* Annotated *

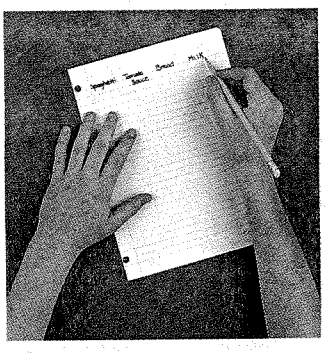
SECTION 1

Energy Flow in Ecosystems

DISCOVER ACTIVITY

Where Did Your Dinner Come From?

1. Across the top of a page, list the different types of foods you ate for dinner last night.
2. Under each item, write the name of the plant, animal, or other organism that is the source of that food. Some foods have more than one source. For example, bread is made from flour (which is made from a plant such as wheat) and yeast (which is a fungus).



Think It Over

Classifying Count the different organisms that contributed to your dinner. How many of your food sources were plants? How many were animals?

GUIDE FOR READING

- What energy roles do organisms play in an ecosystem?
- How much energy is available at each level of an energy pyramid?

Reading Tip As you read, create a flowchart showing one possible path of energy through an ecosystem.

Pushing off from its perch on an oak tree limb, the kestrel glides over a field dotted with yellow flowers. In the middle of the field, the bird pauses. It hovers above the ground like a giant hummingbird. Despite strong gusts of wind, the bird's head remains steady as it looks for prey. It takes a lot of energy for the kestrel to hover in this way, but from this position it can search the field below for food.

Soon the kestrel spots a mouse munching the ripening seedhead of a blade of grass. Seconds later the kestrel swoops down and grasps the mouse in its talons. The bird carries the mouse back to the tree to feed.

Meanwhile, a lynx spider hides among the petals of a nearby flower. An unsuspecting bee lands on the flower for a sip of nectar. The spider grabs the bee and injects its venom into the bee's body. The venom kills the bee before it can respond with its own deadly sting.

This sunny field is an ecosystem, made up of living and nonliving things that interact with one another. You can see that many interactions in this ecosystem involve eating. The spider eats a bee that eats nectar, while the kestrel eats a mouse that eats grass. Ecologists study such feeding patterns to learn how energy flows within an ecosystem.

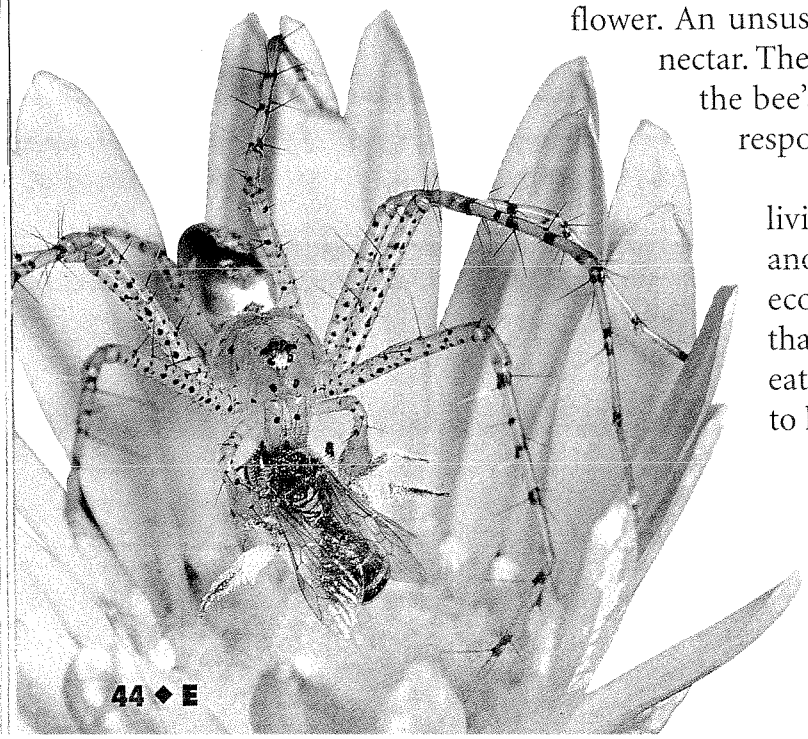


Figure 1 Cradled in a gumweed flower, a green lynx spider attacks an unsuspecting bee. These organisms are involved in feeding interactions.

