CHAPTER 2

Interactions in Ecosystems

Chapter Preview

What do you need to live? How are your needs different from those of other living things on Earth? Where do the things that you need come from? What would happen if something you needed was not available?

Life exists almost everywhere on Earth. All life, and everything needed to maintain it, exists within a thin layer of land, sea, and air. While the estimates vary, some scientists believe that as many as 40 million different species may populate the planet. But only about 3 million of them have been identified and given a name. Only a few thousand of them have been studied in detail. Scientists attempt to learn more about each living thing. But they do not stop there.

To fully understand the world of living things, scientists look at how organisms interact with each other and with their environment. No living thing can exist in isolation. Every organism is linked to other organisms on the planet. Trying to understand all of the relationships that exist among different living things, as well as with their surroundings, is the goal of ecology.

KEY IDEAS

- **Living things are connected to each other in complex interrelationships.**
- **Biotic and abiotic factors are responsible for shaping a community of living things.**
- **Nutrients cycle within ecosystems.**
- **Energy flows through ecosystems.**

TRY THIS: Modelling Interactions

Skills Focus: communicating, recording

In this activity, you will explore the interactions that one organism has with the other organisms around it, and with the environment in which it lives.

Materials: notebook or graphic organizer

1. Create a graphic organizer to represent interactions between a spider and its environment.
2. Consider what the spider eats. What other organisms might compete with it for the same food? What eats spiders? Consider other relationships as well.
3. Consider the non-living factors that affect the spider.
4. Add these organisms, relationships, and factors in your graphic organizer. Connect the interactions by drawing lines between them and the spider.

A. In what way is this model of representing interrelationships useful?

B. What are the weaknesses of this type of model for showing interrelationships?

C. Why are models like this one useful for understanding interrelationships among organisms and their environments?

D. The spider is just one organism. What can you predict about modelling interactions that occur between all of the living things on planet Earth?

2.1 Biotic and Abiotic Factors in Ecosystems

Ecology is the study of how organisms interact with each other and with their physical environment. Ecologists collect information about living things, and then look for patterns to explain the observations. This is an enormous challenge because there is a tremendous variety of organisms and so many different relationships among them. It is for this reason that ecologists organize their study into several levels (Figure 1).

The first and simplest level of organization that ecologists study is a single living thing or **organism**. They study the behaviours, the functions, and the body structures that an organism has in order to survive in its **habitat**, or region in which it lives. For example, they might study how a sea otter captures food or how its body is specialized for the marine habitat. But most organisms do not live as isolated individuals. Usually organisms live as a **population** (the second level of organization), which is all of the organisms of the same species that share a habitat. Ecologists might study how the number of sea otters in the waters of coastal British Columbia changes over time. But populations interact with other populations of organisms.

Did You KNOW?

Sounds like Greek to Me!

The word "ecology" comes from two Greek words: *oikos*, which means "house," and *logos* or "word," referring to study. So, ecology is literally the science of studying the place where something lives.

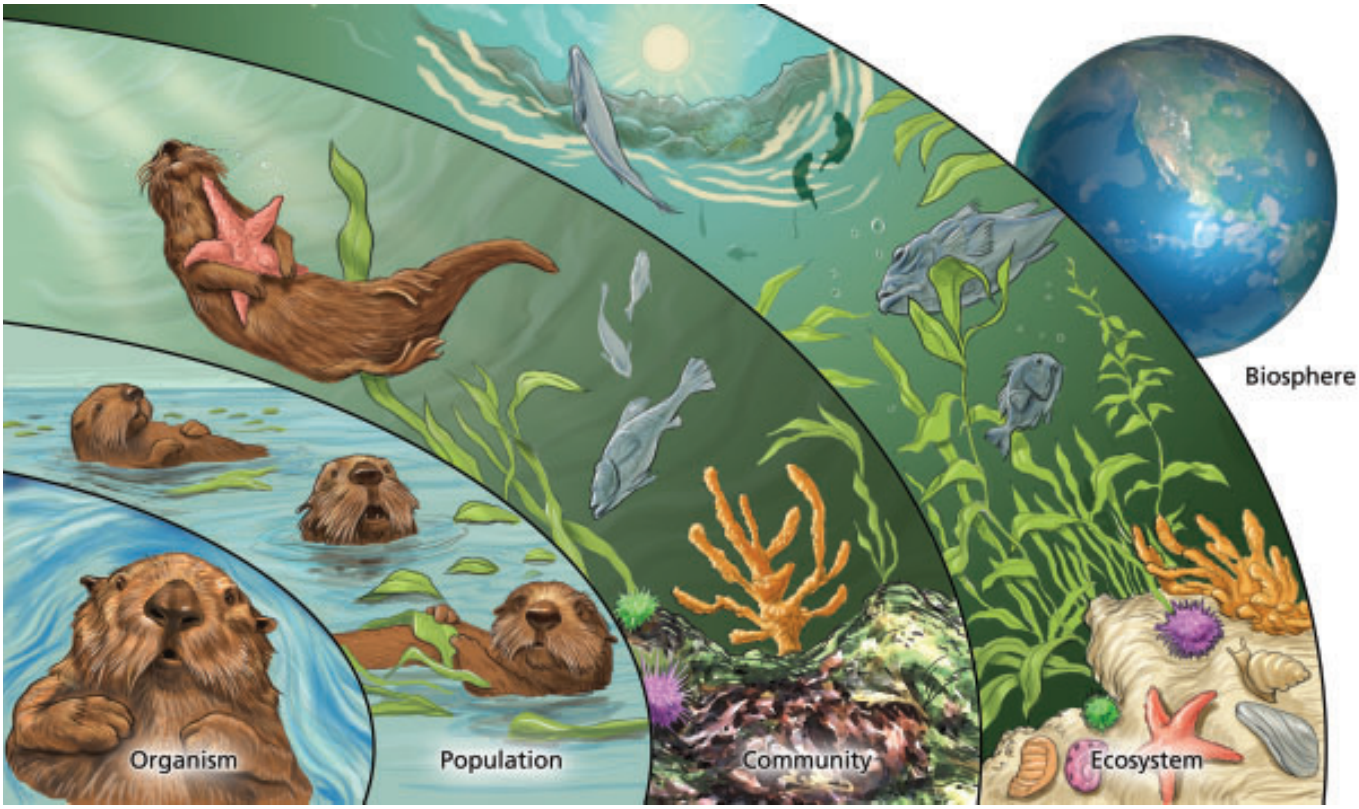


Figure 1 The study of ecology involves organisms, populations, communities, and ecosystems. The biosphere includes all of the ecosystems on Earth.

STUDY TIP

Check your understanding. Are you able to recall the levels within the biosphere? If not, reread the main ideas and words in bold, and re-examine Figure 1, on page 21.

To learn more about the ecosystems found in British Columbia, go to **www.science.nelson.com** GO

All of the different populations in a particular area interact, forming a **community**, which is the third level of organization. The community that lives within the kelp beds off the coast of British Columbia includes many populations of plants, fish, and invertebrates like sea urchins, sea stars, and sponges. At the community level, an ecologist might study how the number of sea urchins affects the number of sea otters in the kelp bed community. They are interested in ways that internal and external factors affect the size of the populations in a community.

An **ecosystem**, which is the fourth and most complex level of organization, includes the living community as well as the physical environment in which the organisms live. GO

Factors such as the introduction of a new species or a temperature change would have a huge impact on the kelp bed community. An ecosystem is simply a convenient way to look at interactions between the living and the non-living things in an area. It is not defined by size or complexity. It could be as small as the spaces in a rotting log, or as big as the ocean. You could even think of Earth as one big ecosystem, but because of its complexity it is usually considered on a different level called the **biosphere**. The biosphere is the total area of Earth where living things are found, including the soil, atmosphere, and ocean.

TRY THIS: Make a Model Ecosystem

Skills Focus: conducting, recording, communicating, questioning, evaluating

In this activity, you will combine living and non-living factors to create your own ecosystem.

Materials: 3–4 L jar with lid, 250 g of sand or gravel, 4–5 aquatic snails, 2 small guppies, 4–5 aquatic plants

Handle glass products with care. Assemble the equipment where it will stand so that it does not need to be moved after being filled.

1. Place 2–3 cm of sand or gravel into a large jar.
2. Fill the jar with tap water to within 5 cm of the top. Let it stand without the lid on for 48 h.
3. Add the aquatic plants, snails, and guppies.
4. Place the lid on the jar and seal tightly.
5. Place the jar in an area where it can receive indirect sunlight for 1 week.

A. What was the purpose of sealing your model ecosystem?

B. What is the source of carbon dioxide that the algae and plants require?

C. What is the source of oxygen that the fish and snails require?

D. How do the plants and animals get the necessary nutrients?

E. What would happen to the ecosystem if one of the fish died?

There are two types of environmental factors in an ecosystem, the living community and the physical environment. The living components of the ecosystem are called **biotic factors**. For example, in the kelp beds off the coast of British Columbia the biotic factors include the plants, fish, and invertebrates, as well as the complex interactions occurring between them. The non-living components, or **abiotic factors**, include the physical and chemical components in the environment. Some of the more significant

abiotic factors are temperature, wind, water, sunlight, and oxygen. The abiotic factors in the kelp beds would include (among others) the water temperature, the currents, and factors such as an oil spill.

Abiotic and biotic factors are connected to each other (Figure 2). As organisms live, they alter the environment around them, which in turn affects the organisms. This type of balance, where there is continuous change but the overall system remains stable, is called **dynamic equilibrium**. Ecosystems are normally able to adjust to small changes from within. The importance of abiotic factors cannot be emphasized enough. The difference in abiotic factors like climatic conditions and soil quality determines the distribution of life and contributes to diversity within the biosphere. 2A • *Investigation*

Sometimes one factor, known as a **limiting factor**, is the most critical factor in determining the types of organisms that can exist in an ecosystem. For example, the large Douglas fir trees in our Pacific coastal forests grow only in regions with high annual rainfall. In aquatic environments, important limiting factors are sunlight, temperature, and the amount of dissolved oxygen in the water.

