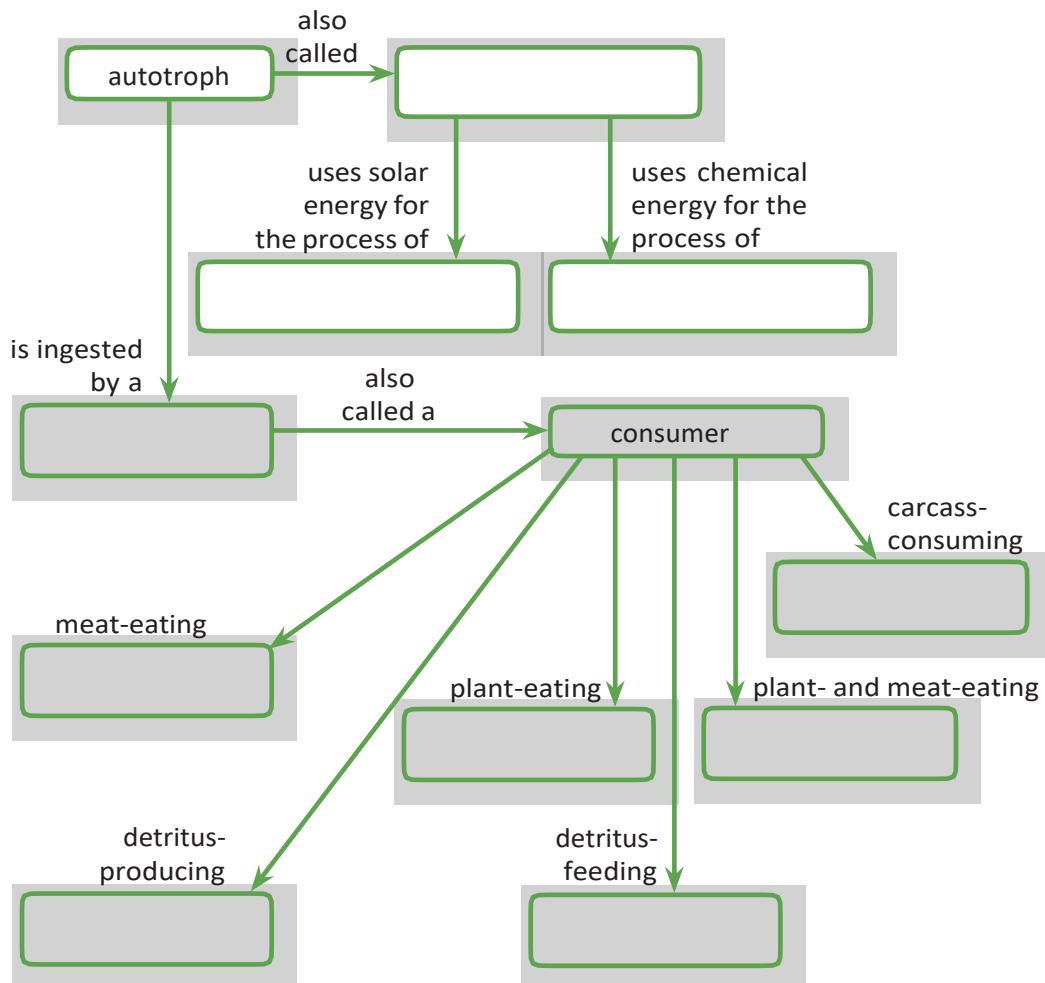


# Energy, Producers, and Consumers

**READING TOOL Make Connections** The concept map below shows the relationships between different organisms in this lesson. As you read, complete the concept map using vocabulary terms and other key terms from the lesson. After you have completed the concept map, use a colored pencil to shade all the producers. Then use a different colored pencil to shade all the consumers.



# Lesson Summary

As you read, circle the answers to each Key Question. Underline any words you do not understand.

## BUILD Vocabulary

**autotroph** organism that is able to capture energy from sunlight or chemicals and use it to produce its own food from inorganic compounds; also called a producer

**primary producer** first producer of energy-rich compounds that are later used by other organisms

**photosynthesis** process used by plants and other autotrophs to capture light energy and use it to power chemical reactions that convert carbon dioxide and water into oxygen and energy-rich carbohydrates such as sugars and starches

**chemosynthesis** process in which chemical energy is used to produce carbohydrates

## Primary Producers

KEY QUESTION What are primary producers?