Energy Roles

Do you play an instrument in your school band? If so, you know that each instrument has a role in a piece of music. For instance, the flute may provide the melody, while the drum provides the beat. Although the two instruments are quite different, they both play important roles in creating the band's music. In the same way, each organism has a role in the movement of energy through its ecosystem. This role is part of the organism's niche in the ecosystem. The kestrel's role is different from that of the giant oak tree where it was perched. But all parts of the ecosystem, like all parts of the band, are necessary for the ecosystem to work.

An organism's energy role is determined by how it obtains energy and how it interacts with the other living things in its ecosystem. **An organism's energy role in an ecosystem may be that of a producer, consumer, or decomposer.**

Producers Energy first enters most ecosystems as sunlight. Some organisms, such as plants, algae, and certain microorganisms, are able to capture the energy of sunlight and store it as food energy. As Figure 2 shows, these organisms use the sun's energy to turn water and carbon dioxide into molecules such as sugars and starches. As you recall from Chapter 1, this process is called photosynthesis.

An organism that can make its own food is a **producer.** Producers are the source of all the food in an ecosystem. For example, the grass and oak tree are the producers for the field ecosystem you read about at the beginning of the section.

In a few ecosystems the producers obtain energy from a source other than sunlight. One such ecosystem is found in rocks deep beneath the ground. Since the rocks are never exposed to sunlight, how is energy brought into this ecosystem? Certain bacteria in this ecosystem produce their own food using the energy in a gas, hydrogen sulfide, that is found in their environment.

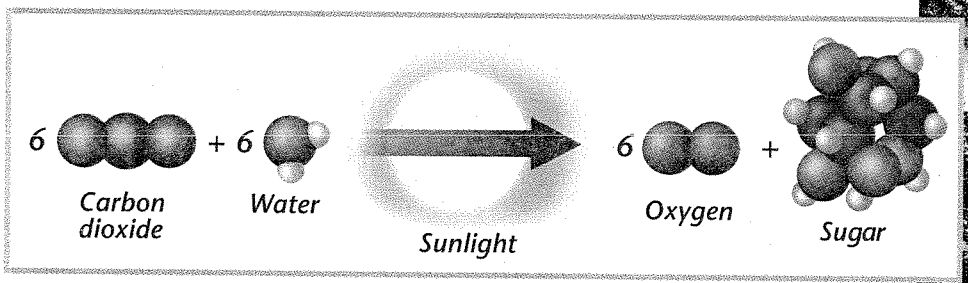


Figure 2 The sunlight streaming through this redwood forest is the source of energy for the ecosystem. Plants convert the sun's energy to stored food energy through the process of photosynthesis.
Interpreting Diagrams *What substances are needed for photosynthesis? What substances are produced?*

