Environmental Interdependence

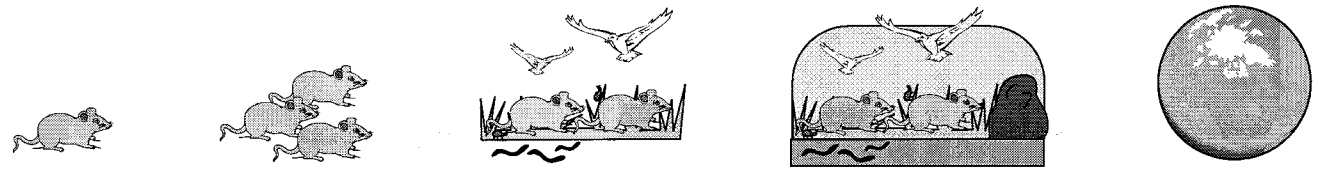
Section 19.1
Introduction to Ecology

Pre-View 19.1

- **Ecology** – the study of living organisms as they interact with their environment
- **Organism** – an individual living thing; examples: a mouse, an ant, a mountain lion
- **Species** – a group of similar organisms that can interbreed and produce fertile offspring
- **Population** – organisms of the same species that live in the same place and at the same time
- **Community** – different populations of different species that live in the same place at the same time
- **Ecosystem** – a community of living organisms plus their nonliving environment
- **Biotic factors** – the living organisms in an ecosystem
- **Abiotic factors** – nonliving parts of an ecosystem; examples: rocks, soil, air, water
- **Biosphere** – all the combined ecosystems of the world where organisms can live
- **Niche** – an organism's role in its ecosystem
- **Habitat** – the place where an organism lives

Ecology studies the relationships between living organisms and their environment. First review some terms that explain what makes up an ecosystem. First, an **organism** is an individual living thing, like a field mouse. A **species** is defined as a group of very similar organisms that can interbreed and produce fertile offspring. Organisms of the same species that live in the same place and at the same time make up a **population**. All the different populations of different species that live in the same place and at the same time make up a **community**. For example, a field of grass, field mice, earthworms, insects, lizards, birds, and buffalo might make up a community. These living organisms are called **biotic factors**. A community of living organisms *and* their environmental surroundings, such as soil, rocks, and bodies of water, make up an **ecosystem.** The nonliving parts of the ecosystem, such as the soil, rocks, water, pH, temperature, atmospheric gases, pollution, etc., are called **abiotic factors**. All of the ecosystems in the world make up the **biosphere**, the part of the earth where living organisms can survive.

Levels of Ecological Organization



Example: A pond ecosystem consists of water, algae, minnows, bass, catfish, water grasses, and a rocky bottom. Which of these are biotic factors and which are abiotic factors?

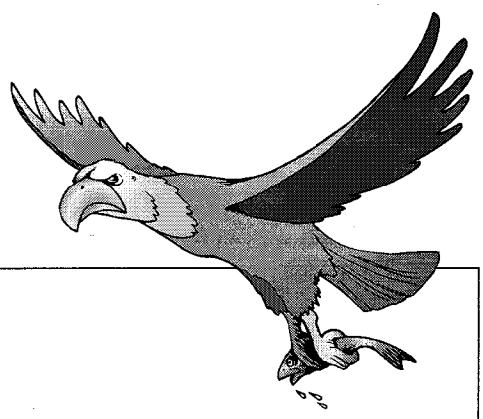
Biotic factors are the living organisms: algae, minnows, bass, catfish, water grasses.

Abiotic factors are the nonliving items: water and the rocky bottom. It could also include things such as the dissolved oxygen in the water, which can be an important abiotic factor for an pond ecosystem.

When studying ecosystems, you may come across two more terms: niche and habitat. A **niche** is the role that a species plays in an ecosystem. For example, the niche of a mouse might be to live in a grass prairie, to build a nest below the ground, to eat mostly seeds and insects, to disperse seeds, and to provide food for snakes and hawks. These are all roles that the mouse might play in its environment. A **habitat** is the place where a plant or an animal lives. For example, the habitat of the mouse mentioned above is a grass prairie.

