

## Food Webs and Ecological Pyramids

If you ran blindfolded through a forest in Ontario, you would not likely run into a moose or trip over a raccoon. Instead, you would quickly hit a tree or trip over the plants tangled around your feet (Figure 1).



**Figure 1** There are many more large plants than large animals in this ecosystem.

Why are there so many large trees and other plants and so few large animals? Why are you surrounded by hundreds of hungry black flies and mosquitoes but not hundreds of birds or frogs ready to eat them? The answers lie in the relationships between species in ecosystems. Each species is influenced and limited by its surroundings and by the resources it requires. Think about which plants and animals are abundant and which are rare in the ecosystem you live in.

### Ecological Niches

**ecological niche** the function a species serves in its ecosystem, including what it eats, what eats it, and how it behaves

Every species interacts with other species and with its environment in a unique way. These interactions define the **ecological niche** of a species. This is the role of a species within its ecosystem. A species' niche includes what it feeds on, what eats it, and how it behaves. No two species occupy identical niches.

The niche of a black bear is as follows: black bears feed on tender plant parts such as nuts and berries (Figure 2). They supplement their diet with insects and other small animals. Bears may carry seeds long distances in their digestive systems before the seeds are expelled and germinate. Bears go into hibernation during the winter. While they have few predators other than human hunters, black bears are themselves fed on by many blood-feeding insects and are hosts to a variety of parasites.

A key feature of any ecosystem is the feeding roles of each species. In Section 2.4, we distinguished between producers and consumers according to how organisms obtain their energy. Consumers can be further subdivided depending on what types of organisms they eat (Table 1).



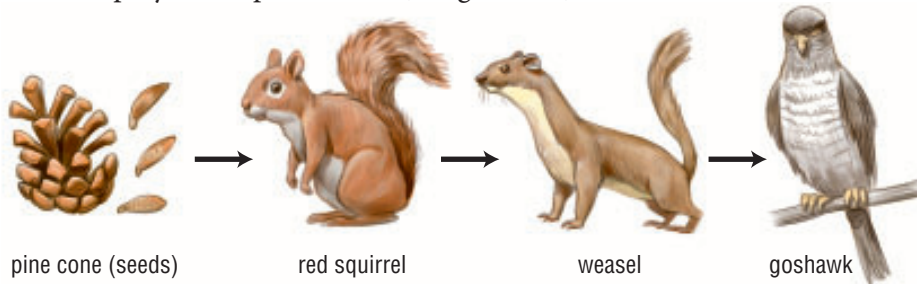
**Figure 2** Black bears eat berries and nuts.

**Table 1** Types of Consumers

Feeding role	Definition
herbivore	animal that eats plants or other producers
carnivore	animal that eats other animals
omnivore	animal that eats both plants and animals
scavenger	animal that feeds on the remains of another organism

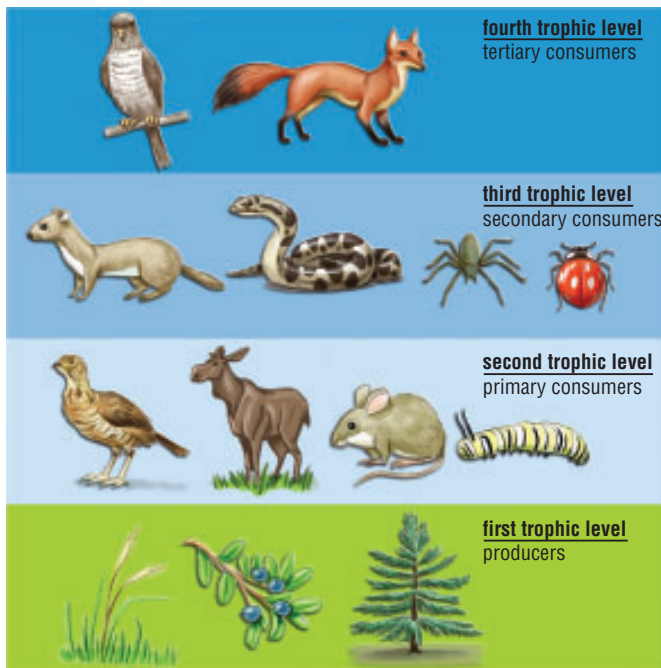
## Food Chains and Food Webs

The most common interactions between species are through feeding relationships. The easiest way to display these relationships is with **food chains**. Food chains illustrate who eats whom in an ecosystem. In Figure 3, the seeds of a producer (the pine tree) are eaten by a herbivore (the red squirrel), which is in turn eaten by a carnivore (the weasel). The weasel then falls prey to a top carnivore (the goshawk).