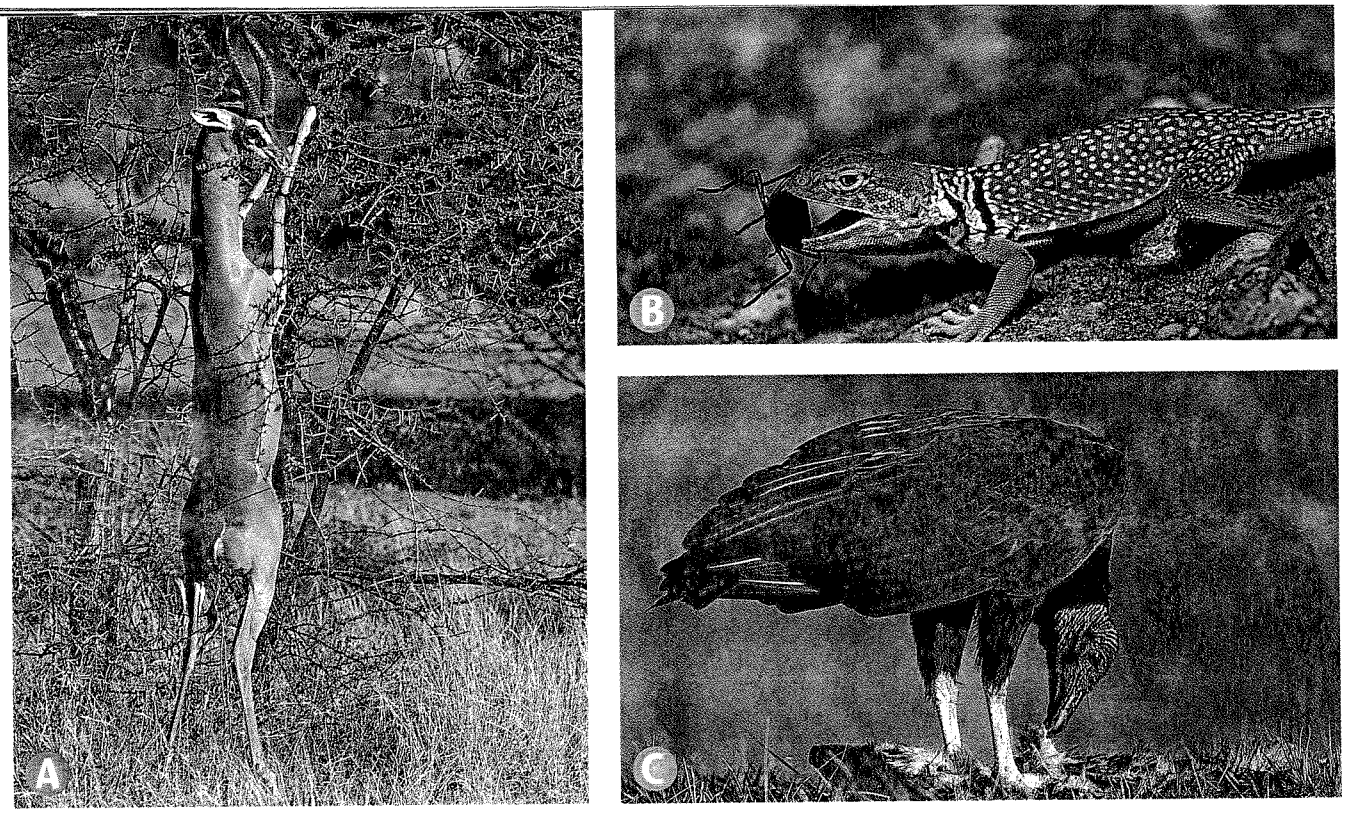


Figure 3 Consumers are classified by what they eat. **A.** An agile gerenuk stands on its hind legs to reach these leaves. Consumers that eat plants are called herbivores. **B.** Carnivores like this collared lizard eat only animals. **C.** A black vulture is a scavenger, a carnivore that feeds on the remains of dead organisms.

Consumers Other members of the ecosystem cannot make their own food. These organisms depend on the producers for food and energy. An organism that obtains energy by feeding on other organisms is a **consumer.**

Consumers are classified by what they eat. Consumers that eat only plants are called **herbivores.** This term comes from the Latin words *herba,* which means grass or herb, and *vorare,* which means to eat. Some familiar herbivores are caterpillars, cattle, and deer. Consumers that eat only animals are called **carnivores.** This term comes from the same root word *vorare,* plus the Latin word for flesh, *carnis.* Lions, spiders, and snakes are some examples of carnivores. A consumer that eats both plants and animals is called an **omnivore.** The Latin word *omni* means all. Crows, goats, and most humans are examples of omnivores.

Some carnivores are scavengers. A **scavenger** is a carnivore that feeds on the bodies of dead organisms. Scavengers include catfish and vultures.

Decomposers What would happen if there were only producers and consumers in an ecosystem? As the organisms in the ecosystem continued to take water, minerals, and other raw materials from their surroundings, these materials would begin to run low. If these materials were not replaced, new organisms would not be able to grow.

All the organisms in an ecosystem produce waste and eventually die. If these wastes and dead organisms were not somehow removed from the ecosystem, they would pile up until they overwhelmed the living things. Organisms that break down wastes and

Sharpen your Skills

Observing ACTIVITY

Sprinkle a few drops of water on a slice of bread. Enclose the bread in a sealable plastic bag. Seal the bag tightly with tape and put it in a warm, dark place. Observe the bread daily for about two weeks. **CAUTION:** *Do not open the bag.* Write a few sentences describing the changes you observe. What is responsible for the change?

dead organisms and return the raw materials to the environment are called **decomposers.** Two major groups of decomposers are bacteria and fungi, such as molds and mushrooms. While obtaining energy for their own needs, decomposers return simple molecules to the environment. These molecules can be used again by other organisms.

Checkpoint What do herbivores and carnivores have in common?

Figure 4 A cluster of honey mushrooms grows among dead leaves. Mushrooms are familiar decomposers.