Did You KNOW?

Abiotic Technology

Many of the technologies you use everyday were invented in response to an existing abiotic factor. Furnaces, air conditioners, solar panels, and many other technologies are just a few of the adaptations humans have made in response to abiotic factors.

2A • *Investigation*

The Effect of Abiotic Factors on a Yeast Population

To perform this investigation, turn to page 42.

In this investigation, you will investigate the effects of abiotic factors on populations.

(a) (b) (c)

Figure 2 Abiotic factors such as (a) frost and biotic factors such as (b) pests and (c) other organisms affect the growth of the biotic factors like crops.

TRY THIS: A Day at the Beach

Skills Focus: recording, communicating

Abiotic factors have a large impact on living things. In this activity, you will explore the biotic and abiotic factors that can influence a day of outdoor fun.

Materials: notebook or graphic organizer

1. Plan a great day at the beach. Make a list of all of the things you should consider in your planning.

A. What abiotic factors should you consider?

B. Identify biotic factors that might be a part of your day at the beach.

C. How would these abiotic and biotic factors differ if you were planning a great day of skiing or snowboarding?

2.1 CHECK YOUR Understanding

1. Compare the following terms. Give both similarities and differences.
   (a) ecosystem and habitat
   (b) organism and population
   (c) biosphere and community
   (d) ecosystem and community
2. What level of organization within the biosphere is represented by each of the following?
   (a) a herd of water buffalo
   (b) the plants and animals on the Serengeti plain of Africa
   (c) a lake and all of the organisms that live within it
   (d) a grizzly bear
   (e) sunflowers growing in a garden
3. Which level of organization is being considered in each of the following ecological studies?
   (a) observing how the talons of a bald eagle are used to capture food
   (b) observing the migratory pattern of a flock of snow geese
   (c) observing the impact of a hazardous chemical spill on living things in a nearby stream
   (d) observing the nest-building behaviour of hummingbirds
   (e) observing the effect of fleas on the health of house pets
   (f) measuring the changes in oxygen levels of a small lake during periods of rapid plant growth
4. Why is the science of ecology important?
5. List at least three characteristics of ecosystems that make them challenging to understand in detail.
6. Provide two other situations besides ecology in which it is helpful to use a classification system like the one developed by ecologists.
7. The mouth of a dog or Earth itself could each be defined as entire ecosystems. What characteristics do they have in common that makes this similar classification appropriate?
8. Use Figure 3 to answer the following questions:

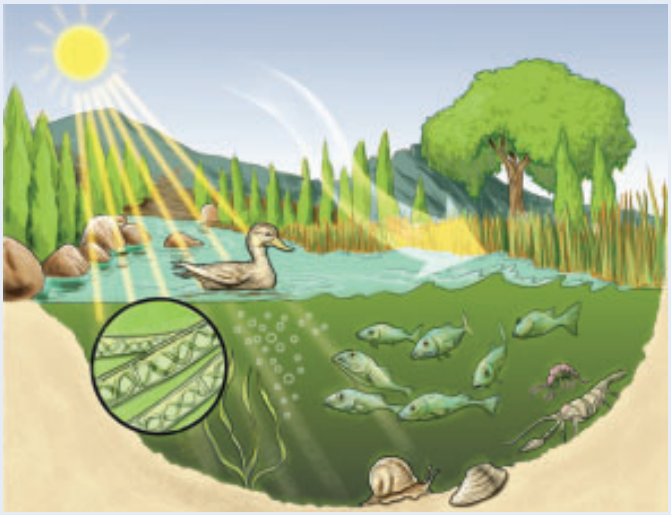


Figure 3

   (a) Identify each of the following from the illustration. Explain your reasoning.
      i) two biotic factors
      ii) two abiotic factors
      iii) a limiting factor
   (b) Describe the relationship between the abiotic and biotic factors that you selected.
   (c) Which abiotic factor could be altered to have the greatest effect on the ecosystem? Explain your reasoning.

2.2 Ecological Roles and Relationships

We can look at an ecosystem as a complex network of interactions. Within an ecosystem, all organisms need to carry out basic essential life functions such as growth, movement, repair, and reproduction. In order to perform these functions, organisms must take in food, water, and other nutrients. **Nutrients** are the elements and compounds that organisms must have in order to live and grow. Nutrients include water, oxygen, vitamins, and minerals, as well as the foods we eat that provide fats, proteins, and carbohydrates. Some organisms, like plants, can make their own food, while other organisms need to consume food in order to live.

LEARNING TIP

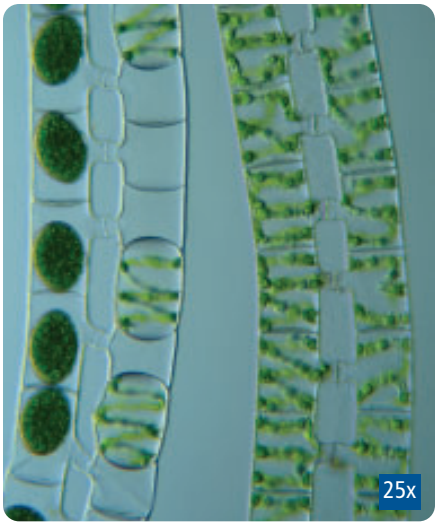
Active readers interact with the text. As you read Section 2.2 go back and forth between the words in bold and the photographs. Ask yourself, "How can I figure out the meanings of unfamiliar terms from cues in the text and illustrations?"

Producers

The **producers** or **autotrophs** (Figure 1) are organisms that make their own food, usually using energy from the Sun in a process called photosynthesis. You will learn more about this process in Chapter 4. Producers are also an important food source for other organisms.

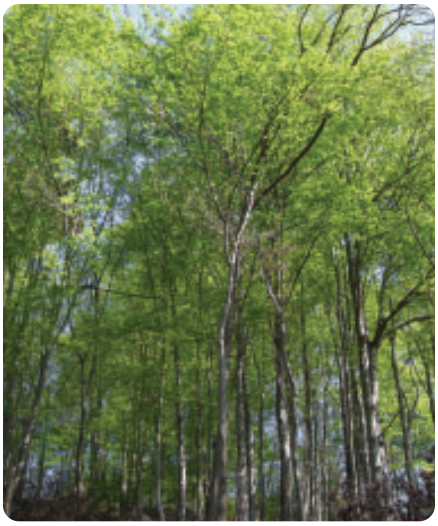
Almost all plants can photosynthesize, and on land they are the most important type of producer. In aquatic environments, producer organisms called algae photosynthesize as well. Algae include some plant-like protists (single-celled, eukaryotic organisms), single and multicellular plants, and some photosynthetic bacteria. Microscopic algae are called **phytoplankton**.

Some producers are not photosynthetic and can live on the ocean floor or deep within caves, in the total absence of light. Instead of using the energy of the Sun, they use the thermal and chemical energy of Earth's interior in a process called chemosynthesis.



(a)

(b)



(c)

Figure 1 Producers come in all shapes and sizes, including (a) *spirogyra* algae, (b) purple lupins, and (c) deciduous trees. What they share in common is the ability to make food from inorganic materials and a source of energy, such as the Sun.

To learn more about the role of organisms in an ecosystem, watch the animation found at **www.science.nelson.com**

Consumers

Organisms that consume other organisms or biotic waste in order to survive are called **consumers** or **heterotrophs**. Consumers ingest other organisms and break down the chemical bonds within those organisms to obtain energy and carbon. You will learn more about this process in Chapter 4.

Consumers that eat producers are called **herbivores** or **primary consumers.** Herbivores include insects and animals, such as caterpillars and elk, that eat plants (Figure 2). In aquatic environments, herbivores include microscopic **zooplankton** that eat phytoplankton. Consumers that eat other consumers are called **carnivores**, such as those shown in Figure 3. Some organisms called **omnivores** eat both producers and other consumers (Figure 4). Humans are omnivores, as are grizzly bears that eat a variety of foods including salmon and insects as well as fruits and berries.

(a)

(b)

Figure 2 (a) The elk and (b) caterpillar are both herbivores. Both rely on producers as food.

(a)

(b)

Figure 3 (a) The killer whale and (b) praying mantis are both carnivores. They eat other consumers in order to gain the energy they need to survive.

(a)

(b)

Figure 4 (a) Grizzly bears and (b) humans are both omnivores. They eat producers as well as other consumers.

Detrivores are consumer organisms that feed on the waste material in an ecosystem, including the bodies of other organisms that have recently died, plant debris, and animal feces (Figure 5). **Decomposers** are a special type of consumer that breaks down the complex molecules found in dead organisms and waste matter into simpler molecules. Decomposers like bacteria and fungi cause the decay of material. Decomposer organisms like bacteria are nature's recyclers. They make the nutrients contained in waste and dead matter available to producers once again through a process called **biodegradation** (Figure 6). In areas where decomposers are abundant, rich fertile soil exists. Ecosystems with few decomposers have very little decay, and as a result the soil tends to be thin and low in nutrients.

(a)

(b)

Figure 5 Organisms such as (a) earthworms and (b) hagfish that feed on the waste and remains of other organisms are called detrivores.

