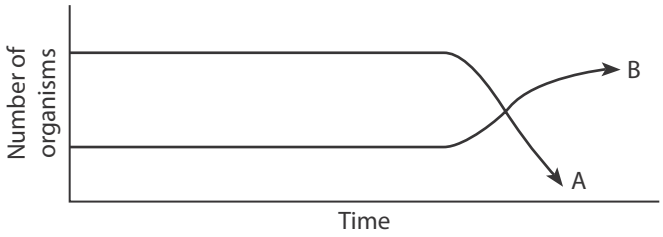
**7.** Which term includes all of the interactions that occur between the organisms and the physical factors in a pond environment?

(1) population
(2) ecosystem
(3) abiotic
(4) competition

**8.** The amount of salt in the air and water of coastal areas determines which species can exist there. In these areas, salt functions as a

(1) source of energy
(2) biotic factor
(3) food source
(4) limiting factor

**9.** This graph shows the changes in two populations of herbivores in a grassy field.




A possible reason for these changes is that

(1) all of the plant populations in this habitat decreased
(2) population B competed more successfully for food than population A
(3) population A produced more offspring than population B
(4) population A consumed members of population B

## Population Interactions

There is a wide diversity of interacting species in most ecosystems. Most of the interactions occur as organisms obtain their food. Every population is linked, directly or indirectly, with all of the other populations in the ecosystem. Each population has one or more specific roles in the ecosystem. As a result, maintaining the ecosystem's diversity is essential to its stability.

### Roles in the Ecosystem

The role that each species plays in an ecosystem is called its **ecological niche.** Only one species at a time can occupy a particular niche. If two species attempt to fill the same role in an ecosystem, competition results. Usually, one species will be more suited to the niche, which forces the other species to move on or face elimination. Eventually, only one species will occupy each niche.

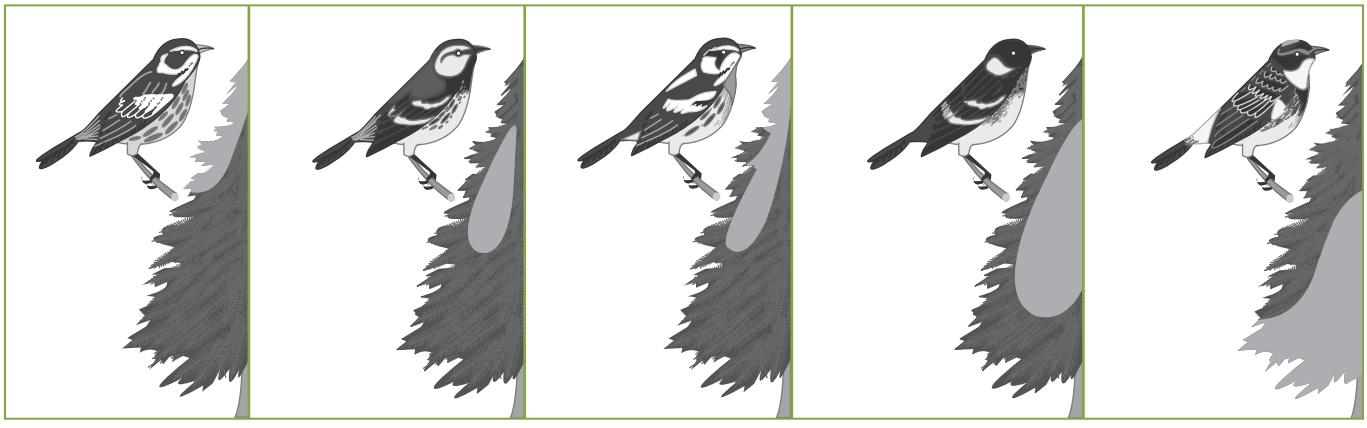


**Figure 6-4. Feeding patterns among warblers:** Several warbler species feed in spruce trees, but they actually occupy different niches because each species feeds in a different part of the spruce tree.

Sometimes it appears as if different populations occupy the same niche. For example, deer and moose often live in the same area and seem to eat the same plants. A closer examination reveals that the deer and moose have different food preferences and only compete when food is very scarce. Similarly, several bird species may seem to nest and feed in the same tree. In reality, it is more probable that the birds are nesting in different parts of the tree and eating different insects. For example, the northeastern United States is home to several species of warblers. Five of those species feed on the insects that live in spruce trees. As shown in Figure 6-4, each species feeds in a different part of the tree.

Competition for a particular ecological niche often occurs when a foreign species enters an area. The new species may be more successful than the native species, partly because the newcomer may not have any natural enemies to control its population. Humans frequently bring foreign species into an area either on purpose or accidentally. One example is the zebra mussels that were brought to the Great Lakes on cargo ships. The zebra mussel has become a major problem in New York waterways.

## Relationships in an Ecosystem

In every ecosystem, populations of different species are linked together in a complex web of interactions. Sometimes these relationships are competitive; occasionally they are cooperative. For example, termites have one-celled organisms in their intestinal tracts. These unicellular organisms help the termites digest their food. The tiny organisms gain a place to live and plenty of food, and the termites can make use of a food supply that they would not be able to digest without this cooperative relationship.

Other relationships benefit one organism and have no effect on the other. For example, when a shark attacks and eats its prey, small pieces of the food drift downward. Smaller fish swimming below the shark feed on these scraps. The small fish benefit, but the shark is unaffected.

**Food Chains** Among the most common relationships in any ecosystem are the predator-prey relationships. **Food chains,** such as those shown in Figure 6-5, illustrate the relationships between prey and predator. In simple terms, the food chain shows what eats what.

Organism's niches are partly defined by how they obtain their food. For example, photosynthetic organisms make their own food and in the process, store the sun's energy. They are known as **autotrophs** (self-feeders) or **producers**. They provide a source of food energy for almost all other living things.

**Heterotrophs** must acquire food by consuming other organisms. **Herbivores** are heterotrophs that survive on plant tissues; **carnivores** are heterotrophs that eat other animals. Heterotrophs are also known as **consumers.**

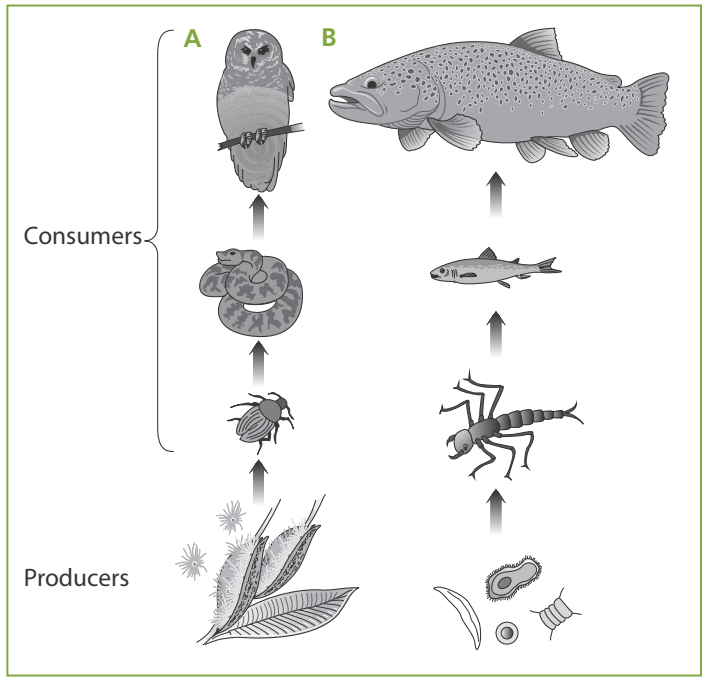



**Figure 6-5. Typical food chains:** A field ecosystem (A) and a pond ecosystem (B)

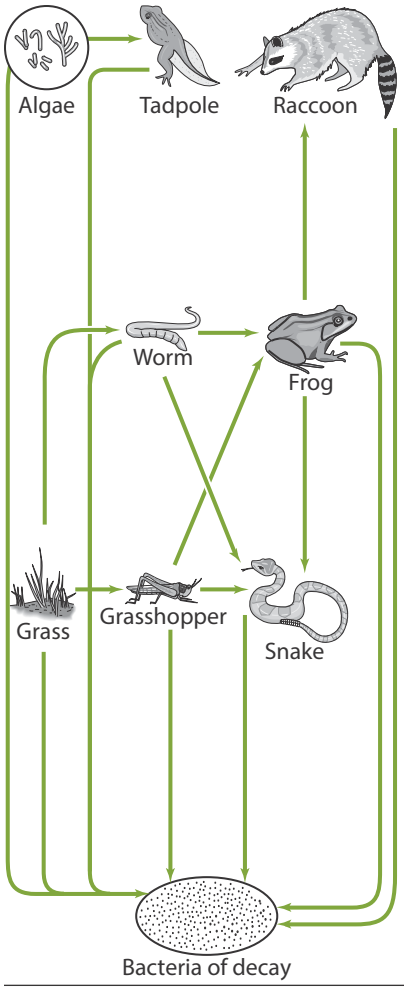



**Figure 6-6. A simplified food web near a pond**

The wastes and dead bodies of all these organisms are consumed by the **decomposers.** The decomposers recycle materials that can then be reused by producers.