Environmental Interdependence

Section 19.2
Ecological Relationships



Pre-View 19.2

- **Herbivore** – an animal that eats plants
- **Predator** – an animal that catches and eats another animal
- **Prey** – an animal that is subject to being caught and eaten by another animal
- **Carnivore** – an animal that eats only other animals
- **Omnivore** – an animal that eats both plants and animals
- **Competition** – the conflict between organisms when they try to use the same resources at the same time
- **Competitive exclusion** – the idea that if two different species compete for the same resources, one will survive and the other will not
- **Cooperation** – the relationship among members of a population that helps one another; example: hunting as a pack
- **Symbiotic relationship** – the relationship between two species that live closely together
- **Mutualism** – a symbiotic relationship in which both species benefit
- **Commensalism** – a symbiotic relationship in which only one species benefits but the other is neither helped nor harmed
- **Parasitism** – a symbiotic relationship in which one species benefits and the other is harmed
- **Parasite** – an organism that gets its nutrients by feeding on another living organism
- **Host** – an organism on which a parasite feeds

Organisms co-exist in an ecosystem by forming certain types of relationships. These relationships can be helpful to one another, or they can be harmful.

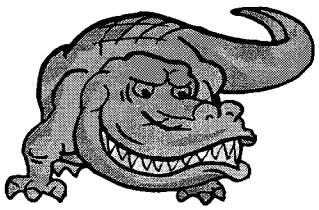
Plant-Herbivore

One type of relationship is between plants and the animals that eat plants. Plant-eating consumers are called **herbivores**. A cow eating grass is an example of a plant-herbivore interaction.

Predator-Prey

Another type of relationship is a **predator-prey** relationship. **Predators** are members of a species that capture and eat members of another species, the **prey**. Predators that eat only other animals are called **carnivores**. Some animals eat both plants and other animals, and these animals are called **omnivores**. A fox is an omnivore; it will eat mice, squirrels, and snakes, but it will also eat seeds and berries.

Example 1: A hawk hunting and consuming a rabbit would be an example of a predator-prey relationship, and the hawk is a carnivore.



Competition

Some relationships in a community or ecosystem are due to **competition**. Whenever organisms try to use the same resources, such as light, food, water, or space, at the same time and in the same place, they must compete with each other for the use of the resources. Competition may exist for the organisms within the same population, or there may be competition between different species. The extinction of one species in an area due to competition with another species is called **competitive exclusion.**

Example 2: Two male alligators compete for territory and for females. One male will be more dominant than the other and better able to survive.

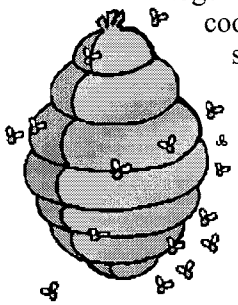
The alligators are an example of competition within a population. Both alligators belong to the same species.

Example 3: Two different species of birds compete with each other for the same nesting space, food source, and water supply. One of the species will be more successful than the other species, and the other species may fail to survive.

The birds represent competition between two different species.

Cooperation

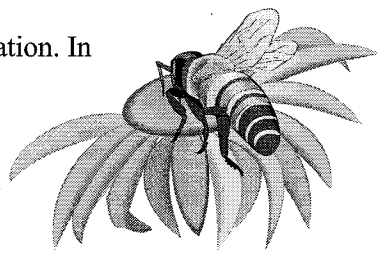
Not all interactions among organisms is negative. **Cooperation** is a relationship within certain populations to work together for a common goal. Social insects, such as honeybees, termites, and ants, show a form of cooperation. They form colonies and divide labor so that the entire colony benefits. For example, some gather food, some rear young, and some defend the nest. Another example of cooperation can be seen in pack animals.



Example 4: Wolves form a pack, which is similar to a family. The wolf pack has a hierarchy of dominance, but they cooperate together to hunt and to kill prey. They also help one another rear their young.

Mutualism

There are several types of relationships called **symbiotic relationships** that result when two species live together very closely. The word *symbiosis* means *living together.*



One type of symbiosis is **mutualism**, which is sometimes considered a type of cooperation. In a mutualistic relationship, two different species benefit from their relationship to one another. The relationship between flowering plants and their pollinators is an example of mutualism. Many flowers have bright colors and are sweet-smelling to attract insects. The flowers provide the insects with nectar and pollen. In turn, the insects go from flower to flower and help pollinate the plants. Both the plants and the insects benefit.

Commensalism

Sometimes only one species is helped in a symbiotic relationship, and the other species is neither helped nor harmed. This type of relationship is called **commensalism**.