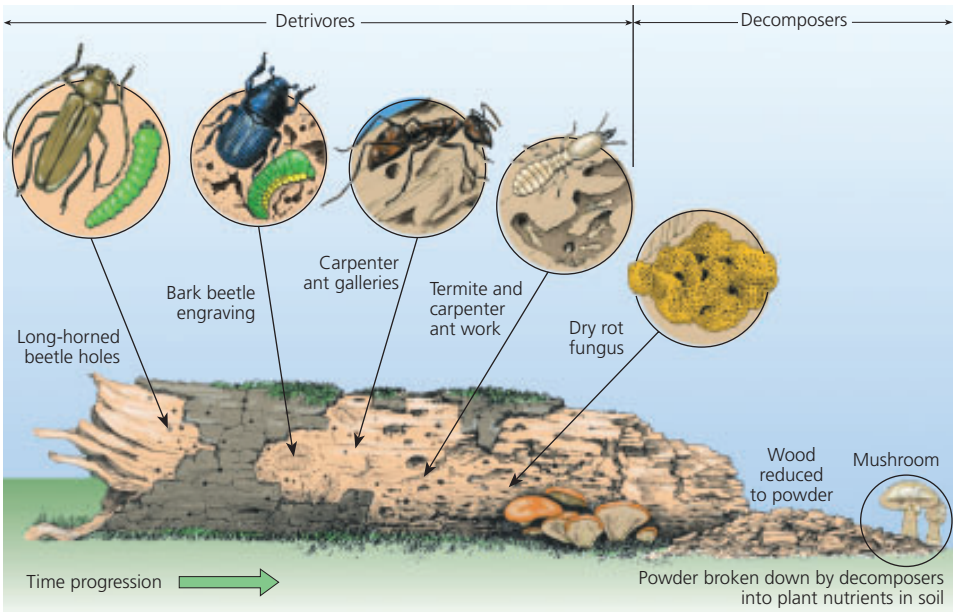


Figure 6 Decomposers such as fungi and bacteria, as well as detrivores like insects and other scavengers, form a complex community within a log. Eventually they break the log down, releasing the nutrients into the soil.

TRY THIS: Leaf Debris

Skills Focus: conducting, recording, communicating, questioning, observing, predicting

In this activity, you will explore leaf litter for signs of decomposers and the work that they do.

Materials: fallen rotting leaves; hand lens or dissecting microscope

Some people have reactions to airborne microbes in decomposing material. Use caution if you have allergies or asthma.

1. Collect some fallen leaves that have been on the ground for some time.
2. Observe the leaves under a hand lens or dissecting microscope. Look for any signs of decomposers.

A. What characteristics help you to identify a decomposer?

B. What kind of organism is mould? What role do moulds play in a forest ecosystem?

C. What other organisms can you find in your sample? What roles do they play in a forest ecosystem?

D. What do you think will eventually happen to the material contained in the leaves?

E. Select two abiotic factors and predict how they will affect the process occurring in the rotting leaves.

Figure 7 Not all predators are fast, with sharp claws and teeth. This sea star is a predator.

Predators

Predation occurs when a consumer captures and eats another organism, such as when a **predator** like a mountain lion captures, kills, and eats a **prey** animal such as a deer. It is common to think of predators as fast-moving carnivores, but the term more broadly refers to any consumer in an ecosystem. Organisms as varied as sea stars, centipedes, rabbits, and tigers are all predators (Figure 7).

At first glance it might seem that a predator simply reduces the population of prey in a community. However, there tends to be a cyclic rise and fall in both populations called the **predator–prey cycle** (Figure 8). The cycle begins when the prey population decreases as the predators eat the prey. Then, the predator population decreases as available prey run out. The cycle continues as the decreased number of predators allows more prey to survive, and the prey population rebounds. The predator population then increases because it now has an abundant food supply. The predators reduce the prey population and the cycle begins again. A distinct characteristic of this cycle is the time lag of the predator population. This refers to the delay as the predator population responds to the changes in the prey population.

The cycle in actual populations, such as the Canadian lynx and the snowshoe hare (Figure 9), is much more complex than the simple predator–prey cycle predicts and only slightly resembles the simplified model shown in Figure 8. However, the model remains useful to understand the cycling of the two interrelated populations. 2B *Investigation*

In natural populations there are several other environmental factors at work and effectively two predator–prey cycles. Remember! Herbivores are predators as well and have a predator–prey relationship with the plants they eat. Both populations are interacting with the prey they consume.

2B *Investigation*

Predator–Prey Simulation

To perform this investigation, turn to page 44.

In this investigation, you will simulate the interactions between a predator and a prey species.

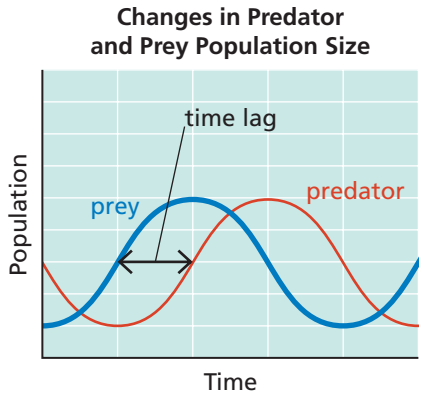


Figure 8 The predator–prey model describes the cycling of the predator and prey populations.

Figure 9 The interaction between the snowshoe hare and the Canadian lynx is one of the best known illustrations of the predator–prey cycle.

2.2 CHECK YOUR Understanding

1. Compare the following terms. Give both similarities and differences.
   (a) producer and consumer
   (b) omnivore and carnivore
   (c) carnivore and herbivore
2. The word "autotroph" literally means "self-feeder." Why is this term appropriate in reference to producers?
3. The word "heterotroph" literally means "other-feeder." Why is this term appropriate in reference to consumers?
4. How does a consumer differ from a decomposer?
5. What role do decomposers fill in an ecosystem?
6. List five producers and five consumers that live near your home.
7. Compare a herbivore, a carnivore, and a detrivore. Indicate both similarities and differences.
8. In your own words, define "nutrient."
9. Which of the following classifications is most appropriate for bread mould and mushrooms?
   A. producers
   B. herbivores
   C. carnivores
   D. decomposers
10. Often farmers will plough the remains of their crops into the soil. Explain why this is a better option than taking them away to burn.
11. Which of the following terms refers to organisms that are able to cause biodegradation?
    A. herbivores
    B. omnivores
    C. carnivores
    D. decomposers
12. The word "omnivore" is from two Latin words: *omne* meaning "all" or "everything" and *vorare* meaning "to devour." What characteristic of omnivores makes this an appropriate name for them? In what ways is the name misleading?
13. The interaction between the snowshoe hare and the Canadian lynx has been documented for over 100 years.
    (a) In what ways is the predator–prey cycle shown in Figure 10 similar to the idealized model shown in Figure 8?
    (b) In what ways is it different?
    (c) Suggest factors that may be responsible for any difference you see.

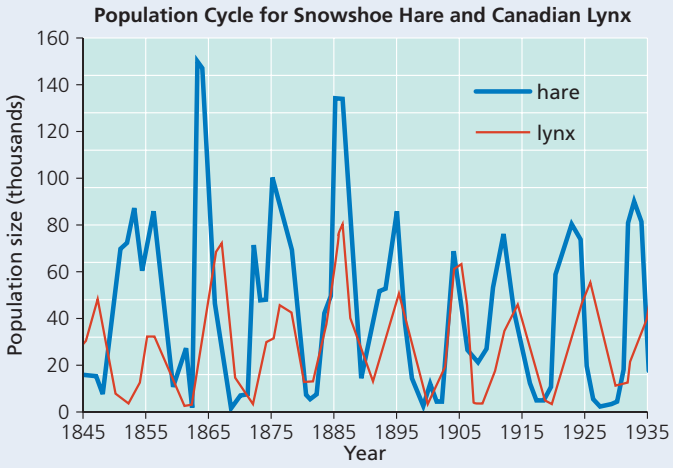


Figure 10

14. Create a six-column table with the following headings: producer, herbivore, carnivore, omnivore, decomposer, detrivore. Insert examples of each type of organism in the proper column.
15. Draw the predator–prey cycle shown in Figure 8 into your notebook. Describe what happens to cause each direction change on the graph. Clearly label the time lag.

2.3 Symbiosis

Figure 1 A fungus and a green algae form a composite organism (a lichen) through symbiosis.

Symbiosis refers to any close relationship between two different species. Symbiotic relationships are the most specialized form of species interaction and each species often develops very specialized behaviours, life cycles, or structures. There are three types of symbiotic relationships: mutualism, commensalism, and parasitism.

Mutualism is a relationship in which both species obtain some benefit from the interaction. For example, lichens are made up of a fungus and a photosynthetic organism, usually a green algae. The fungus grows around the algae, protecting the algae which then makes food for the fungus through the process of photosynthesis (Figure 1).

Commensalism is an interaction in which one organism benefits while the other is unaffected. Relationships of this type often are difficult to detect and the term is usually applied to situations where there is no obvious cost or benefit to one of the organisms. For example, the relationship between barnacles and grey whales is usually classified as commensalism. The barnacles live on the hide of the whale and feed passively from the water passing by, while there is no apparent benefit or harm to the grey whale (Figure 2).

LEARNING TIP

Periodically stop reading to recall what you have read. Ask yourself, "What are some examples of mutualism, commensalism, and parasitism?"

Figure 2 The whale barnacle has a commensal relationship with the grey whale.

Parasitism occurs when one organism lives and feeds on, or in, the body of another organism called the **host**. The **parasite** benefits from the relationship by getting its nutrients from the host. The host is harmed by the relationship, but the death of the host means the loss of a habitat for the parasite, so the host's death usually comes slowly, if at all. From the perspective of any host, the parasite is harmful. The host is often starved for

nutrients, and may be unable to reproduce or carry out some basic life functions. However, parasites can have a positive role, because they control species' population growth and prevent them from becoming too abundant. In this way, parasites ensure the survival of the strongest and healthiest members of a population. Nevertheless, parasites are responsible for many serious diseases.

Biologists estimate that as many as 25 % of all animal species may be parasites. Parasites often have hooks or suckers for attaching to the host. In some parasitic species, only the reproductive system is well developed. Tapeworms that live in the intestine of their host can absorb nutrients directly through their skin. Tapeworms, ticks, and fleas, as well as many bacteria and protozoa, are among the parasites that are responsible for widespread disease among animals and humans (Figure 3).