Two other feeding relationships between organisms do not fit into the typical predator-prey categories. These organisms are similar to predators in that they feed on other organisms, but different in that they do not kill the organisms for food. **Scavengers,** such as vultures, are consumers that eat dead organisms. They are nature's "clean-up crew." Scavengers, however, are not decomposers. Dead bodies and wastes still have to be broken down by decomposers. **Parasites** are organisms that attack other live organisms (called **host** organisms), but rarely kill them. Parasites usually live on or in the body of their host. Ticks, for example, may live on a dog and also feed on its blood.

Notice in Figure 6-5 that both food chains begin with autotrophs—the photosynthetic producers—and end with consumers. The intermediate heterotrophs (the herbivores and carnivores that rely on others for food) are often, but not always, part of food chains. All of the organisms in a food chain, if not eaten by others, are eventually consumed by decomposers. So a food chain may be as simple as: grass → decay bacteria.

Decomposers may be included at the end of a food chain, but it is important to remember that they actually consume and break down the chemical materials in all dead organisms and in the wastes of all living organisms.

**Food Webs** Normally, each organism feeds on more than one kind of organism. Because organisms normally have more than one food source, food chain diagrams are oversimplified. **Food webs,** as shown in Figure 6-6, are diagrams that show the more complex feeding relationships among producers, consumers, and decomposers. The food web shows the many interconnected food chains that exist in the ecosystem. Because organisms have several food choices, ecosystems often remain stable even when one population shows a major decline in numbers. The organisms that feed on the declining population simply rely more heavily on one of their other food choices until the declining population recovers.

## Review Questions

**Set 6.2**

**10.** The diagram below illustrates the feeding areas of two populations in the same ecosystem during the summer and fall. Both populations feed on oak trees.


The portion of the diagram labeled X most likely indicates that

(1) these populations compete for food in the fall, but not in the summer
(2) the species are separated by a geographic barrier in the summer
(3) the supply of oxygen is greater in the summer than in the fall
(4) mating occurs between the species in the fall, but not in the summer

**11.** An earthworm lives and reproduces in the soil. Through its feeding, excretion, and tunneling activities, the worm adds nutrients and allows air to enter the soil. Together, these statements describe the earthworm's

(1) habitat (3) niche
(2) nutrition (4) environment

**12.** Among the populations of any natural community, the basic food supply is always a critical factor because it is

(1) produced by all organisms
(2) synthesized from oxygen
(3) a means of transferring energy
(4) present in surplus amounts

**13.** A consumer–producer relationship is best illustrated by

(1) foxes eating mice
(2) leaves growing on trees
(3) rabbits eating clover
(4) fleas living on a cat

**Base your answers to questions 14 through 16 on the food chain below and on your knowledge of biology.**

**rosebush→aphid→beetle→spider→toad→snake**

**14.** Which organism in this food chain can transform light energy into chemical bond energy?

**15.** At which stage in this food chain will the population with the smallest number of organisms probably be found?

(1) spider (3) rosebush
(2) aphid (4) snake

**16.** If all of the aphids were killed off due to the spraying of pesticides, what would happen to the number of toads this ecosystem could support?

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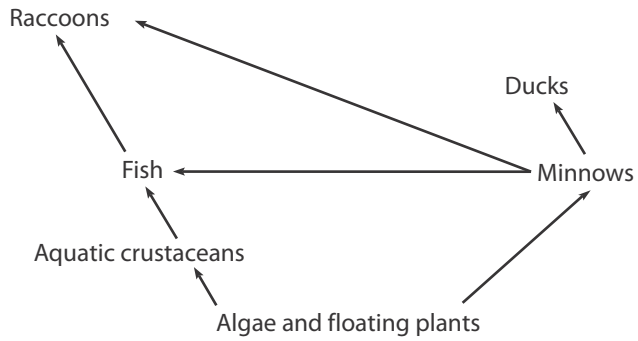
**17.** Which group of organisms is *not* represented in the food web below?




(1) consumers (3) producers
(2) carnivores (4) decomposers

**18.** Which organisms are chiefly responsible for the recycling of dead matter?

(1) parasites (3) decomposers
(2) viruses (4) producers

**19.** In a natural community in New York State, the producer organisms might include

(1) bacteria, fungi, and viruses
(2) deer, rabbits, and squirrels
(3) grasses, maple trees, and weeds
(4) trout, peas, and earthworms

**20.** Which sequence illustrates a generalized food chain in a natural community?

(1) autotroph → herbivore → carnivore
(2) autotroph → herbivore → autotroph
(3) heterotroph → herbivore → carnivore
(4) consumer → autotroph → carnivore

**21.** In a food chain consisting of photosynthetic organisms, herbivores, carnivores, and organisms of decay, the principal function of the photosynthetic organisms is to

(1) capture energy from the environment
(2) provide material for decay
(3) prevent erosion of the topsoil
(4) release energy from organic compounds

**22.** A characteristic shared by both predators and parasites is that they

(1) feed on decomposing plant material
(2) capture and kill animals for food
(3) live inside their hosts
(4) attack a living food source

**23.** As you drive down the highway, you may see crows feeding on dead animals. As a result of this nutritional pattern, crows may be classified as

(1) scavengers (3) herbivores
(2) predators (4) producers

**24.** When the food relationships in a habitat are illustrated by means of a diagram, the result is always a complicated weblike pattern. This is due to the fact that

(1) many consumers are adapted to use more than one food source
(2) producer organisms always outnumber the consumer organisms
(3) matter is lost in an ecosystem as it moves from producers to consumers
(4) both producers and consumers require oxygen for metabolic processes

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**25.** Although three different butterfly species all inhabit the same flower garden in an area, competition between the butterflies rarely occurs. The most likely explanation for this lack of competition is that the butterflies

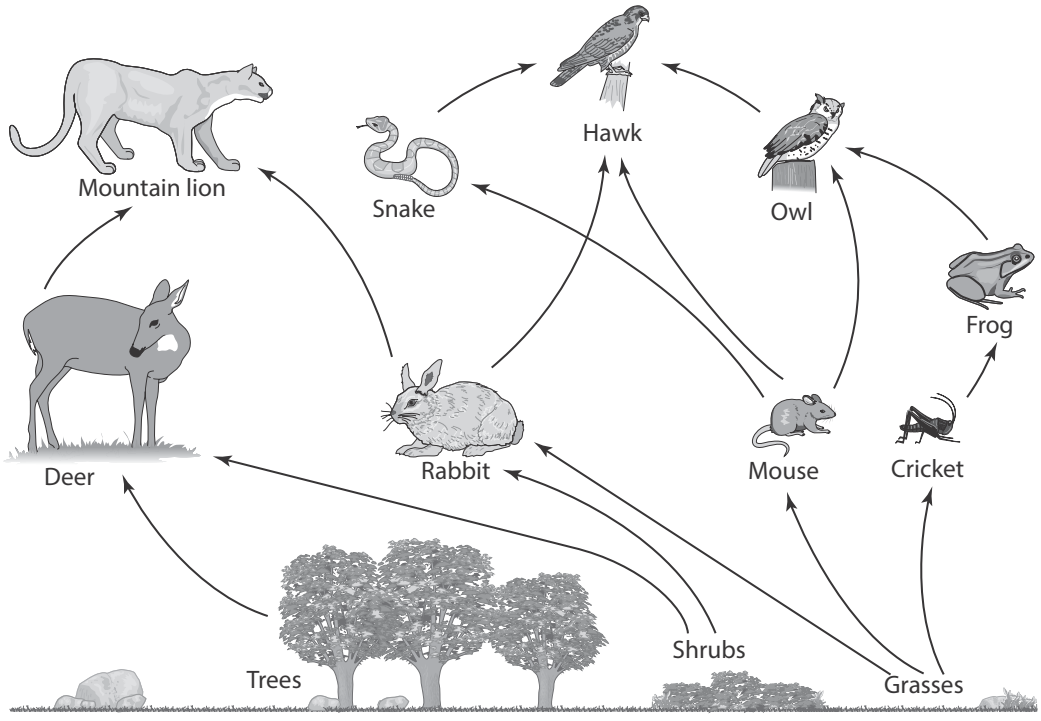
(1) occupy different niches
(2) have a limited supply of food
(3) share food with each other
(4) are able to interbreed

**26.** In the diagram below, which organisms are components of the same food chain?

(1) trees, mountain lion, snake, and hawk
(2) trees, rabbit, deer, and shrubs
(3) grasses, cricket, frog, and mouse
(4) grasses, mouse, snake, and hawk

**27.** In the diagram of a food chain below, what do the arrows indicate?

(1) the direction in which organisms move in the environment
(2) the direction of energy flow through a series of organisms
(3) the order of importance of the various organisms
(4) the return of chemical substances to the environment



## Energy Flow Through an Ecosystem

Almost all organisms use the solar energy stored in food to power their life processes. That energy, however, does not remain in the organism forever. Every second of every day, an animal that is not eating has less energy in its tissues than it had a few seconds before. This energy loss occurs because the organism is continually breaking the chemical bonds in food to use the energy to live. As it is released to make ATP and then used in the cells, much of the energy is converted to heat and is lost to the environment. Only a small amount can actually be used by the cells. As a result, each next step in the food chain has less of the original solar energy available to it.

