3.1 What Is Ecology?

Key Questions

- *What is ecology?*
- *What are biotic and abiotic factors?*
- *What methods are used in ecological studies?*

Vocabulary

biosphere • species • population • community • ecology • ecosystem • biome • biotic factor • abiotic factor

Taking Notes

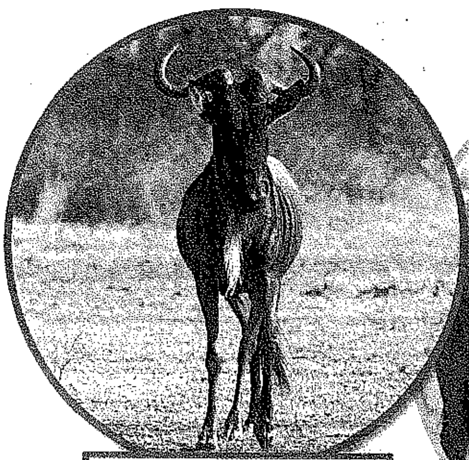
Venn Diagram Make a Venn diagram that shows how the environment consists of biotic factors, abiotic factors, and some components that are truly a mixture of both. Use examples from the lesson.

THINK ABOUT IT Lewis Thomas, a twentieth-century science writer, was sufficiently inspired by astronauts' photographs of Earth to write: "Viewed from the distance of the moon, the astonishing thing about the earth . . . is that it is alive." Sounds good. But what does it mean? Was Thomas reacting to how green Earth is? Was he talking about how you can see moving clouds from space? How is Earth, in a scientific sense, a "living planet"? And how do we study it?

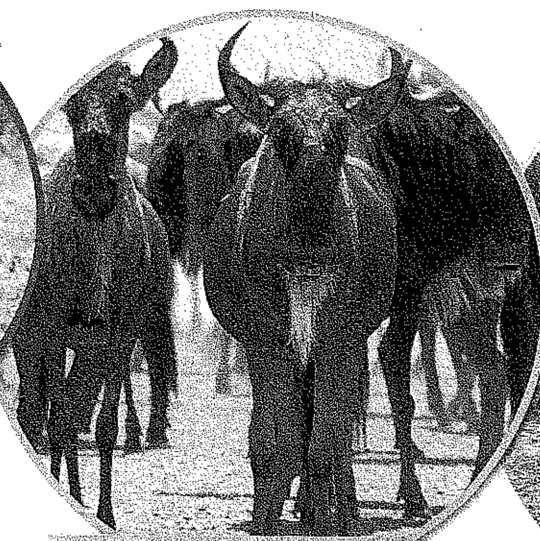
Studying Our Living Planet

What is ecology?

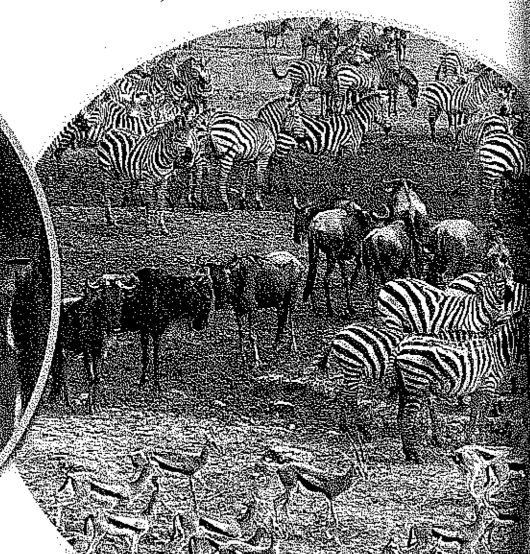
When biologists want to talk about life on a global scale, they use the term *biosphere*. The **biosphere** consists of all life on Earth and all parts of the Earth in which life exists, including land, water, and the atmosphere. The biosphere contains every organism, from bacteria living underground to giant trees in rain forests, whales in polar seas, mold spores drifting through the air—and, of course, humans. The biosphere extends from about 8 kilometers above Earth's surface to as far as 11 kilometers below the surface of the ocean.



Individual Organism
A **species** is a group of similar organisms that can breed and produce fertile offspring.



A **population** is a group of individuals that belong to the same species and live in the same area.



An assemblage of different populations that live together in a defined area is called a **community.**

The Science of Ecology Organisms in the biosphere interact with each other and with their surroundings, or environment. The study of these interactions is called **ecology.** **Ecology is the scientific study of interactions among organisms and between organisms and their physical environment.** The root of the word *ecology* is the Greek word *oikos*, which means "house." So, ecology is the study of nature's "houses" and the organisms that live in those houses.

Interactions within the biosphere produce a web of interdependence between organisms and the environments in which they live. Organisms respond to their environments and can also change their environments, producing an ever-changing, or dynamic, biosphere.

BUILD Vocabulary

PREFIXES The prefix *inter-* means "between or among." *Interdependence* is a noun that means "dependence between or among individuals or things." The physical environment and organisms are considered interdependent because changes in one cause changes in the other.

Ecology and Economics The Greek word *oikos* is also the root of the word *economics.* Economics is concerned with human "houses" and human interactions based on money or trade. Interactions among nature's "houses" are based on energy and nutrients. As their common root implies, human economics and ecology are linked. Humans live within the biosphere and depend on ecological processes to provide such essentials as food and drinkable water that can be bought and sold or traded.

Levels of Organization Ecologists ask many questions about organisms and their environments. Some ecologists focus on the ecology of individual organisms. Others try to understand how interactions among organisms (including humans) influence our global environment. Ecological studies may focus on levels of organization that include those shown in **Figure 3–1.**

In Your Notebook *Draw a circle and label it "Me." Then, draw five concentric circles and label each of them with the appropriate level of organization. Describe your population, community, etc.*

