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Mr. Hall's 7th Grade Ecology Flexbook

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CHAPTER 1 Introduction to Ecology

Lesson Objectives

- Define ecology.
- Describe how organisms can interact with their environments.
- Describe levels of organization in ecology.

Check Your Understanding

- What is an adaptation?
- What is the scientific method?

Vocabulary

- abiotic
- biome
- biosphere
- biotic
- community
- ecology
- ecosystem

What is Ecology?

Life Science can be studied at many different levels. You can study small things like molecules or cells. Or you can study big things like whole organisms or groups of organisms. The largest level that you can study is the level of ecology. **Ecology** is the study of how living organisms interact with each other and with their environment.

Because it is such a large field, ecology involves many different fields, including geology, soil science, geography, meteorology, genetics, chemistry, and physics. You can also divide ecology into the study of different organisms, such as animal ecology, plant ecology, insect ecology, and so on.

A **biome** is a large community of plants and animals that live in the same place. Ecologists can also study biomes. For example, ecologists can study the Arctic, the tropics, or the desert (**Figure** 1.1). Can you think of different species or biomes that ecologists could study?

Ecologists do two types of research:

1. Field studies.
2. Laboratory studies.

Field studies involve collecting data outside in the natural world. An ecologist who completes a field study may travel to a tropical rain forest and count all of the insects that live in a certain area. Laboratory studies involve working inside, not in the natural world. Sometimes, ecologists collect data from the field, and then analyze it in the lab. Also, they use computer programs to predict what will happen to organisms in who live in a specific area. For example, they may make predictions about what happens to insects in the rainforest after a fire.

FIGURE 1.1
An example of a biome, the Atacama Desert, in Chile.

Organisms and Environments

All organisms have the ability to grow and reproduce. To grow and reproduce, organisms must get materials and energy from the environment.

An organism's environment includes two types of factors:

1. **Abiotic** factors are the parts of the environment that have never been alive, such as sunlight, climate, soil, water and air.
2. **Biotic** factors are the parts of the environment that are alive, or were alive and then died, such as plants, animals, and their remains.

Biotic factors, like organisms, interact with abiotic factors. For example, all animals (biotic factors) breathe in oxygen (abiotic factor). All plants (biotic factor) absorb carbon dioxide (abiotic factor).

Can you think of another way that abiotic and biotic factors interact with each other?

Levels of Organization in Ecology

Ecology can be studied at small levels or at large levels. Levels of organization are described below from the largest to the smallest:

- The **biosphere** is the part of the planet that has living things on it (**Figure** 1.2 and **Table** 1.1). This is most of Earth.
- An **ecosystem** is the living things in an area interacting with all of the abiotic parts of the environment (**Figure** 1.3).
- A **community** are all of the populations of different species that live in the same area and interact with one another.
- A population is a group of organisms belonging to the same species that live in the same area and interact with one another.

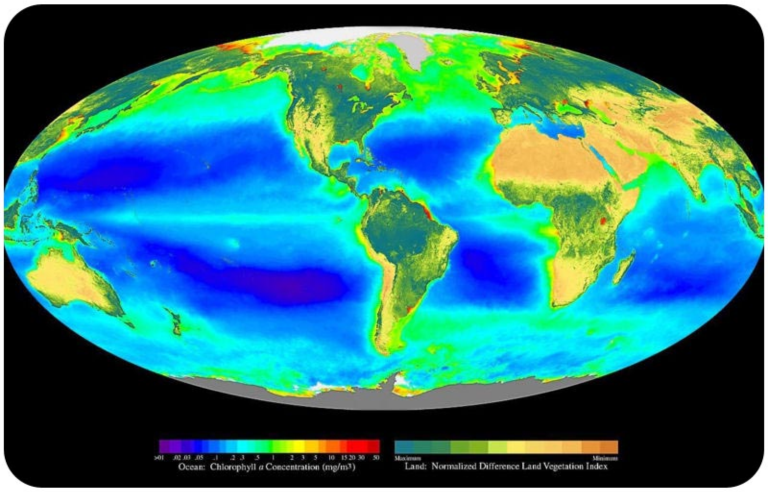

FIGURE 1.2
The global biosphere, which includes all areas that contain life, from the sea to the atmosphere.

TABLE 1.1: Ecological Range

Level	Definition
population	organisms belonging to the same species that live in the same area and interact with one another
community	populations of different species that live in the same area and interact with one another
ecosystem	a natural unit composed of all the living forms in an area, interacting with all the abiotic components of the environment
biosphere	the part of the planet that has living things

FIGURE 1.3
Satellite image of Australia

Ecologists study ecosystems at every level. They can ask different types of questions at each level. Examples of these questions are given in **Table** 1.2, using the zebra as an example.

TABLE 1.2: Ecological Ecosystems

Level	Question
Individual	How do zebras keep water in their bodies?
Population	What causes the growth of a zebra populations?
Community	How does a disturbance, like a fire or predator, affect

Review Questions

Recall

1. Name three fields you can study when you study ecology.
2. Define ecosystem.
3. Define organism.
4. What are the four main levels of organization in ecology?

Apply Concepts

5. What is the difference between field studies and laboratory studies?
6. What is the difference between a population and a community?
7. Explain why almost the entire planet is a biosphere.

Critical Thinking

8. Give an example of how an abiotic factor can interact with the environment.
9. A question that an ecologist could ask at the population level is, “What factors control zebra populations?” Think of two examples of how other species may affect the zebra population.

Further Reading / Supplemental Links

- http://www.ecokids.ca/pub/index.cfm
- http://www.eco-pros.com/ecologykids.htm
- http://www.kidsolr.com/science/page12.html
- http://www.southplainfield.lib.nj.us/homeworklinks/Ecology.htm
- http://www.surfnetkids.com/ecology.htm;
- http://en.wikipedia.org/wiki

Points to Consider

- What do you think causes populations to grow?
- What causes populations to decrease?

References

1. . MSLS-23-01-atacama-desert.
2. . MSLS-23-02-global-biosphere.
3. . MSLS-23-03-great-barrier-reef.

CHAPTER 2 Ecosystems

Lesson Objectives

- Define ecosystem.
- Discuss how biotic and abiotic factors play a role in ecosystems.
- Explain what a niche is and its importance in an ecosystem.
- Describe what a habitat is and how an organism is adapted to live in the habitat.

Check Your Understanding

- What is a community?
- What are the different types of community interactions?

Vocabulary

- habitat
- niche

What is an Ecosystem?

The next level after community is an ecosystem. An ecosystem consists of all the biotic factors (plants, animals and micro-organisms) interacting with all of the abiotic factors (water, soil, and air, for instance) in the same area.

You can find an ecosystem in a large body of freshwater or in a small piece of dead wood. Other examples of ecosystems include the coral reef, the Greater Yellowstone ecosystem, the rainforest, the savanna, the tundra, the desert and the urban ecosystem (**Figure** 2.1).

Ecosystems need energy. They mostly get their energy in the form of sunlight. Matter is also recycled in ecosystems. Recycling of nutrients is important so they can always be available. Elements like carbon, nitrogen, and water are used over and over again by organisms. Human ecosystems could be a household, neighborhood, college, or even a nation. Human ecosystems interact with each other. Since humans live virtually all over the planet today, nearly all ecosystems could be considered human ecosystems.

In 2005, the largest assessment ever conducted of the earth's ecosystems was done by a research team of over 1,000 scientists. The study concluded that in the past 50 years, humans have altered the earth's ecosystems more than any other time in our history.

Biotic and Abiotic Factors

Biotic factors of an ecosystem include all living parts. Examples of biotic factors include bacteria, fungi, unicellular and multicellular plants, and unicellular and multicellular animals.

Abiotic factors are non-living chemical and physical factors in the environment. The six major abiotic factors are water, sunlight, oxygen, temperature, soil and climate (such as humidity, atmosphere, and wind). Other factors include carbon dioxide, geography, and geology.

Abiotic and biotic factors interact within ecosystems and also between ecosystems. For example, water may be recycled between ecosystems, by the means of a river or ocean current. Some species, such as salmon or freshwater eels, move between marine and freshwater ecosystems.

FIGURE 2.1
An example of a desert ecosystem in Baja California, showing Saguaro cacti.