Figure 6-7 shows how the energy is lost. Only the energy stored in the body tissues of each organism is passed to the next consumer in the chain. Because of the energy loss described above, most of the original stored energy is lost in just a few steps of the food chain. For this reason, food chains are usually quite short.

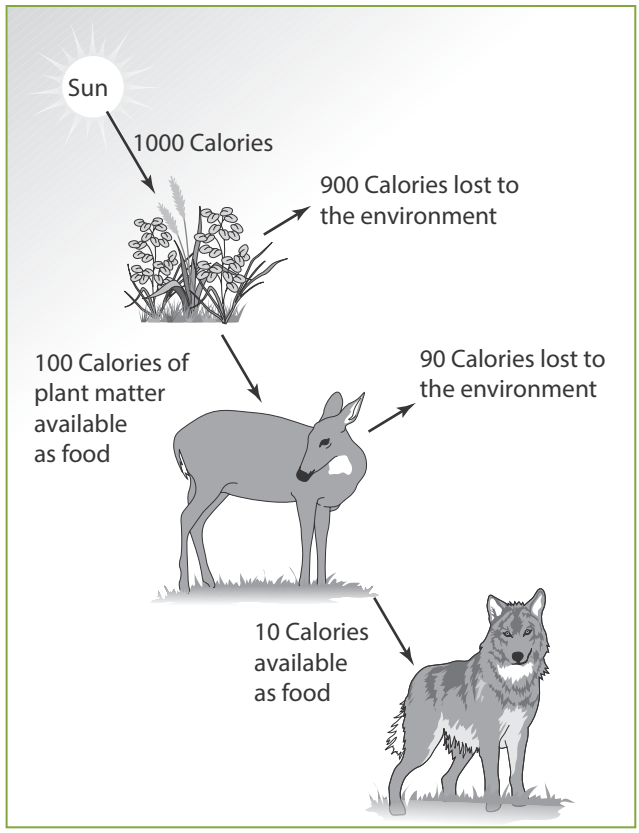



**Figure 6-7. As energy is transferred, much of it is lost to the environment as heat.**

An **energy pyramid,** shown in Figure 6-8, is a diagram that illustrates the transfer of energy through a food chain or web. Each block of the energy pyramid represents the amount of energy that was obtained from the organisms below it. Only this amount of energy is available to the organisms in the next higher block. Notice that each level is smaller due to the loss of heat as the organisms carry on their life activities.

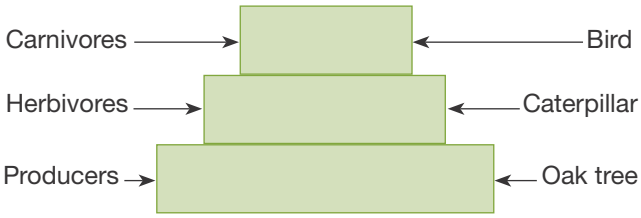



**Figure 6-8. An energy pyramid: Each block in the energy pyramid illustrates the amount of energy available for use by organisms at the next level above it. (Energy for decomposers actually comes from organisms at all the levels, so they are not shown in this simplified pyramid.)**

A continual input of energy, typically from the sun, is required to start the process and to keep it going. Producer organisms capture this energy and store it in the chemical bonds of the food molecules they make. The flow of energy that accompanies the transfer of the food shown in food chains and webs is essential to life on Earth. In spite of this constant drain of energy to the environment, life continues because the sun continues to provide energy.

## Recycling and Reusing Materials

The parts of dead organisms that are not consumed during one of the other steps in the food chain are not wasted. Decomposers extract the last bit of energy contained in the dead organisms (as well as the energy in the waste products from living organisms) and use it to sustain their life processes. As they do so, they return the raw materials contained in the once-living matter to the soil. This process of breaking down dead organisms, as well as the wastes produced by living organisms, into their raw materials and returning those materials to the ecosystem is known as decomposition.

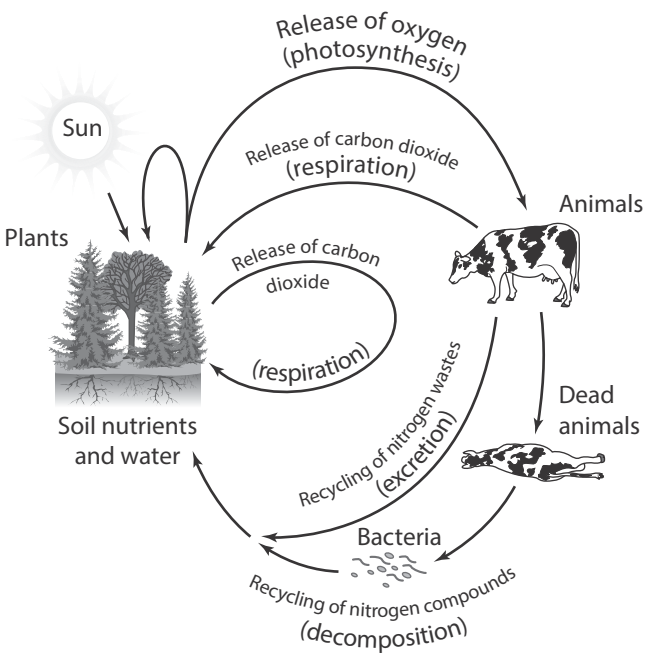



**Figure 6-9. The recycling of materials in ecosystems: Dead organisms and wastes must be recycled in ecosystems so that their raw materials can be made available for re-use by producer organisms. The gas exchanges of photosynthesis and respiration, along with the action of decomposers, are crucial to the recycling process.**

Two examples of organisms that fill the role of decomposers are bacteria and fungi. Because of the actions of decomposers, the atoms and molecules in living things cycle through both the nonliving and living parts of the biosphere. As they do, chemical elements, such as carbon, hydrogen, oxygen, and nitrogen, that make up the bodies of living things pass through food webs and are combined and recombined in different ways in different living organisms. For example, plants trap carbon dioxide and water molecules in energy-rich compounds (such as glucose and starch) during photosynthesis. When plants need energy to power their cell processes or are eaten by a consumer, these molecules may be broken down and used by the organism. During respiration, energy is released by the cells and molecules of carbon dioxide and water returned to the environment.

Much of the cycling of materials in ecosystems is carried out by decomposers. Figure 6-9 shows some of the ways matter cycles throughout the ecosystem.

## Review Questions

**Set 6.3**

**28.** Decomposition and decay of organic matter are accomplished by the action of

(1) green plants (3) viruses and algae
(2) bacteria and fungi (4) scavengers

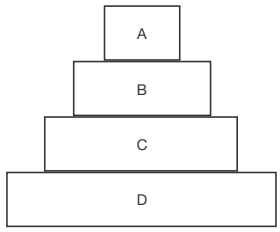
**29.** Which statement best describes energy transfer in a food web?

(1) Energy is transferred to consumers, which convert it to nitrogen and use it to make amino acids.
(2) Energy from producers is converted into oxygen and transferred to consumers.
(3) Energy from the sun is stored in green plants and transferred to consumers.
(4) Energy is transferred to consumers, which use it to produce food.

**30.** Organisms that eat goats obtain less energy from the goats than the goats obtain from the plants they eat. This is because the goats

(1) pass on most of the energy to their offspring
(2) convert solar energy to food energy
(3) store all of their energy in milk
(4) use energy for their own metabolism

**Base your answers to questions 31 and 32 on the energy pyramid below and on your knowledge of biology.**




**31.** If birds eat insects that feed on corn, which level on this pyramid would birds occupy?

(1) A (2) B (3) C (4) D

**32.** Which statement concerning the energy in the pyramid is correct?

(1) The producer organisms contain the least amount of energy.
(2) Stored energy decreases as it is passed from consumer to consumer.
(3) Consumers contain more energy than producers.
(4) Decomposers are the source of energy for this pyramid.