In this food chain, some of the chemical energy stored in the pine seeds is passed through the red squirrel to the weasel and ends up in the goshawk. In this way, food chains show how energy passes through an ecosystem. Remember that all organisms continually use and release energy to their environment. This means that energy is continuously lost from all levels of the food chain.

Ecologists refer to the **trophic level**, or feeding level, to describe the position of an organism along a food chain. Producers occupy the lowest, or first, trophic level. Herbivores occupy the second trophic level, and carnivores occupy the third and fourth trophic levels (Figure 4).



Food chains do not exist in nature. They are used to show simple feeding relationships. Food chains are part of more complex sets of relationships that exist among species. Many herbivores eat pine seeds. Red squirrels eat a wide range of foods and are themselves food for a variety of predators. A more accurate, but still incomplete, way to illustrate interactions is with a **food web**. This shows a series of interconnecting food chains.

**food chain** a sequence of organisms, each feeding on the next, showing how energy is transferred from one organism to another

**Figure 3** A simple food chain in a forest ecosystem

### LEARNING TIP

#### Reading Food Chains

In a food chain diagram, the arrows show the direction of food and energy flow. Arrows are read as “is eaten by.” For example, the red squirrel is eaten by the weasel.

**trophic level** the level of an organism in an ecosystem depending on its feeding position along a food chain

**Figure 4** Species can be divided into trophic levels depending on how they obtain their energy.

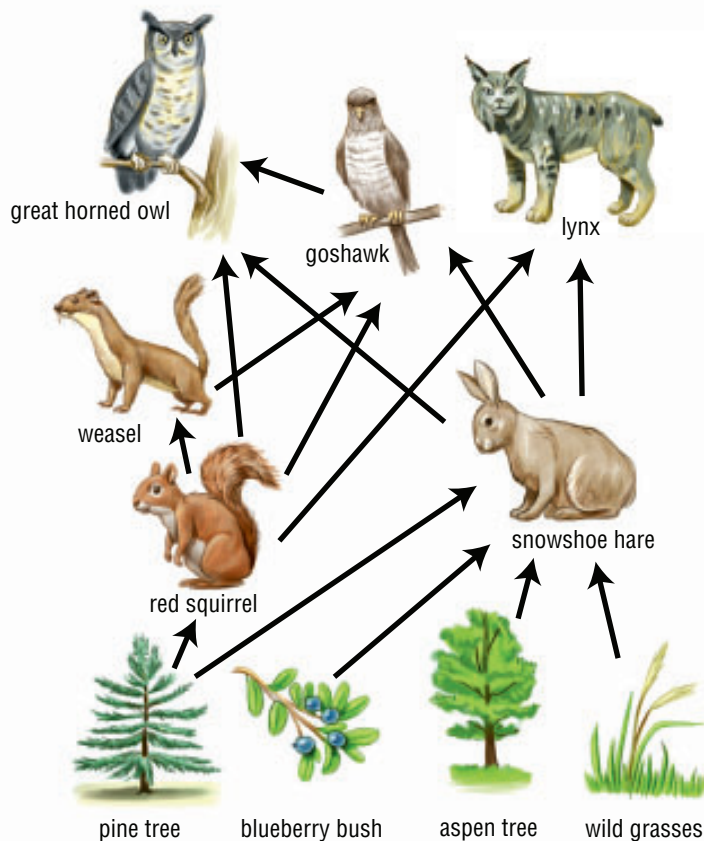
**food web** a representation of the feeding relationships within a community