Many plant parasites gain nutrients from a host plant instead of producing their own food through photosynthesis. Some plant parasites cannot photosynthesize at all, and must gain nutrients from a host plant instead. Mistletoe is a common parasite of lodgepole pine and Douglas fir trees in British Columbia (Figure 4). GO

STUDY TIP

A summary answers the question, "What is the writer really saying?" Create a summary card for the three types of symbiosis. Ask yourself, "What are the main ideas in each paragraph? How would I explain them in my own words?"

To learn more about parasitism, go to **www.science.nelson.com** GO

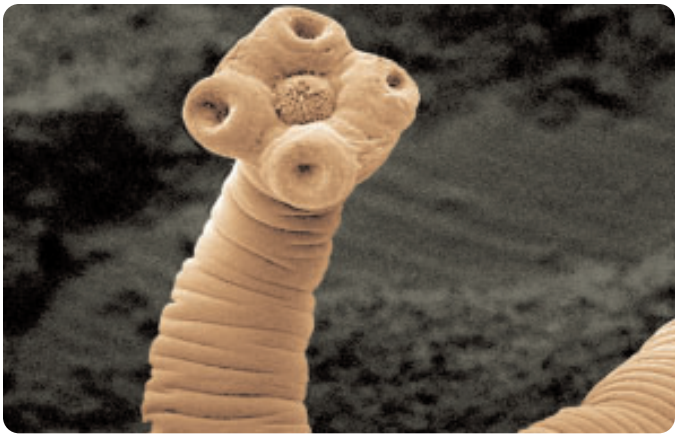


Figure 3 The tapeworm is highly specialized for survival in the mammalian digestive system.

Figure 4 Parasites like mistletoe can cause damage to trees in British Columbia's forests.

TRY THIS: Host Sweet Host

Skills Focus: recording, communicating, researching

Parasites are not usually the primary cause of the death of the host organism. Instead, the host organism dies from a secondary cause due to its weakened condition. Parasites often have very complex life cycles that help them to move to a new host body on a regular basis.

Materials: research materials

1. Choose an internal parasite to study, such as a fluke, a tapeworm, a roundworm, or a species of *Plasmodium* or *Trypanosome*.
2. Research the methods by which it gets from one host body to the next.

   www.science.nelson.com GO

A. Draw the life cycle of your chosen parasite, indicating how it moves between hosts.

B. How does the parasite get its nutrients?

C. Describe the effect of the parasite on the host's body.

2.3 CHECK YOUR Understanding

1. What characteristics of parasitism would lead some scientists to classify it as a form of predation? What characteristics of parasitism suggest that it is not a form of predation?
2. Why is it often difficult to distinguish between mutualism and commensalism?
3. Give an example of a situation in which humans are involved in symbiotic relationships, including commensalism, parasitism, and mutualism.
4. Suggest several reasons why it is beneficial for a parasite to be small.
5. Create a graphic organizer to compare the different types of symbiosis.
6. Which type of relationship is illustrated by each of the following situations?
   (a) a small tick that slowly sucks the blood from a black tail deer
   (b) a grizzly bear that leaves the bodies of salmon as food for birds and small mammals
   (c) a bat that pollinates a plant as it feeds on nectar from a flower
7. In which of the following situations do both organisms benefit?
   A. predation
   B. parasitism
   C. mutualism
   D. commensalism
8. *Streptococcus* bacteria in the human mouth digest sugars and produce lactic acid that dissolves tooth enamel, causing cavities. Which of the following types of interactions is represented by this example?
   A. predation
   B. parasitism
   C. mutualism
   D. commensalism
9. *Corynebacterium* are microscopic bacteria that live on the surface of the human eye. They feed off the secretions and discarded cells and do not seem to affect the human they are living on. Which of the following types of interactions is represented by this example?
   A. predation
   B. parasitism
   C. mutualism
   D. commensalism
10. *Helicobacter pylori* is a bacteria that can thrive in stomach acid, where they are known to cause stomach ulcers. Which of the following types of interactions is represented by this example?
    A. predation
    B. parasitism
    C. mutualism
    D. commensalism
11. Biologists estimate that as many as 25 % of all living things are parasites. Suggest several characteristics that may allow them to be so successful.
11. Many parasites have complex life cycles involving two or more host species. How does this fact ensure the survival of the parasite?
12. Explain how parasites may actually improve the survival of many animal populations.
13. Some plant species have a mutualistic relationship with a single species of pollinator. Explain how this might be an advantage to the plant. Explain how this might lead to the extinction of the plant species.

2.4 Trophic Levels and Energy Flow

As one organism eats another, nutrients and energy move through the ecosystem, passing from producers to consumers. The nutrients are recycled through the process of biodegradation but the energy only moves in one direction through the community (Figure 1). This means that ecosystems require a continuous source of energy, such as the Sun.

To learn more about energy flowing and materials cycling, watch the animation at **www.science.nelson.com**

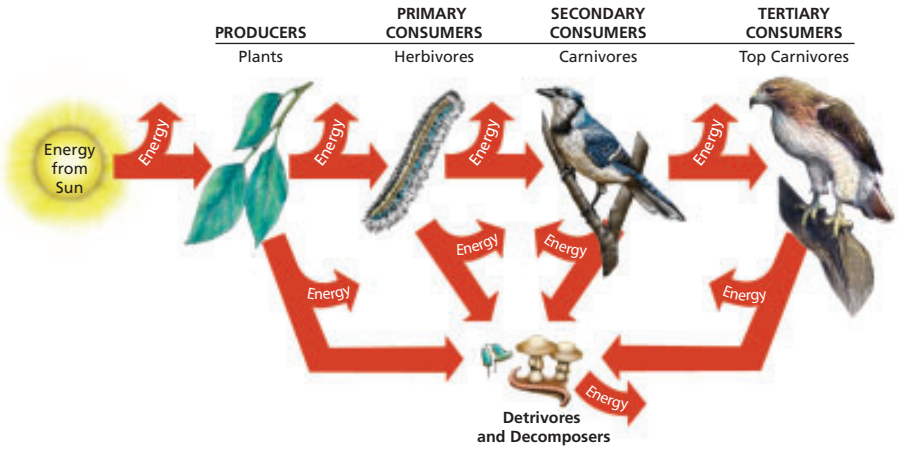


Figure 1 Nutrients cycle through ecosystems, but energy flows and eventually leaves. Energy must be continually supplied to the ecosystem by the Sun.

A **trophic level** describes the position of the organism in relation to the order of nutrient and energy transfers in an ecosystem (Figure 2). All producers belong to the first trophic level. The herbivores that consume the producers belong to the second trophic level, while carnivores occupy the upper trophic levels. Decomposers play a unique role and consume material from all of the trophic levels, so they can be shown in all consumer trophic levels.

To test your knowledge about trophic levels, go to **www.science.nelson.com**

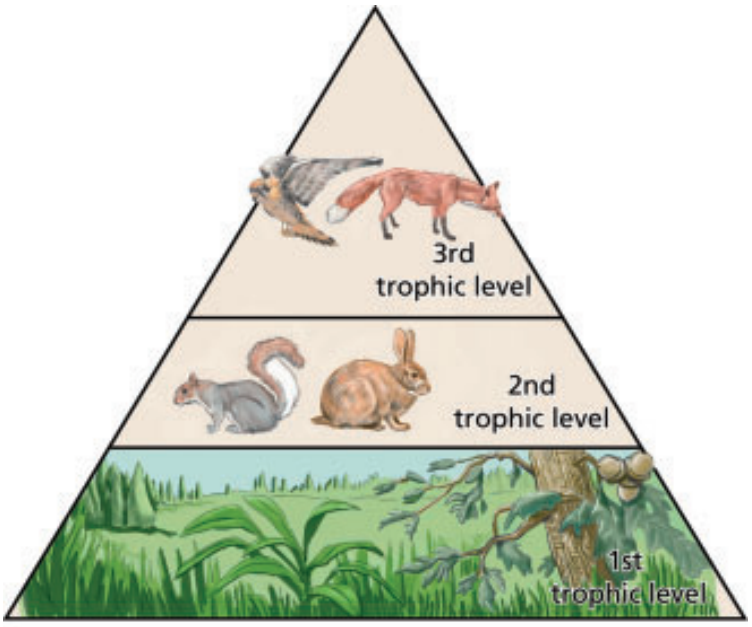


Figure 2 In an ecosystem, all of the organisms that consume the same type of food belong to the same trophic level. Decomposers could be shown at each consumer trophic level because they consume material from all trophic levels.

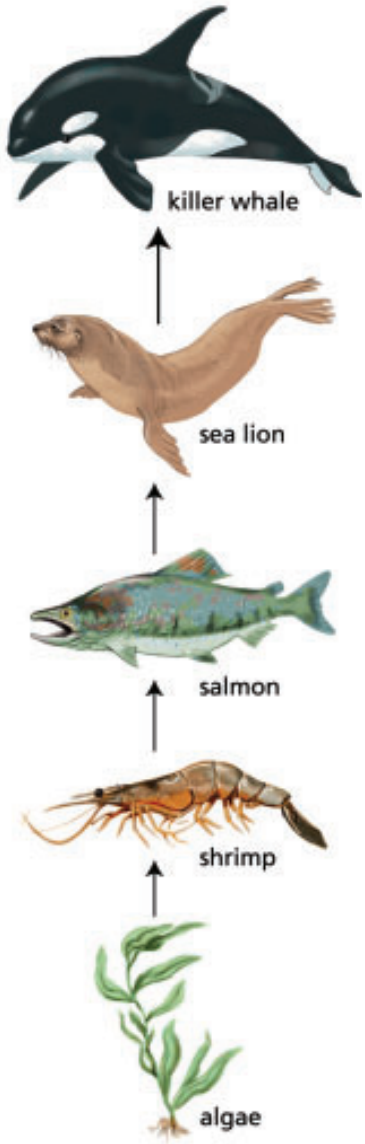


Figure 3 This food chain shows one way that nutrients and energy might flow in an ecosystem found in the waters of the Pacific Ocean off the coast of B.C.