**33.** Most green algae are able to obtain carbon dioxide from the environment and use it to synthesize organic compounds. This activity is an example of

(1) cellular respiration
(2) autotrophic nutrition
(3) heterotrophic nutrition
(4) heterotrophic respiration

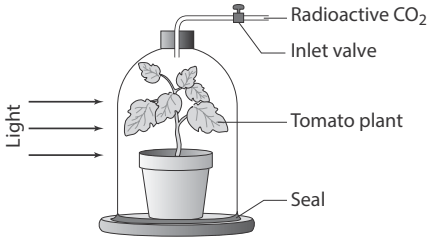
**Base your answers to questions 34 through 37 on the activities described in the paragraphs below and on your knowledge of biology.**

A tomato plant was placed under a sealed bell jar and exposed to light. Carbon dioxide containing radioactive carbon was introduced into the bell jar as shown in the following diagram. After an hour, the inlet valve was closed. Later, the entire plant was removed from the soil and cleaned by rinsing it in water.

A Geiger counter indicated radioactivity in the roots. These roots were then dried and chopped into very small pieces. The chopped roots were sprinkled into an aquarium containing a very hungry goldfish that was *not* radioactive.

Four days later, the fish was removed from the aquarium and a tissue section of the fish was tested with the Geiger counter. The counter indicated an above-normal level of radioactivity in the fish tissues.

**34.** Which cycle is primarily being studied by means of this investigation?




(1) oxygen
(2) carbon
(3) nitrogen
(4) water

**35.** A control setup for this investigation would be identical to the one described except for the replacement of the

(1) tomato plant with a geranium plant
(2) goldfish with a tadpole
(3) radioactive carbon dioxide with atmospheric carbon dioxide
(4) soil with distilled water

**36.** By which process was the radioactivity incorporated into the material that was transported to the roots?

(1) growth
(2) mitosis
(3) photosynthesis
(4) respiration

**37.** This investigation suggests that when plants are eaten by animals, some of the plant materials may be

(1) changed to animal tissue
(2) separated into smaller molecules before being digested
(3) eliminated by the animal in a form that allows the plant to grow again
(4) used in regulating the animal's digestive processes

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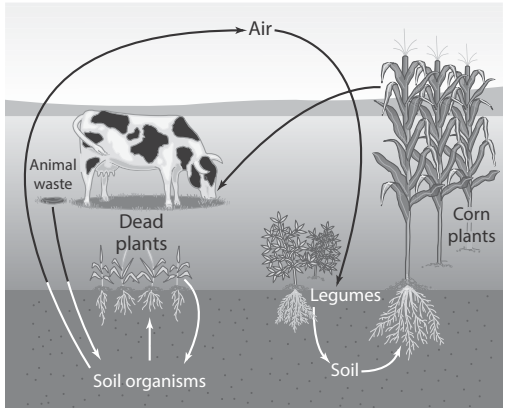
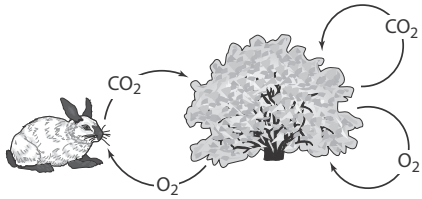
**38.** A cycling of materials is represented in the diagram below.




Which statement is supported by the events shown in the diagram?

(1) Materials are cycled between living organisms only.
(2) Materials are cycled between heterotrophic organisms only.
(3) Materials are cycled between the living and nonliving components of the environment only.
(4) Materials are cycled between autotrophic organisms only.

**39.** Which ecological principle is best illustrated by the diagram below?




(1) In an ecosystem, material is cycled among the organisms and the environment.
(2) In an ecosystem, the number of producers and consumers is equal.
(3) Competition within a species results in natural selection.
(4) An ecosystem requires a constant source of energy.

## Diversity Benefits Species and Habitats

As a result of evolution, there is a great diversity of species on Earth. Almost every ecosystem is populated by many species, each occupying its own special niche. The interrelationships and interdependencies of these species help to keep ecosystems stable, and the diversity of species increases the chance that at least some organisms will survive in the face of large environmental changes.

**Biodiversity** is a measurement of the degree to which species vary within an ecosystem. There is a strong connection between biodiversity and the stability of an ecosystem. A natural forest, for example, contains many different species of trees. If disease or insects attack one population, nearby trees of another species are likely to survive. The mix of species in the ecosystem also makes it difficult for the disease organisms to move quickly through this environment. Here, biodiversity serves as a barrier to the spread of disease or insect attack. In contrast, on a tree farm where all of the trees are planted and are of a single species, the entire population could be seriously damaged by a single disease or insect attack.

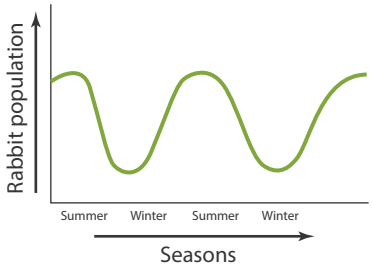



**Figure 6-10. Rabbit populations:** Rabbit populations may rise and fall over the course of a year, but from year to year they follow the same pattern if the environment is stable.

The interactions between organisms may allow an ecosystem to remain stable for hundreds or thousands of years. In established, stable ecosystems, populations tend to increase and decrease in size in a predictable pattern. Over time, however, the size of the population remains relatively stable. For example, when the prey population increases, a large food supply causes the size of the predator population to rise. Because each predator requires many prey to meet its energy needs, the prey population rapidly decreases. Soon, with the decline in a prey population, some of the predators begin to starve. When only a few predators remain alive, the prey population reproduces and greater numbers of prey survive. The cycle begins anew. Figure 6-10 illustrates the seasonal change in a rabbit population.

The loss of biodiversity in an ecosystem upsets its stability. Removing species from an environment often causes instability due to the loss of organisms that were filling critical ecological niches.

Many species may be lost when natural disasters or human activities cause large-scale destruction to habitats. Clearing large areas of tropical rain forest, for example, has disrupted many ecosystems; some may never recover. Although some species may be able to return to a damaged ecosystem, others with critical roles may be totally lost. The interdependencies between populations in the original ecosystem may have been so great that if biodiversity is lost, the ecosystem may never be restored to its original state.

Species can also be lost when humans do not consider the environmental impact of their actions. For example, offering bounties for the removal of predatory mountain lions from some environments sounded like a good idea at one time, but it led to population explosions of deer herds. Soon the deer overpopulated the area, and their overgrazing reduced the food supply so much that many deer starved. The overgrazing also led to soil erosion that caused permanent environmental damage.

When humans clear land for agricultural purposes, the loss of biodiversity may also lead to an unstable environment. Disease and insect pests present major problems to farmers whose crops are genetically similar. For these farmers, any disruption threatens to affect the entire crop. Farmers are constantly in search of ways to control insect pests and diseases in their crops, because they have created an environment that is always in danger of serious disruption. In natural ecosystems, the diversity of species provides no such concentration of one kind of food, making it far less likely that any single pest or disease will cause problems.

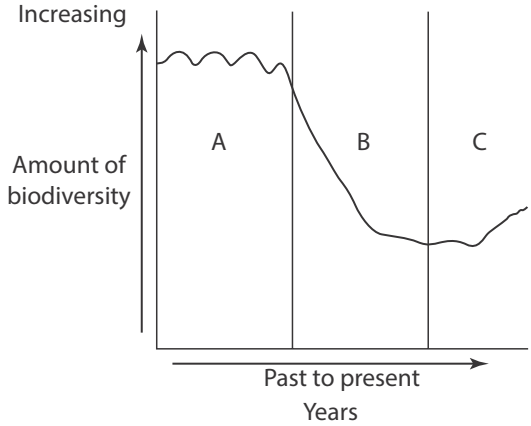
### Biodiversity Benefits Humans

Biodiversity also represents one of the greatest resources known to humans. It ensures the availability of a rich variety of genetic material, some of which may prove valuable to humans. Though still largely untapped, the genetic diversity found in rain forests has provided humans with medicines, insecticides, and other useful resources. If we destroy ecosystems, we lose much of the biodiversity they hold. As diversity is lost, potentially valuable resources are lost with it.