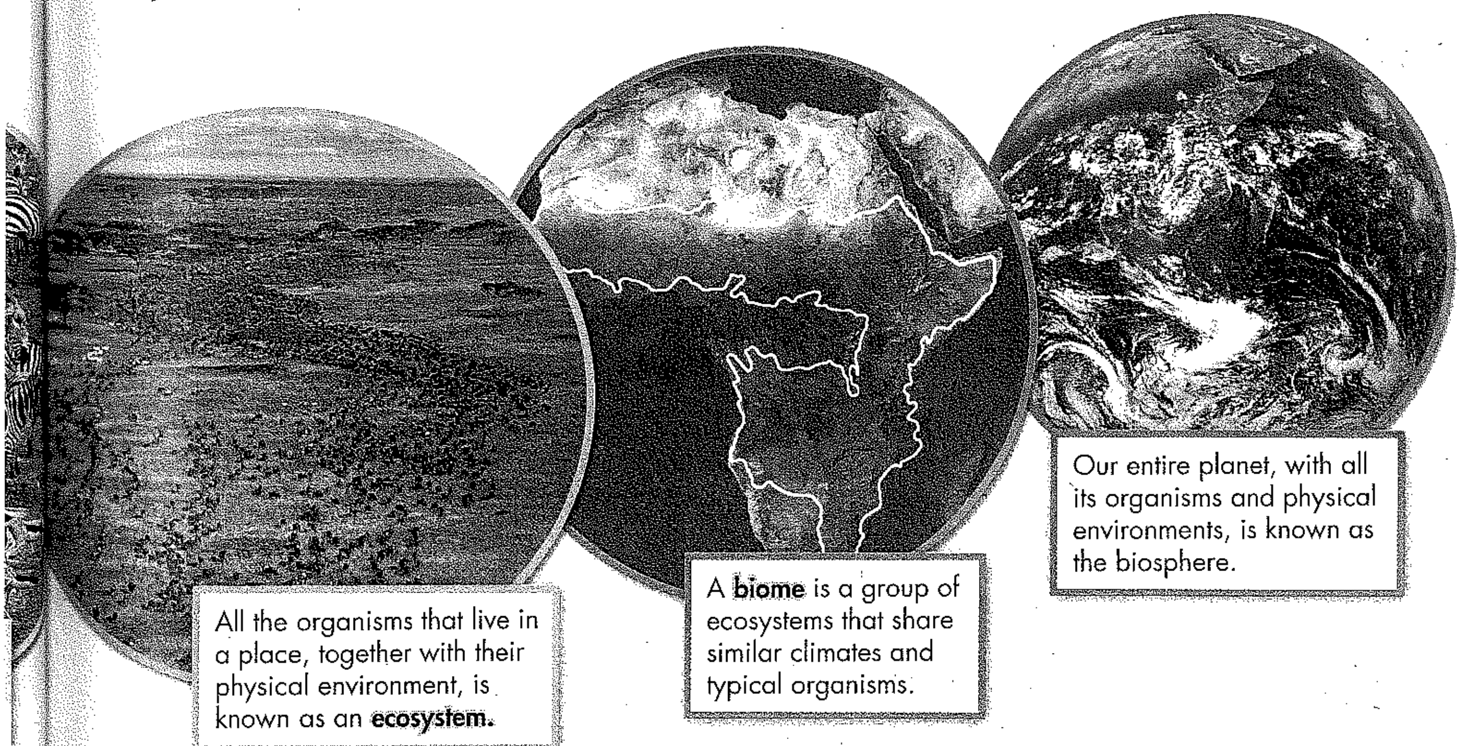


FIGURE 3–1 Levels of Organization The kinds of questions that ecologists may ask about the living environment can vary, depending on the level at which the ecologist works. **Interpret Visuals** ***What is the difference between a population and a community?***

Biotic and Abiotic Factors

What are biotic and abiotic factors?

Ecologists use the word *environment* to refer to all conditions, or factors, surrounding an organism. Environmental conditions include biotic factors and abiotic factors, as shown in **Figure 3–2.**

Biotic Factors **The biological influences on organisms are called biotic factors.** A **biotic factor** is any living part of the environment with which an organism might interact, including animals, plants, mushrooms, and bacteria. Biotic factors relating to a bullfrog, for example, might include algae it eats as a tadpole, insects it eats as an adult, herons that eat bullfrogs, and other species that compete with bullfrogs for food or space.

Abiotic Factors **Physical components of an ecosystem are called abiotic factors.** An **abiotic factor** is any nonliving part of the environment, such as sunlight, heat, precipitation, humidity, wind or water currents, soil type, and so on. For example, a bullfrog could be affected by abiotic factors such as water availability, temperature, and humidity.

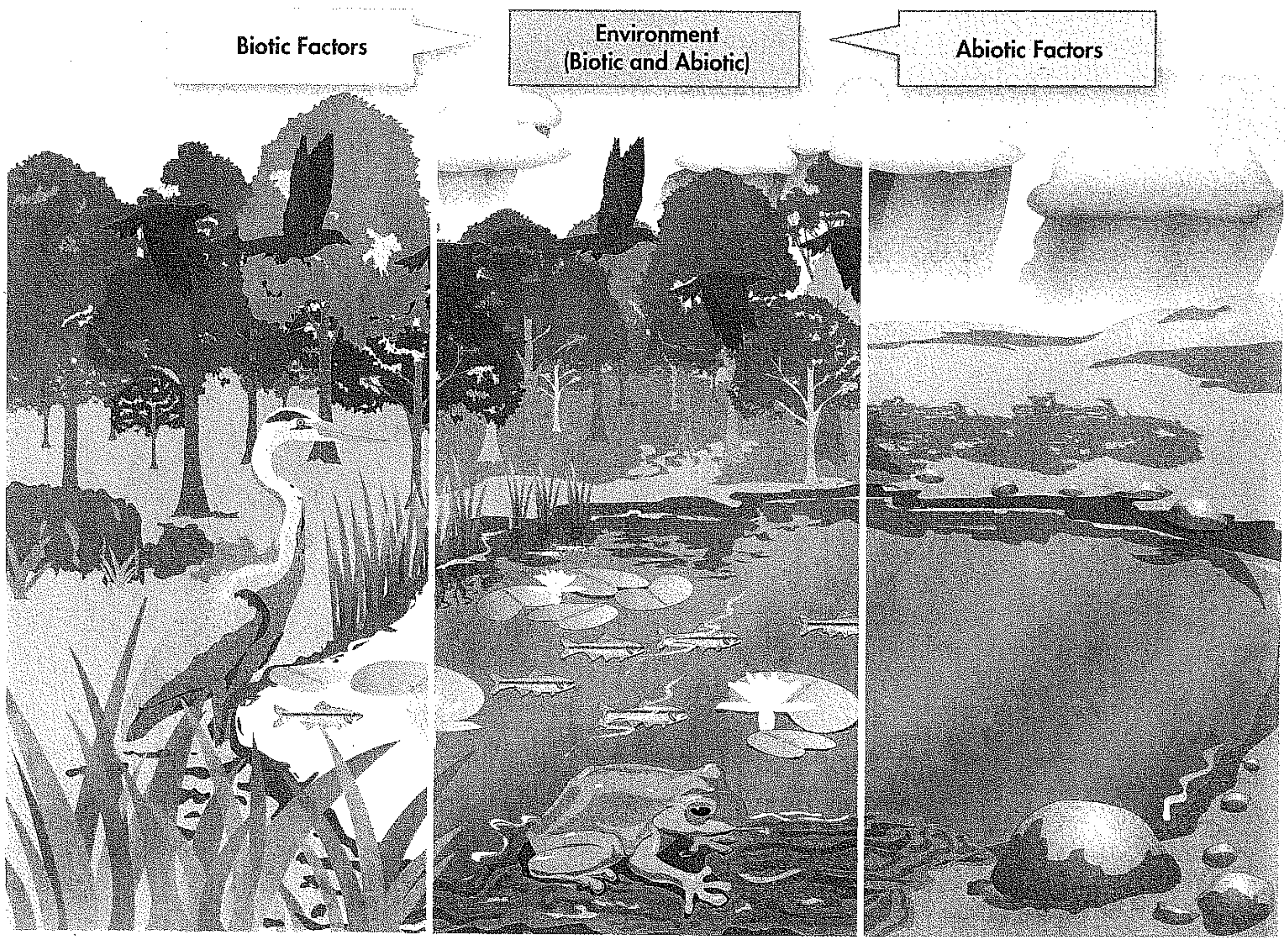


FIGURE 3–2 Biotic and Abiotic Factors Like all ecosystems, this pond is affected by a combination of biotic and abiotic factors. Some environmental factors, such as the "muck" around the edges of the pond, are a mix of biotic and abiotic components. Biotic and abiotic factors are dynamic, meaning that they constantly affect each other. **Classify** ***What biotic factors are visible in this ecosystem?***

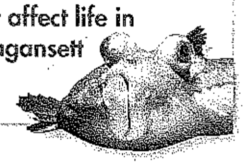
Biotic and Abiotic Factors Together The difference between biotic and abiotic factors may seem to be clear and simple. But if you think carefully, you will realize that many physical factors can be strongly influenced by the activities of organisms. Bullfrogs hang out, for example, in soft "muck" along the shores of ponds. You might think that this muck is strictly part of the physical environment, because it contains nonliving particles of sand and mud. But typical pond muck also contains leaf mold and other decomposing plant material produced by trees and other plants around the pond. That material is decomposing because it serves as "food" for bacteria and fungi that live in the muck.