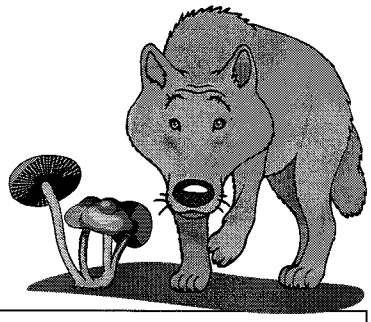
Example 5: A small crustacean called a barnacle lives attached to rocks, wood, shells, or other things that are in the ocean, including whales. The whales do not benefit from having the barnacles attached to them, but the barnacles benefit since the water movement of the swimming whales carries food particles to the barnacles.

Parasitism

The other type of symbiotic relationship is parasitism. In **parasitism**, one organism benefits at the expense of another organism. The **parasite** lives in or on another organism called a **host** and gets its nutrients from the host. The host is not usually killed but is weakened. For example, the roundworms that can live inside dogs and cats are parasites.

Environmental Interdependence

Section 19.3
The Flow of Energy In Ecosystems



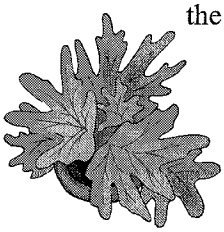
Pre-View 19.3

- **Producer** (or **autotroph**) – organism that makes its own food usually by using energy directly from the sun
- **Consumer** (or **heterotroph**) – organism that cannot make its own food and must get energy by eating producers or other consumers
- **Primary consumer** – a consumer that eats producers (usually plants)
- **Secondary consumer** – a consumer that eats a primary consumer
- **Tertiary consumer** – a consumer that eats a secondary consumer
- **Decomposer** (or **saprotroph**) – organism that eats dead or decaying organisms

All organisms must have energy to live, but where does that energy come from? Think about how much energy you have used today by the time you read this sentence. Where did you get that energy, and where did it go when you used it? If these questions bring to mind cellular respiration and photosynthesis as you reviewed in Section 8, you are definitely on the right track. Let's look at where energy comes from and how it flows through living organisms.

Producers/Autotrophs

The ultimate energy source for life on earth is the sun. Less than 1% of the energy that reaches earth from the sun is used by living organisms, but that small percentage fuels life.

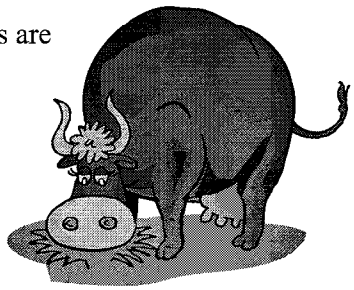


Producers are organisms that can use energy directly from the sun to produce simple sugars that other organisms can use as food. Plants are probably the most familiar producers on earth. Producers are also called **autotrophs** because they make their own food and do not need to "eat" other organisms to survive. Autotrophs capture energy from the sun, and they use the sun's energy to make organic compounds (sugar and other carbohydrates) out of inorganic materials (carbon dioxide and water). This conversion usually happens by photosynthesis, a process that should be familiar to you.

Consumers/Heterotrophs

Consumers are organisms that get their energy by eating either producers or other consumers. The cells of consumers do not contain chloroplasts, so they cannot make their own food. Consumers are also called **heterotrophs** because they must depend on other organisms for their food.

Think about a cow, which eats grass. The cow doesn't make its own energy; it gets energy from the grass it eats. A cow is a consumer. The grass contains energy in the form of carbohydrates. Through the process of cellular respiration (reviewed in Section 8.2), the cow breaks down the carbohydrates to obtain energy to live.



Since cows consume producers, they are called **primary consumers**. Primary consumers are often herbivores, eating only producers. A primary consumer may also be an omnivore, eating both producers and other consumers, but in the role of primary consumer, the omnivore must eat plants (or other producers). Primary consumers are never carnivores.

A wolf may then eat the cow, and the cow becomes the source of energy for the wolf. The wolf is also a consumer, but when it eats a primary consumer like a cow, it is called a **secondary consumer**. Secondary consumers are often carnivores, but they also may be omnivores. An omnivore that acts as a secondary consumer will eat another consumer.

A **tertiary consumer** is one that eats a secondary consumer. Let's say a minnow eats algae, a producer. The minnow is the primary consumer. Then a bass eats the minnow. The bass is a secondary consumer. Next a bear eats the bass. The bear is a tertiary consumer.