## Review Questions — Set 6.4

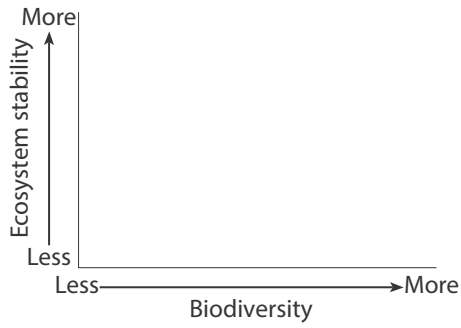
**Base your answers to questions 40 and 41 on the information and graph below and on your knowledge of biology.**

During the 1970s, Canadian forests in New Brunswick were heavily sprayed to control the spruce budworms that were damaging the spruce trees. Ecologists discovered that, along with the budworm, bees of many species—including sweat bees and bumblebees—had also been killed. All of the bees were important for pollinating flowers so the plants could produce fruit. Miles away from the spruce forests, blueberry growers were devastated when their blueberry yield declined by 75 percent over the same time period as the spraying was taking place. The graph shows the biodiversity present in the Canadian spruce forests prior to, during, and after the spraying.




**40.** As the number of insect species declined due to spraying, the blueberry production decreased. Explain how these two events might be related even though the pesticide did not land directly on the blueberry plants. [1]

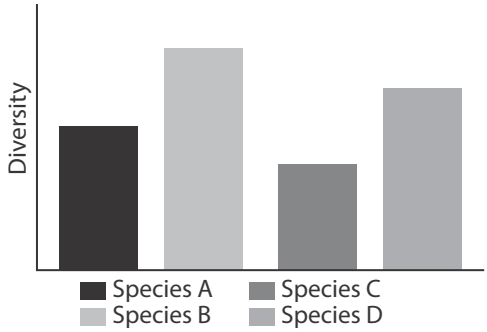
**41.** On the graph provided below, draw a line that shows the relationship of ecosystem stability to changes in biodiversity. [1]




**42.** Explain why medical researchers are concerned when the biodiversity of an ecosystem decreases. [1]

**43.** The color, taste, and juiciness of a particular variety of strawberry makes it very popular. Growers are able to plant hundreds of acres of this variety, and all the plants are exactly the same, since they reproduce asexually. Explain why this lack of diversity in the strawberry field could prove to be a problem for the growers. [1]

**44.** The graph shows the biodiversity present in four different species living in the same area.




If the environment were to change dramatically or if a new plant disease were to be introduced, which plant species would be the most likely to have individuals that could survive the disease?

(1) Species A
(2) Species B
(3) Species C
(4) Species D

**45.** A forest community is made up of thousands of species of organisms and can exist practically unchanged for hundreds of years. This stability is due to the

(1) diversity of organisms present
(2) abundance of insects that feed on plants
(3) changes in the climate of the area
(4) lack of decomposers in the forest

## Environmental Changes

Many environments, such as the bare rock on a mountaintop, have few resources that can provide homes for living organisms. Through natural processes, these environments will change over long periods of time to become habitats for many diverse species. The series of changes by which one habitat changes into another is called **ecological succession.**

In the process of ecological succession, each community causes modifications to its environment. The modifications result in changes that make it more suitable for another community. The original species that lived there may find it harder to adapt to these changes, while the new species coming in may be able to compete more successfully for the new niches.

For example, as grasses grow in an area with very shallow soil, they add organic matter, making the soil deeper and more fertile. Shrubs are then able to live in this modified environment and will eventually produce enough shade to eliminate the grasses growing below them. Over a period of many years, these gradual changes may result in the formation of a stable forest community that can last for hundreds or even thousands of years. (In dry or cold climates, succession may not advance to the forest stage, but the final stage will be a stable ecosystem that can last for many years.)

Climatic changes, natural disasters, and the activities of animals (including humans) can alter stable ecosystems. These changes may occur rapidly, perhaps due to a forest fire or flood, or slowly, as when a long-term drought or climate change occurs. Altered environments undergo a slow series of successional changes that return them to a point where long-term stability is possible. In this process, an existing community of organisms is replaced by different communities over a period of time ranging from a few decades to thousands of years.

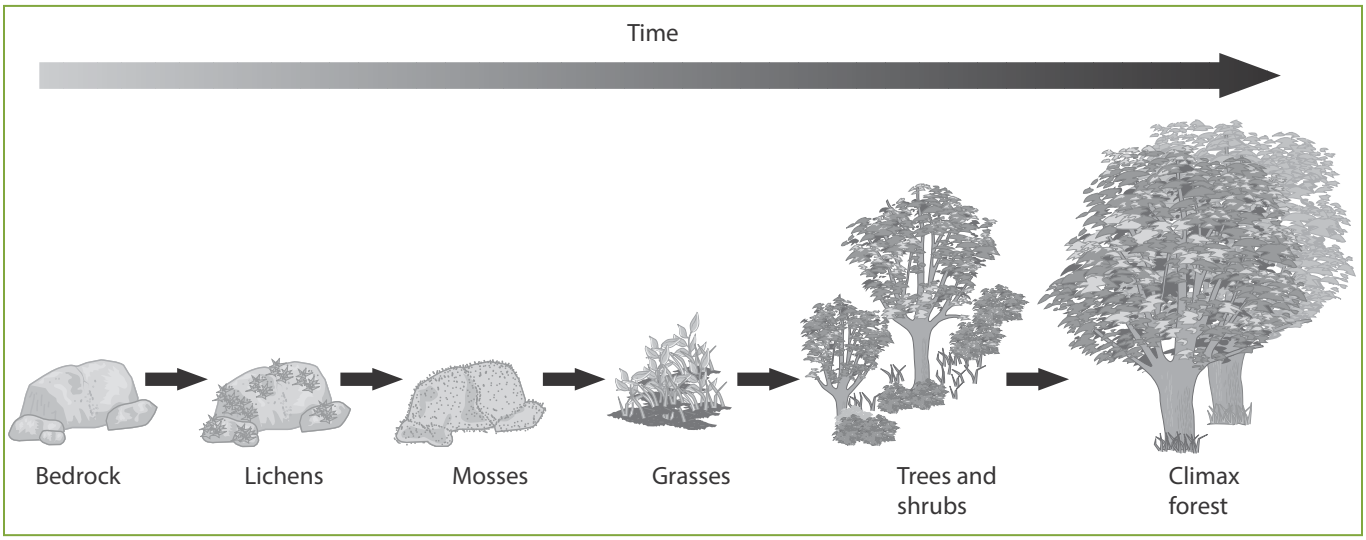



**Figure 6-11. Succession from bare rock to a forest:** As the depth of the soil increases, it can support the root systems of larger plants.

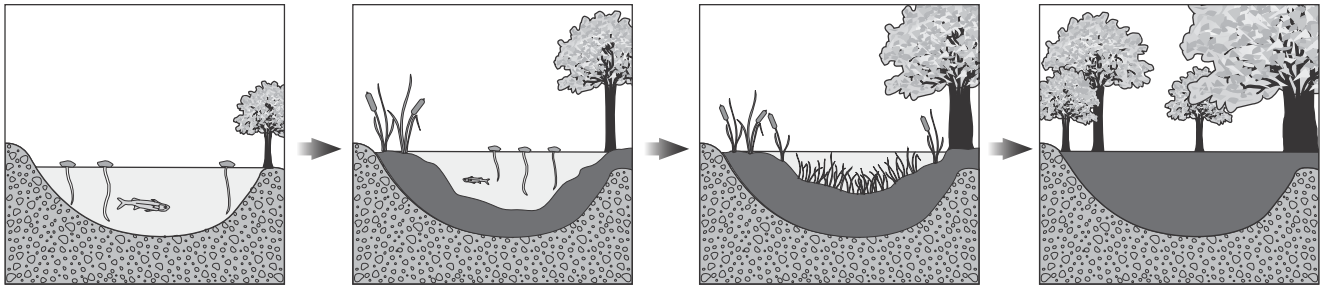
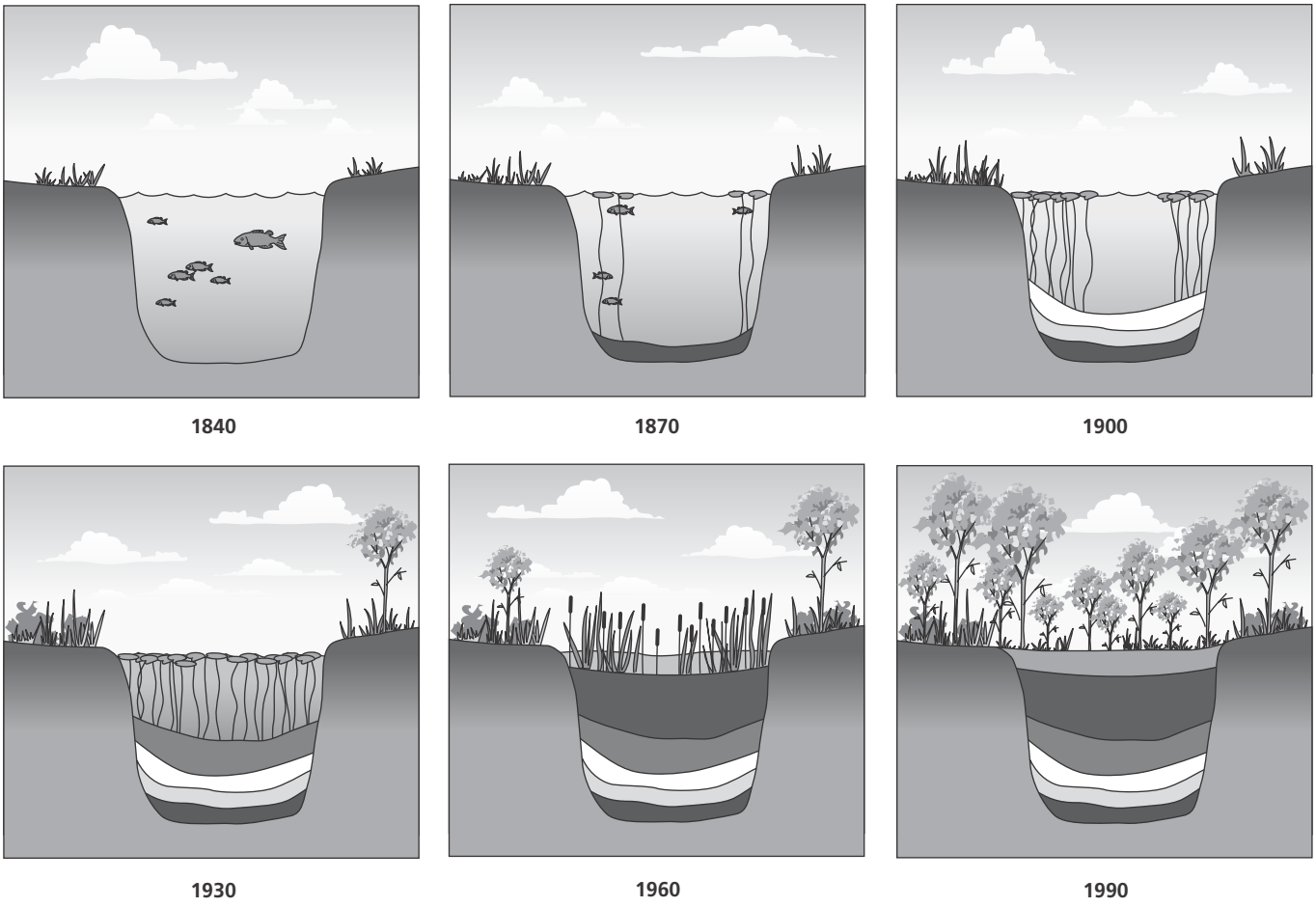