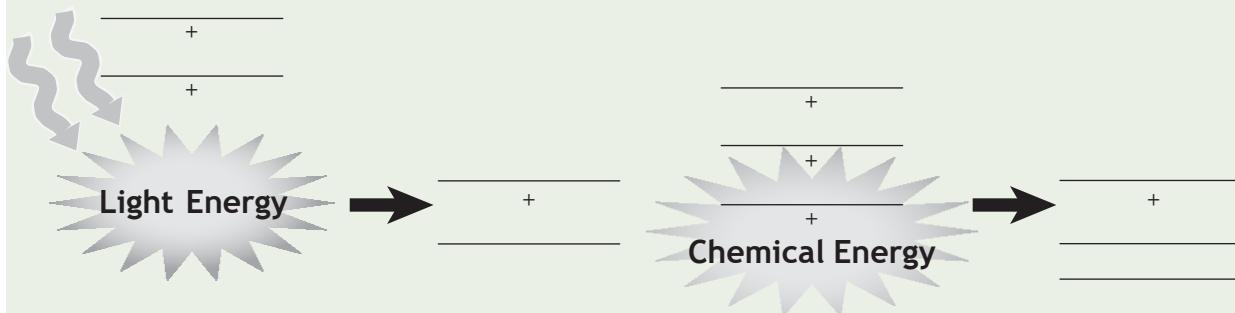
All living things need energy, but no living thing can create energy. Organisms called **autotrophs** capture energy from nonliving sources. Autotrophs store this energy in forms that make it available to other organisms, which is why they are also called **primary producers**. Primary producers are the first producers of energy-rich compounds that can be used by other organisms. All life depends on primary producers.

**Energy From the Sun** The energy for most life on Earth comes from sunlight. Algae and plants absorb solar energy through the process of **photosynthesis**. Photosynthesis uses light energy to power chemical reactions that convert carbon dioxide and water into oxygen and energy-rich carbohydrates such as sugars and starches. This process also adds oxygen to the atmosphere and removes carbon dioxide. Algae and plants are the main primary producers in most ecosystems.

**Life Without Light** Some bacteria can capture energy from inorganic molecules such as hydrogen sulfide. These bacteria use a process called **chemosynthesis** (kee moh SIN thuh sis), in which chemical energy is used to produce carbohydrates.

## Visual Reading Tool: Photosynthesis and Chemosynthesis

Write the names of the reactants and products of photosynthesis and chemosynthesis.



1. Describe how photosynthesis and chemosynthesis differ in terms of how energy is converted.

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2. What important product do both photosynthesis and chemosynthesis have in common?

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Chemosynthetic bacteria thrive in places of total darkness and high temperature, such as Earth's crust and volcanic vents in the ocean floor. They are also found in underground streams, caves, and the mud of tidal flats.

## Consumers

 **KEY QUESTION** *How do consumers obtain energy and nutrients?*

Animals, fungi, and many bacteria cannot capture energy directly from sunlight or inorganic sources. These organisms, called **heterotrophs** (*HET uh roh trohfs*), acquire energy from other organisms, usually by eating them. Heterotrophs are also called **consumers**. Consumers are organisms that rely on other organisms for energy and nutrients.

**Types of Consumers** Consumers are classified by the way they acquire energy and nutrients.

- Carnivores eat other animals.
- Herbivores eat plant leaves, roots, seeds, and fruits.
- Omnivores, such as humans, eat both plants and animals.
- Scavengers eat carcasses of dead animals.
- Decomposers “feed” by chemically breaking down organic matter. This produces **detritus**, small pieces of dead and decaying plant and animal remains.
- Detritivores (dee *TRYT uh vawrz*) chew or grind detritus into smaller pieces, often digesting the decomposers that live on detritus.

**Beyond Consumer Categories** Many organisms do not fit neatly into one category. For example, some carnivores, such as hyenas, will scavenge. Many aquatic animals eat a mixture of algae, animal carcasses, and other organic matter.