Decomposers and Detritivores

Decomposers (sometimes called **saprotrophs**) are a type of heterotroph, but they are not usually considered consumers. Instead of eating other living organisms, decomposers break down dead organisms into matter called **detritus**. The detritus is then eaten by organisms called **detritivores**, which convert the organic material into inorganic material. For example, when the wolf dies, bacteria and fungi are decomposers that break down the dead tissues. Detritivores are usually small invertebrates, like earthworms and nematodes, which further break down materials and return elements to the soil to be used again by producers. Decomposers and detritivores use the energy from the dead material to live. Decomposers and detritivores make use of the lowest energy level. Note that they do not recycle energy, but they do recycle matter, and producers benefit the most from their efforts.

The Flow of Energy and Nutrients

In Section 18, you reviewed how nutrients, such as water, carbon, nitrogen, and oxygen, cycled through an ecosystem. These nutrients are not used up by the living organisms but instead are recycled to be used over and over again.

From sunlight to producers, from producers to consumers, from consumers to other consumers, and from consumers to decomposers, energy flows through an ecosystem. Unlike nutrients, energy flows only in one direction and is not recycled. Although energy is never really "lost," it is eventually converted into heat energy, which cannot be reused by living organisms to make food.

The flow of energy and nutrients is summarized in figure 19-1. Producers get energy from the sun. Consumers get nutrients and energy from the producers. When producers and consumers die, decomposers get nutrients and energy from them. Decomposers break down nutrients into an inorganic form, and those nutrients can then be used again by producers. Producers must then get more energy from the sun to begin the cycle again.

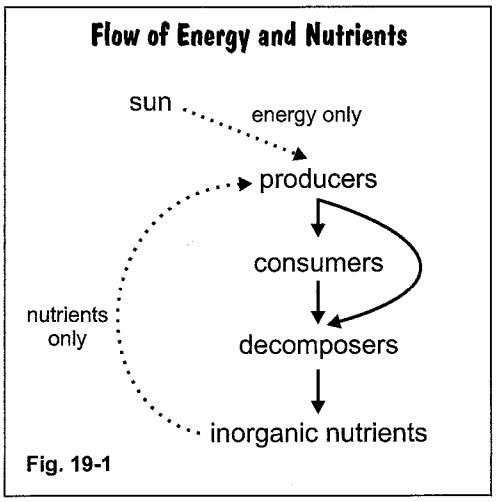


Fig. 19-1

Environmental Interdependence

Section 19.4
Food Chains, Food Webs, and Energy Pyramids

Pre-View 19.4

- **Food chain** – a simple representation of how energy is passed from a producer to consumers
- **Food web** – a more complex representation of how energy is passed from producers to consumers in an ecosystem
- **Trophic level** – each "step" in a food chain that represents how many times energy has been transferred from one organism to the next
- **Energy pyramid** – a representation in the shape of a pyramid that shows how energy is passed from one trophic level to the next
- **Top consumer** (or **top predator**) – animal at the top of a food chain; usually a carnivore that has no natural predators

Food Chains

The simple explanation for the flow of energy from autotrophs to heterotrophs is called a **food chain**. A simple example of a food chain is shown in figure 19-2.