## DID YOU KNOW?

### Bizarre Niches

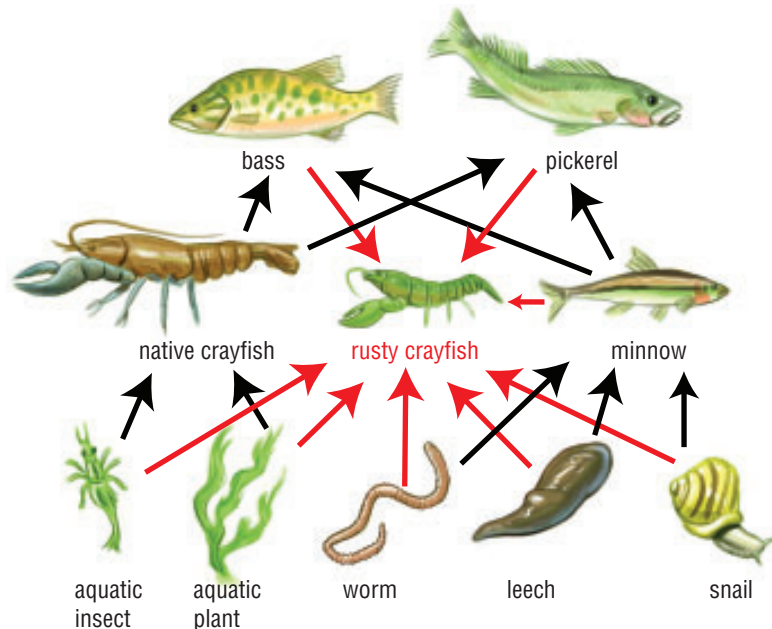
Pearlfish are marine fish with slender bodies. Most species of pearlfish hide inside the digestive system of sea cucumbers (simple marine animals). They enter and exit through the anus! Some species of pearlfish have evolved to live inside the sea cucumber, feeding on its internal organs.

Food webs are highly complex, with consumers feeding on many species (Figure 5). The large number of interactions tends to reduce the vulnerability of any one species to the loss or decline of another species. For this reason, complex food webs are thought to be more stable than simple food webs.



**Figure 5** A partial food web of the boreal forest. A complete model of the interactions in this ecosystem food web would show thousands of species including scavengers and decomposers which feed on dead organisms and wastes. Note that the food chain from Figure 3 is embedded in this food web. What would happen if the lynx was removed from the food web?

Food webs are useful tools to figure out what may happen when a species is removed from or added to an ecosystem. For example, if a species is removed from a food web, the species it feeds on may increase dramatically in numbers. Conversely, the population of a newly introduced species may disrupt the entire food chain (Figure 6).



**Figure 6** The invasive rusty crayfish (labelled in red) competes with native crayfish for many of the same foods. It also feeds on the eggs of bass and pickerel. Large fish feed on native crayfish but usually avoid eating the rusty crayfish.

**SKILLS:** Predicting, Analyzing, Communicating

In this activity, you will examine a rainforest food web.

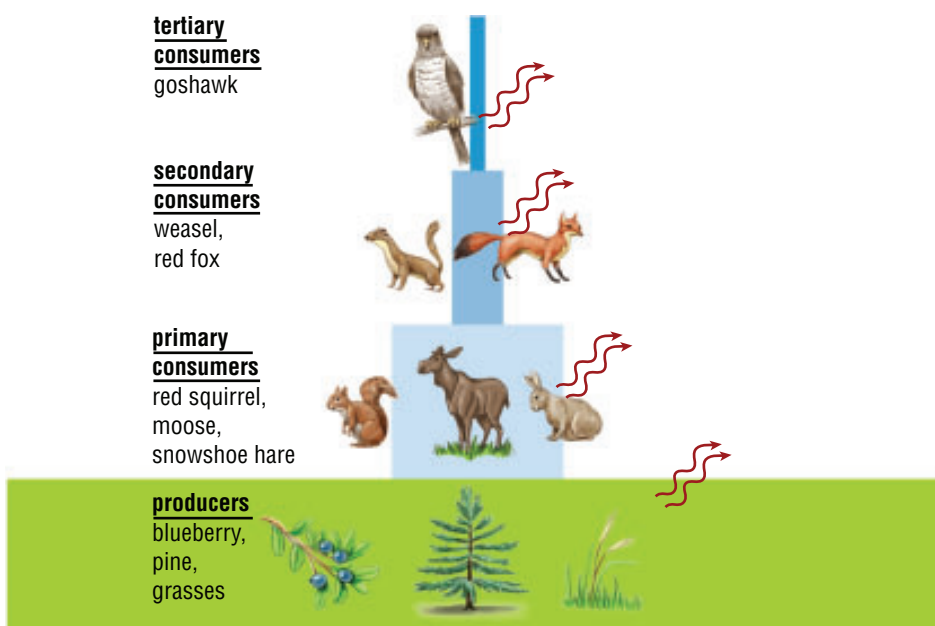
**Equipment and Materials:** set of rainforest species cards; large piece of paper; glue stick; coloured pencils or markers