Taking a slightly wider view, the "abiotic" conditions around that mucky shoreline are strongly influenced by living organisms. A leafy canopy of trees and shrubs often shade the pond's shoreline from direct sun and protect it from strong winds. In this way, organisms living around the pond strongly affect the amount of sunlight the shoreline receives and the range of temperatures it experiences. A forest around a pond also affects the humidity of air close to the ground. The roots of trees and other plants determine how much soil is held in place and how much washes into the pond. Even certain chemical conditions in the soil around the pond are affected by living organisms. If most trees nearby are pines, their decomposing needles make the soil acidic. If the trees nearby are oaks, the soil will be more alkaline. This kind of dynamic mix of biotic and abiotic factors shapes every environment.

In Your Notebook *In your own words, explain the difference between biotic and abiotic factors. Give three examples of each.*

MYSTERY CLUE

What are three examples of abiotic factors that might affect life in Narragansett Bay?



Quick Lab
GUIDED INQUIRY

How Do Abiotic Factors Affect Different Plant Species?

❶ Gather four paper cups. Use a pencil to punch three holes in the bottom of each cup. Fill two cups with equal amounts of sand and two cups with the same amount of potting soil. **CAUTION:** *Wash your hands well with soap and warm water after handling soil or plants.*

❷ Plant five rice seeds in one sand-filled cup and five rice seeds in one soil-filled cup. Plant five rye seeds in each of the other two cups. Label each cup with the type of seeds and soil it contains.

❸ Place all the cups in a warm, sunny location. Each day for two weeks, water the cups equally and record your observations of any plant growth.

Analyze and Conclude

1. **Analyze Data** In which medium did the rice grow better—sand or soil? Which was the better medium for the growth of rye?

2. **Infer** Soil retains more water than sand does, providing a moister environment. What can you infer from your observations about the kind of environment that favors the growth of rice? What kind of environment favors the growth of rye?

3. **Draw Conclusions** Which would compete more successfully in a dry environment—rice or rye? Which would be more successful in a moist environment?

FIGURE 3–3 Ecology Field Work The three fundamental approaches to ecological research involve observing, experimenting, and modeling. This ecologist is measuring a giant *Rafflesia* flower in Borneo.

Ecological Methods

What methods are used in ecological studies?

Some ecologists, like the one in **Figure 3–3,** use measuring tools to assess changes in plant and wildlife communities. Others use DNA studies to identify bacteria in marsh mud. Still others use data gathered by satellites to track ocean surface temperatures. **Regardless of their tools, modern ecologists use three methods in their work: observation, experimentation, and modeling. Each of these approaches relies on scientific methodology to guide inquiry.**

Observation Observation is often the first step in asking ecological questions. Some observations are simple: Which species live here? How many individuals of each species are there? Other observations are more complex: How does an animal protect its young from predators? These types of questions may form the first step in designing experiments and models.

Experimentation Experiments can be used to test hypotheses. An ecologist may, for example, set up an artificial environment in a laboratory or greenhouse to see how growing plants react to different conditions of temperature, lighting, or carbon dioxide concentration. Other experiments carefully alter conditions in selected parts of natural ecosystems.

Modeling Many ecological events, such as effects of global warming on ecosystems, occur over such long periods of time or over such large distances that they are difficult to study directly. Ecologists make models to help them understand these phenomena. Many ecological models consist of mathematical formulas based on data collected through observation and experimentation. Further observations by ecologists can be used to test predictions based on those models.

3.1 Assessment

Review Key Concepts

1. a. **Review** What are the six different major levels of organization, from smallest to largest, that ecologists commonly study?
   b. **Apply Concepts** Give an example of two objects or activities in your life that are interdependent. Explain your choice.
2. a. **Review** Is weather a biotic or abiotic factor?
   b. **Compare and Contrast** How are biotic and abiotic factors related? What is the difference between them?
3. a. **Review** Describe the three basic methods of ecological research.
   b. **Apply Concepts** Give an example of an ecological phenomenon that could be studied by modeling. Explain why modeling would be useful.

PRACTICE PROBLEM

4. Suppose you want to know if the water in a certain stream is safe to drink. Which ecological method(s) would you use in your investigation? Explain your reasoning and outline your procedure.

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3.2 Energy, Producers, and Consumers

THINK ABOUT IT At the core of every organism's interaction with the environment is its need for energy to power life's processes. Ants use energy to carry objects many times their size. Birds use energy to migrate thousands of miles. You need energy to get out of bed in the morning! Where does energy in living systems come from? How is it transferred from one organism to another?

Primary Producers

What are primary producers?

Living systems operate by expending energy. Organisms need energy for growth, reproduction, and their own metabolic processes. In short, if there is no energy, there are no life functions! Yet, no organism can create energy—organisms can only use energy from other sources. You probably know that you get your energy from the plants and animals you eat. But where does the energy in your food come from? For most life on Earth, sunlight is the ultimate energy source. Over the last few decades, however, researchers have discovered that there are other energy sources for life. For some organisms, chemical energy stored in inorganic chemical compounds serves as the ultimate energy source for life processes.

Only algae, certain bacteria, and plants like the one in **Figure 3–4** can capture energy from sunlight or chemicals and convert it into forms that living cells can use. These organisms are called **autotrophs.** Autotrophs use solar or chemical energy to produce "food" by assembling inorganic compounds into complex organic molecules. But autotrophs do more than feed themselves. Autotrophs store energy in forms that make it available to other organisms that eat them. That's why autotrophs are also called **primary producers.** **Primary producers are the first producers of energy-rich compounds that are later used by other organisms.** Primary producers are, therefore, essential to the flow of energy through the biosphere.

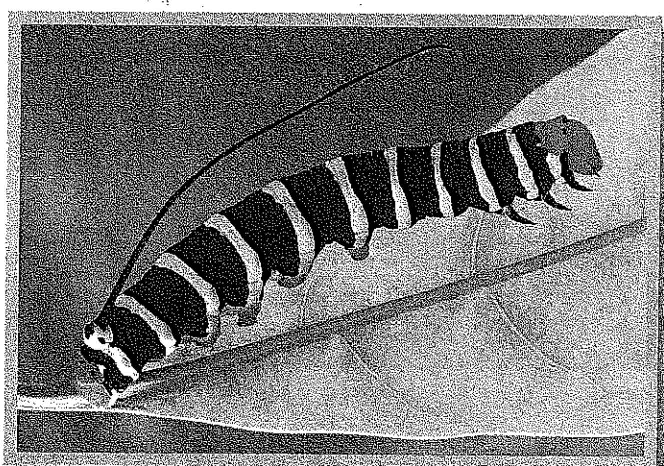


FIGURE 3–4 Primary Producers Plants obtain energy from sunlight and turn it into nutrients that can, in turn, be eaten and used for energy by animals such as this caterpillar.

Key Questions

What are primary producers?

How do consumers obtain energy and nutrients?

Vocabulary

autotroph • primary producer • photosynthesis • chemosynthesis • heterotroph • consumer • carnivore • herbivore • scavenger • omnivore • decomposer • detritivore

Taking Notes

Concept Map As you read, use the highlighted vocabulary words to create a concept map that organizes the information in this lesson.