Niche

Each organisms plays a particular role, or niche, in its ecosystem. A **niche** is the role a species or population plays in the ecosystem. In other words, a niche is how an organism "makes a living." A niche will include the food of an organism and how it obtains its food and space. Different species can hold similar niches in different locations. The same species may occupy different niches in different locations. Species of the Australian grasslands have the same niche. Once a niche is left vacant, other organisms can fill that position. When the tarpan, a small, wild horse found mainly in southern Russia, became extinct in the early 1900s, the niche was filled by a small horse breed, the konik (**Figure** 2.2).

FIGURE 2.2
The konik horse, which filled the niche left by the tarpan, a horse that became extinct in the early 1900s in southern Russia.

When plants and animals are introduced, either intentionally or by accident, into a new environment, they can occupy new niches or the existing niches of native organisms. Sometimes new species out-compete native species. They can even become a serious pest.

For example, kudzu, a Japanese vine, was planted in the southeastern United States in the 1870s to help control soil loss. Kudzu had no natural predators, so it was able to out-compete native species of vine and take over their niches (**Figure** 2.3).

FIGURE 2.3
Kudzu, a Japanese vine, introduced intentionally to the southeastern United States, has out-competed the native vegetation.

As discussed in the previous lesson, the competitive exclusion principle states that if niche overlap occurs, either one species will be excluded, character displacement will happen (as in Darwin's Finches), or the species will go extinct.

Habitat

The **habitat** is the environmental area where a particular species lives (**Figure** 2.4). Abiotic factors are used to describe a habitat. The average amount of sunlight received each day, the range of annual temperatures, and average yearly rainfall can all describe a habitat. These and other factors will affect the kind of traits an organism must have in order to survive there (**Figure** 2.5 and **Figure** 2.6).

Habitat destruction means what it sounds like - a species' habitat is destroyed. Habitat destruction can cause a species' population to decrease. If bad enough, it can also cause species to go extinct. Clearing large areas of land for housing developments or businesses can cause habitat destruction. Poor fire management, pest and weed invasion, and storm damage can also destroy habitats.

National parks, nature reserves, and other protected areas all preserve habitats. The *Environmental Problems* chapter will discuss habitat destruction in further detail.

Habitats can also be examined from a human point of view. The environments where we live, work, and reproduce are our habitats.

Lesson Summary

- An ecosystem consists of all the biotic and abiotic factors interacting together in an area.

FIGURE 2.4
Santa Cruz, the largest of the northern Channel Islands, has the most diverse of habitats in the sanctuary, including a coastline with steep cliffs, coves, gigantic caves, and sandy beaches.

FIGURE 2.5
Another example of a type of habitat, showing a meadow and representative vegetation.

- Biotic factors include all living components of an ecosystem. Abiotic factors are the non-living chemical and physical factors in the environment.
- The niche concept is one of the most important ideas associated with ecosystems.
- If niche overlap occurs, then the competitive exclusion principle comes into play.
- The habitat is the area where a particular species, species population, or community lives.
- Habitat destruction is a major cause of population decrease, leading to possible extinction.
- Both the ecosystem and habitat can be looked at from a human point of view.

Review Questions

Recall

1. Give three examples of ecosystems.
2. List the six most common abiotic factors.

FIGURE 2.6
The above image shows wetland reeds, another type of habitat.

3. What is a niche?
4. Give an example of an organism filling a vacant niche.
5. What is a habitat?

Apply Concepts

6. Why might a newly introduced species become a pest?
7. Name three abiotic factors that can be used to describe a habitat.
8. Give one example of an organism and its niche that is not included in the chapter.

Critical Thinking

9. Species that travel distances between important areas for their survival, like migrating birds, may be particularly vulnerable to habitat destruction. How might the creation of multiple national parks or nature reserves help such species?

Further Reading / Supplemental Links

- Unabridged Dictionary, Second Edition. Random House, New York, 1998.
- http://www.kidsgeo.com/geography-for-kids/0164-ecosystems.php
- http://en.wikipedia.org/wiki

Points to Consider

- Now that you understand what makes up an ecosystem, what additional factors do you think might be added to get to the next level, the biome?
- How do you think what you have learned about abiotic and biotic factors might be applied to the classification of different biomes?

- The biosphere is considered to be a global ecological system. Given all you now know about ecology, what do you think the biosphere consists of?

References

1. . MSLS-23-16-Baja-desert.
2. . MSLS-23-17-konik-horse.
3. . MSLS-23-18-kudzu.
4. . MSLS-23-19-santa-cruz.
5. . MSLS-23-20-meadow.
6. . MSLS-23-21-Wetland-reeds.

CHAPTER 3 Flow of Energy

Lesson Objectives

- Describe how autotrophs use energy to produce organic molecules.
- Identify different types of consumers, and give examples of each type.
- Explain how decomposers resupply elements to producers.
- Describe food chains and food webs, and explain how energy is transferred between their trophic levels.

Introduction

Energy enters most ecosystems from sunlight. However, some ecosystems, such as hydrothermal vent ecosystems at the bottom of the ocean, receive no sunlight and obtain energy instead from chemical compounds. Energy is used by some organisms in the ecosystem to make food. These organisms are called primary producers, or autotrophs, which include small plants, algae, photosynthetic prokaryotes and chemosynthetic prokaryotes. From primary producers, energy eventually is transferred to all the other organisms in the ecosystem through consumers or decomposers known as heterotrophs.

Producers

Producers are organisms that produce organic compounds from energy and simple inorganic molecules. Producers are also called **autotrophs**, which literally means "self nutrition." This is because producers synthesize food for themselves. They take energy and materials from the abiotic environment and use them to make organic molecules. Autotrophs are a vital part of all ecosystems. The stability of the producers is vital to the survival of every ecosystem; without this stability an ecosystem may not thrive; in fact, the ecosystem may collapse. The organic molecules the producers make are needed by all the organisms in the ecosystem. There are two basic types of autotrophs: photoautotrophs and chemoautotrophs. They differ in the type of energy they use to synthesize food.

Photoautotrophs

Photoautotrophs are organisms that use energy from sunlight to make food by photosynthesis. As you may recall from the *Photosynthesis* Chapter, **photosynthesis** is the process by which carbon dioxide and water are converted to glucose and oxygen, using sunlight for energy. Glucose, a carbohydrate, is an organic compound that can be used by autotrophs and other organisms for energy. As shown in **Figure** 3.1, photoautotrophs include plants, algae, and certain bacteria.

Plants are the most important photoautotrophs in land-based, or terrestrial, ecosystems. There is great variation in the plant kingdom. Plants include organisms as different as trees, grasses, mosses, and ferns. Nonetheless, all plants are eukaryotes that contain chloroplasts, the cellular "machinery" needed for photosynthesis.

Algae are photoautotrophs found in most ecosystems, but they generally are more important in water-based, or aquatic, ecosystems. Like plants, algae are eukaryotes that contain chloroplasts for photosynthesis. Algae include single-celled eukaryotes, such as diatoms, as well as multicellular eukaryotes, such as seaweed.

Photoautotrophic bacteria, called **cyanobacteria**, are also important producers in aquatic ecosystems. Cyanobacteria were formerly called *blue-green algae*, but they are now classified as bacteria. Other photosynthetic bacteria, including purple photosynthetic bacteria, are producers in terrestrial as well as aquatic ecosystems.

