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**

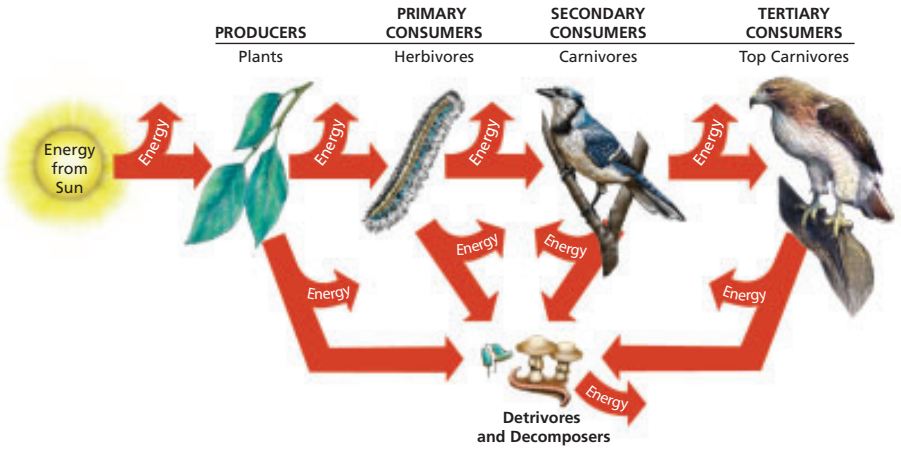

Figure 1 Nutrients cycle through ecosystems, but energy flows and eventually leaves. Energy must be continually supplied to the ecosystem by the Sun.

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**

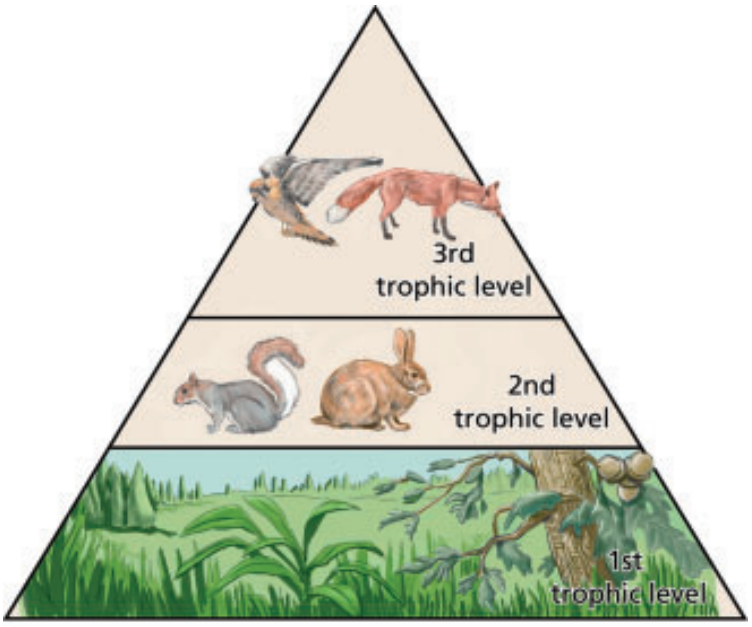

Figure 2 In an ecosystem, all of the organisms that consume the same type of food belong to the same trophic level. Decomposers could be shown at each consumer trophic level because they consume material from all trophic levels.

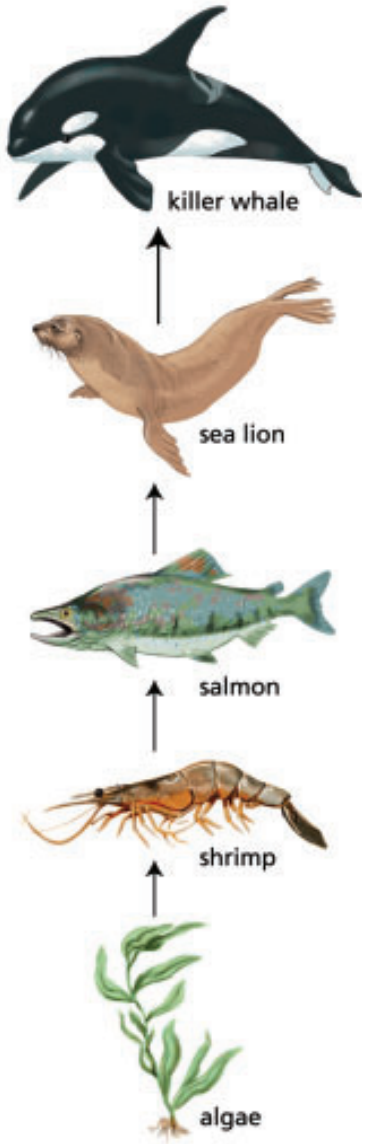

Figure 3 This food chain shows one way that nutrients and energy might flow in an ecosystem found in the waters of the Pacific Ocean off the coast of B.C.

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.