Consumers in one category may differ from one another in subtle ways. Herbivores may eat different parts of plants. Different plant parts often contain different amounts of available energy. Fruits and seeds are easy to digest and contain a lot of energy and nutrients. Leaves are plentiful but hard to digest and poor in nutrients. No multicellular organism by itself can break down the cellulose molecules found in leaves. Animals that eat leaves have cellulose-digesting microorganisms inside their guts!

Some grazing animals, such as cattle, spend a long time chewing their food into pulp. When they swallow the pulp, it goes into a part of their digestive tract that has microorganisms that can break down cellulose. Many grazers regurgitate the mixture of food and bacteria, called cud. They chew the cud and swallow it again. With all this extra work, grazers extract only a small amount of energy from the plants they eat. They must spend a lot of time eating.

### BUILD Vocabulary

**heterotroph** organism that obtains food by consuming other living things; also called a consumer

**consumer** organism that relies on other organisms for its energy and food supply; also called a heterotroph

**detritus** small pieces of dead or decaying plant or animal remains

**Word Origins** The word element *-troph* comes from the Greek word *trophos*, which means “feeder.” The word elements *auto-* and *hetero-* are also of Greek origin. *Autos* means “self,” while *heteros* means “other.”

Using the word elements, explain the difference between an autotroph and an heterotroph.

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### READING TOOL

#### Academic Words

**produce** create or form something as part of a physical, chemical, or biological process

**acquire** to gain an object or asset for oneself

Look at the photosynthesis diagram on the prior page. If there were suddenly no sunlight reaching Earth, how would this affect the ability of plants to produce carbohydrates?

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# Energy Flow in Ecosystems

**READING TOOL Main Idea and Details** As you read your textbook, identify the main ideas and details or evidence that support the main ideas. Use the lesson headings to organize the main ideas and details. Record your work in the table. Two examples are entered for you.

Heading	Main Idea	Details/Evidence
<b>Food Chains and Food Webs</b>		
Food Chains	A food chain shows how energy transfers through feeding relationships.	
Food Webs <ul style="list-style-type: none"><li>• Food Chains Within Food Webs</li><li>• Decomposers and Detritivores in Food Webs</li></ul>		
Food Webs and Disturbance		
<b>Ecological Pyramids</b>		
Pyramids of Energy		On average, about 10% of the energy is transferred from one trophic level to the next.
Pyramids of Biomass Numbers		

# Lesson Summary

As you read, circle the answers to each Key Question. Underline any words you do not understand.

## BUILD Vocabulary

**food chain** a series of in an ecosystem steps in which organisms transfer energy by eating and being eaten

**phytoplankton** photosynthetic algae found near the surface of the ocean

**food web** network of complex interactions formed by the feeding relationships among the various organisms in an ecosystem

**Use Prior Knowledge** A chain could be made of beads on a string, or loops of paper or metal. Many chains could join together to make a model of a spider web. Food chains join together to form a food web.

Draw a model of a spider web. Then describe how a spider web is similar to a food web.

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## Food Chains and Food Webs

**KEY QUESTION** How does energy flow through ecosystems?

When one organism eats another, energy moves from the “eaten” to the “eater.” In every ecosystem, primary producers and consumers are linked through feeding relationships. These relationships vary, but energy in an ecosystem always flows in one direction: from primary producers through various consumers.

**Food Chains** The simplest way to think of energy moving through an ecosystem is to imagine it flowing along a food chain. A **food chain** is a series of organisms in which energy is transferred from one organism to another. Food chains vary in length, with some food chains having just one or two steps from a primary producer. For example, in a short food chain, a plant is eaten by a herbivore, which is eaten by a carnivore. Other food chains can be much longer. For example, food chains in the ocean may have four or five steps from primary producers to the largest fish. In the ocean, primary producers are usually tiny floating algae called **phytoplankton**. Phytoplankton are eaten by small animal plankton. The animal plankton are eaten by a series of larger consumers.

**Food Webs** Many animals eat more than one kind of food. This means that the movement of energy and matter is not a simple chain, but can be much more complicated. A network of feeding interactions, through which both energy and matter move, is called a **food web**.