BUILD Vocabulary

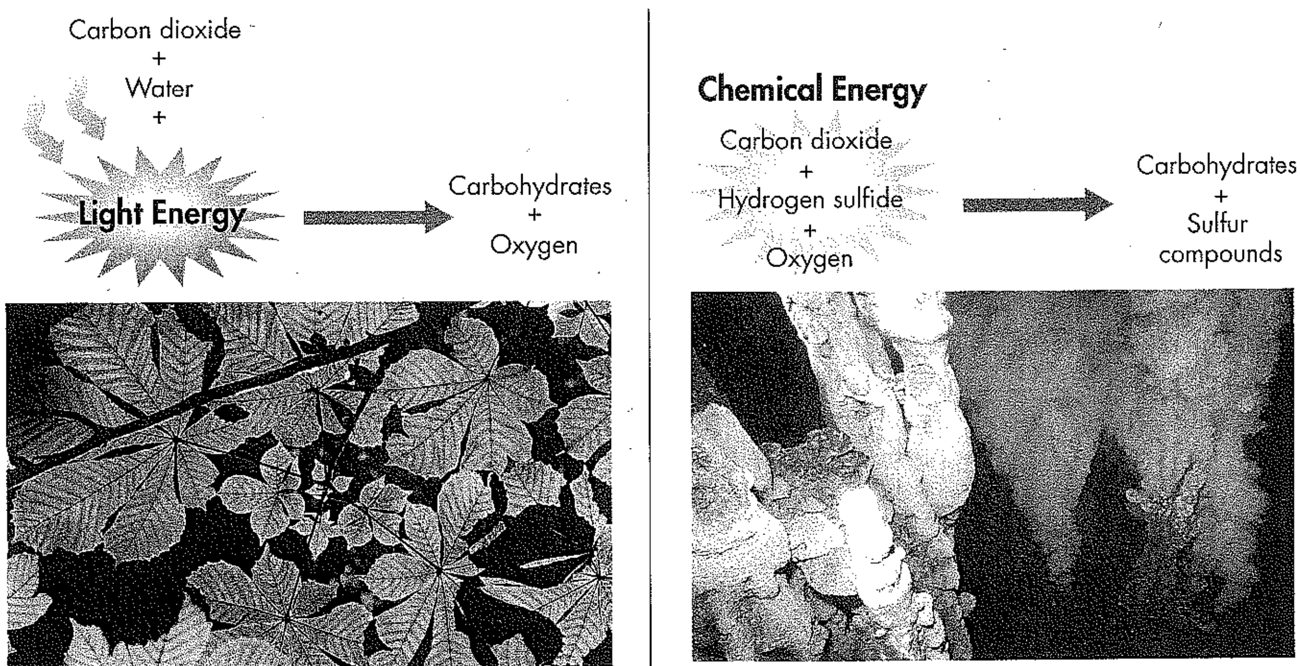
PREFIXES The prefix *auto-* means "by itself." The Greek word *trophikos* means "to feed." An **autotroph** can, therefore, be described as a "self feeder," meaning that it does not need to eat other organisms for food.

Energy From the Sun The best-known and most common primary producers harness solar energy through the process of photosynthesis. **Photosynthesis** captures light energy and uses it to power chemical reactions that convert carbon dioxide and water into oxygen and energy-rich carbohydrates such as sugars and starches. This process, shown in **Figure 3–5** (below left), adds oxygen to the atmosphere and removes carbon dioxide. Without photosynthetic producers, the air would not contain enough oxygen for you to breathe! Plants are the main photosynthetic producers on land. Algae fill that role in freshwater ecosystems and in the sunlit upper layers of the ocean. Photosynthetic bacteria, most commonly cyanobacteria, are important primary producers in ecosystems such as tidal flats and salt marshes.

Life Without Light About 30 years ago, biologists discovered thriving ecosystems around volcanic vents in total darkness on the deep ocean floor. There was no light for photosynthesis, so who or what were the primary producers? Research revealed that these deep-sea ecosystems depended on primary producers that harness chemical energy from inorganic molecules such as hydrogen sulfide. These organisms carry out a process called **chemosynthesis** (kee moh SIN thuh sis) in which chemical energy is used to produce carbohydrates as shown in **Figure 3–5** (below right). Chemosynthetic organisms are not only found in the deepest, darkest ocean, however. Several types of chemosynthetic producers have since been discovered in more parts of the biosphere than anyone expected. Some chemosynthetic bacteria live in harsh environments, such as deep-sea volcanic vents or hot springs. Others live in tidal marshes along the coast.

In Your Notebook *In your own words, explain the differences and similarities between photosynthetic and chemosynthetic producers.*

FIGURE 3–5 Photosynthesis and Chemosynthesis Plants use the energy from sunlight to carry out the process of photosynthesis. Other autotrophs, such as sulfur bacteria, use the energy stored in chemical bonds in a process called chemosynthesis. In both cases, energy-rich carbohydrates are produced. **Compare and Contrast** ***How are photosynthesis and chemosynthesis similar?***