1. Obtain a set of “rainforest species cards.” Each card will have the name of a species and a brief description of its living habits. For simplicity, decomposers have not been included.
  2. On a large piece of paper, spread out the species cards. Place the producers near the bottom, the carnivores near the top, and the herbivores in the middle. Glue each card in position.
  3. Use light pencil lines to connect species that feed on other species. Include arrows to indicate the direction of energy flow. The arrows should point from the food supplier to the food consumer.
  4. Colour in the pencil arrows using the following colour code: A green line joins any plant to any of its consumers. A blue line joins any herbivore to any of its consumers. A red line joins any carnivore to any of its consumers.
  5. Brainstorm three or four other species that live in tropical rainforests. Add them to your food web.
- A. How many connections did you include in your initial food web? **K/U**
  - B. Which species do you think would be most affected if anteaters were removed from this ecosystem? **T/I**
  - C. How would the removal of fig wasps alter this ecosystem? What would happen to the population of fig trees over a long period of time? Explain. **T/I C**
  - D. Which species had the most direct connections to other species within the ecosystem? Was this surprising? Explain. **T/I C**
  - E. Unlike tropical rainforests, the tundra has relatively few species. How might the loss of a species in the tundra compare to the loss of a species in a tropical rainforest? **T/I**
  - F. Describe how food webs show the interdependence of one species on all other species. **T/I**

## Ecological Pyramids

Another way ecologists illustrate how ecosystems function is through ecological pyramids. **Ecological pyramids** display relationships between trophic levels in ecosystems. The three types of ecological pyramids are energy, numbers, and biomass. An energy pyramid illustrates energy loss and transfer between trophic levels (Figure 7).

**ecological pyramid** a representation of energy, numbers, or biomass relationships in ecosystems



**Figure 7** Only a small proportion of the total energy at any given trophic level is passed on to the next level. Energy is used in biological processes such as growth and reproduction and is lost as thermal energy (red arrows).

**Making Connections**

When trying to make connections with a text, use prompts or questions such as

- I already know about . . .
- It makes me wonder why . . .
- Does this text remind me of something I have experienced?
- Does the information in this selection match or differ from information I have read in other texts?

The size of each layer in the energy pyramid represents the amount of energy available at that trophic level. A continuous supply of energy is essential for all living things. By examining how energy flow is depicted in these diagrams, you will gain a better understanding of the relationships between species, including why some species are much more abundant than others.

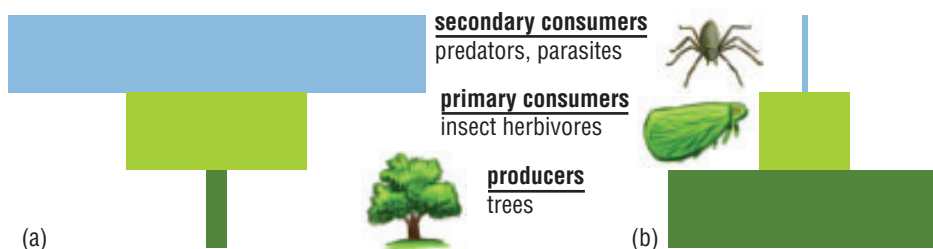
As one organism consumes another, it obtains both the physical matter (nutrients) and the chemical food energy it needs to survive, grow, and reproduce. However, each time energy is used, some of it is released to the environment as thermal energy. You can feel an example of lost thermal energy by placing your hand on your forehead. Organisms such as plants also release small quantities of thermal energy to the environment.