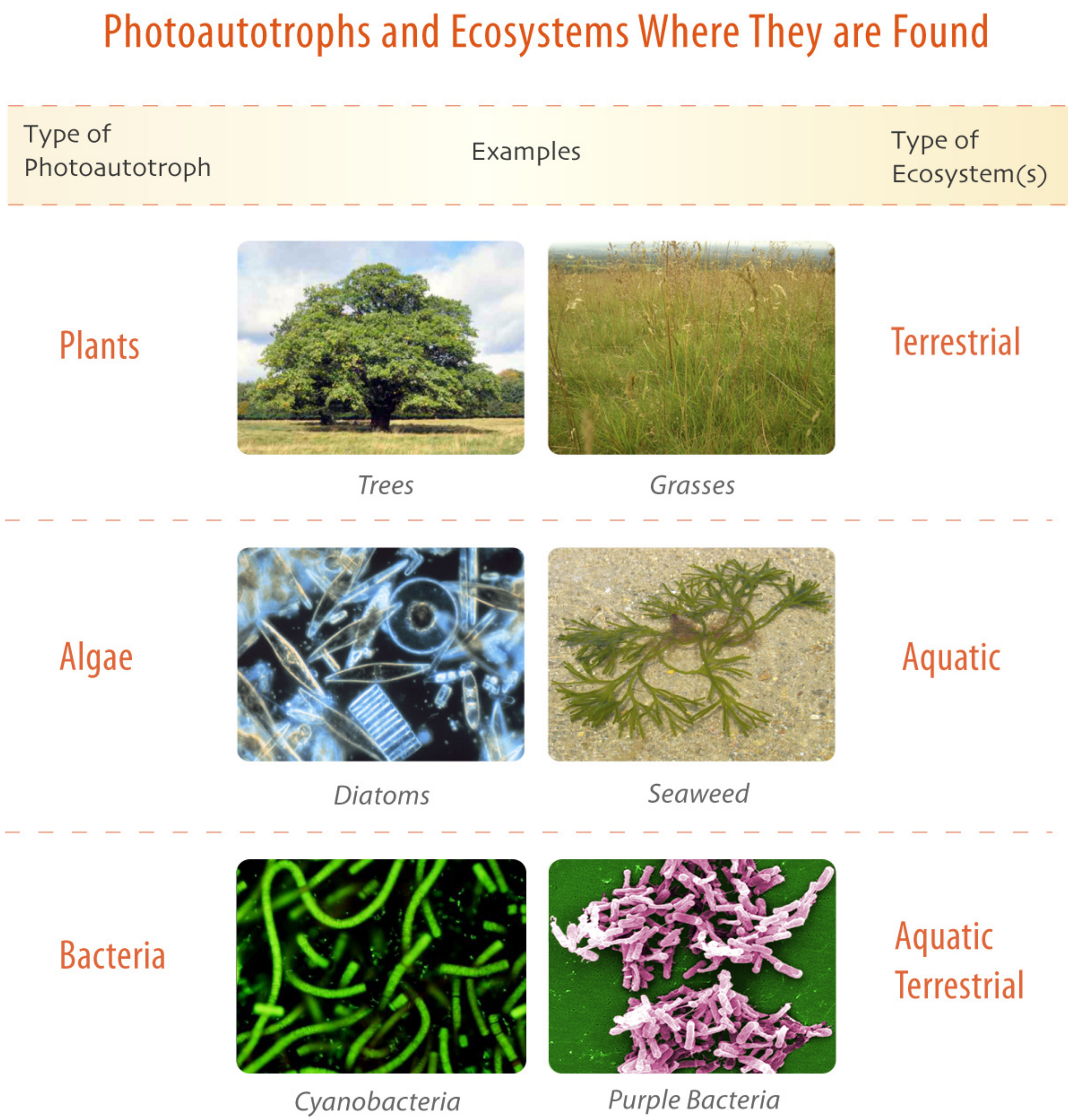

FIGURE 3.1
Different types of photoautotrophs are important in different types of ecosystems. Each type of photoautotroph pictured here is an important producer in some ecosystem.

Both cyanobacteria and algae make up **phytoplankton**. Phytoplankton refers to all the tiny photoautotrophs found on or near the surface of a body of water. Phytoplankton usually is the primary producer in aquatic ecosystems.

Chemoautotrophs

In some places where life is found on Earth, there is not enough light to provide energy for photosynthesis. In these places, producers called **chemoautotrophs** use the energy stored in chemical compounds to make organic molecules by chemosynthesis. **Chemosynthesis** is the process by which carbon dioxide and water are converted to carbohydrates. Instead of using energy from sunlight, chemoautotrophs use energy from the oxidation of inorganic compounds, such as hydrogen sulfide (H_2S). Oxidation is an energy-releasing chemical reaction in which a molecule, atom, or ion loses electrons.

Chemoautotrophs include bacteria called nitrifying bacteria, which you will read more about in Lesson 3. Nitrifying bacteria live underground in soil. They oxidize nitrogen-containing compounds and change them to a form that plants can use.

Chemoautotrophs also include archaea. **Archaea** are a domain of microorganisms that resemble bacteria. Most archaea live in extreme environments, such as around hydrothermal vents in the deep ocean. Hot water containing hydrogen sulfide and other toxic substances escapes from the ocean floor at these vents, creating a hostile environment for most organisms. Near the vents, archaea cover the sea floor or live in or on the bodies of other organisms, such as tube worms. In these ecosystems, archaea use the toxic chemicals released from the vents to produce organic compounds. The organic compounds can then be used by other organisms, including tube worms. Archaea are able to sustain thriving communities, like the one shown in **Figure** 3.2, even in these hostile environments.

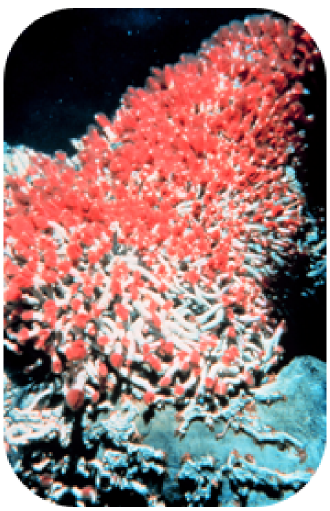

FIGURE 3.2

Red tube worms, each containing millions of archaea microorganisms, grow in a cluster around a hydrothermal vent in the deep ocean floor. Archaea produce food for themselves (and for the tube worms) by chemosynthesis.

Consumers

Consumers are organisms that depend on producers or other types of organisms for food. They are also called **heterotrophs**, which literally means "other nutrition." Heterotrophs are unable to make organic compounds from inorganic molecules and energy. Instead, they take in organic molecules by consuming other organisms. All animals and fungi and many bacteria are heterotrophs. A few insect-eating plants are also heterotrophic. Heterotrophs can be classified on the basis of the types of organisms they consume. They include herbivores, omnivores, and carnivores.

Herbivores

Herbivores are organisms that consume only producers such as plants or algae. In most ecosystems, herbivores form a necessary link between producers and other consumers. Herbivores transform the energy stored in producers to compounds that can be used by other organisms.

In terrestrial ecosystems, many animals and fungi and some bacteria are herbivores. Herbivorous animals include deer, rabbits, and mice. Herbivores may specialize in particular types of plants, such as grasses, or specific plant parts, such as leaves, nectar, or roots. Examples of herbivores are shown in **Figure** 3.3.