Photosynthesis **Chemosynthesis**

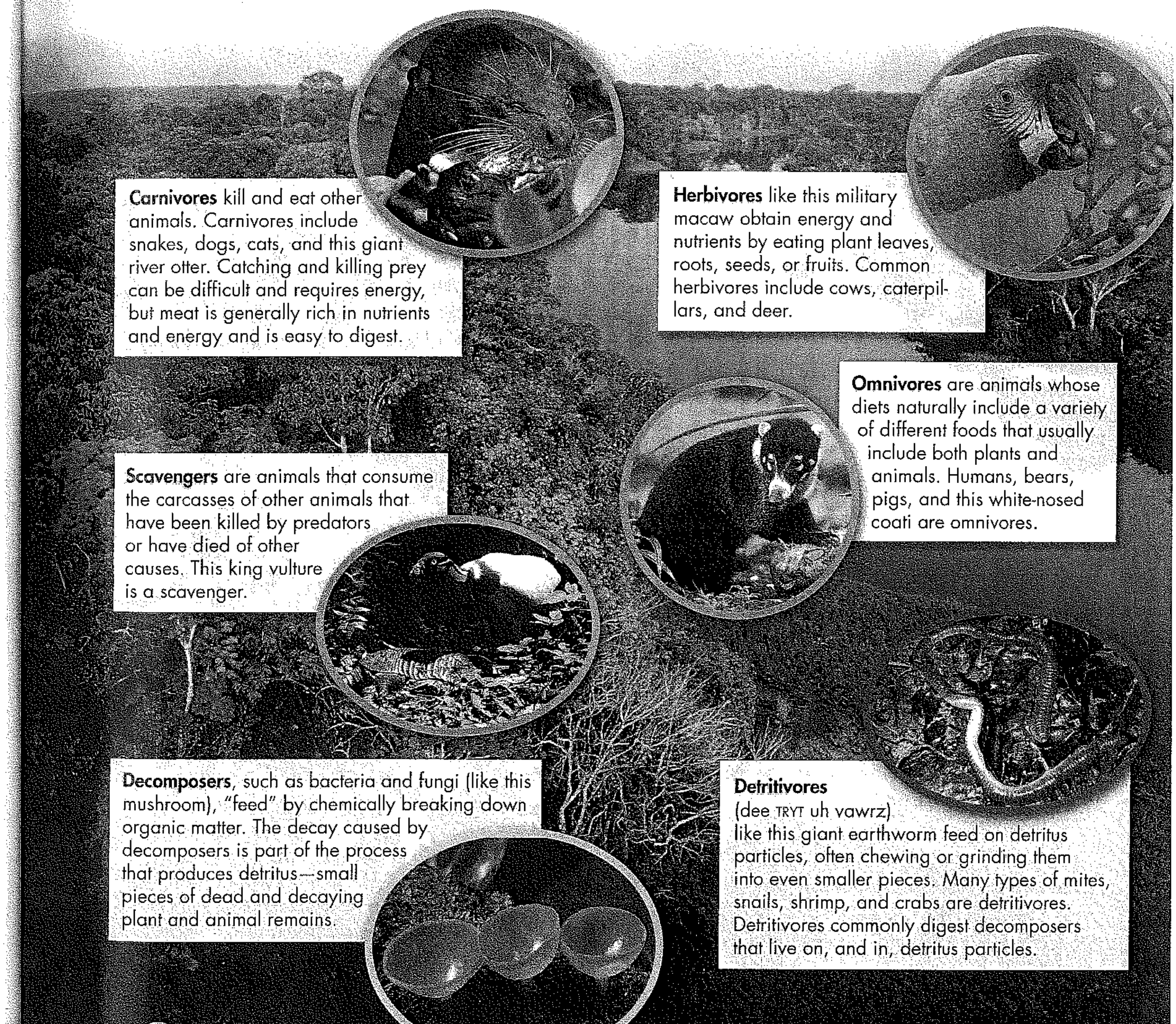
Consumers

🔑 *How do consumers obtain energy and nutrients?*

Animals, fungi, and many bacteria cannot directly harness energy from the environment as primary producers do. These organisms, known as **heterotrophs** (HET uh roh trohfs) must acquire energy from other organisms—by ingesting them in one way or another. Heterotrophs are also called **consumers.** 🔑 **Organisms that rely on other organisms for energy and nutrients are called consumers.**

Types of Consumers Consumers are classified by the ways in which they acquire energy and nutrients, as shown in **Figure 3–6.** As you will see, the definition of *food* can vary quite a lot among consumers.

FIGURE 3–6 Consumers Consumers rely on other organisms for energy and nutrients. The Amazon rain forest shelters examples of each type of consumer as shown here.



Quick Lab
GUIDED INQUIRY

How Do Different Types of Consumers Interact?

1. Place a potted bean seedling in each of two jars.

2. Add 20 aphids to one jar and cover the jar with screening to prevent the aphids from escaping. Use a rubber band to attach the screening to the jar.

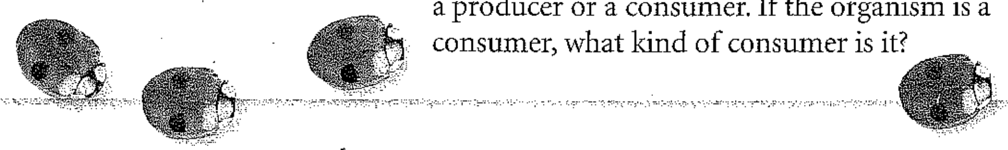
3. Add 20 aphids and 4 ladybird beetles to the second jar. Cover the second jar as you did the first one.

4. Place both jars in a sunny location. Observe the jars each day for one week and record your observations each day. Water the seedlings as needed.

Analyze and Conclude

1. Observe What happened to the aphids and the seedling in the jar without the ladybird beetles? What happened in the jar with the ladybird beetles? How can you explain this difference?

2. Classify Identify each organism in the jars as a producer or a consumer. If the organism is a consumer, what kind of consumer is it?



MYSTERY CLUE

Bacteria are important members of the living community in Narragansett Bay. How do you think the bacterial communities on the floor of the bay might be linked to its producers and consumers?

Beyond Consumer Categories Categorizing consumers is important, but these simple categories often don't express the real complexity of nature. Take herbivores, for instance. Seeds and fruits are usually rich in energy and nutrients, and they are often easy to digest. Leaves are generally poor in nutrients and are usually very difficult to digest. For that reason, herbivores that eat different plant parts often differ greatly in the ways they obtain and digest their food. In fact, only a handful of birds eat leaves, because the kind of digestive system needed to handle leaves efficiently is heavy and difficult to fly around with!

Moreover, organisms in nature often do not stay inside the tidy categories ecologists place them in. For example, some animals often described as carnivores, such as hyenas, will scavenge if they get a chance. Many aquatic animals eat a mixture of algae, bits of animal carcasses, and detritus particles—including the feces of other animals! So, these categories make a nice place to start talking about ecosystems, but it is important to expand on this topic by discussing the way that energy and nutrients move through ecosystems.

3.2 Assessment

Review Key Concepts

1. a. Review What are the two primary sources of energy that power living systems?

b. Pose Questions Propose a question that a scientist might ask about the variety of organisms found around deep-sea vents.

2. a. Review Explain how consumers obtain energy.

b. Compare and Contrast How are detritivores different from decomposers? Provide an example of each.

BUILD VOCABULARY

3. The word *autotroph* comes from the Greek words *autos,* meaning "self," and *trophe,* meaning "food or nourishment." Knowing this, what do you think the Greek word *heteros,* as in *heterotroph,* means?

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3.3 Energy Flow in Ecosystems

THINK ABOUT IT What happens to energy stored in body tissues when one organism eats another? That energy moves from the "eaten" to the "eater." You've learned that the flow of energy through an ecosystem always begins with either photosynthetic or chemosynthetic primary producers. Where it goes from there depends literally on who eats whom!

Key Questions

How does energy flow through ecosystems?

What do the three types of ecological pyramids illustrate?

Vocabulary

food chain • phytoplankton • food web • zooplankton • trophic level • ecological pyramid • biomass

Taking Notes

Preview Visuals Before you read, look at **Figure 3–7** and **Figure 3–9.** Note how they are similar and how they are different. Based on the figures, write definitions for *food chain* and *food web.*

Food Chains and Food Webs

How does energy flow through ecosystems?

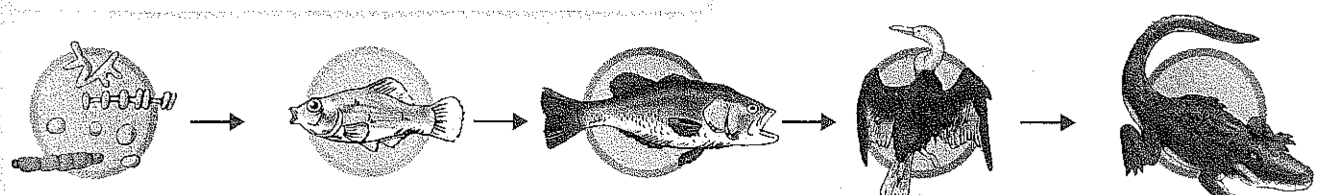
In every ecosystem, primary producers and consumers are linked through feeding relationships. Despite the great variety of feeding relationships in different ecosystems, energy always flows in similar ways. **Energy flows through an ecosystem in a one-way stream, from primary producers to various consumers.**

Food Chains You can think of energy as passing through an ecosystem along a food chain. A **food chain** is a series of steps in which organisms transfer energy by eating and being eaten. Food chains can vary in length. For example, in a prairie ecosystem, a primary producer, such as grass, is eaten by an herbivore, such as a grazing antelope. A carnivore, such as a coyote, in turn feeds upon the antelope. In this two-step chain, the carnivore is just two steps removed from the primary producer.

In some aquatic food chains, primary producers are a mixture of floating algae called **phytoplankton** and attached algae. As shown in **Figure 3–7,** these primary producers may be eaten by small fishes, such as flagfish. Larger fishes, like the largemouth bass, eat the small fishes. The bass are preyed upon by large wading birds, such as the anhinga, which may ultimately be eaten by an alligator. There are four steps in this food chain. The top carnivore is therefore four steps removed from the primary producer.