Food Chains and Food Webs

As you have read, energy enters most ecosystems as sunlight, and is converted into sugar and starch molecules by producers. This energy is transferred to each organism that eats a producer, and then to other organisms that feed on these consumers. The movement of energy through an ecosystem can be shown in diagrams called food chains and food webs.

A **food chain** is a series of events in which one organism eats another and obtains energy. You can follow one food chain from the field ecosystem below. The first organism in a food chain is always a producer, such as the grass in the field. The second organism is a consumer that eats the producer, and is called a first-level consumer. The mouse is a first-level consumer. Next, a second-level consumer eats the first-level consumer. The second-level consumer in this example is the kestrel.

A food chain shows one possible path along which energy can move through an ecosystem. But just as you do not eat the same thing every day, neither do most other organisms. Most producers and consumers are part of many food chains. A more realistic way to show the flow of energy through an ecosystem is a food web. A **food web** consists of the many overlapping food chains in an ecosystem.

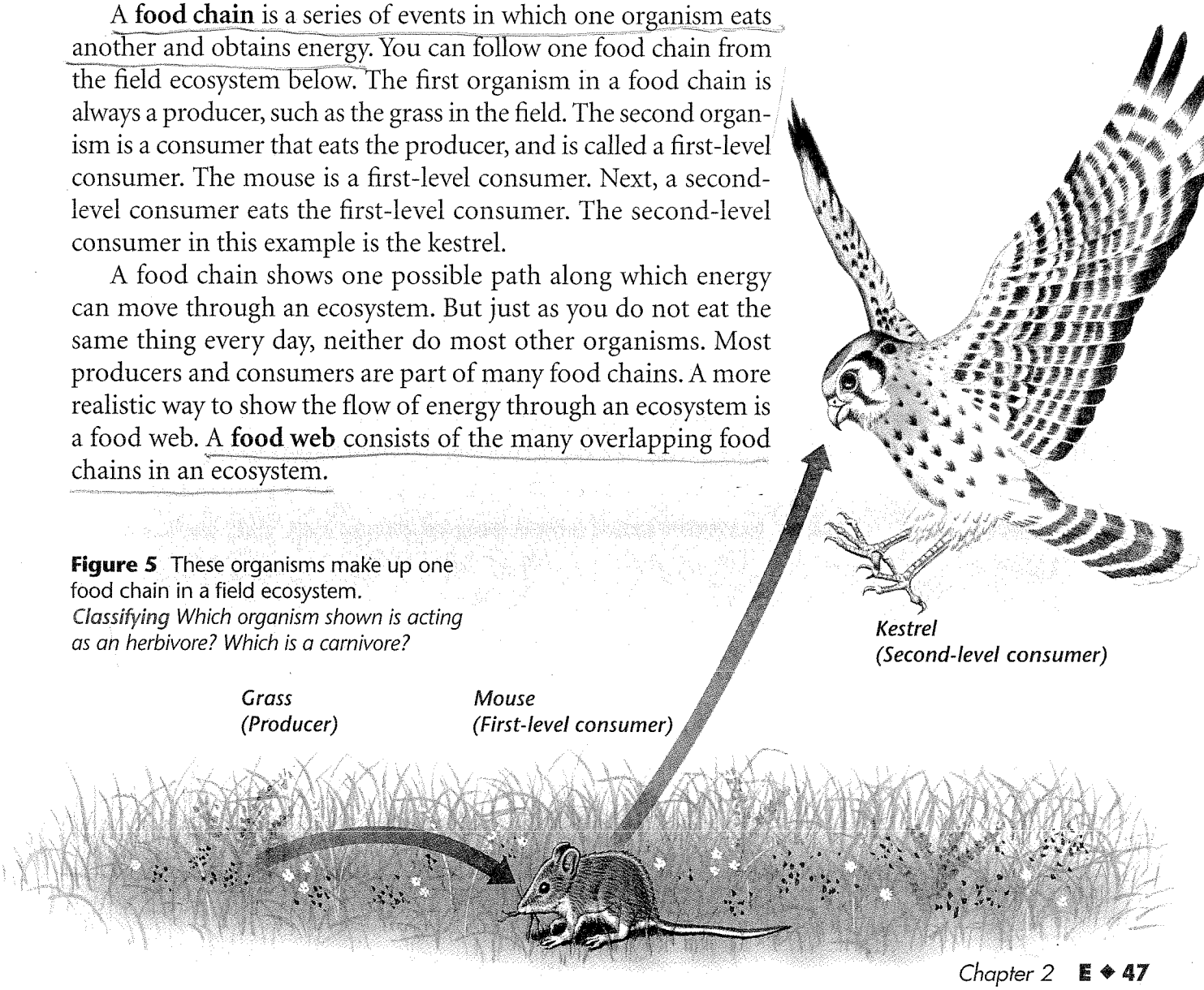
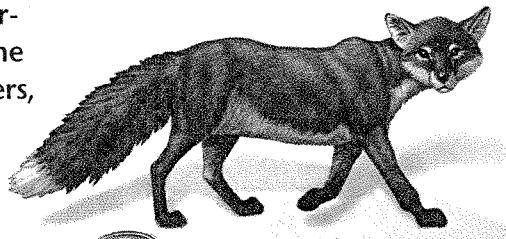