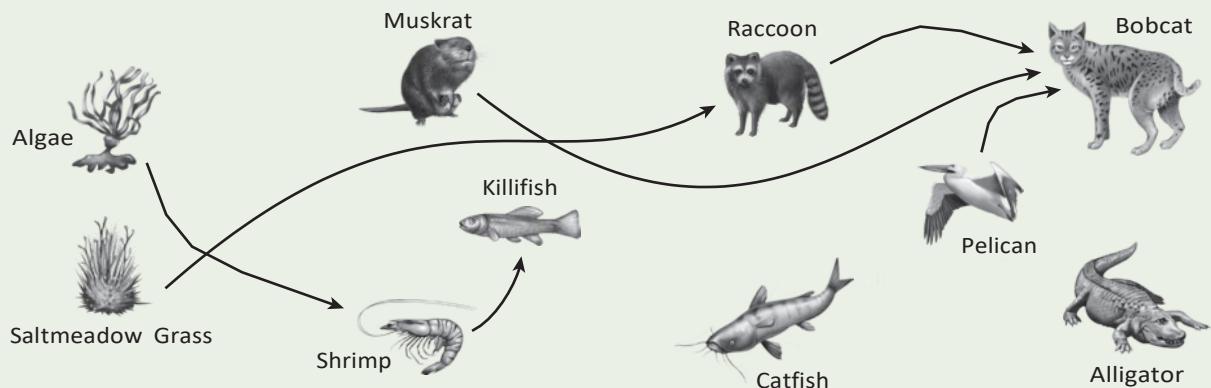
**Food Chains Within Food Webs** Within a food web, there are many food chains connecting a primary producer to different consumers. A food web, therefore, is a network that includes all the food chains in an ecosystem. Food webs can be very complicated because of the large number of producers and consumers found within some ecosystems.

### Decomposers and Detritivores in Food Webs

Decomposers and detritivores have vital roles in the movement of energy and matter through food webs. Many producers and consumers die without being eaten. Decomposers convert dead material to detritus, which is eaten by detritivores. Decomposition also releases matter in the form of nutrients that can be used by primary producers. Without decomposers, nutrients would remain locked within dead organisms.

## Visual Reading Tool: Food Webs

1. Find a food chain that connects algae to the alligator. Then find another food chain from the saltmeadow grass to the alligator. Use two pencils of different colors to highlight the two food chains.



2. How are primary producers important to the alligator's energy supply?

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3. How could decomposers be added to the diagram? Which parts of the food web do they affect?

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**Food Webs and Disturbance** Changes to a food web can cause a variety of effects. These effects are hard to predict because food webs are complex. Sometimes the effects of changes are minor. Some animals can adjust well to changes in food webs, for example, if they eat a variety of foods. Other times a change can have dramatic effects throughout a food web.

### READING TOOL

#### Academic Words

**adjust** To adjust is to change slightly, often to meet a need. Some animals adjust their diets when food sources change.

**Look at the food web above. Suppose that the population of pelicans declined. Bobcats may adjust and eat more \_\_\_\_\_**

## Ecological Pyramids

**KEY QUESTION** *How do ecological pyramids help analyze energy flow through trophic levels?*

Each step in a food chain or food web is called a **trophic level**. Primary producers make up the first trophic level. Consumers occupy the other levels. **Ecological pyramids** are models of trophic levels in a food chain or food web. The shape of the pyramid shows the relative amount of energy or matter in each level.

**Pyramids of Energy** Only a small amount of the energy in any trophic level is available to organisms at the next trophic level. This is because organisms use much of the energy they consume on processes to stay alive. Energy is also released as heat. Pyramids of energy show the relative amount of energy available at each trophic level of a food chain or food web. The pyramid is widest at the bottom. The shape of the pyramid shows the efficiency of energy transfer between levels. On average, about 10 percent of the energy in one trophic level is transferred up to the next trophic level.

### Pyramids of Biomass and Pyramids of Numbers

The amount of living tissue in a trophic level is called its **biomass**. The amount of biomass in a trophic level is determined by the amount of energy in that level. A pyramid of biomass is a model that shows the relative amount of living organic matter in each trophic level of an ecosystem.