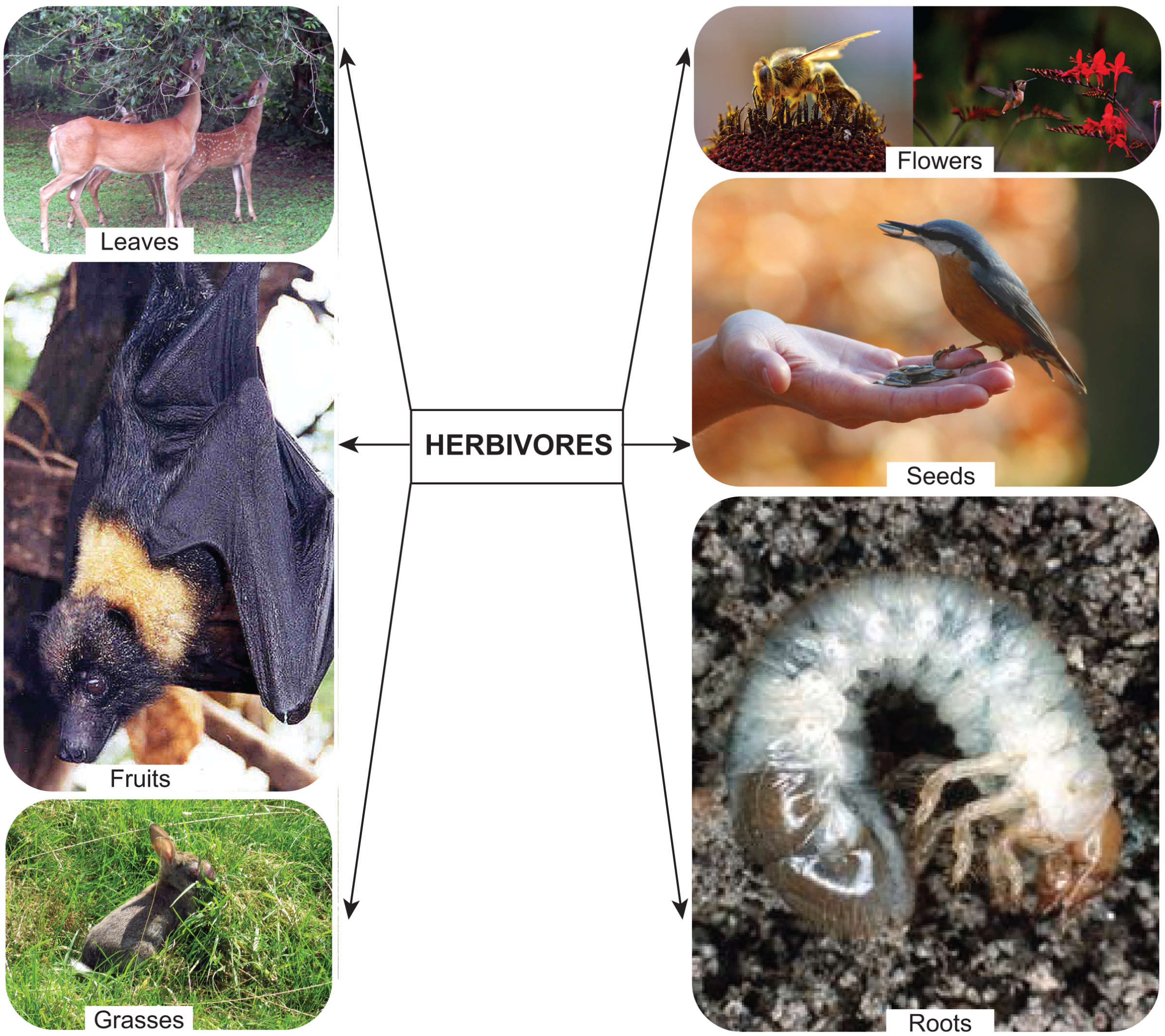

FIGURE 3.3
Deer browse on leaves. A hummingbird sips nectar from a flower. A bee gathers pollen from a flower. Many bats, including this one, primarily eat fruit. Some birds mainly eat seeds. A rabbit eats grasses. Beetle larvae like this one eat plant roots.

In aquatic ecosystems, the main herbivores are the heterotrophic organisms that make up zooplankton. **Zooplankton** refers to all the small organisms that feed on phytoplankton. These organisms include both single-celled organisms such as protozoa and multicellular organisms such as jellyfish. Phytoplankton and zooplankton together make up large communities of producers and herbivores called **plankton**.

Carnivores

Carnivores are organisms that eat a diet consisting mainly of herbivores or other carnivores. Carnivores include lions, wolves, polar bears, hawks, frogs, fish, and spiders. Animals that eat only meat are called obligate carnivores. They generally have a relatively short digestive system that cannot break down the tough cellulose found in plants. Other carnivores, including dogs, can digest plant foods but do not commonly eat them. Certain carnivores, called **scavengers**, mainly eat the carcasses of dead animals. Scavengers include vultures, raccoons, and blowflies.

A tiny minority of plants—including Venus flytraps and pitcher plants—are also carnivorous. These plants trap and digest insects. Some fungi are carnivorous as well. Carnivorous fungi capture and digest microscopic protozoan organisms such as amoebas.

Omnivores

Omnivores are organisms that eat both plants and animals as primary food sources. Humans are an example of an omnivorous species. Although some humans eat foods derived only from plants or only from animals, the majority of humans eat foods from both sources. Other examples of omnivorous animals are pigs, brown bears, gulls, and crows. Aquatic omnivores include some species of fish, such as piranhas.

Decomposers

When a plant or animal dies, it leaves behind energy and matter in the form of the organic compounds that make up its remains. **Decomposers** are organisms that consume dead organisms and other organic waste. They recycle materials from the dead organisms and waste back into the ecosystem. These recycled materials are used by the producers to remake organic compounds. Therefore, decomposers, like producers, are an essential part of every ecosystem, and their stability is essential to the survival of each ecosystem. In essence, this process completes and restarts the "circle of life." As stated above, scavengers consume the carcasses of dead animals. The remains of dead plants are consumed by organisms called detritivores.

Decomposers, producers and consumers (**6e**) are reviewed at http://www.youtube.com/watch?v=_Z2SIdzT5jU (4:17).

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Detritivores

When plants drop leaves or die, they contribute to detritus. **Detritus** consists of dead leaves and other plant remains that accumulate on the ground or at the bottom of a body of water. Detritus may also include animal feces and other organic debris. Heterotrophic organisms called **detritivores** feed on detritus. Earthworms, millipedes, and woodlice are detritivores that consume rotting leaves and other dead plant material in or on soil. Dung beetles, like the one shown in **Figure 4**, consume feces. In aquatic ecosystems, detritivores include “bottom feeders,” such as sea cucumbers and catfish.

FIGURE 3.4
Dung beetle rolling a ball of feces to its nest to feed its offspring.

Saprotrophs

After scavengers and detritivores feed on dead organic matter, some unused energy and organic compounds still remain. For example, scavengers cannot consume bones, feathers, and fur of dead animals, and detritivores cannot consume wood and other indigestible plant material. Organisms called **saprotrophs** complete the breakdown of any remaining organic matter. The main saprotrophs that decompose dead animal matter are bacteria. The main saprotrophs that decompose dead plant matter are fungi. Fungi are also the only organisms that can decompose dead wood. Single-celled protozoa are common saprotrophs in aquatic ecosystems as well as in soil.

Saprotrophs convert dead organic material into carbon dioxide and compounds containing nitrogen or other elements needed by living organisms. The elements are then available to be used again by producers for the synthesis of organic compounds.

Food Chains and Food Webs

Food chains and food webs represent the feeding relationships in ecosystems. They show who eats whom. Therefore, they model the flow of energy and materials through ecosystems.

Food Chains

A **food chain** represents a simple linear pathway through which energy and materials are transferred from one species to another in an ecosystem. In general, food chains show how energy and materials flow from producers to consumers. Energy and materials also flow from producers and consumers to decomposers, but this step usually is not included in food chains. Two examples of food chains are shown in **Figure** 3.5.

A musical summary of food chains (**6f**) can be heard at http://www.youtube.com/watch?v=TE6wqG4nb3M (2:46).

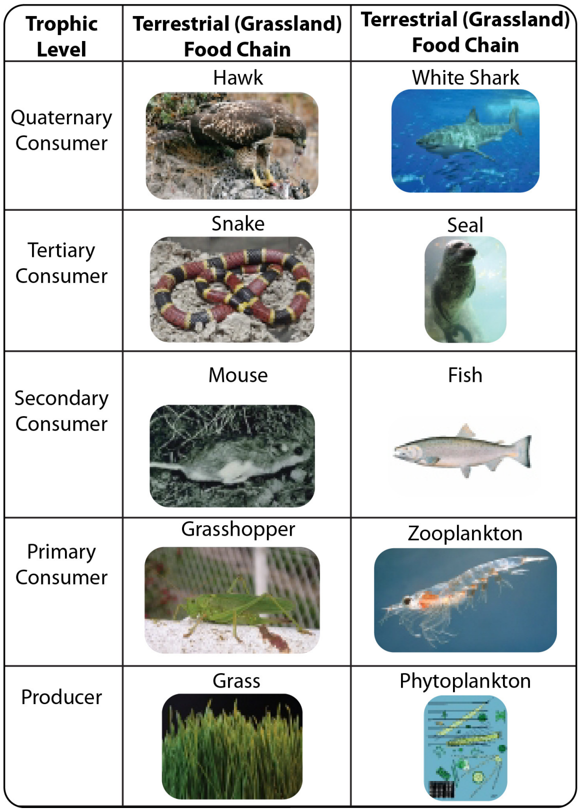
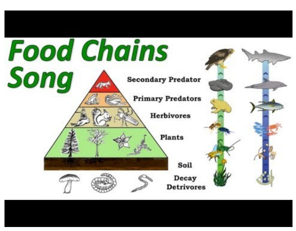


FIGURE 3.5



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Food Webs

Food chains tend to be overly simplistic representations of what really happens in nature. Most organisms consume multiple species and are, in turn, consumed by multiple other species. A food web represents these more complex interactions. A **food web** is a diagram of feeding relationships that includes multiple intersecting food chains. An example of a food web is shown in **Figure** below.