Figure 5 These organisms make up one food chain in a field ecosystem.
Classifying Which organism shown is acting as an herbivore? Which is a carnivore?

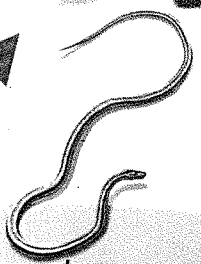
EXPLORING *a Food Web*

A food web consists of many interconnected food chains. Trace the path of energy through the producers, consumers, and decomposers.



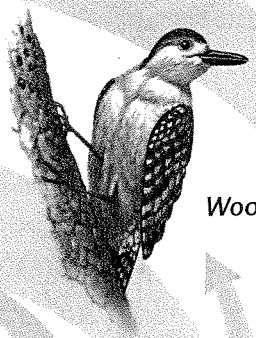
Red fox

4 **Red arrows** *show energy moving from* ***second-level consumers*** *to* ***third-level consumers.*** *The top consumer in this food web is a fox.*



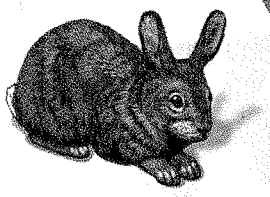
Garter snake

Shrew

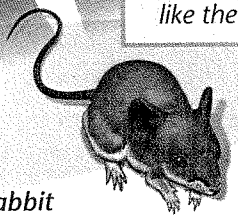


Woodpecker

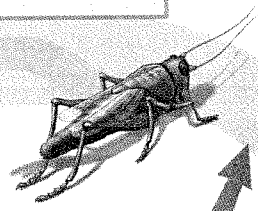
3 **Yellow arrows** *show energy moving from* ***first-level consumers*** *to* ***second-level consumers.*** *Second-level consumers may be carnivores, like the shrew, or omnivores, like the mouse.*



Cottontail rabbit



Field mouse

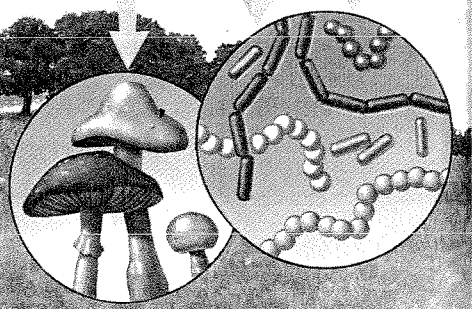


Grasshopper

Termite

5 ***Decomposers*** *consume the wastes and remains of other organisms. This renews the supply of raw materials for the producers.*

2 **Blue arrows** *show the movement of energy from* ***producers*** *to* ***first-level consumers.*** *All first-level consumers are herbivores.*



Fungi and bacteria

1 ***Producers*** *form the base of the food web. The grasses, trees, and other plants use raw materials and sunlight to make sugars and starches.*

In *Exploring a Food Web* on the facing page, you can trace the many food chains in a woodland ecosystem. Note that an organism may play more than one role in an ecosystem. For example, an omnivore such as the mouse is a first-level consumer when it eats grass. But when the mouse eats a grasshopper, it is a second-level consumer.

Checkpoint *What are the organisms in one food chain shown in the food web on the facing page?*

Energy Pyramids

When an organism in an ecosystem eats, it obtains energy. The organism uses some of this energy to move, grow, reproduce, and carry out other life activities. This means that only some of the energy will be available to the next organism in the food web.

A diagram called an **energy pyramid** shows the amount of energy that moves from one feeding level to another in a food web. The organisms at each level use some of the energy to carry out their life processes. **The most energy is available at the producer level. At each level in the pyramid, there is less available energy than at the level below.** An energy pyramid gets its name from the shape of the diagram—wider at the base and narrower at the top, resembling a pyramid.