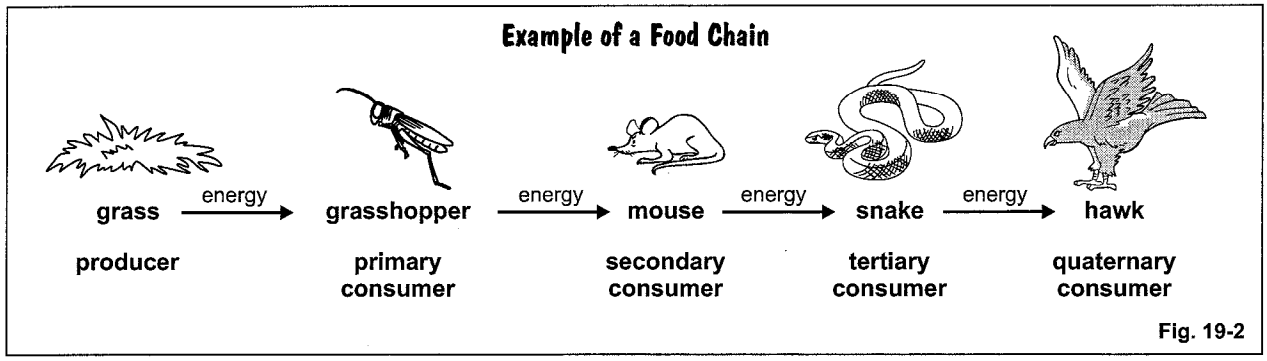


Fig. 19-2

In the food chain shown in figure 19-2, the grass is the producer. The grasshopper eats the grass, so it is the primary consumer. The grass gives energy to the grasshopper. The mouse eats the grasshopper, so the mouse is the secondary consumer. The mouse gets its energy from the grasshopper. The snake then eats the mouse. The snake is the tertiary consumer, which simply means "third level" consumer. The snake is then eaten by the hawk. The hawk is the quaternary consumer, or "fourth level" consumer. So you can see how a food chain represents how energy is passed from one organism to the next.

Note: Don't let the terms "tertiary" and "quaternary" scare you. "Tertiary" is another word for "third." Quaternary is another word for "fourth."

Example 1: In the food chain given in figure 19-2, which organisms are predators? Which are prey?

The mouse, the snake, and the hawk are all predators. The grasshopper is prey for the mouse, the mouse is prey for the snake, and the snake is prey for the hawk.

Food Web

The relationships between the organisms in an ecosystem are usually more complex than a simple food chain. These more complex interactions form a network that can be shown in a **food web**. An example of a simple food web is shown in figure 19-3. Notice that decomposers are also included in this food web.