**Figure 6-12. Succession from a lake to a forest**

There are two commonly observed patterns of succession. A community of mostly bare rock will gradually accumulate soil, leading to a progression of vegetation types from grasses to shrubs, and eventually a forest. This process is seen in Figure 6-11.

Another commonly observed example of ecological succession is the change from a lake community to a forest. The lake will gradually accumulate sediments from erosion and the buildup of organic debris from plants and dead organisms. As the lake fills in, it becomes shallower. After many years, it may become a swamp. The filling-in continues, and eventually a mature forest may result. Successional changes from lake to forest are shown in Figure 6-12.

**Base your answers to questions 46 through 49 on the sequence of diagrams below and on your knowledge of biology.**




**46.** This sequence of diagrams best illustrates

(1) succession
(2) evolution
(3) the effects of acid rain
(4) a food chain

**47.** If no human intervention or natural disaster occurs, by the year 2050 this area will most likely be a

(1) lake
(2) swamp
(3) desert
(4) forest

**48.** The natural increase in the amount of vegetation from 1840 to 1930 is related to the

(1) decreasing water depth
(2) increasing amount of sunlight
(3) presence of bottom-feeding fish
(4) use of the pond for fishing

**49.** Describe what would happen over the fifty years following 1990 if a fire burned off all of the vegetation in the area. [1]

---

**Base your answers to questions 50 and 51 on the information below and on your knowledge of biology.**

If you travel inland from the shores of the present Lake Michigan, which was once much larger than it is today, you would travel through the following areas:

1. the present sandy beach
2. grasses
3. a cottonwood forest
4. a pine forest
5. an oak forest
6. a beech-maple forest (where the original shoreline was located)

**50.** The sequence of plant growth is an illustration of

(1) succession
(2) a food chain
(3) evolution
(4) an autotroph pyramid

**51.** Describe why the plants growing in the area of the old shoreline are beech and maple trees and no longer the grasses observed near the new shoreline. [1]

---

**52.** When a stable forest community is destroyed by fire, the community usually is

(1) not restored
(2) restored in a series of successive changes
(3) restored only if humans reforest the area
(4) changed into a permanent grassland

**53.** The conditions that existed in a forest before a fire will be established mainly by

(1) the water cycle
(2) the carbon cycle
(3) succession
(4) evolution

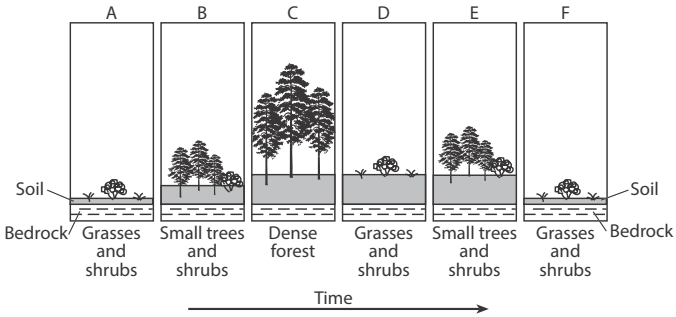
**54.** Which statement accurately describes ecological succession?

(1) The lack of animals in an altered ecosystem speeds up the process of natural succession.
(2) Abrupt changes in an ecosystem only result from human activities.
(3) After a major disaster, stable ecosystems can never become established again.
(4) An abrupt change in an ecosystem can lead to a long-term gradual change.

**55.** When Mount St. Helens erupted in 1980, a portion of the surrounding area was covered by lava, which buried all of the vegetation. Four months later, *Anaphalis margaritacea* plants were found growing out of lava rock crevices. The beginning of plant regrowth in this area is a part of the process known as

(1) species preservation
(2) evolution
(3) biotic competition
(4) succession

**Base your answers to questions 56 through 58 on the diagram below, which represents the changes in an ecosystem over a period of 100 years, and on your knowledge of biology.**




**56** State one biological explanation for the changes in types of vegetation observed from *A* through *C*. [1]

**57** Identify one human activity that could be responsible for the change from *C* to *D*. [1]

**58** Predict what would happen to the soil and vegetation of this ecosystem after stage *F*, assuming no natural disaster or human interference. [1]

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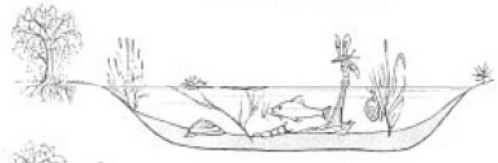
**59** The diagrams below show some changes in an environment over time.

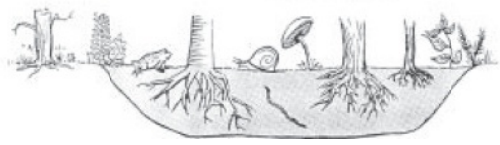
(A)

(B)



(C)

(D)



Which phrase best describes this sequence of diagrams?

(1) the path of energy through a food web in a natural community
(2) the altering of an ecosystem by a natural disaster
(3) natural communities replacing each other in an orderly sequence
(4) similarities between an aquatic ecosystem and a terrestrial ecosystem

**Directions**

Review the Test-Taking Strategies section of this book. Then answer the following questions. Read each question carefully and answer with a correct choice or response.