LEARNING TIP

As you examine Figure 3, make connections to what you already know. How is a food chain connected to what you have already learned about producers, consumers, and trophic levels?

Food Chains

A pathway taken by nutrients and energy through the trophic levels of an ecosystem is called a **food chain**. A diagram for a food chain shows arrows directed from one species to the next. The arrows indicate that the first organism is food for the next. Within an ecosystem, many food chains will exist and interact. Grazing food chains involve the typical producer–herbivore–carnivore pathway. Herbivores are primary consumers and they eat the producers from the first trophic level. Carnivores that eat herbivores are called secondary consumers. These include organisms like foxes, praying mantises, and salmon. Tertiary (or third level) consumers eat these secondary consumers. Tertiary consumers, such as eagles or harbour seals, might become food for quaternary (fourth level) consumers. Organisms like killer whales or lions might be included in this group. The top carnivore is at the highest trophic level, and has no natural predators. Its body, along with others in the community, decomposes after death and provides nutrients to the producers in the community.

Figure 3 shows an example of a simple grazing food chain for the waters off the coast of British Columbia. In this ecosystem, algae are the producers. They may be eaten by shrimp, which are in turn eaten by salmon. A sea lion may feed upon the salmon, and a killer whale might be the top carnivore. Food chains highlight predator-prey cycles that exist within a community. It is clear that the size of one population could affect others. If the number of killer whales increases, it is likely that there will be a decrease in the number of seals, which in turn leads to an increase in the number of salmon. A change in one population sends a ripple of change through the food chain. The simplified feeding model represented by the food chain becomes useful in monitoring population changes within an ecosystem. There are many examples of grazing food chains, but they all start with a producer and end with a carnivore.

Ecologists have traditionally placed decomposers as the final step in a grazing food chain, but now consider them separately. A detritus food chain begins with dead material and waste. Bacteria and fungi, along with the materials they decompose, become food for scavengers such as worms, millipedes, or larger decomposers, and in turn, these organisms are eaten by small carnivores (Figure 4). When an organism is eaten, there are always some parts that are not able to be digested by the consumer. A wolf that eats an elk cannot digest the antlers, hooves, teeth, hair, and bones. As a result, most of the energy contained in these components does not move through the grazing food chain. Instead, the nutrients contained in these materials become available to decomposers, or are slowly broken down by sunlight and weathering. In this way, the nutrients contained in waste material are recycled for use by other organisms. In ecosystems with deep rich soil, over 90 % of the nutrients and energy contained in plants decompose and move through the detritus food chain. Ecosystems with few decomposers have very

little decay. As a result, the soil tends to be thin and low in nutrients. The condition of the soil is important in determining the types of producers that can grow, and therefore also affects the types of communities that can develop.

The detritus food chain is important in another way as well. Scavengers, such as vultures, prevent the spread of disease as they feed on the decaying bodies of recently killed animals. In this way, they help to maintain the health of plant and animal populations within the ecosystem. The grazing and detritus food chains are closely linked because small carnivores like shrews and raccoons are often part of both energy pathways.

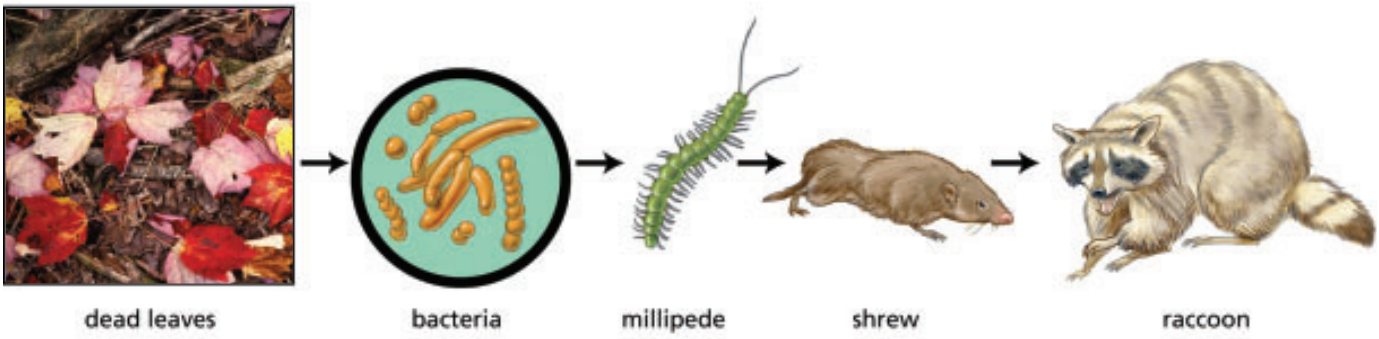


Figure 4 The detritus food chain makes the nutrients in dead organisms and waste available to other organisms.

TRY THIS: Exploring a Detrivore Microhabitat

Skills Focus: questioning, observing, identifying, concluding, recording, communicating

Explore the decomposers and detrivores in a rotting log.

Materials: gloves, safety goggles, tools (such as screwdriver, pliers, hammer), newspaper or large garbage bag, large plastic basin, newly collected rotting log, several small dishes or jars, magnifying glass or hand lens, field guides

Be careful of centipedes; they are capable of inflicting a painful bite. Wear gloves when collecting the log.

1. Collect a section of rotting log with as much moss, fungus, and decay as possible.
2. Put on gloves and safety goggles. Place your log section in a large plastic basin on newspaper or a large garbage bag.
3. Use your tools to carefully pry open the log.
4. Place any organisms you find in several small dishes or jars for closer observation.

A. Use a magnifying glass or hand lens and field guide to identify your organisms. If you cannot identify them, carefully describe them.

B. Which components that you observed are parts of the log ecosystem and which components are parts of the log community?

C. Describe one organism–organism interaction you observed.

D. Describe one organism–environment interaction you observed.

E. Draw one food chain that occurs within the community that lives inside the rotting log.

Food Webs

Energy relationships in a real ecosystem are too complex to be illustrated by a single food chain. Most consumers eat a variety of foods, and more than one consumer species will eat the same species of organism. A more accurate picture of the nutrient and energy pathways in an ecosystem can be seen in a **food web**, which represents many cross-linked food chains (Figure 5). The organisms in a food web are arranged by trophic level, with the producers and the consumers in successive levels. Figure 5 shows that a killer whale occupies the third, fourth, or fifth (top) trophic level, depending on the prey it is eating. Often top carnivores will occupy more than one trophic level because of the limited availability of prey at the top level.

LEARNING TIP

Pause, think, and evaluate what you have learned. Ask yourself, "What do I now know about a food chain and food web that I didn't know before? Have any of my ideas changed as a result of what I have read? What questions do I still have?"

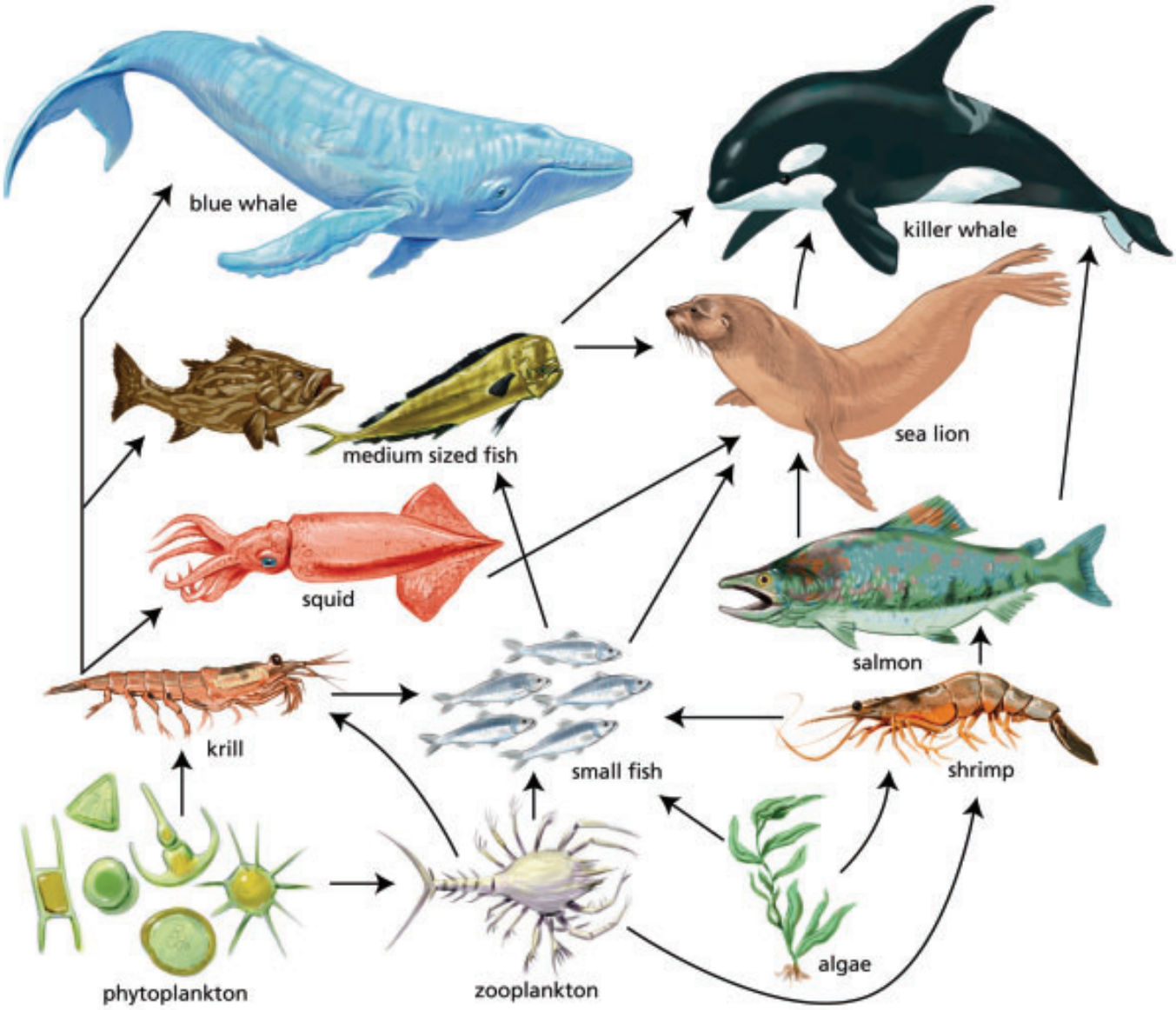


Figure 5 A food web, like this one for the Pacific Ocean, gives us a more complete picture of all of the different feeding relationships in an ecosystem.