Trophic Levels and Energy Transfer

The different feeding positions in a food chain or web are called **trophic levels**. The first trophic level consists of producers, the second of primary consumers, the third of secondary consumers, and so on. There usually are no more than four or five trophic levels in a food chain or web. Humans may fall into second, third, and fourth trophic levels of food chains or webs. They eat producers such as grain, primary consumers such as cows, and tertiary consumers such as salmon.

Energy is passed up the food chain from one trophic level to the next. However, only about 10 percent of the total

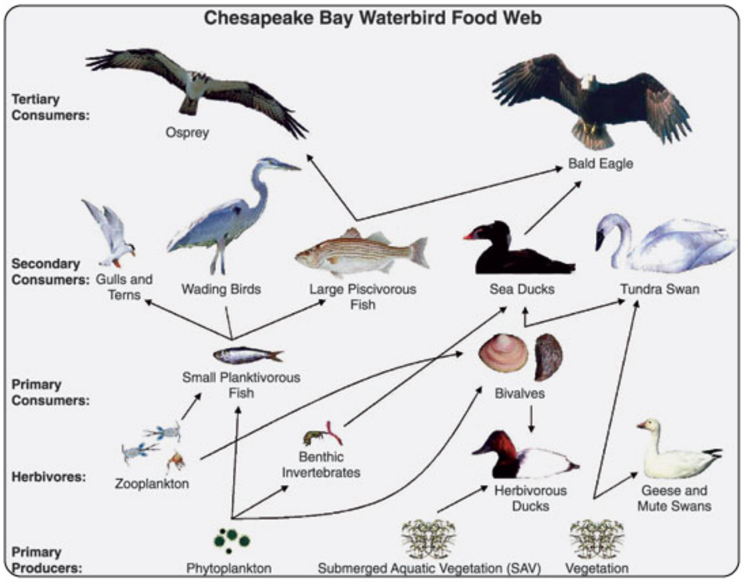

FIGURE 3.6
Food Web. This food web consists of several different food chains. Which organisms are producers in all of the food chains included in the food web?

energy stored in organisms at one trophic level is actually transferred to organisms at the next trophic level. The rest of the energy is used for metabolic processes or lost to the environment as heat. As a result, less energy is available to organisms at each successive trophic level. This explains why there are rarely more than four or five trophic levels. The amount of energy at different trophic levels can be represented by an energy pyramid like the one in **Figure** 3.7.

Pyramid of Energy

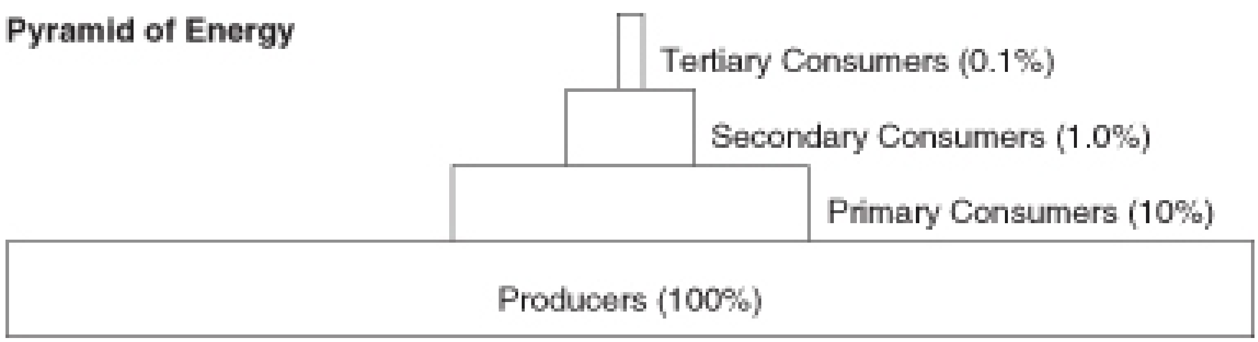

FIGURE 3.7
This pyramid shows the total energy stored in organisms at each trophic level in an ecosystem. Starting with primary consumers, each trophic level in the food chain has only 10 percent of the energy of the level below it. The pyramid makes it clear why there can be only a limited number of trophic levels in a food chain or web.

Because there is less energy at higher trophic levels, there are usually fewer organisms as well. Organisms tend to be larger in size at higher trophic levels, but their smaller numbers still result in less biomass. **Biomass** is the total mass of organisms in a trophic level (or other grouping of organisms). The biomass pyramid in **Figure** 3.8 shows how biomass of organisms changes from first to higher trophic levels in a food chain.

Energy pyramids (**6f**) are discussed at http://www.youtube.com/watch?v=8T2nEMzk6_E&feature=related (1:44).

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Pyramid of Biomass

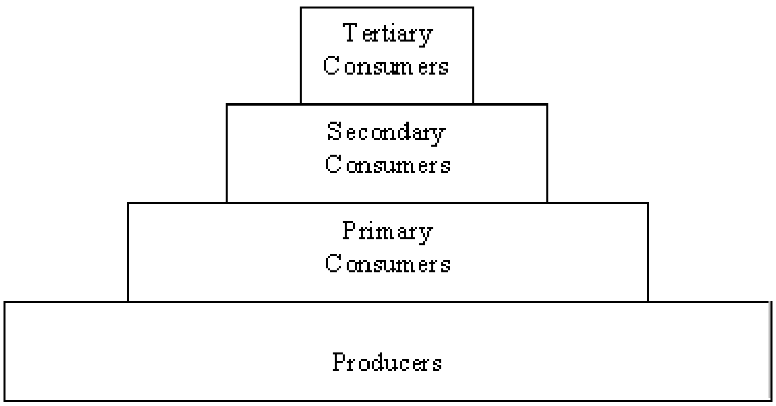

FIGURE 3.8

This pyramid shows the total biomass, or mass of organisms, at each trophic level in an ecosystem. How does this pyramid relate to the energy pyramid in

The materials in dead organisms and wastes at all trophic levels are broken down by decomposers. Organisms such as detritivores and saprotrophs return needed elements to the ecosystem and use up most remaining energy. Because of the reduction in energy at each trophic level, virtually no energy remains. Therefore, energy must be continuously added to ecosystems by producers.

Lesson Summary

- Producers in ecosystems are autotrophs. They use energy from sunlight or chemical compounds to synthesize organic molecules from carbon dioxide and other simple inorganic molecules.
- Consumers in ecosystems are heterotrophs, or organisms that consume other organisms for food. Consumers include herbivores such as deer, carnivores such as lions, and omnivores such as humans.
- Decomposers break down dead organisms and other organic wastes in ecosystems. They resupply producers with the elements they need to synthesize organic compounds.
- Food chains and food webs model feeding relationships in ecosystems. They show how energy and materials are transferred between trophic level when consumers eat producers or other organisms.

Review Questions

1. How do autotrophs use energy to produce organic molecules?
2. Define three different types of consumers, and name an example of each.
3. How do decomposers resupply elements to producers?
4. How is energy transferred between trophic levels in a food chain?
5. In the food web figure, identify two independent food chains.

6. If one million kilocalories of energy are stored in producers in an ecosystem, how many kilocalories can be transferred to tertiary consumers in the ecosystem? Show the calculations that support your answer.
7. Draw a terrestrial food chain that includes four trophic levels.
8. All organisms consist of carbon compounds. Infer how the amount of carbon stored in organisms changes from one trophic level to the next. Explain your answer.