## Part A

1 The members of an animal community are usually similar in
(1) size
(2) structure
(3) food requirements
(4) environmental requirements

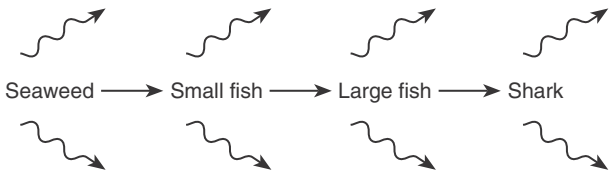
2 Which is a biotic factor that affects the size of a population in a specific ecosystem?
(1) the average temperature of the ecosystem
(2) the number and kinds of soil minerals in the ecosystem
(3) the number and kinds of predators in the ecosystem
(4) the concentration of oxygen in an ecosystem

3 In order to be self-sustaining, an ecosystem must contain
(1) a large number of organisms
(2) a warm, moist environment
(3) a constant source of energy
(4) organisms that occupy all of the niches

4 An overpopulation of deer in a certain area will most likely lead to
(1) a decrease in the number of predators of the deer
(2) an increase in the number of autotrophs available for food
(3) a decrease in the incidence of disease
(4) an increase in competition between the deer

5 For a natural ecosystem to be self-sustaining, many essential chemical elements must be
(1) converted to energy
(2) changed into fossil fuels such as oil and coal
(3) permanently removed from the environment
(4) cycled between organisms and the environment

6 A food chain is illustrated below.

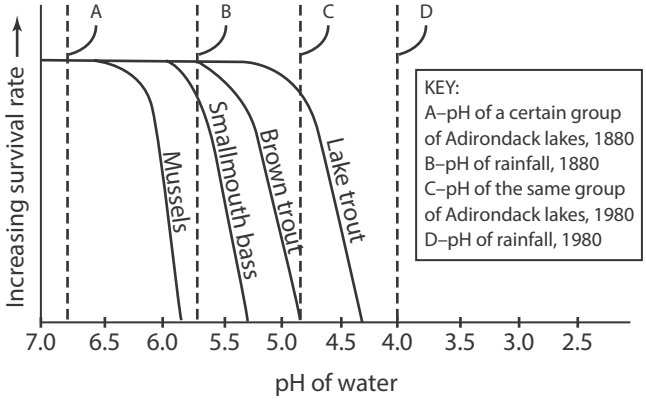



The arrows represented as ⟿ most likely indicate
(1) energy released into the environment as heat
(2) oxygen produced by respiration
(3) the absorption of energy that has been synthesized
(4) the transport of glucose away from the organism

## Part B

**Base your answers to questions 7 and 8 on the information and graph below and on your knowledge of biology.**

**The Effect of pH on Survival Rates of Selected Species in Certain Adirondack Lakes**




–*National Geographic* (adapted)

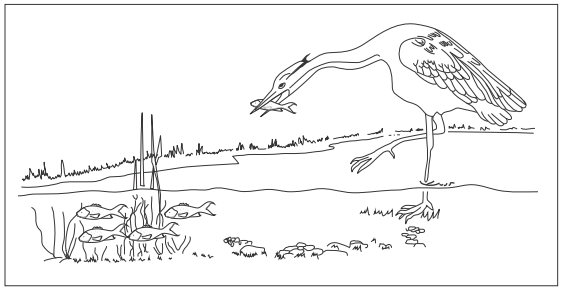
7 State how the pH of these Adirondack lakes changed between 1880 and 1980. [1]

8 State the effect that the pH change in these Adirondack lakes had on lake trout, brown trout, smallmouth bass, and mussels. [1]

9 Which types of organisms must be present in an ecosystem if the ecosystem is to be maintained?
(1) producers and carnivores
(2) producers and decomposers
(3) carnivores and decomposers
(4) herbivores and carnivores

**10** Although three different bird species all inhabit the same type of tree in an area, competition between the birds rarely occurs. The most likely explanation for this lack of competition is that these birds
(1) have different ecological niches
(2) eat the same food
(3) have a limited supply of food
(4) are unable to interbreed

**11** Identify one abiotic factor that would directly affect the survival of the fish shown in the diagram below. [1]



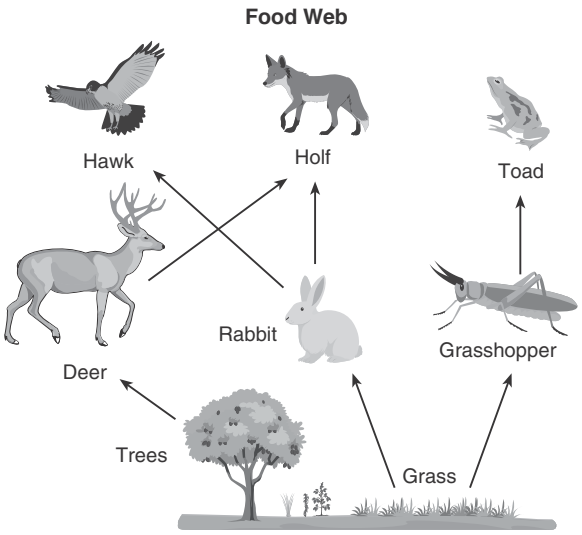
**12** Which pair of terms would most likely apply to the same organism?
(1) heterotroph and herbivore
(2) heterotroph and autotroph
(3) autotroph and parasite
(4) producer and predator

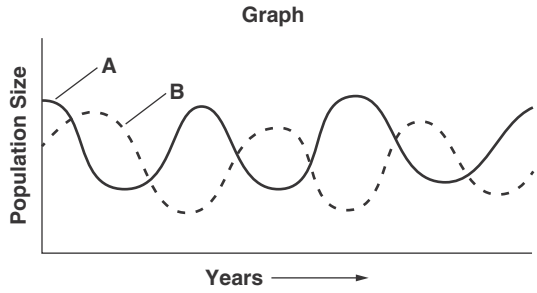
**13** A food chain is represented below.

**corn plants → field mice → garter snakes → red-tailed hawks**

The most abundant organisms in the food chain would be the
(1) corn plants
(2) field mice
(3) garter snakes
(4) red-tailed hawks

**Base your answers to questions 14 through 16 on the food web and graph and on your knowledge of biology. The graph represents the interaction of two different populations, A and B, in the food web.**

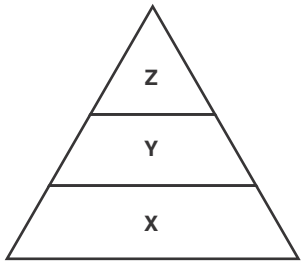



**14** Population A is made up of living animals. The members of population B feed on these living animals. The members of population B are most likely
(1) scavengers
(2) autotrophs
(3) predators
(4) parasites

**15** Identify one heterotroph from the food web that could be a member of population A. [1]

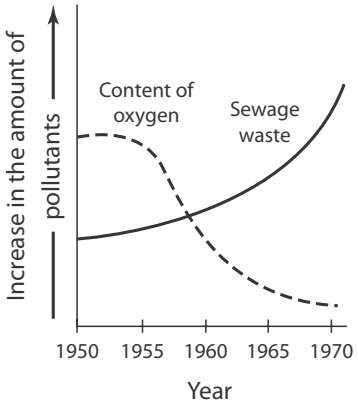
**16** An energy pyramid is shown below.

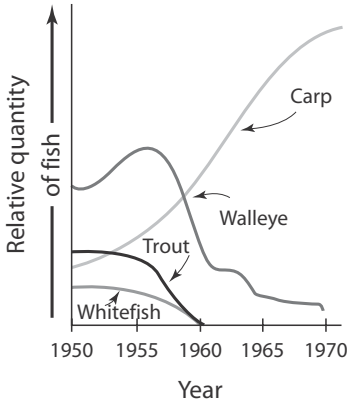



Identify one organism shown in the food web that would be found at level X. [1]

**Base your answers to questions 17 through 20 on the graphs below that show data on some environmental factors affecting a large New York lake.**

**17** Which relationship can be correctly inferred from the data present?




(1) As sewage waste increases, the oxygen content decreases.
(2) As sewage waste increases, the oxygen content increases.
(3) As oxygen content decreases, the carp population decreases.
(4) As oxygen level decreases, the trout population increases.

**18** The greatest change in the lake's whitefish population occurred in the years between
(1) 1950 and 1955 (3) 1960 and 1965
(2) 1955 and 1960 (4) 1965 and 1970

**19** Identify the fish species that appears to withstand the greatest degree of oxygen depletion. [1]

**20** Explain the impact of increased sewage levels on the biodiversity of the lake ecosystem. Support your answer with specific examples from the graph. [1]

**Base your answers to questions 21 through 24 on the information below and data table.**

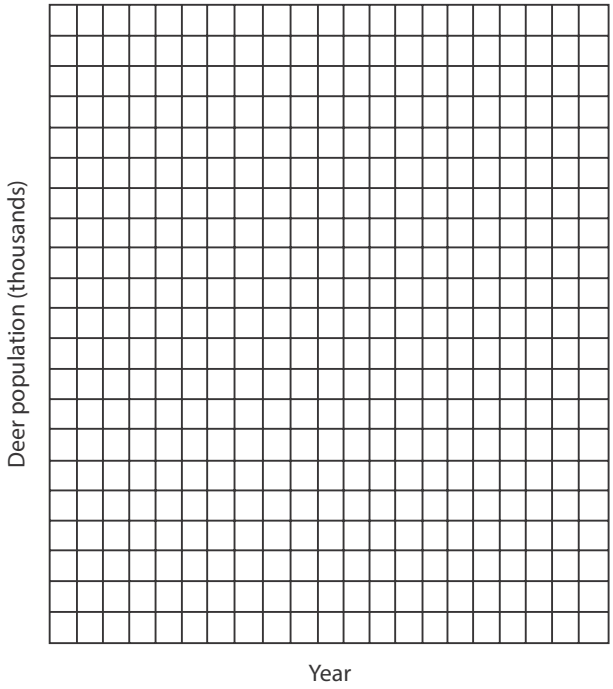
A field study was conducted to observe a deer population in a given region over time. The deer were counted at different intervals over a period of 40 years. During this period, both ranching and the hunting of deer and their predators increased in the study region. A summary of the data is presented in the table.