A pyramid of numbers is a model that shows the relative number of individual organisms at each trophic level in an ecosystem. The pyramid of numbers for an ecosystem is usually similar in shape to the pyramid of biomass. The number of organisms on each level decreases from the level below it. Sometimes consumers are much smaller than the organisms they feed upon. For example, thousands of insects may eat from a single tree. In such cases, the pyramid of numbers may be upside down, but the pyramid of biomass will still be smaller at the top than at the bottom.

### BUILD Vocabulary

**trophic** (TROH fik) level each step in a food chain or food web

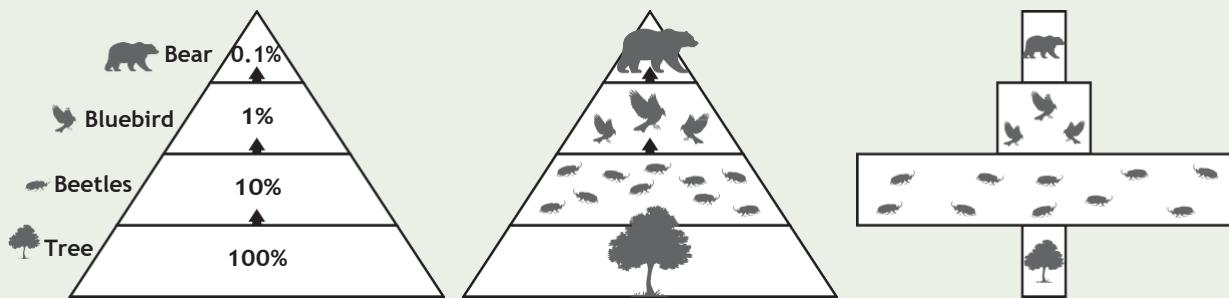
**ecological** (ee coh lah gi kal)

**pyramid** illustration of the relative amounts of energy or matter contained within each trophic level in a food chain or food web

**biomass** the total mass of living tissue within a trophic level

**Word Origins** The word *trophic* comes from a Greek word that means “food or feeding.” □ What other terms did you study in this chapter that contain the root word *troph*?

Visual Reading Tool: Ecological Pyramids



Write the name of the pyramid on the line above each pyramid. Then, below, explain the relationships among trophic levels that are shown by the pyramids.

# Cycles of Matter

**READING TOOL** Compare and Contrast Before you read, preview the cycle diagrams in your textbook. Note the similarities and differences of the cycles in the graphic organizer.

Water Cycle

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Carbon Cycle

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Nitrogen Cycle

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All Three Cycles

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As you read, circle the answers to each Key Question. Underline any words you do not understand.

## Lesson Summary

### Recycling in Nature

**KEY QUESTION** *How does matter flow between trophic levels and among ecosystems?*

All organisms contain the compounds water, carbohydrates, lipids, nucleic acids, and proteins. These compounds are mainly made of the elements oxygen, hydrogen, carbon, nitrogen, phosphorus, and potassium. Organisms cannot make these elements. These elements, like all matter, can never be created or destroyed. Matter flows from one trophic level to another. Matter also moves by being recycled within and among ecosystems. These cycles of elements and compounds are called **biogeochemical cycles**.

The processes that occur in biogeochemical cycles are:

- Biological processes occur in the biosphere and are any activities done by organisms, such as photosynthesis.
- Geological processes occur in the geosphere and include volcanoes, earthquakes, and formation of rock.

- Chemical and physical processes mostly occur in the hydrosphere or atmosphere and include the formation of precipitation, the flow of water, and lightning.
- Human activities that affect cycles of matter on a global scale include the burning of fossil fuels and forests.

## The Water Cycle

 **KEY QUESTION** *How does water cycle globally?*

Water cycles among the hydrosphere, atmosphere, and geosphere—sometimes outside the biosphere and sometimes in it. Water enters the atmosphere as water vapor when it evaporates from bodies of water. Water evaporates from leaves through transpiration (tran spuh RAY shun).

Water vapor condenses into droplets that form clouds. Droplets fall as rain, snow, sleet, or hail. On land, precipitation flows along the surface as runoff. Runoff enters streams and rivers and flows into oceans or lakes. Water enters the soil as groundwater and then enters plants through their roots. Water then reenters the atmosphere through evaporation and transpiration. Human activity, such as the cutting of forests, affects the water cycle in an ecosystem.