2.4 CHECK YOUR Understanding

1. Why is sunlight essential to most food chains and food webs?
2. Explain the term "trophic level" in your own words.
3. Define and give three examples of a top carnivore.
4. Contrast food webs and food chains.
5. Energy flows through two different food chains in an ecosystem: grazing and detritus food chains. Describe each food chain. How does energy enter and leave each food chain?
6. Consider the food chain shown in Figure 6.

grass → insect → frog → snake

Figure 6

   (a) How would a decline in the number of frogs affect each of the other organisms in this food chain?
   (b) Redraw this food chain with the addition of bacteria, in order to show the role of decomposers in this community.
7. Why is energy flow in an ecosystem considered a one-way process?
8. (a) What type of food is eaten by a consumer in the second trophic level?
   (b) What type of food is eaten by a consumer in the third trophic level?
9. Is it possible for an organism to belong to more than one trophic level? Explain, using an example and description.
10. In your notebook, sketch a food web containing at least six organisms. Write labels to represent the organisms. Complete the food web by connecting the organisms with arrows.
11. What is meant by the statement "nutrients cycle, but energy flows"?
12. Use the food web shown in Figure 7 to answer the following questions:
   (a) Which organisms are the top carnivores in this food web?
   (b) Which organisms are the producers in this food web?
   (c) If the population of grasshoppers was eliminated from the area, what organisms would lose one of their food sources?
   (d) Which organisms in the food web could be classified as primary consumers? Which organisms in the food web could be classified as secondary consumers?

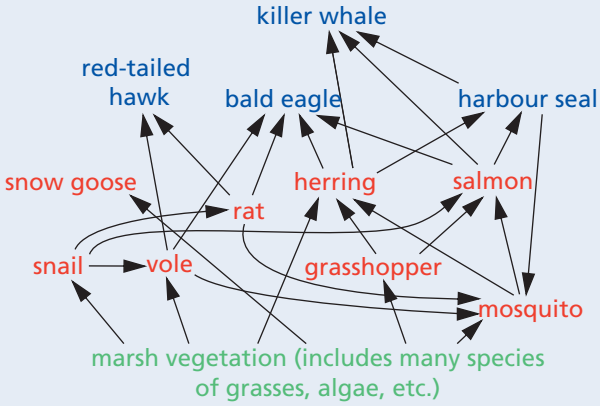


Figure 7

KELP-MART: THE BOUNTY OF A KELP FOREST

The biodiversity found in kelp forests is part of one of the most dynamic and productive ecosystems found anywhere in the biosphere.

The diversity of organisms that make kelp forests their home is impressive (Figure 1). These plant-like giants of the sea can grow as much as 30 cm each day. They prefer cold, nutrient-rich waters that form the base of one of the most biologically productive and dynamic ecosystems on Earth and extend into both the Arctic and Antarctic circles. Foraging sea otters, frolicking in the tangles of long stipes of B.C. coastal kelp forests, are offered a diverse buffet of sea urchins, clams, and crabs. Found in shallow, open coastal waters worldwide, kelp forests provide not only a plentiful bounty for the ocean but also a staggering array of products useful to humans.

Brown seaweeds, such as those of kelp forests, produce substances called alginates. Alginates are classified as complex carbohydrates and possess a unique molecular structure that forms heat-stable, non-melting compounds. These compounds are ideal as food stabilizers and thickening agents to prolong the shelf life and increase the mass and volume of food products. Imagine runny ice cream or watery ranch salad dressing. Without alginates, you would probably not experience mealtimes in the same way. In fact, you probably consume alginates daily because their use is so widespread in our food products.

Often labelled as sodium alginates, these food additives can be found in ice cream, soups, creamy liquids such as salad dressings, yogurt, relishes and sauces, and both frozen and dehydrated foods. Products of algae can also be found in cosmetics, antacid preparations, and paper and textile products.

So, the next time you make a trip to the grocery store, remember the extensive contribution of the kelp forests. Not only are they the producers in intricate ocean food webs, but they are also the source of key ingredients that give many of our manufactured food products the texture and appearance we expect and demand as discerning consumers.

Figure 1 Otters are not the only creatures that take advantage of the kelp forests!

2.5 Ecological Pyramids

Often, the pathway of energy through an ecosystem is illustrated by an **ecological pyramid**, also called a **food pyramid**. Ecologists use three basic types of pyramids: a pyramid of energy, a pyramid of numbers, and a pyramid of biomass.

Did You KNOW?

Where Does the Energy Go?

The First Law of Thermodynamics states that energy cannot be created or destroyed but can only change from one form to another. The Second Law of Thermodynamics states that an energy transformation between two different forms is never 100 %. Some energy is always lost as heat in the process.

Pyramid of Energy

A **pyramid of energy** is an ecological pyramid that uses blocks of different lengths to represent how much energy is available in each trophic level. The blocks are stacked one on top of the other, with producers on the bottom and carnivores on the top. The size of each layer represents the amount of energy present in that trophic level. Since the amount of energy available at each trophic level is less than the one below it, the diagram always has a pyramid shape (Figure 1); however, the size of the layers is not always proportional.

On average, only about 10 % of the energy present in one trophic level is passed on to the level above, as shown in Figure 1. Most of the energy at any level is used for basic life processes of the organisms at that level, such as movement, reproduction, and maintaining body temperature. Energy is also lost as heat at each trophic level, reducing the energy available to the next level even more. The low rate of energy transfer limits the number of trophic levels. Ecosystems rarely contain more than four levels because there is simply not enough energy in all the organisms at the top trophic level to support any more levels above them.

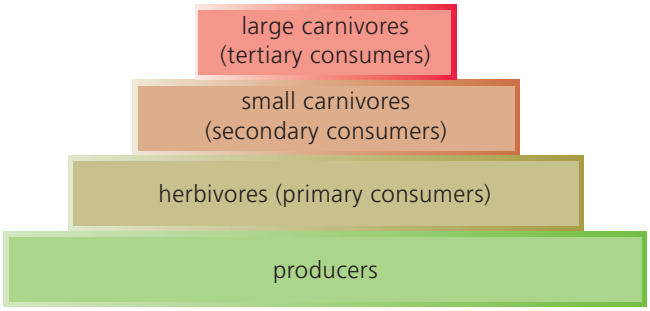


Figure 1 In a pyramid of energy, the amount of energy passing from one trophic level to the next is not always constant. The basic shape of the energy pyramid is constant however, and each level is always smaller than the one below it.

TRY THIS: The Energy You Eat

Skills Focus: recording, evaluating, analyzing, communicating

You can determine how much land was needed to produce the foods you eat.

Materials: notebook or graphic organizer

1. Record amounts of everything you eat in a 24-hour period. Determine how many kilojoules you ate from plant and from animal products, using an energy counter or by recording values from packaging.
2. To determine your annual energy intake, multiply your values by 365 days.
3. Determine how much land was needed by dividing the energy intake from plants by 8350 kJ/m^2 and dividing the energy intake from animals by 835 kJ/m^2.

A. Is it a more efficient use of land to eat plant or animal products? Explain.

B. What changes could people make to their diets in order to reduce the amount of land needed to make their food?

C. How might your average energy intake compare with people living in less developed regions of the world?

Pyramid of Numbers

A **pyramid of numbers** represents the actual number of organisms present in each trophic level. The shape of a pyramid of numbers varies widely depending on the physical size of the producers. For example, grasslands have very large numbers of small producers, while a forest of similar size might contain only a few large trees. A single tree might support thousands of small herbivores like insects. For a grassland community, a pyramid of numbers would have the typical shape (Figure 2). For a forest community, the producer level would likely be smaller than the herbivore layer above it (Figure 3). This distorted shape can be expected whenever a few large producers support large populations of small herbivores.

LEARNING TIP

Reinforce your understanding of pyramid of numbers and pyramid of biomass by examining Figures 2 to 4.

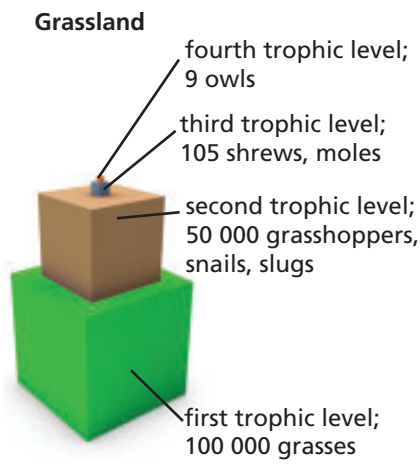


Figure 2 In a grassland community, there are fewer carnivores than herbivores and many more producers than herbivores.