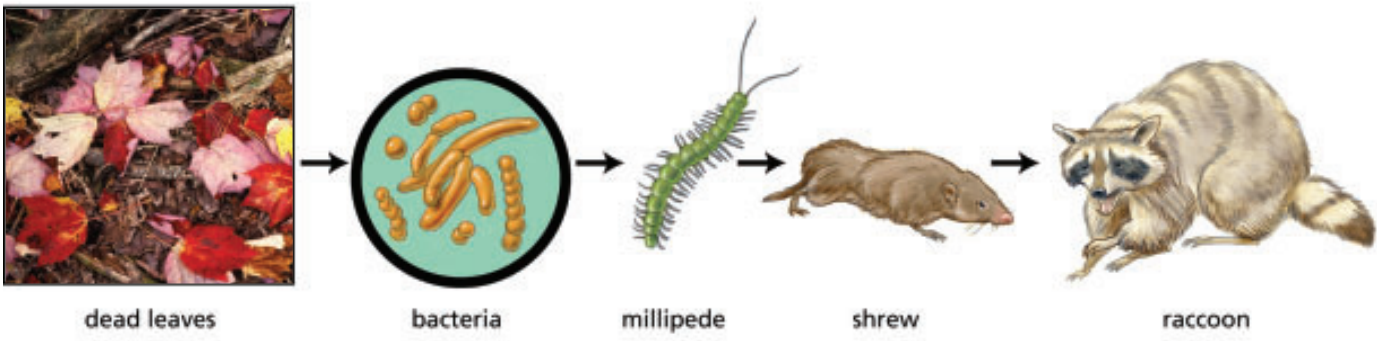

Figure 4 The detritus food chain makes the nutrients in dead organisms and waste available to other organisms.

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?"

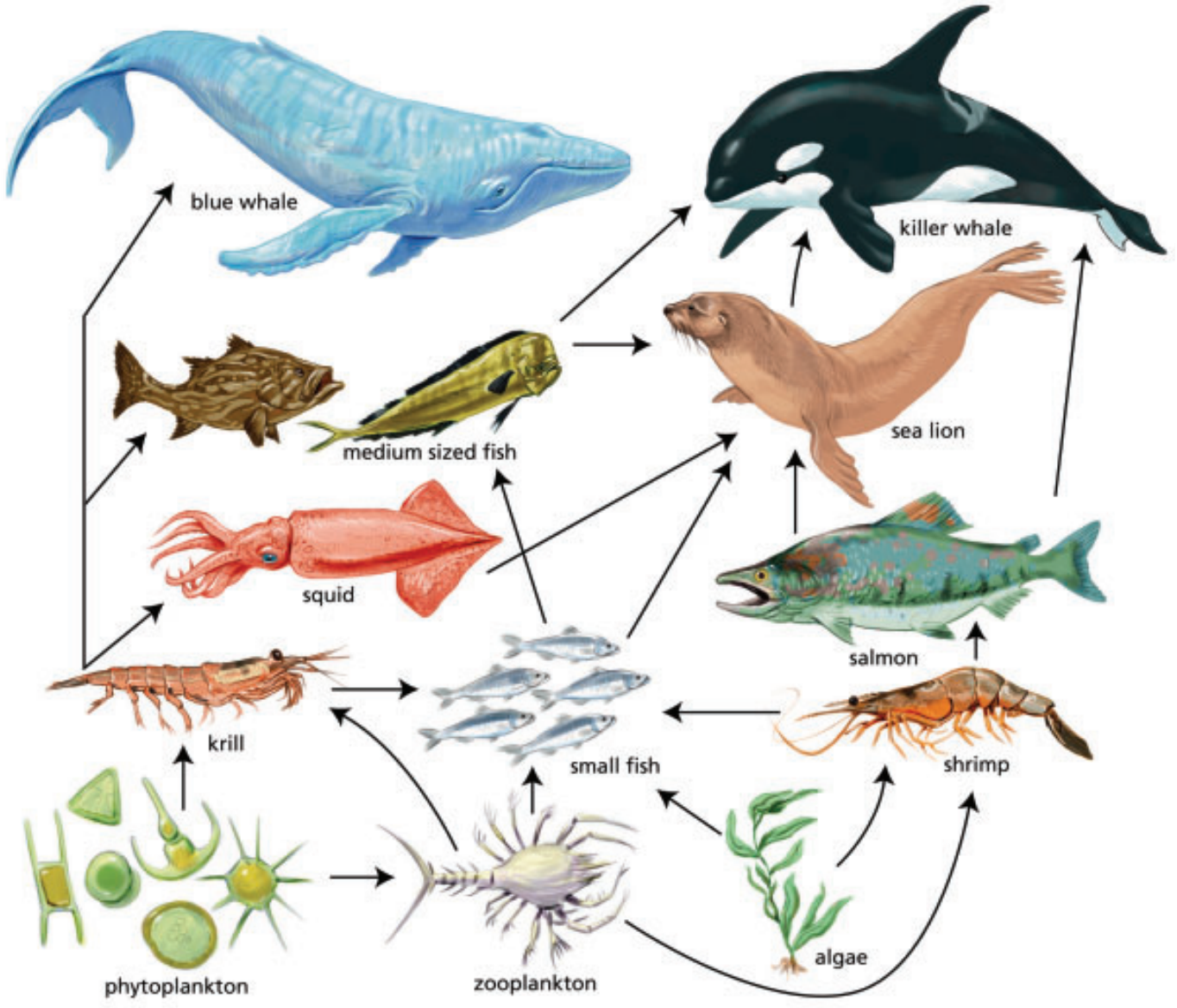

Figure 5 A food web, like this one for the Pacific Ocean, gives us a more complete picture of all of the different feeding relationships in an ecosystem.

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?

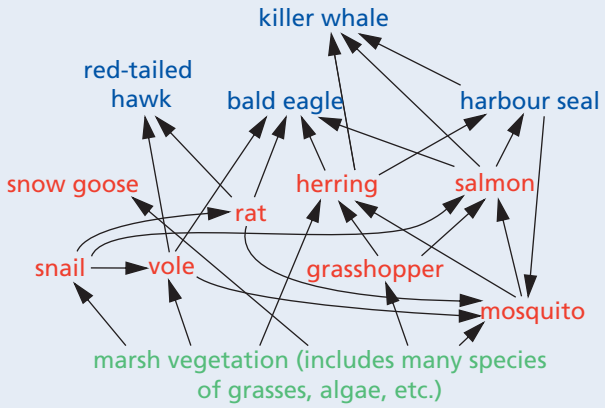

Figure 7