FIGURE 3–7 Food Chains Food chains show the one-way flow of energy in an ecosystem. **Apply Concepts** ***What is the ultimate source of energy for this food chain?***

Primary producer   Herbivore   Carnivore



Food Webs In most ecosystems, feeding relationships are much more complicated than the relationships described in a single, simple chain. One reason for this is that many animals eat more than one kind of food. For example, on Africa's Serengeti Plain, herbivores, such as zebras, gazelles, and buffaloes, often graze upon several different species of grasses. Several predators such as lions, hyenas, and leopards, in turn, often prey upon those herbivores! Ecologists call this network of feeding interactions a **food web.**

▶ ***Food Chains Within Food Webs*** The Everglades are a complex marshland ecosystem in southern Florida. Here, aquatic and terrestrial organisms interact in many overlapping feeding relationships that have been simplified and represented in **Figure 3–9.** Starting with a primary producer (algae or plants), see how many different routes you can take to reach the alligator, vulture, or anhinga. One path, from the algae to the alligator, is the same food chain you saw in **Figure 3–7.** In fact, each path you trace through the food web is a food chain. You can think of a food web, therefore, as linking together all of the food chains in an ecosystem. Realize, however, that this is a highly simplified representation of this food web, in which many species have been left out. Now, you can begin to appreciate how complicated food webs are!

▶ ***Decomposers and Detritivores in Food Webs*** Decomposers and detritivores are as important in most food webs as other consumers are. Look again at the Everglades web. Although white-tailed deer, moorhens, raccoons, grass shrimp, crayfish, and flagfish feed at least partly on primary producers, most producers die without being eaten. In the detritus pathway, decomposers convert that dead material to detritus, which is eaten by detritivores, such as crayfish, grass shrimp, and worms. At the same time, the decomposition process releases nutrients that can be used by primary producers. Thus, decomposers recycle nutrients in food webs as seen in **Figure 3–8.** Without decomposers, nutrients would remain locked within dead organisms.

In Your Notebook *Explain how food chains and food webs are related.*

BUILD Vocabulary

ACADEMIC WORDS The verb **convert** means "to change from one form to another." Decomposers convert, or change, dead plant matter into a form called detritus that is eaten by detritivores.

VISUAL ANALOGY

FIGURE 3–8 Earth's Recycling Center Decomposers break down dead and decaying matter and release nutrients that can be reused by primary producers. **Use Analogies** ***How are decomposers like a city's recycling center?***

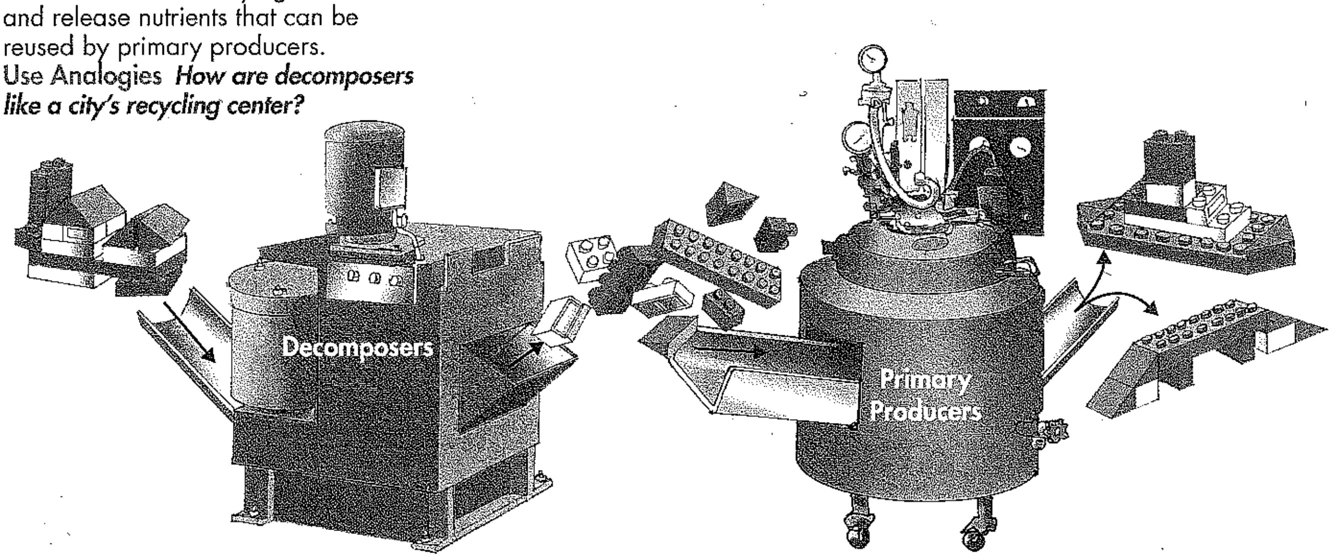
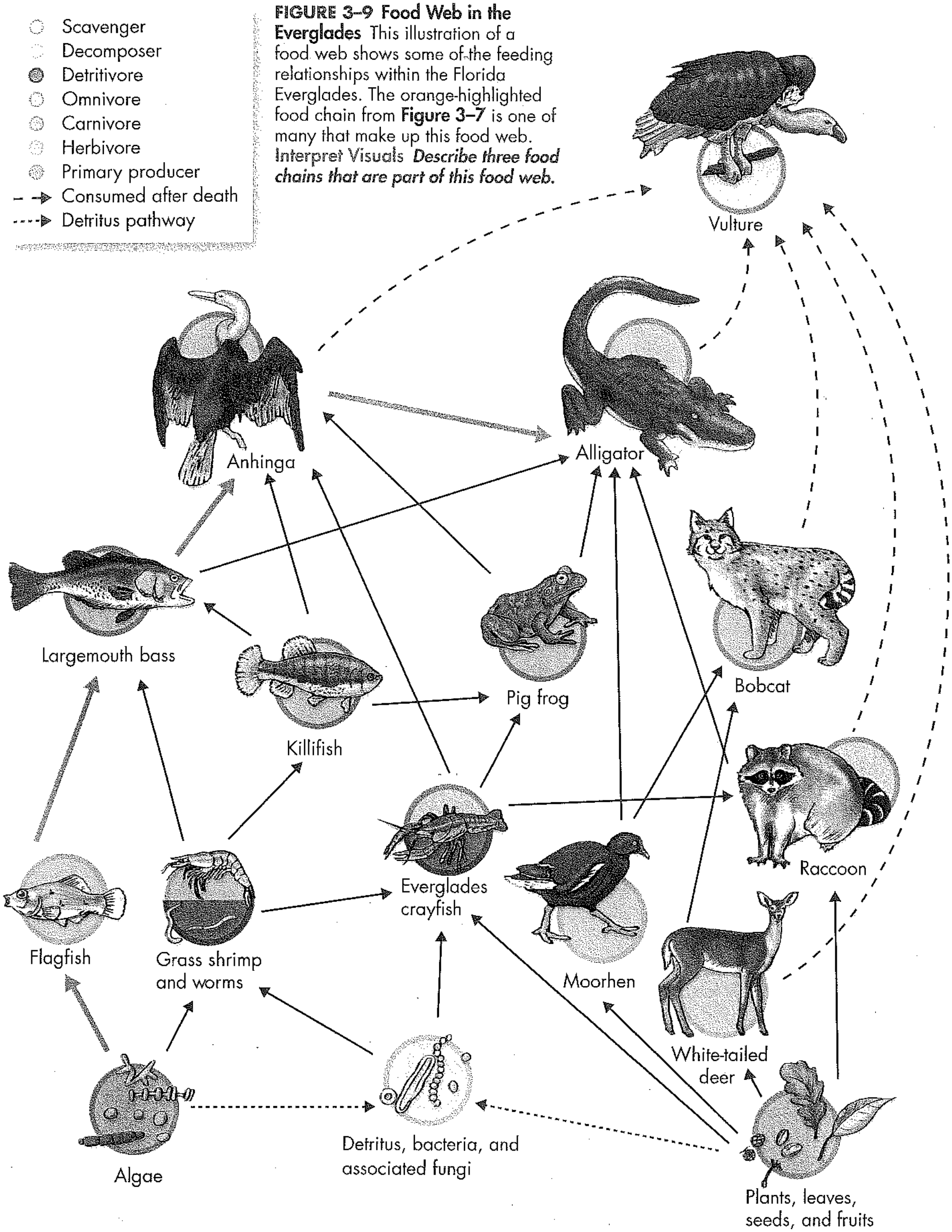