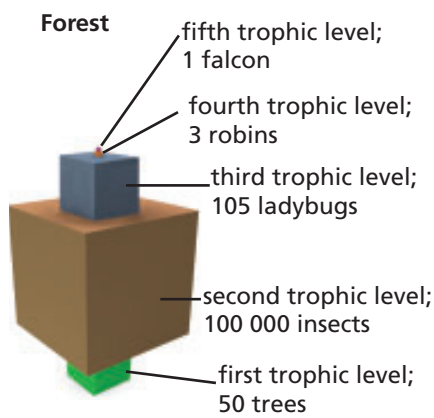


Figure 3 Pyramids of numbers are poor indicators of available energy. In a forest community, a single large organism such as a tree could be food for many small herbivores.

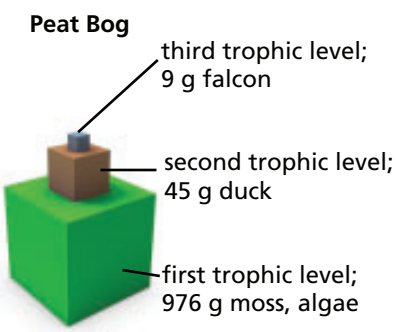


Figure 4 A typical pyramid of biomass

Pyramid of Biomass

Ecologists attempt to represent the total mass of the living things in each trophic level using a **pyramid of biomass**. These pyramids provide a snapshot in time of the mass at each trophic level in a community. In most communities, the pyramid of biomass has the standard pyramid shape (Figure 4), but sometimes the shape is inverted. This usually occurs in aquatic systems when a small biomass of producers, such as algae, supports a larger biomass of herbivores, such as fish. This is possible because the algae reproduce very quickly and are able to replace the biomass that is being consumed.

2.5 CHECK YOUR Understanding

1. Why are producers essential to a stable ecosystem?
2. List two factors that are responsible for the small percent of energy that passes from one trophic level to the next.
3. Why can more herbivores than carnivores live in equal-sized ecosystems?
4. On average, how much energy is available to organisms in the third trophic level if 5000 kJ were available at the first trophic level?
   A. 5 kJ
   B. 50 kJ
   C. 500 kJ
   D. 5000 kJ
5. Describe the effects of removing all of the herbivores from an ecosystem. Which organisms would be affected and how?
6. Explain why ecosystems usually contain only a few trophic levels.
7. Why do energy pyramids have the specific shape that they do?
8. Explain the similarities and differences between an ecological pyramid of energy, a pyramid of biomass, and a pyramid of numbers for a coniferous forest.
9. You have the option of choosing between a beef steak or a plate of beans and rice. Both meals provide you with 1000 kJ of energy. How will your choice affect the amount of energy required from the ecosystem?
10. Create a concept map that shows the path of energy in an ecosystem. Include the following terms in your diagram: herbivore, producer, carnivore, detrivore, trophic level, food web, food chain, and any additional terms you require.
11. Why does energy only flow in one general direction (from producer to consumer) in an ecosystem?
12. Which biome is most likely to have a pyramid of numbers that looks like Figure 5? Justify your answer.

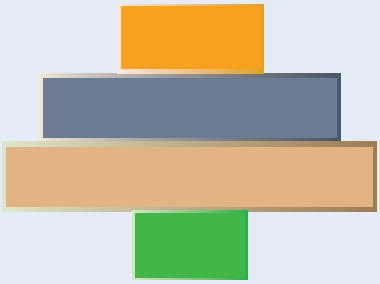


Figure 5

13. Draw two different energy pyramids for the food web in Figure 5 on page 36.
14. How might the shape of an energy pyramid differ throughout the year in a region that has a cold winter and a warm summer?
15. What types of organisms are able to make use of the energy that is not present in the top level of an energy pyramid?

2A Investigation

The Effect of Abiotic Factors on a Yeast Population

In this investigation, you will observe the effect of changes in abiotic factors on the growth of a yeast population. Yeast is a type of fungus and is often used in the production of bread.

Question

What are the optimal conditions for the growth of yeast?

Prediction

Predict what conditions of temperature, pH, and nutrient availability will be best for the growth of yeast.

Experimental Design

In this investigation, you will observe evidence of yeast growth under different experimental conditions. The population's cellular activity will be measured under different abiotic conditions.

Materials

- 8 large clean test tubes labelled #1–#8
- 25 mL graduated cylinder
- 3 600 mL beakers
- thermometer
- measuring spoons
- active dry yeast
- sugar
- vinegar (acid)
- ammonia solution (base)
- pH paper
- ice
- safety goggles

INQUIRY SKILLS

○ Questioning	● Conducting	● Evaluating
○ Hypothesizing	● Recording	● Synthesizing
● Predicting	● Analyzing	● Communicating
○ Planning		

Acids and bases, even weak ones, can cause irritation to skin. If any acid or base solution is spilled, clean it up immediately. If any solution falls on skin, flush it well with running water. Report any instances to your teacher.

Procedure

Part 1: The Effect of Temperature on Yeast Respiration

1. Read through the Procedure and copy the tables to record your observations in each part. Remember to give your tables a title.
2. Put on your safety goggles. Prepare three separate water baths in the 600 mL beakers: one bath at 0 °C (containing ice water), one bath at 50 °C, and one bath near 100 °C.
3. Measure 2.5 mL of yeast and 2.5 mL of sugar into three separate test tubes labelled #1, #2, and #3. Add 10 mL of room-temperature water to each of the test tubes. Place one test tube into each of the three water baths.
4. Leave the test tubes in the water baths for 15 min. Record your observations in Table 1. While you are waiting, set up Part 2 of the Investigation.

Table 1

Test tube	Temperature	Observation
#1	0 °C	
#2	50 °C	
#3	100 °C	

Part 2: The Effect of pH on Yeast Respiration

5. Measure 2.5 mL of yeast and 2.5 mL of sugar into another set of test tubes labelled #4, #5, and #6. Add 10 mL of water to test tube #4. Add 10 mL of acid solution to test tube #5. Add 10 mL of base solution to test tube #6.
6. Use the pH paper to determine the approximate pH of each solution. Place all three test tubes in the 50 °C water bath.
7. Leave the test tubes in the water baths for 15 min. Record your observations in Table 2. While you are waiting, set up Part 3 of the Investigation.

Table 2

Test tube	pH	Observation
#4		
#5		
#6		

Part 3: The Effect of Nutrient Availability on Yeast Respiration

8. Measure 2.5 mL of yeast into two test tubes labelled #7 and #8. Add 2.5 mL sugar to test tube #7. Do not add any sugar to test tube #8. Add 10 mL of room-temperature water to each test tube. Place both test tubes in the 50 °C water bath.
9. Leave the test tubes in the water baths for 15 min. Record your observations in Table 3.

Table 3

Test tube	Nutrient	Observation
#7	Sugar present	
#8	Sugar absent	

Conclusion

Complete the following items to answer the question posed at the beginning of the investigation.

Analysis

(a) What temperature was most suitable for the growth of yeast? Suggest a reason for this conclusion.

(b) What pH was the most suitable for the growth of yeast? Suggest a reason for this conclusion.

(c) What effect did the presence of sugar have on the rate of yeast growth?

Evaluation

(d) Did your observations support your prediction? Explain.

(e) Why was it important that all of the materials added to each test tube were accurately measured?

(f) Three test tubes containing water and sugar were placed in the 50 °C water bath. Did they all produce the exact same result? Explain any differences.

(g) For each of the three parts of this experiment, list the independent variable.

(h) Describe what measures were taken to ensure that each part of this experiment was controlled.

Synthesis

(i) How does this investigation show that biotic and abiotic factors are interacting?

(j) List three additional abiotic factors that you think might affect the growth rate of yeast.

(k) How can an understanding of abiotic factors assist farmers in finding the best farming techniques?

(l) Use the term "limiting factor" to summarize the observed effects of temperature, pH, and nutrient availability in this investigation.

2B Investigation

Predator–Prey Simulation

Ecologists often use models and simulations to help understand natural processes. In this investigation, you will simulate a predator–prey relationship between two species: the great horned owl and the white-footed deer mouse (Figure 1).

Figure 1

Question

Can a predator–prey relationship effectively regulate the size of both species' populations?

Prediction

Predict what pattern will describe the changes in size of the predator and prey populations.

Experimental Design

In this investigation, you will use models of predators and prey to simulate the predator–prey cycle responsible for population regulation.

INQUIRY SKILLS

- ○ Questioning
- ○ Hypothesizing
- ● Predicting
- ○ Planning
- ● Conducting
- ● Recording
- ● Analyzing
- ● Evaluating
- ● Synthesizing
- ● Communicating

Materials

- metre stick
- 20 10 cm × 10 cm cardboard squares (predator)
- 200 3 cm × 3 cm paper squares (prey)
- masking tape
- graph paper
- 2 coloured pencils

Procedure

1. Use masking tape to mark out a 1 m × 1 m boundary on a flat tabletop or floor. You may also use a flat desktop.
2. Scatter five prey cards throughout the area. Hold a predator card at least 10 cm above the surface and drop it in the marked area, trying to capture as many prey as possible.
3. If the predator card touches at least three prey cards, remove those prey cards. They have been eaten.
4. If the predator card does not touch at least three prey cards, remove the predator card and leave the prey cards. The predator has starved.
5. If at any time the number of prey or predators drops to zero, replace them with five prey or one predator card as needed.
6. Copy Table 1 in your notebook. Leave room for additional rows, and give it a title. Record the number of surviving prey and surviving predators. This represents one generation. You will need to record 20 generations.
7. Double the population of surviving predators and surviving prey. They have reproduced.
8. Scatter enough prey cards to represent the new population of the area.

Table 1

Generation	Initial prey	Prey caught	Surviving prey	Initial predators	Surviving predators
1	5			1	
2					
3					
4					

9. Continue to repeat Steps 3 through 8 for a total of 20 generations.
10. Graph the number of prey and predators present at the beginning of each generation. Use a scale of 0–200 for prey and 0–20 for predators. Include this as part of your results.

Conclusion

Complete the following items to answer the question posed at the beginning of the investigation.

Analysis

(a) Which population showed the first increase in size?