In general, only about 10 percent of the energy at one level of a food web is transferred to the next, higher, level. The other

Figure 6 Organisms use energy to carry out their life activities. A lioness uses energy to chase her zebra prey. The zebras use energy to flee.

TRY THIS

Weaving a Food Web

ACTIVITY

This activity shows how the organisms in a food web are interconnected.

1. Your teacher will assign you a role in the food web.
2. Hold one end of each of several pieces of yarn in your hand. Give the other ends of your yarn to the other organisms to which your organism is linked.
3. Your teacher will now eliminate one of the organisms. Everyone who is connected to that organism should drop the yarn connecting them to it.

Making Models How many organisms were affected by the removal of one organism? What does this activity show about the importance of each organism in a food web?

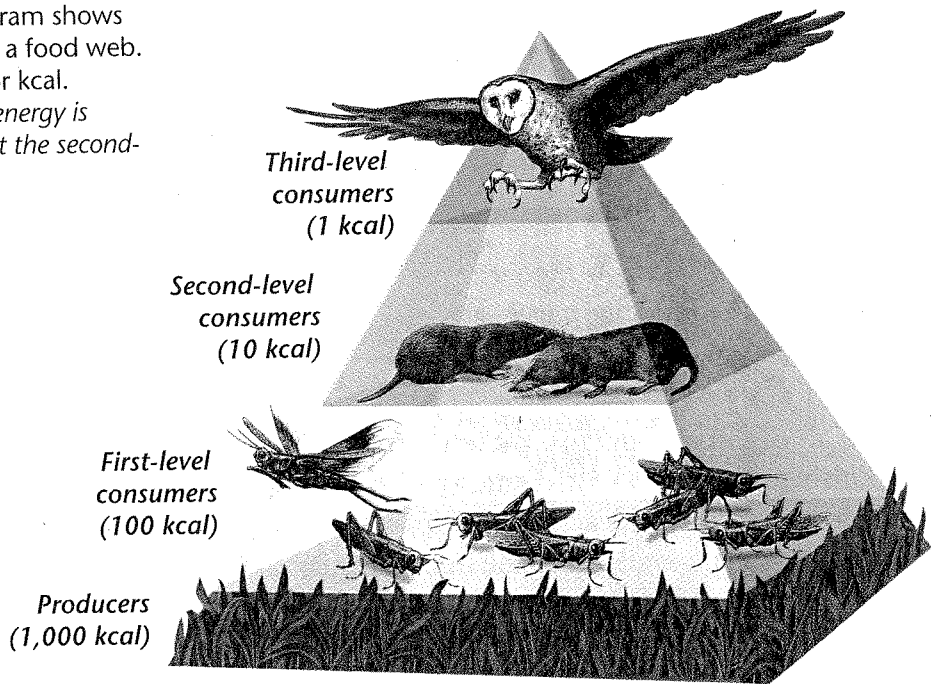


Figure 7 This energy pyramid diagram shows the energy available at each level of a food web. Energy is measured in kilocalories, or kcal. ***Calculating*** *How many times more energy is available at the producer level than at the second-level consumer level?*

90 percent of the energy is used for the organism's life processes or is lost as heat to the environment. Because of this, most food webs only have three or four feeding levels. Since 90 percent of the energy is lost at each step, there is not enough energy to support many feeding levels.

But the organisms at higher feeding levels of an energy pyramid do not necessarily require less energy to live than organisms at lower levels. Since so much energy is lost at each level, the amount of energy in the producer level limits the number of consumers the ecosystem can support. As a result, there usually are few organisms at the highest level in a food web.

Section 1 Review

1. Name the three energy roles of organisms in an ecosystem. How does each type of organism obtain energy?
2. How does the amount of available energy change from one level of an energy pyramid to the next level up?
3. Name and define the four types of consumers.
4. What is the source of energy for most ecosystems?
5. **Thinking Critically Making Generalizations** Why are food webs a more realistic way of portraying ecosystems than food chains?

CHAPTER PROJECT 2

Check Your Progress

By now you should have constructed your compost chambers and chosen a variable to investigate. Design your plan for observing the effect of this variable on the decomposition process. Submit your plan to your teacher for approval. (*Hint:* As part of your plan, include how you will collect data to measure decomposition in your compost chambers.)