**Deer Population Changes 1900-1940**

| Year | Deer Population (thousands) |
|---|---|
| 1900 | 3.0 |
| 1910 | 9.5 |
| 1920 | 65.0 |
| 1924 | 100.0 |
| 1926 | 40.0 |
| 1930 | 25.0 |
| 1940 | 10.0 |

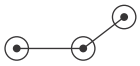
Using the information in the data table, construct a line graph on the grid following the directions below.

**Deer Population Changes 1900-1940**




**21** Mark an appropriate scale, without any breaks in the data, on each labeled axis. [1]

**22** Plot the data for the deer population on the grid. Connect the points and surround each point with a small circle.

Example: 

**23** During which 10-year period did the greatest increase in the deer population occur?

(1) 1900–1910 (3) 1920–1930
(2) 1910–1920 (4) 1930–1940

**24** State one possible action that could have been taken to help maintain a more stable population of deer in the area. [1]

---

**Base your answers to questions 25 through 28 on the information below and on your knowledge of biology.**

For 25 years, hay was cut from the same 10 acres on a farm. During these years, shrews, grasshoppers, spiders, rabbits, and mice were seen in this hayfield. After the farmer retired, he no longer cut the hay, and the field was left unattended.

**25** Which description best matches the events in the former hayfield over the next few decades?

(1) The plant species will change, but the animal species will remain the same.
(2) The animal species will change, but the plant species will remain the same.
(3) Neither the plant species nor the animal species will change.
(4) Both the plant species and the animal species will change.

**26** The grasshoppers, spiders, shrews, and other organisms, along with the soil minerals, amount of rainfall, and other factors, constitute

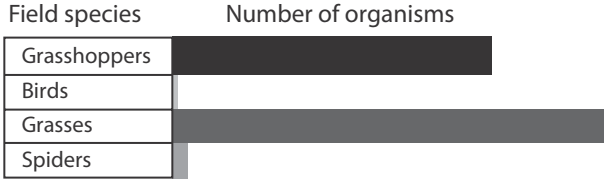
(1) an ecosystem (3) a biosphere
(2) a species (4) a food web

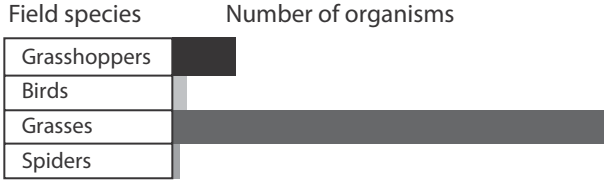
**27** Just before he retired, the farmer determined the population size of several of the field species during the months of May, July, and August. The results are recorded in the table below.

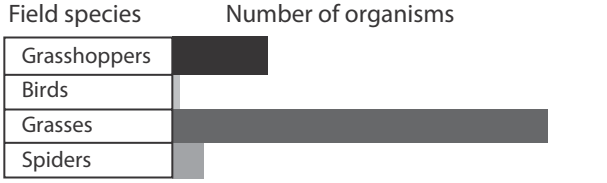
| Field Species | Number of Organisms | | |
|---|---|---|---|
| | May | July | August |
| Grasshoppers | 1,000 | 5,000 | 1,500 |
| Birds | 250 | 100 | 100 |
| Grasses | 7,000 | 20,000 | 6,000 |
| Spiders | 75 | 200 | 500 |

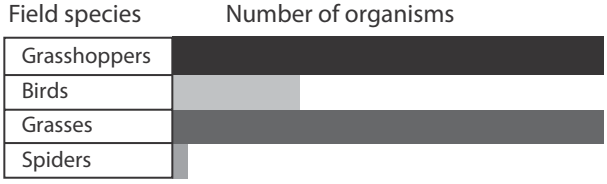
Draw a food chain that represents the most likely feeding relationships among four of the organisms (grasshoppers, birds, grasses, and spiders) that live in the field. [1]

**28** Which graph best represents the relative population size of the field species for May?

(1)



(2)



(3)



(4)
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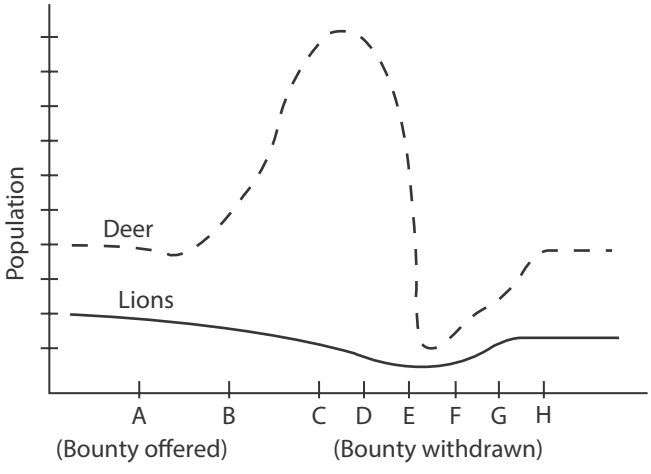
**Base your answers to questions 29 and 30 on the information below and on your knowledge of biology.**



The graph shows the relative populations of mountain lions and deer in a certain geographic area that is generally favorable to both animals. At the time indicated by point A, hunters were offered a bounty payment for each mountain lion killed. Later, at the time indicated by point E, these bounties were withdrawn and hunting mountain lions was discouraged.

**29** Which explanation best accounts for the fact that, according to the graph, the deer population is always higher than the mountain lion population?
(1) The geographic location is more favorable for deer than for mountain lions.
(2) Hunters are likely to kill more mountain lions than deer.
(3) The organism serving as the food supply is normally more numerous than its predator.
(4) Mountain lions usually produce more offspring than deer.

**30** The graph is an illustration of the principle that
(1) predators serve an important purpose in a balanced ecosystem
(2) human intervention has little permanent impact on the survival of animal species
(3) deer need the protection of humans in order to survive the attacks of their natural enemies
(4) mountain lions do not pose the greatest danger to deer in their struggle for survival

## Part C

**31** State *two* reasons why it is important to preserve biodiversity. [1]

**32** Explain the difference between a habitat and a niche. [1]

**Base your answers to questions 33 through 35 on the information below and on your knowledge of biology.**

The last known wolf native to the Adirondack Mountains of New York State was killed over a century ago. Several environmental groups have recently proposed reintroducing the wolf to the Adirondacks. These groups claim there is sufficient prey to support a wolf population in this area. These prey include beaver, deer, and moose. Opponents of this proposal state that the Adirondacks already have a dominant predator, the Eastern coyote.

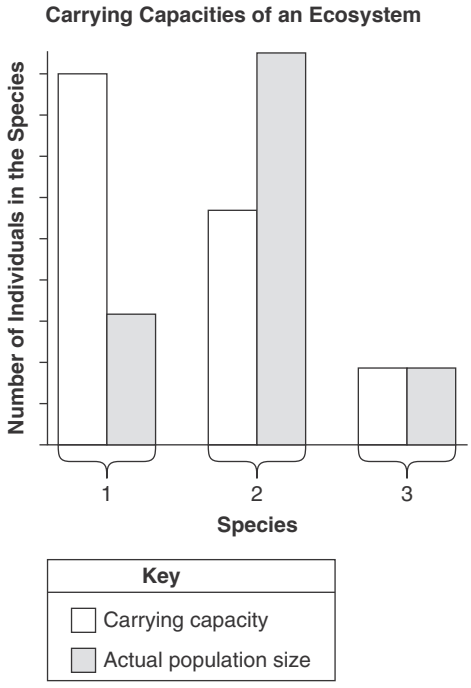
**33** State one effect the reintroduction of the wolf may have on the coyote population within the Adirondacks. Explain why it would have this effect. [1]

**34** Explain why the coyote is considered a limiting factor in the Adirondack Mountains. [1]

**35** State one ecological reason why some individuals might support the reintroduction of wolves to the Adirondacks. [1]

**Base your answers to questions 36 and 37 on the information and graph below and on your knowledge of biology. The graph contains information about an ecosystem.**

The graph below shows the carrying capacities of an ecosystem for three different species, 1, 2, and 3, that inhabit an area and the actual population sizes of these three different species in the area.




**36** Identify which species population would most likely have the greatest competition among its members. Support your answer using information from the graph. [1]

**37** Explain how an ecosystem can have three different carrying capacities. [1]