Further Reading / Supplemental Links

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Vocabulary

Archaea
A prokaryotic domain of microorganisms that resemble bacteria; most archaea live in extreme environments, such as around hydrothermal vents in the deep ocean and are chemoautotrophs.

autotrophs
Organisms that produce organic compounds from energy and simple inorganic molecules; also known as producers.

carnivores
Organisms that eat a diet consisting mainly of herbivores or other carnivores.

chemoautotrophs
Organisms that use the energy stored in chemical compounds to make organic molecules by chemosynthesis.

chemosynthesis
The process by which carbon dioxide and water are converted to carbohydrates; uses energy from the oxidation of inorganic compounds.

consumers
Organisms that depend on producers or other types of organisms for food.

decomposers
Organisms that consume dead organisms and other organic waste.

detritivores
Organisms that consume the remains of dead plants (detritus).

detritus
Dead leaves and other plant remains that accumulate on the ground or at the bottom of a body of water.

food chain
A simple linear pathway through which energy and materials are transferred from one species to another in an ecosystem.

food web
A diagram of feeding relationships that includes multiple intersecting food chains.

herbivores
Organisms that consume only producers such as plants or algae; form a necessary link between producers and other consumers.

heterotrophs
Organisms that depend on producers or other types of organisms for food; also called consumers.

omnivores
Organisms that eat both plants and animals as primary food sources.

oxidation
An energy-releasing chemical reaction in which a molecule, atom, or ion loses electrons.

photoautotrophs
Organisms that use energy from sunlight to make food by photosynthesis; includes plants, algae, and certain bacteria.

photosynthesis
The process by which carbon dioxide and water are converted to glucose and oxygen, using sunlight for energy.

phytoplankton
All the tiny photoautotrophs found on or near the surface of a body of water; usually is the primary producer in aquatic ecosystems; includes both cyanobacteria and algae.

plankton
Large communities of producers and herbivores; made up of phytoplankton and zooplankton.

producers
Organisms that produce organic compounds from energy and simple inorganic molecules.

saprotrophs
Organisms that complete the breakdown of any remaining organic matter, such as bones, feathers, and fur of dead animals, and wood and other indigestible plant material.

scavengers
Carnivores that mainly eat the carcasses of dead animals.

trophic levels
The different feeding positions in a food chain or web.

zooplankton
All the small organisms that feed on phytoplankton; includes both single-celled organisms such as protozoa and multicellular organisms such as jellyfish.

Points to Consider

Matter recycles through the biotic components of ecosystems as producers synthesize organic compounds and other organisms consume the compounds.

- Do you think abiotic components of ecosystems also play roles in recycling matter?
- What abiotic components do you think might be involved? For example, what abiotic components do you think might be involved in the cycling of water?

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CHAPTER 4 Cycles of Matter

Lesson Objectives

- Describe the key features of the water cycle.
- Describe the key features of the nitrogen cycle.
- Describe the key features of the carbon cycle.

Check Your Understanding

- What types of organisms break down animal remains and wastes to release nutrients?
- What are the main chemical elements that are essential for life?

Vocabulary

- biogeochemical cycles
- fossil fuels
- global warming
- groundwater
- nitrogen fixation
- precipitation
- runoff
- transpiration

The Water Cycle

Chemicals and nutrients are recycled in an ecosystem in **biogeochemical cycles**. This recycling process involves both the biotic factors and the abiotic factors of the ecosystem. Through biogeochemical cycles, nutrients are constantly being passed through living organisms to non-living matter and back again, over and over. These recycled nutrients contain the elements carbon and nitrogen.

Water is obviously an extremely important aspect of every ecosystem. Life cannot exist without water. Many organisms contain a large amount of water in their bodies, and many live in water, so the water cycle is essential to life on earth. Water is cycled through the biotic and abiotic factors of an ecosystem, moving between living things and non-living things, such as clouds, rivers, and oceans (**Figure** 4.1).

The water cycle does not have a real starting or ending point, since it is an endless recycling process, but we will start with the oceans. Here are the steps in the water cycle:

1. Water evaporates from the surface of the oceans, leaving behind salts. As the water vapor rises, it collects and is stored in clouds.
2. As water cools in the clouds, condensation occurs. Condensation is when gases turn back into liquids.
3. Condensation creates precipitation. **Precipitation** includes rain, snow, hail, and sleet. The precipitation allows the water to return again to the Earth's surface.
4. When precipitation lands on land, the water can sink into the ground to become part of our underground water reserves, also known as **groundwater**. Much of this underground water is stored in aquifers, which are porous layers of rock that can hold water.

Run-off

Most precipitation that occurs over land, however, is not absorbed by the soil and is called **runoff**. This runoff collects in streams and rivers and moves back into the ocean.

Transpiration

Water also moves through the living organisms in an ecosystem. Plants soak up large amounts of water through their roots. The water then moves up the plant and evaporates from the leaves in a process called **transpiration**. The process of transpiration, like evaporation, returns water back into the atmosphere.

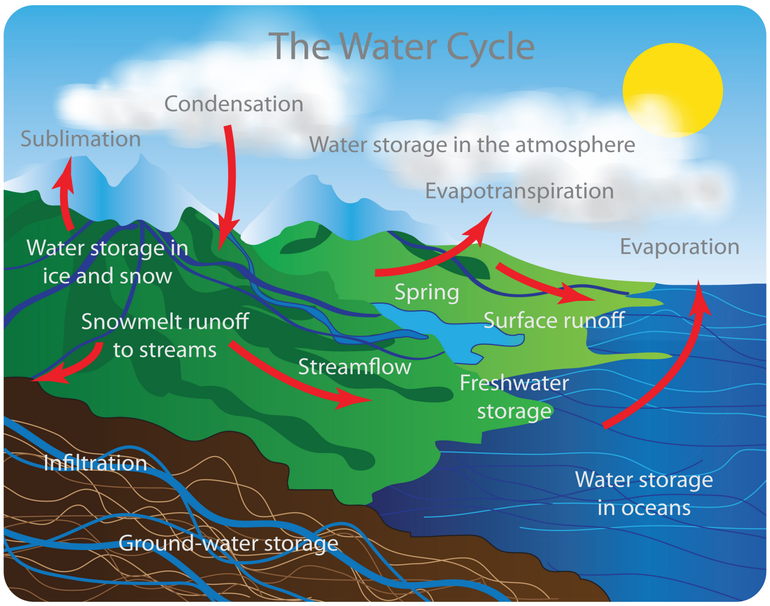
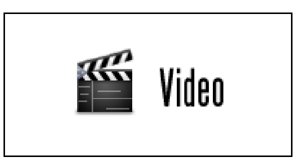


FIGURE 4.1
The water cycle.

See http://www.youtube.com/watch?v=4Cb3SIMRCIE&NR=1 for an animation of the water cycle (3:14).



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The Carbon Cycle

Carbon is one of the most common elements found in living organisms. Chains of carbon molecules form the backbones of many molecules, such as carbohydrates, proteins, and lipids. Carbon is constantly cycling between living things and the atmosphere (**Figure** 4.2).

In the atmosphere, there is carbon dioxide. Producers capture the carbon dioxide and convert it to glucose through the process of photosynthesis. As consumers eat producers or other consumers, they gain the carbon from those organisms. Some of this carbon is lost, however, through the process of cellular respiration. That means when our cells burn food for energy, carbon dioxide is released. We, like all animals, exhale this carbon dioxide and return it back to the atmosphere. Also, carbon dioxide is released to the atmosphere as an organism dies and decomposes.

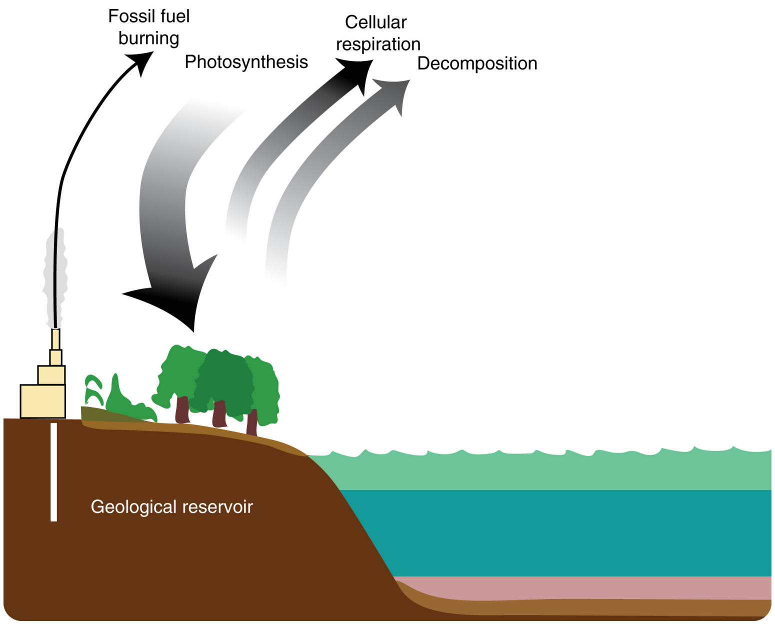


FIGURE 4.2
The carbon cycle.