FIGURE 3–9 Food Web in the Everglades This illustration of a food web shows some of the feeding relationships within the Florida Everglades. The orange-highlighted food chain from **Figure 3–7** is one of many that make up this food web. **Interpret Visuals** ***Describe three food chains that are part of this food web.***



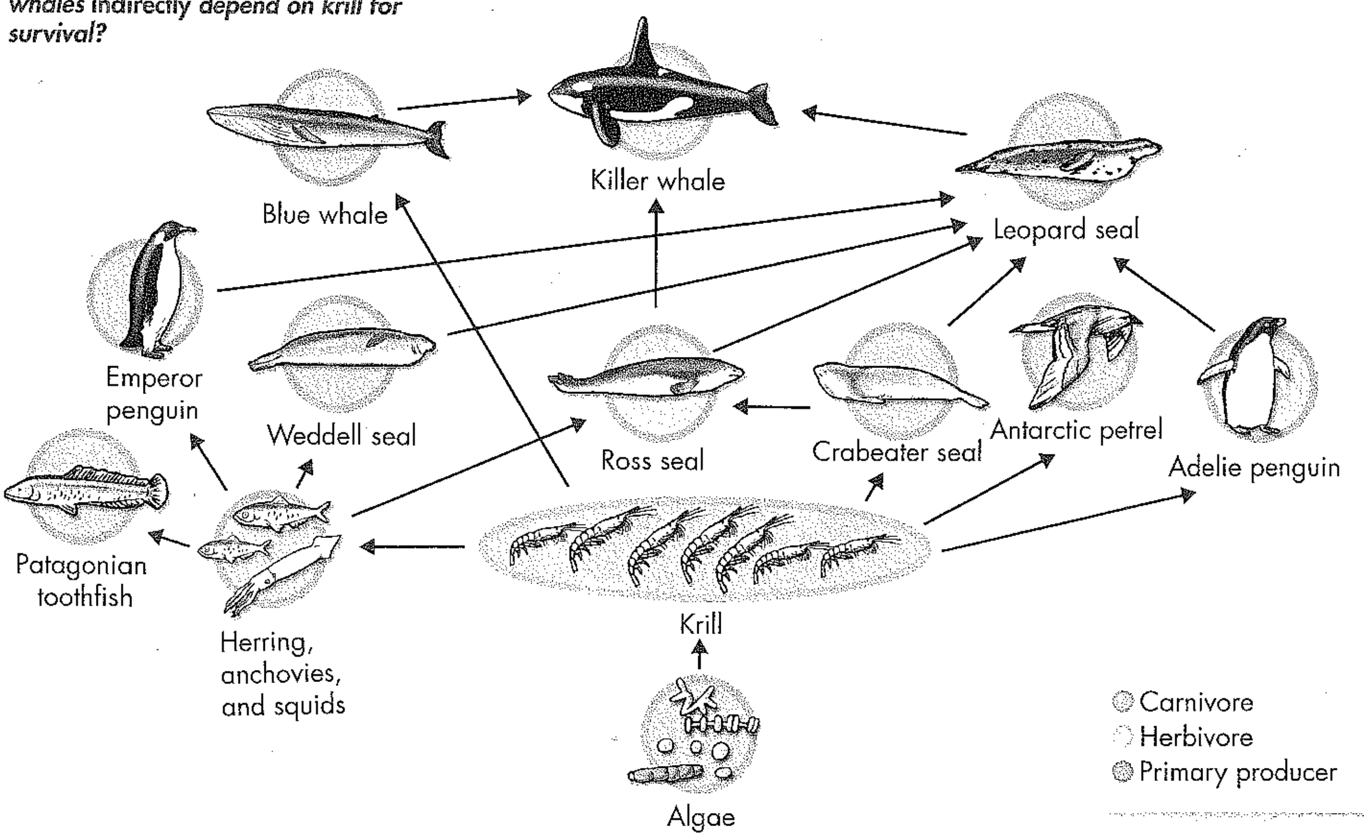
MYSTERY CLUE

Researchers discovered that zooplankton in Narragansett Bay now graze on floating algae more actively through the winter than they ever did before. What effect do you think this might have on the annual late-winter "bloom" of algae that occurs in the water?

Food Webs and Disturbance Food webs are complex, so it is often difficult to predict exactly how they will respond to environmental change. Look again at **Figure 3–9**, and think about the questions an ecologist might ask about the feeding relationships in it following a disturbance. What if an oil spill, for example, caused a serious decline in the number of the bacteria and fungi that break down detritus? What effect do you think that might have on populations of crayfish? How about the effects on the grass shrimp and the worms? Do you think those populations would decline? If they did decline, how might pig frogs change their feeding behavior? How might the change in frog behavior then affect the other species on which the frog feeds?

Relationships in food webs are not simple, and, as you know, the food web in **Figure 3–9** has been simplified! So, you might expect that answers to these questions would not be simple either, and you'd be right. However, disturbances *do* happen, and their effects can be dramatic. Consider, for example, one of the most important food webs in the southern oceans. All of the animals in this food web, shown in **Figure 3–10,** depend directly or indirectly on shrimplike animals called krill, which feed on marine algae. Krill are one example of a diverse group of small, swimming animals, called **zooplankton** (zoh oh PLANK tun), that feed on marine algae. Adult krill browse on algae offshore, while their larvae feed on algae that live beneath floating sea ice. In recent years, krill populations have dropped substantially. Over that same period, a large amount of sea ice around Antarctica has melted. With less sea ice remaining, there are fewer of the algae that grow beneath the ice. Given the structure of this food web, a drop in the krill population can cause drops in the populations of all other members of the food web shown.

FIGURE 3–10 Antarctic Food Web All of the animals in this food web depend on one organism: krill. Disturbances to the krill's food source, marine algae, have the potential to cause changes in all of the populations connected to the algae through this food web. **Interpret Visuals** ***What do ecologists mean when they say that killer whales indirectly depend on krill for survival?***



Trophic Levels and Ecological Pyramids

What do the three types of ecological pyramids illustrate?