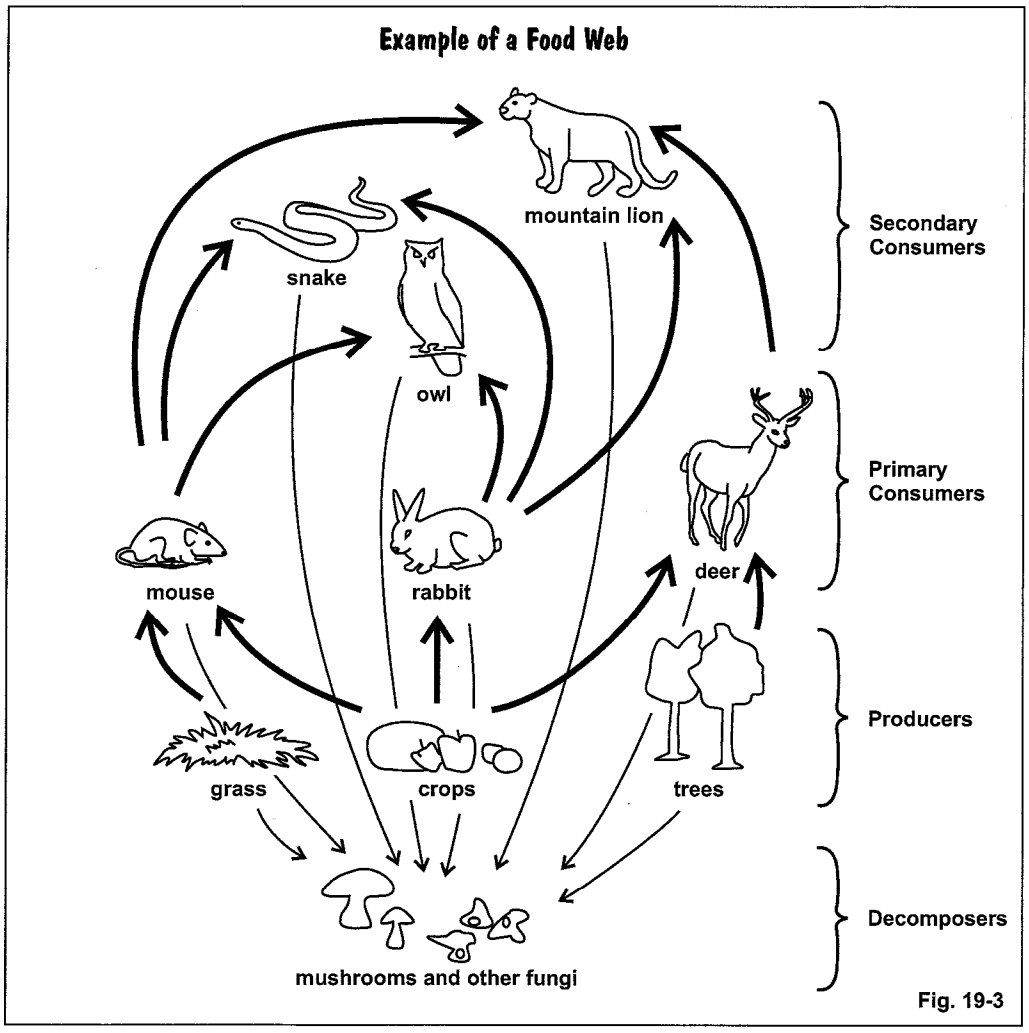


Fig. 19-3

A food web also represents the transfer of energy from one organism to another, but instead of giving one path, it gives a network of paths. In figure 19-3, you can see that an owl may eat a mouse, or it may eat a rabbit. A mountain lion may eat a deer, a rabbit, or a mouse. It can get its energy from any of these other organisms.

Example 2: In the food web given in figure 19-3, which organisms are shown as herbivores?

Remember that herbivores eat producers. In this food web, the mouse, the rabbit, and the deer are herbivores.

Energy Pyramids

Every step in the food web or food chain represents a **trophic level**. Trophic levels indicate how many times energy has been transferred. The first trophic level is made up of producers (autotrophs). The next levels are made of heterotrophs, or consumers. The organisms in each level obtain energy from the organisms in the level below them.

The way that energy is transferred to each trophic level is often shown in an **energy pyramid**. An example of an energy pyramid is given in figure 19-4. Only about 10% of the energy at each level is transferred to the next higher level. The rest of the energy is used by the organism itself for respiration, metabolism, movement, etc, and some of the energy is lost to the environment as heat. In figure 19-4, only 10% of the energy captured by grass ends up in the tissues of the mouse that eats the grass. Then, only 10% of that energy, or 1% of the original amount, goes to the snake that eats the mouse. Even less energy is then available to the hawk that eats the snake. The higher up an organism is on the energy pyramid, the less energy is available for that organism. A tertiary consumer has less energy available to it than a secondary consumer. Decomposers and detritivores are always on the lowest energy level in any particular food chain or food web. Producers, on the other hand, have the most energy available.

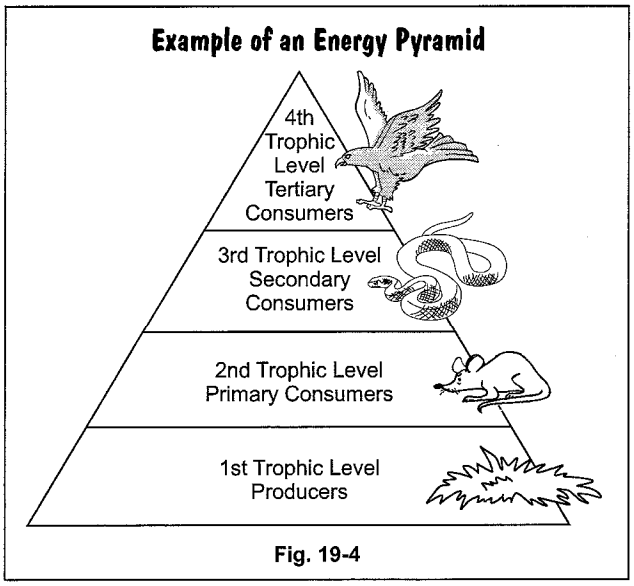


Fig. 19-4

Example 3: For the energy pyramid given in figure 19-4, which organism receives the least energy from producers?

Energy decreases as trophic levels increase. The hawk at the top of the energy pyramid receives the least energy from the grass shown in trophic level one.

Not only is there less energy available in each level of an energy pyramid, there are also fewer nutrients stored as food in the living tissues. For example in figure 19-4, only a small percentage of the nutrients in the grass will be stored in the tissues of the mouse. Even fewer nutrients will be stored in the snake and the hawk. As a result, an ecosystem will have fewer snakes than mice and fewer hawks than snakes. Think about this another way. One snake must eat several mice to survive, so an ecosystem will support fewer snakes than it will mice. If you suddenly introduced a lot more snakes into an ecosystem, many of the snakes would die for lack of food, and the balance would soon be restored. So remember that the higher an organism is on a food pyramid, the fewer will be present in the ecosystem.

The organism at the top of a food chain or energy pyramid is called the **top consumer** or the **top predator**. A top consumer has no natural predators, so it is not normally eaten by another animal. The top consumer is a usually a large carnivore. Examples include eagles, wolves, tigers, lions, and sharks.