Plants use the energy they obtain from the Sun for growth, reproduction, and cellular activities. Some of this energy is lost to the environment. As a result, less energy is available for the herbivores that eat the plants. Herbivores use most of the energy they obtain from plants for their own life processes. Only about 10 % of the energy taken in by the individuals at one trophic level is passed on to individuals at the next level. For example, a moose that is eight years old does not possess the food energy of all the plants it has eaten since it was born. A wolf that eats the moose would obtain only a small portion of the lifetime energy consumption of the moose.

Species in the highest trophic levels have less energy available to them than species near the bottom. This often results in their populations being much smaller than species lower in the food chain. This is why an ecosystem will have fewer predators, such as hawks, than herbivores, such as mice.

Populations that occupy different trophic levels vary in their numbers and their **biomass**, which is the total mass of all individuals combined. A pyramid of numbers shows the number of individuals of all populations in each trophic level, whereas a pyramid of biomass shows the total mass of organisms in each trophic level (Figure 8).

**biomass** the mass of living organisms in a given area



**Figure 8** (a) A simplified pyramid of numbers and (b) a pyramid of biomass for a deciduous forest ecosystem

An energy pyramid will always decrease in size from lower to higher trophic levels (remember Figure 7 on page 45). This is not always the case with pyramids of numbers or biomass. In a forest ecosystem, the tiny plant-feeding insects in the second trophic level outnumber the trees in the first trophic level (Figure 9, next page). The biomass of all the trees, however, is much greater than the biomass of herbivores, so this pyramid of biomass will have a typical pyramid shape.

Organisms that feed at lower trophic levels generally have much more energy and biomass available to them. For this reason, herbivores are usually more numerous than carnivores. It also means that disruptions or changes at lower trophic levels can have profound impacts on the entire ecosystem.



**Figure 9** There will always be more aphids than plants in a forest, but the biomass of plants will be greater.

As omnivores, humans feed at most trophic levels (although some people choose to be herbivores). As you will learn, the choices we make about our feeding patterns have significant implications for food production and ecosystem sustainability.

### UNIT TASK Bookmark

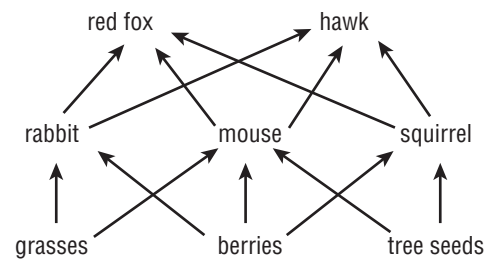
You can apply what you learned about the interactions between species in food webs in this section to the Unit Task described on page 156.

## IN SUMMARY

- Every species occupies a unique ecological niche.
- Feeding relationships between organisms can be represented by food chains, food webs, and trophic levels.
- Energy is continuously being lost to the environment by all living organisms.
- Higher trophic levels always have less energy available to them.
- Ecological pyramids can be used to display energy, number, and biomass relationships.

## CHECK YOUR LEARNING

1. What is meant by the term *ecological niche*? Describe the ecological niche of humans and of three other species. **K/U**
2. Explain the differences between food chains and food webs. **K/U**
3. Describe some possible impacts of adding or removing a species from an ecosystem. **K/U**
4. As you go up from one trophic level to the next, the amount of available energy decreases. Explain where the energy has gone. **K/U**
5. What trophic level contains the greatest biomass in most ecosystems? Explain why this occurs. **K/U**
6. What trophic levels are occupied by carnivores? Provide examples. **K/U**
7. Bison, zebra, and kangaroos are three large mammals. Explain why they have similar ecological niches but cannot be shown in the same food web. **K/U A**
8. (a) How would the food web in Figure 10 change if the red fox were killed off by rabies?  
 (b) What species would benefit?  
 (c) What species might decline? **K/U A**



**Figure 10**