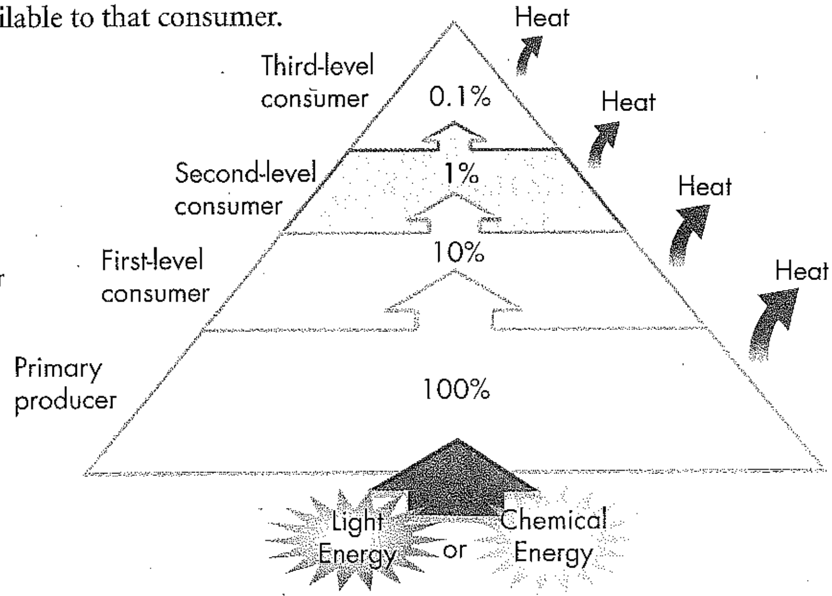
Each step in a food chain or food web is called a **trophic level.** Primary producers always make up the first trophic level. Various consumers occupy every other level. One way to illustrate the trophic levels in an ecosystem is with an ecological pyramid. **Ecological pyramids** show the relative amount of energy or matter contained within each trophic level in a given food chain or food web. There are three different types of ecological pyramids: pyramids of energy, pyramids of biomass, and pyramids of numbers.

In Your Notebook *Make a two-column chart to compare the three types of ecological pyramids.*

Pyramids of Energy Theoretically, there is no limit to the number of trophic levels in a food web or the number of organisms that live on each level. But there is one catch. Only a small portion of the energy that passes through any given trophic level is ultimately stored in the bodies of organisms at the next level. This is because organisms expend much of the energy they acquire on life processes, such as respiration, movement, growth, and reproduction. Most of the remaining energy is released into the environment as heat—a byproduct of these activities. **Pyramids of energy show the relative amount of energy available at each trophic level of a food chain or food web.**

The efficiency of energy transfer from one trophic level to another varies. On average, about 10 percent of the energy available within one trophic level is transferred to the next trophic level, as shown in **Figure 3–11.** For instance, one tenth of the solar energy captured and stored in the leaves of grasses ends up stored in the tissues of cows and other grazers. One tenth of *that* energy—10 percent of 10 percent, or 1 percent of the original amount—gets stored in the tissues of humans who eat cows. Thus, the more levels that exist between a producer and a given consumer, the smaller the percentage of the original energy from producers that is available to that consumer.

FIGURE 3–11 Pyramid of Energy Pyramids of energy show the relative amount of energy available at each trophic level. An ecosystem requires a constant supply of energy from photosynthetic or chemosynthetic producers. **Apply Concepts** ***Explain how the amount of energy available at each trophic level often limits the number of organisms that each level can support.***



Analyzing Data

The 10 Percent Rule

As shown in **Figure 3–11,** an energy pyramid is a diagram that illustrates the transfer of energy through a food chain or food web. In general, only 10 percent of the energy available in one level is stored in the level above. Look at **Figure 3–11** and answer the questions below.

1. **Calculate** If there are 1000 units of energy available at the producer level of the energy pyramid, approximately how many units of energy are available to the third-level consumer? MATH

2. **Interpret Diagrams** What is the original source of the energy that flows through most ecosystems? Why must there be a continuous supply of energy into the ecosystem?

3. **Infer** Why are there usually fewer organisms in the top levels of an energy pyramid?

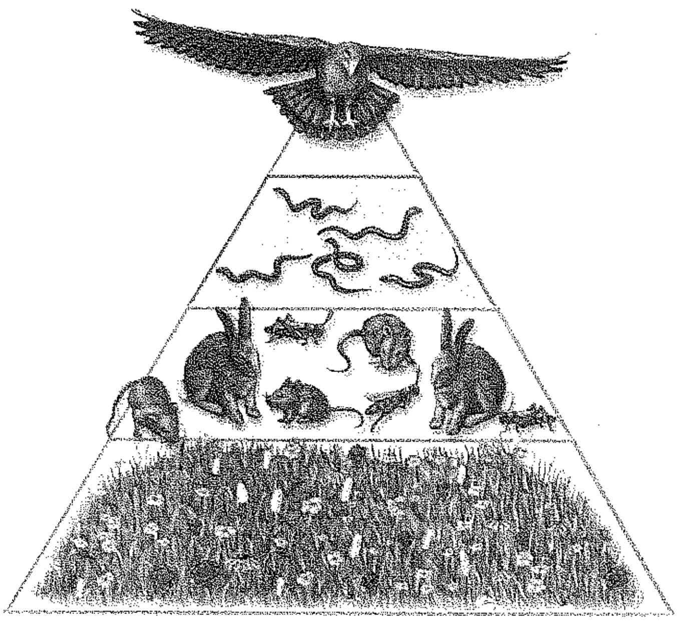


FIGURE 3–12 Pyramids of Biomass and Numbers In most cases, pyramids of biomass and numbers follow the same general pattern. In the field modeled here, there are more individual primary producers than first-level consumers. Likewise, the primary producers collectively have more mass. The same patterns hold for the second and third-level consumers. With each step to a higher trophic level, biomass and numbers decrease.

Pyramids of Biomass and Numbers The total amount of living tissue within a given trophic level is called its **biomass.** Biomass is usually measured in grams of organic matter per unit area. The amount of biomass a given trophic level can support is determined, in part, by the amount of energy available. **A pyramid of biomass illustrates the relative amount of living organic matter available at each trophic level in an ecosystem.**

Ecologists interested in the number of organisms at each trophic level uses a pyramid of numbers. **A pyramid of numbers shows the relative number of individual organisms at each trophic level in an ecosystem.** In most ecosystems, the shape of the pyramid of numbers is similar to the shape of the pyramid of biomass for the same ecosystem. In this shape, the numbers of individuals on each level decrease from the level below it. To understand this point more clearly, imagine that an ecologist marked off several square meters in a field, and then weighed and counted every organism in that area. The result might look something like the pyramid in **Figure 3–12.**

In some cases, however, consumers are much less massive than organisms they feed upon. Thousands of insects may graze on a single tree, for example, and countless mosquitos can feed off a few deer. Both the tree and deer have a lot of biomass, but they each represent only one organism. In such cases, the pyramid of numbers may be turned upside down, but the pyramid of biomass usually has the normal orientation.

3.3 Assessment

Review Key Concepts

1. a. Review Energy is said to flow in a "one-way stream" through an ecosystem. In your own words, describe what that means.

b. Form a Hypothesis Explain what you think might happen to the Everglades ecosystem shown in **Figure 3–9** if there were a sudden decrease in the number of crayfish.

2. a. Review On average, what proportion of the energy in an ecosystem is transferred from one trophic level to the next? Where does the rest of the energy go?

b. Calculate Draw an energy pyramid for a five-step food chain. If 100 percent of the energy is available at the first trophic level, what percentage of that energy is available at the highest trophic level? MATH

Apply the Big idea

Interdependence In Nature

3. Refer to **Figure 3–9,** which shows a food web in the Everglades. Choose one of the food chains within the web. Then, write a paragraph describing the feeding relationships among the organisms in the food chain.

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