## Nutrient Cycles

 **KEY QUESTION** *What is the importance of the main nutrient cycles?*

**Nutrients** are elements that an organism needs to sustain life. Every organism needs nutrients to build tissues and carry out life functions. Like water, nutrients pass through organisms and the environment through biogeochemical cycles. The cycles that carry carbon, nitrogen, and phosphorus through the biosphere are vital for life. Oxygen participates in the carbon, nitrogen, and phosphorus cycles by combining with these elements. Photosynthesis releases oxygen gas. Oxygen is also used in cellular respiration.

**The Carbon Cycle** Carbon is a major component of organic compounds, including carbohydrates, lipids, proteins, and nucleic acids. Fossil fuels are made of carbon. Animal skeletons contain carbon as calcium carbonate. Carbon dioxide ( $\text{CO}_2$ ) is an important gas in the atmosphere.

**Biological Processes** Photosynthesis removes carbon dioxide from the atmosphere. Respiration returns carbon dioxide to the atmosphere. Producers use carbon dioxide to make organic compounds that are consumed by heterotrophs. Decomposers break down organic compounds, releasing carbon (and other nutrients) to the environment. Not all carbon is released by decomposition. Remains of primary producers buried millions of years ago were transformed into fossil fuels.

### READING TOOL

**Use Headings** The headings that organize the text can help you understand what you are reading.  
 On this page, how do the headings show changes in the topic of the text?

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### BUILD Vocabulary

**biogeochemical cycle** process in which elements, chemical compounds, and other forms of matter are passed from one organism to another and from one part of the biosphere to another

**nutrient** chemical substance that an organism needs to sustain life

**Root Words** The Latin word *nutrire* means “to feed or nourish.”  
 What is an example of a nutrient discussed in this lesson? Describe how it helps to nourish an organism.

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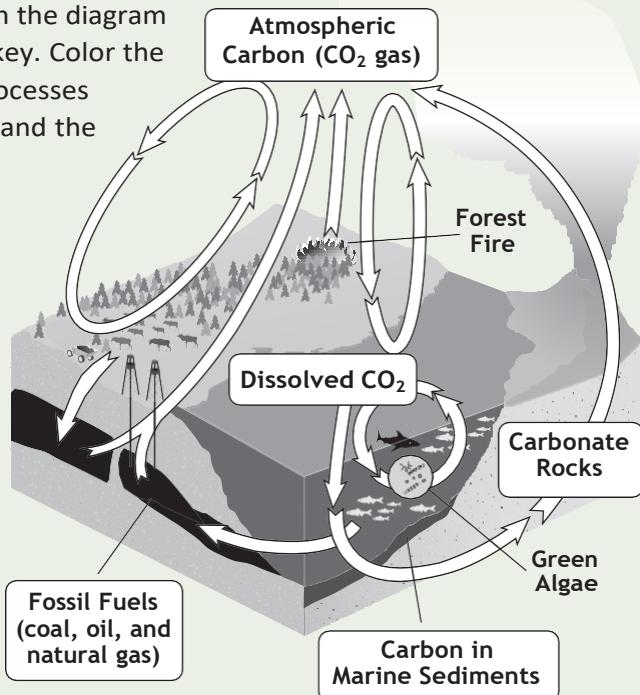
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## Visual Reading Tool: The Carbon Cycle

1. Use colored pencils to color the arrows in the diagram according to the processes listed in the key. Color the biological processes blue; the human processes orange; the geological processes green; and the physical and chemical processes red.



2. Describe one path that a carbon atom could follow through the carbon cycle.

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3. How does the diagram show the effects of photosynthesis and cellular respiration?

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**Geological Processes** Dissolved carbon dioxide in the ocean can form carbonates that combine with skeletons of marine organisms to form rocks. These rocks are driven deep underground by geological activity. Heat and volcanic eruptions release this carbon dioxide into the atmosphere.

**Chemical and Physical Processes** Carbon dioxide is exchanged between the atmosphere and oceans through chemical and physical processes. Carbon dioxide in the atmosphere can dissolve in rainwater, forming a weak acid.