Formation of Fossil Fuels

Millions of years ago, there were so many dead plants and animals that they could not completely decompose before they were buried. These plants and animals are organic matter, with lots of carbon. When organic matter is under pressure for millions of years, it forms **fossil fuels.** Fossil fuels are coal, oil, and natural gas.

When humans dig up and use fossil fuels, we have an impact on the carbon cycle (**Figure** 4.3). The burning of fossil fuels releases more carbon dioxide into the atmosphere than is used by photosynthesis. So, there is more carbon dioxide entering the atmosphere than is coming out of it. Carbon dioxide is known as a greenhouse gas, since it lets in light energy but does not let heat escape, much like the panes of a greenhouse. The increase of greenhouse gasses in the atmosphere is contributing to a global rise in Earth's temperature, known as **global warming** (see the *Environmental Problems* chapter for additional information).

FIGURE 4.3
Human activities like burning gasoline in cars are contributing to a global change in our climate.

The Nitrogen Cycle

Nitrogen is also one of the most common elements in living organisms. It is important for creating both proteins and nucleic acids, like DNA. Nitrogen gas (N_2) is in the majority of the air we breathe, but unfortunately, animals and plants cannot use it when it is a gas. In fact, plants often die from a lack of nitrogen even through they are surrounded by plenty of nitrogen gas.

In order for plants to make use of nitrogen, it must be transformed into molecules they can use. This can be accomplished several different ways (**Figure** 4.4).

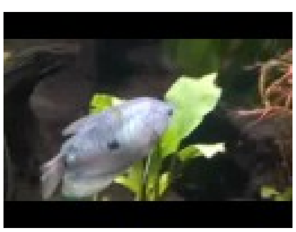
- Lightning: Nitrogen gas can be transformed into nitrate (NO_3^-) that plants can use when lightning strikes.
- **Nitrogen fixation**: Special nitrogen-fixing bacteria can also transform nitrogen gas into useful forms. These bacteria live in the roots of plants in the pea family. In water environments, bacteria in the water can fix nitrogen gas into ammonium (NH_4^+). Ammonium can be used by aquatic plants as a source of nitrogen.
- Nitrogen also is released to the environment by decaying organisms or decaying wastes. These wastes release nitrogen in the form of ammonium. Ammonium in the soil can be turned into nitrate by a two-step process completed by two different types of bacteria. In the form of nitrate, it can be used by plants through a process called assimilation.

Sending Nitrogen back to the Atmosphere

Turning nitrate back into nitrogen gas happens through the work of denitrifying bacteria. These bacteria often live in swamps and lakes. They take in the nitrate and release it as nitrogen gas.

Just like the carbon cycle, human activities impact the nitrogen cycle. These human activities include the burning of fossil fuels, which release nitrogen oxide gasses into the atmosphere. Releasing nitrogen oxide back into the atmosphere leads to problems like acid rain.

The nitrogen cycle is described at http://www.youtube.com/watch?v=pdY4I-EaqJA (5:08).



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Lesson Summary

- During the water cycle, water enters the atmosphere by evaporation, and water returns to land by precipitation.
- During the carbon cycle, animals add carbon dioxide to the atmosphere through respiration, and plants remove carbon dioxide through photosynthesis.
- During the nitrogen cycle, gaseous nitrogen is converted into water-soluble forms that can be used by plants, while denitrifying bacteria turn nitrate back into gaseous nitrogen.

Review Questions

Recall

1. What is the term for the remains of organisms that are burned for energy?

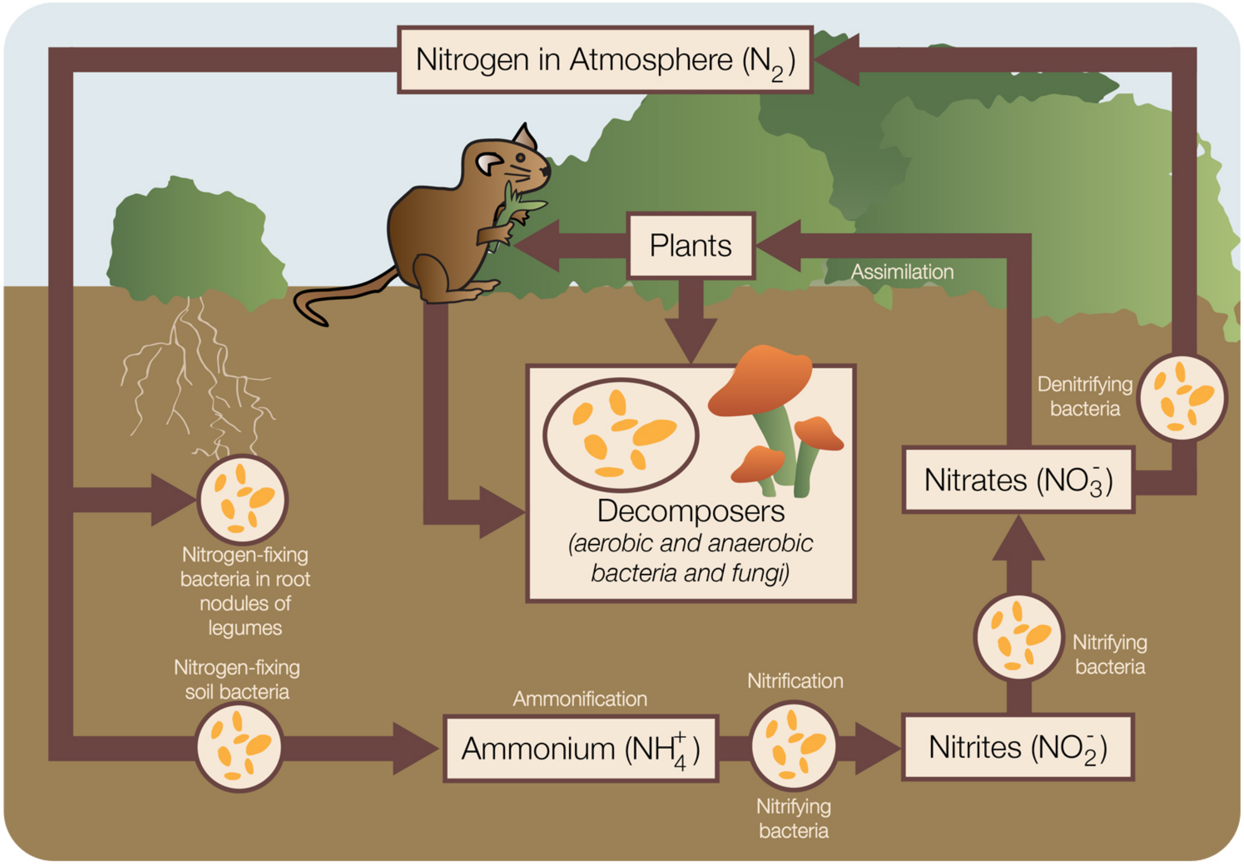

FIGURE 4.4

The nitrogen cycle includes assimilation, when plants absorb nitrogen; nitrogen-fixing bacteria that make the nitrogen available to plants in the form of nitrates; decomposers that transform nitrogen in dead organisms into ammonium; nitrifying bacteria that turn ammonium into nitrates; and denitrifying bacteria that turn nitrates into gaseous nitrogen.

2. How does water in the atmosphere return to the ground?
3. What are some examples of fossil fuels?
4. What biological process “fixes” carbon, removing it from the atmosphere?

Apply Concepts

5. What human activities have thrown the carbon cycle off balance?
6. What is the significance of nitrogen-fixing bacteria?
7. What biological process releases carbon back into the atmosphere?
8. What must happen for plants to use nitrogen in the atmosphere?
9. What is the significance of denitrifying bacteria?

Critical Thinking

10. Why is carbon dioxide referred to as a "greenhouse gas"? Explain the effects of greenhouse gasses on the planet.

Further Reading / Supplemental Links

- http://earthobservatory.nasa.gov/Library/CarbonCycle
- http://www.cosee-ne.net/resources/documents/OceanLiteracyWorkshopIReport.pdf
- http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookcycles.html
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- http://earthguide.ucsd.edu/earthguide/diagrams/watercycle/index.html
- http://en.wikipedia.org/wiki

Points to Consider

- Do ecosystems change over time? Why or why not?
- Can you think of an example of a ecosystem changing over time?