(b) Which population showed the first decrease in size?

(c) What maximum predator population was reached in your simulation?

(d) What maximum prey population was reached in your simulation?

Evaluation

(e) What factors limit the size of the owl (predator) population?

(f) What factors limit the size of the mouse (prey) population?

(g) Use the results of your simulation to describe the principle of time lag.

Synthesis

(h) Explain how your results might change if the area were larger or smaller.

(i) Copy the idealized predator–prey cycle shown in Figure 7 in your notebook. What aspects of your simulation would cause your predator–prey cycle to differ from the idealized model?

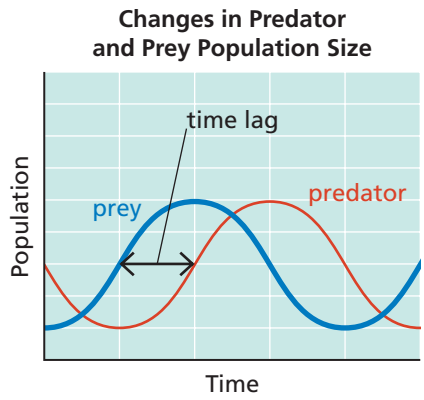


Figure 7

(j) What factors cause predator–prey cycles among actual populations to differ from the idealized predator–prey cycle?

(k) Explain how the owl population could be replenished even when all of the owls present have starved to death.

CHAPTER 2

Review

Interactions in Ecosystems

Key Ideas

Living things are connected to each other in complex interrelationships.

- Living things interact on several levels of organization: organism, population, community, ecosystem, and biosphere.
- A community of organisms and the non-living environment make up an ecosystem.
- Organisms can be producers, consumers, herbivores, carnivores, or decomposers in ecosystems.
- Predators and prey control each other's population size as they go through cycles in their relationship.
- Symbiosis describes complex relationships occurring between two species. The types of symbiotic relationships are mutualism, commensalism, and parasitism.

Biotic and abiotic factors are responsible for shaping a community of living things.

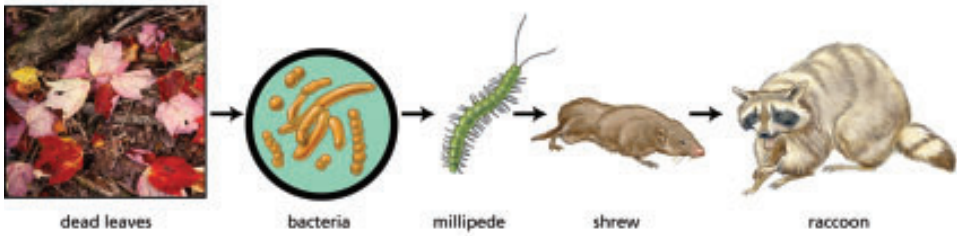
- Relationships between organisms and their environment include both living (biotic) and non-living (abiotic) components.
- Abiotic factors determine the types of organisms that can exist in a community and the characteristics of the environment.
- Biotic factors change continually in response to each other.

Vocabulary

ecology, p. 21
organism, p. 21
habitat, p. 21
population, p. 21
community, p. 22
ecosystem, p. 22
biosphere, p. 22
biotic factors, p. 22
abiotic factors, p. 22
dynamic equilibrium, p. 23
limiting factor, p. 23
nutrients, p. 25
producer, p. 25
autotroph, p. 25
phytoplankton, p. 25
consumer, p. 26
heterotroph, p. 26
herbivore, p. 26
primary consumer, p. 26
zooplankton, p. 26
carnivore, p. 26
omnivore, p. 26
detrivore, p. 27
decomposer, p. 27
biodegradation, p. 27
predation, p. 28
predator, p. 28
prey, p. 28
predator–prey cycle, p. 28
symbiosis, p. 30

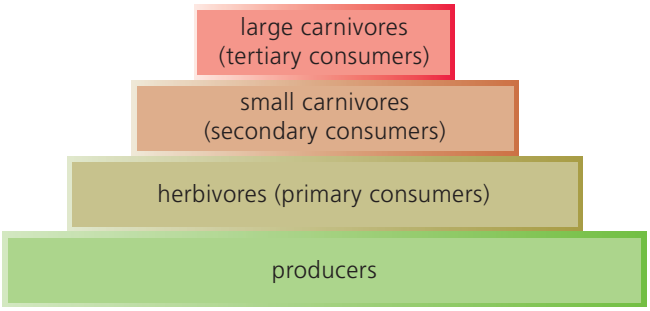
Nutrients cycle within ecosystems.

- Food chains and food webs show how nutrients cycle through ecosystems.
- Each type of organism is found at a trophic level in a food chain or web.
- Decomposers play an important role in recycling nutrients.



Energy flows through ecosystems.

- The primary source of energy for living things is the Sun.
- Producers are able to convert solar energy into a form that living things can use.
- Energy passes from producers to herbivores to carnivores.
- Most terrestrial ecosystems have only three or four trophic levels because energy transfer is inefficient.
- Only about 10 % of the energy at one trophic level is transferred to the next trophic level.



mutualism, p. 30
commensalism, p. 30
parasitism, p. 30
host, p. 30
parasite, p. 30
trophic level, p. 33
food chain, p. 34
food web, p. 36
ecological pyramid, p. 39
food pyramid, p. 39
pyramid of energy, p. 39
pyramid of numbers, p. 40
pyramid of biomass, p. 40

Many of these questions are in the style of the Science 10 Provincial Exam. The following icons indicate an exam-style question and its cognitive level.

K Knowledge U Understanding and Application HMP Higher Mental Processes

Review Key Ideas and Vocabulary

1. Match the term on the left with the correct definition on the right.

Term	Definition
(a) biosphere	I. A community as well as the physical environment
(b) community	II. All of the ecosystems on Earth
(c) ecology	III. All of the individual populations in a particular area
(d) ecosystem	IV. All of the organisms of one type that inhabit a particular area
(e) habitat	V. An individual life form of one specific type
(f) organism	VI. The place where an organism or population lives
(g) population	VII. The study of the interactions between organisms and between their environment

2. Explain the term "interconnectedness" as it applies to ecology.
3. Identify each of the following as a population, community, or ecosystem:
   (a) a pod of killer whales
   (b) a pack of wolves in a forest
   (c) all of the living and non-living things in a pond
   (d) all of the organisms living in a decomposing log
4. List five abiotic factors that affect life in terrestrial ecosystems.
5. Describe five ecosystems of differing size.
6. What is the relationship between the first trophic level and a primary consumer?

K 7. Which of the following terms does *not* represent a level within the biosphere that is studied by ecologists?
   A. cell
   B. ecosystem
   C. population
   D. community

K 8. Which of the following processes could produce the energy necessary to support a community of organisms in a deep cave in the total absence of sunlight?
   A. photosynthesis
   B. biodegradation
   C. decomposition
   D. chemosynthesis

Use What You've Learned

9. A student conducts an experiment to measure the effects of pH on the growth of bread mould (*Rhizopus nigricans*). The student moistened slices of bread with solutions of three different pH levels. The bread slices were incubated at a constant temperature and observed for a period of three days as recorded in Table 1.

Table 1

Day	Number of mould colonies		
	pH = 4.0	pH = 6.0	pH = 8.0
Start	0	0	0
1	0	7	1
2	1	15	3
3	2	27	3

   (a) Graph the results of the experiment using three line graphs on the same set of axes.
   (b) To which pH is the bread mould best adapted?
   (c) What was the purpose of keeping the temperature constant throughout the experiment?
   (d) List three other factors that must be kept constant in order to ensure that the experimental results are valid.
   (e) List three other abiotic factors that might affect the growth of bread mould.
   (f) What would be an appropriate control for this experiment?

U **10.** Which of the following lists includes only abiotic factors?

A. pH, height of trees, water temperature
B. temperature, annual precipitation, rock type
C. solar radiation, nutrient availability, number of decomposers
D. salt concentration, stream flow rate, migration pattern of reindeer

U **11.** Which of the following characteristics distinguishes decomposers from other consumers?

A. the ability to produce food
B. their position within a grazing food chain
C. the tendency to gain nutrition from dead organisms
D. the ability to chemically break down organic compounds

12. Name and define four different categories of consumers. Give two examples of each.

Think Critically

U **13.** A scientist is interested in creating a conservation strategy at the ecosystem level. Which of the following would she have to consider for her strategy to be at the correct level?

A. all regions of Earth where life exists
B. all members of a single species in an area
C. all living and non-living things in an area
D. all members of all of the species in an area

14. What type of food do organisms in the second trophic level eat? What type of food do organisms in the third trophic level eat?

15. Explain how changes in abiotic factors can influence the types of communities that develop in an area.

16. List three different abiotic factors and describe a way in which each of them has had a direct impact on your day so far.

17. Use the food chain shown in Figure 1 to answer the questions.

tree → beetle → spider → mouse → hawk

Figure 1

(a) What level of the biosphere is represented by the food chain?
(b) Which of the organisms in the food chain is an autotroph?
(c) Which of the organisms would belong to a population with the least biomass?
(d) Which level contains the least energy?

18. Use your knowledge of ecological pyramids to construct an energy pyramid, biomass pyramid, and numbers pyramid for the food chain shown in Figure 1.

HMP **19.** A wolf that eats an elk cannot digest the antlers, hooves, teeth, hair, and bones. What do these materials represent?

A. matter available to omnivores
B. energy available to herbivores
C. energy not available to carnivores
D. matter not available to decomposers

20. What effect would spraying insecticides to kill beetles have on the size of a hawk population in the food chain shown in Figure 1? Explain your reasoning.

Reflect on Your Learning

21. Scientists study many different ecosystems. Some are small and some are large. Explain how a puddle and a mountain range are both valid ecosystems. What are the similarities and what are the differences between these ecosystems?

Visit the Quiz Centre at
www.science.nelson.com GO