**Human Activity** When humans burn coal, oil, natural gas, or even forests, we return carbon stored over millions of years to the atmosphere in a very short time. Such human activity has a large impact on the carbon cycle. More carbon dioxide in the atmosphere adds to the greenhouse effect.

**The Nitrogen Cycle** All organisms require nitrogen to make amino acids and nucleic acids. Most nitrogen is in the form of nitrogen gas in the atmosphere. Nitrogen-containing compounds, such as ammonia, nitrite, and nitrate, are in the biosphere, geosphere, and hydrosphere.

**Natural Processes** Nitrogen gas is abundant, but most organisms can't use it. Only certain types of bacteria can convert nitrogen gas into ammonia through a process called **nitrogen fixation**. Nitrogen-fixing bacteria live in soil and on the roots of certain plants. Other bacteria convert ammonia into nitrite and nitrate, which can be used by primary producers. When consumers eat producers, those nitrogen compounds are reused. Decomposers release nitrogen compounds from animal wastes and dead organisms. Some bacteria obtain energy by converting nitrates into nitrogen gas, which is released into the atmosphere in a process called **denitrification**.

**Human Activities** Human involvement in the nitrogen cycle increased greatly when chemists discovered a process to use nitrogen gas from the atmosphere to make chemicals that are used in fertilizer. Humans now use this process to fix more nitrogen than all natural processes combined.

**The Phosphorus Cycle** Phosphorus is necessary for molecules such as nucleic acids. Phosphorus does not cycle through the atmosphere. Phosphorus is found as phosphates in the geosphere, and dissolved in water in the hydrosphere.

## Nutrient Limitation

KEY QUESTION How does nutrient availability affect primary productivity?

If ample sunlight and water are available, the primary productivity of an ecosystem may be limited by the availability of nutrients. Any nutrient whose supply limits productivity is called a **limiting nutrient**.

**Nutrient Limitation in Soil** Plant growth can be limited by the supply of one or more nutrients. Nutrient limitation is why farmers use fertilizers. Most fertilizers contain nitrogen, phosphorus, and potassium. Micronutrients such as calcium, magnesium, sulfur, iron, and manganese are sometimes included in small amounts.

### Nutrient Limitation in Aquatic Ecosystems

Nitrogen is often the limiting nutrient in the ocean. In freshwater, phosphorus is often the limiting nutrient. Runoff from rain may contain fertilizer from farms. This delivers a large amount of limiting nutrients into bodies of water. This stimulates producers such as algae to grow more than normal, causing what is called an algal bloom. Severe algal blooms can disrupt the functioning of ecosystems.

### BUILD Vocabulary

**nitrogen fixation** process of converting nitrogen gas into nitrogen compounds that plants can absorb and use

**denitrification** process by which soil bacteria convert nitrates into nitrogen gas

**limiting nutrient** single essential nutrient that limits productivity in an ecosystem

**Use Prior Knowledge** To fix something is to repair it or make it useful. Nitrogen fixation changes nitrogen into a form that is useful to living things. □ Which type of living things perform nitrogen fixation?

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# 4

# Chapter Review

## Review Vocabulary

Choose the letter of the best answer.

1. The conversion of nitrogen gas ( $N_2$ ) to ammonia is called
    - A. denitrification
    - B. nitrogen cycle
    - C. nitrogen fixation
    - D. nitrogen limitation
  2. Which rely on other organisms for their energy and food supply?
    - A. primary producers
    - B. biomass
    - C. autotrophs
    - D. consumers
- 

Match the vocabulary term to its definition.

3. \_\_\_\_\_ The total amount of living tissue
    - a. biomass
  4. \_\_\_\_\_ Small pieces of dead or decaying plant or animal remains
    - b. denitrification
  5. \_\_\_\_\_ A model of feeding levels in a food chain or food web
    - c. energy pyramid
  6. \_\_\_\_\_ Changing nitrogen compounds to nitrogen gas
    - d. detritus
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## Review Key Questions

Provide evidence and details to support your answers.

7. How does energy flow through ecosystems?

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8. Describe two ways that primary producers produce high-energy compounds.

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9. How does nutrient availability relate to productivity and species survival?

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