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CHAPTER 5 Populations

Lesson Objectives

- Define population.
- Describe how births, deaths and migration affect population size.
- Explain how populations grow.
- Describe how limiting factors affect population growth.
- Describe growth of the human population.

Check Your Understanding

- What is ecology?
- How does an organism interact with its environment?

Vocabulary

- birth rate
- carrying capacity
- death rate
- dispersion
- emigration
- immigration
- limiting factor
- population growth rate

What is a Population?

A population is a group of organisms of the same species, all living in the same area and interacting with each other. Since they live together in one area, members of the same species reproduce together. Ecologists who study populations figure out how healthy or stable the populations are. They also look at how the populations interact with the environment.

First, ecologists will measure the size of the population. The population density is the number of individuals of the same species in a particular area. Ecologists also look at how individuals in a population are spread across an environment. How individuals are spaced within a population is called **dispersion**. Some species may be clumped or clustered (**Figure** 5.1) in an area. Others may be evenly spaced (**Figure** 5.2). Still others may be spaced randomly within an area.

Ecologists also study age and sex. The **birth rate** is the number of births per individual within a specific time period. The **death rate** is the number of deaths within a population during a specific time period. Knowing the birth and death rates of populations gives you information about a population's health. For example, when a population is made up of mostly young organisms, it means that the population is growing.

A population with equal birth and death rates will have equal numbers of individuals at each age level. A population with more individuals at or above an age when they can reproduce means that the number of individuals is decreasing in the population. This is because the organisms in this population cannot reproduce any more, so more children cannot be born, and then the population cannot grow.

FIGURE 5.1
Individuals within this population of purple loosestrife plants are clumped because of the soil quality.

FIGURE 5.2
A population of cacti in the Sonoran Desert generally shows even dispersion due to competition for water.

Births, Deaths, and Migration

Births, deaths and migration all affect population growth. The **population growth rate** tells you if the number of individuals in a population is increasing or decreasing. Population growth rate depends on birth rate and on death rate. You can predict the growth rate by using the simple equation below:

growth rate = birth rate – death rate.

If the birth rate is larger than the death rate, then the population grows. If the death rate is larger than the birth rate, what will happen to the population? The population will go down. If the birth and death rates are equal, then the population will stay the same.

Factors that affect reproduction are:

1. Age at first reproduction.
2. How often an organisms reproduces.
3. The number of offspring.

4. Parental care.
5. How long an organisms is able to reproduce.
6. Death rate of offspring.

Organisms can use different strategies to increase their reproduction rate. Altricial organisms are helpless at birth and their parents give them a lot of care (**Figure** 5.3), while precocial organisms can take care of themselves at birth and do not require help from their parents (**Figure** 5.4). In order to reproduce as much as possible, they use very different strategies.

FIGURE 5.3
A hummingbird nest with young illustrates an altricial reproductive strategy, with a few small eggs, helpless and naked young, and intensive parental care.

FIGURE 5.4
The Canada goose shows a precocial reproductive strategy. It lays a large number of large eggs, producing well-developed young.

Migration

Migration is the movement of individual organisms into or out of a population. Migration affects population growth rate. There are two types of migration:

1. **Immigration** is the movement of individuals into a population from other areas. This increases the population growth rate.
2. **Emigration** is the movement of individuals out of a population. This decreases the population growth rate.

The earlier growth rate equation now looks like this:

growth rate = (birth rate + immigration rate) – (death rate + emigration rate)

One type of migration that you are probably familiar with is the migration of birds. Maybe you have heard that birds fly south for the winter. In the fall, birds fly thousands of miles to the south where is warmer. In the spring, they return to their homes. (**Figure** 5.5).

Monarch butterflies also migrate from Mexico to the northern U.S. in the summer and back to Mexico in the winter. These types of migrations move entire populations from one location to another.

FIGURE 5.5
A flock of barnacle geese fly in formation during the autumn migration in Finland.

Population Growth

If a population is given unlimited amounts of food, moisture, and oxygen, and other environmental factors, it will show a type of growth called exponential growth. Exponential growth means that as a population grows larger, the growth rate increases. This is shown as the J-shaped curve in **Figure** 5.6. You can see that the population grows slowly at first, but as time passes, growth occurs more and more rapidly.

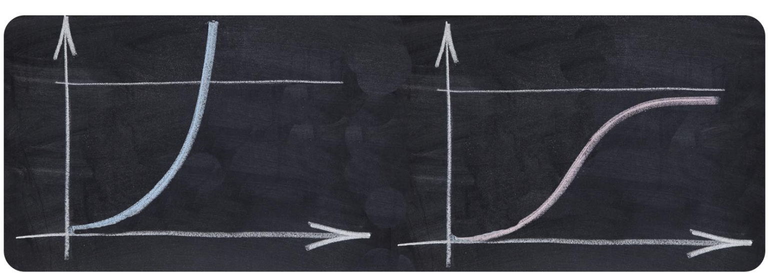

FIGURE 5.6
Growth of populations according to exponential (or J-curve) growth model (left) and logistic (or S-curve) growth model (right)

In nature, organisms do not usually have ideal environments with unlimited food. In nature, there are limits. Sometimes, there will be a lot of food. Sometimes, a fire will wipe out all of the available nutrients. Sometimes a predator will kill many individuals in a population. How do you think these limits affect the way organisms grow?

Usually, populations first grow exponentially. But as populations increase, rates of growth slow down and slowly level off. This is shown as an S-shaped curve in **Figure** 5.6, and is called logistic growth. Why do you think occurs?

Limiting Factors

Limiting factors are things in the environment that can lower the population growth rate. Limiting factors include a low food supply and lack of space. Limiting factors can lower birth rates, increase death rates, or lead to emigration.

When organisms face limiting factors, they show logistic type of growth (S-curve). Competition for resources like food and space cause the growth rate to stop increasing, so the population levels off. This flat line in growth is known as the carrying capacity. The **carrying capacity** is the maximum population size that can be supported in a particular area without destroying the habitat. Limiting factors determine what the carrying capacity is.

Food Supply as Limiting Factor

If there are 12 hamburgers at a lunch table and 24 people sit down at a lunch table, will everyone be able to eat? At first, maybe you will split hamburgers in half, but if more and more people keep coming to sit at the lunch table, you will not be able to feed everyone. This is what happens in nature. But in nature, organisms that cannot get food will die or find a new place to live.

In nature, when the population size is small, there is plenty of food for each individual. When there is plenty of food, organisms can reproduce, so the birth rate is high. As the population increases, the food supply decreases. When food decreases, organisms cannot reproduce as well, so the birth rates goes down. This will cause the population growth rate to decrease.

When the population decreases to a certain level where every individual can get enough food to eat, and the birth and death rates are stable, the population has reached its carrying capacity.

Other Limiting Factors

Other limiting factors include light, water, nutrients or minerals, oxygen, the ability of an ecosystem to recycle nutrients and/or waste, disease and/or parasites, temperature, space, and predation. Can you think of some other factors that limit populations?

Weather is also a limiting factor. For example, an individual *Agave americana* actually likes to grow when it is dry. Rainfall limits reproduction, which in turn limits growth rate. Can you think of some other factors like this?

Human activities can also limit the growth of populations. Such activities include use of pesticides, such as DDT, use of herbicides, and habitat destruction.

What kind of growth rate do you think humans follow? Are they growing exponentially (J-curve) or logistically (S-curve)?

Growth of the Human Population

There are two different beliefs about what type of growth the human population undergoes:

1. Neo-Malthusians believe that human population growth cannot continue without destroying the environment, and maybe humans themselves.

2. Cornucopians believe that the Earth can give humans a limitless amount of resources. They also believe that technology can solve problems caused by limited resources, such as lack of food.

Which do you think is correct?

Does human growth looks like the exponential (J-shaped) graph or the logistic (S-shaped) graph? We don't know all the answers yet, but history gives us some clues. For example, if we look at worldwide human population growth from 10,000 BCE through today, our growth looks like exponential growth. It increases very slowly at first, but later grows at a faster rate. It also does not approach a carrying capacity (**Figure** 5.7). So maybe humans show exponential growth.

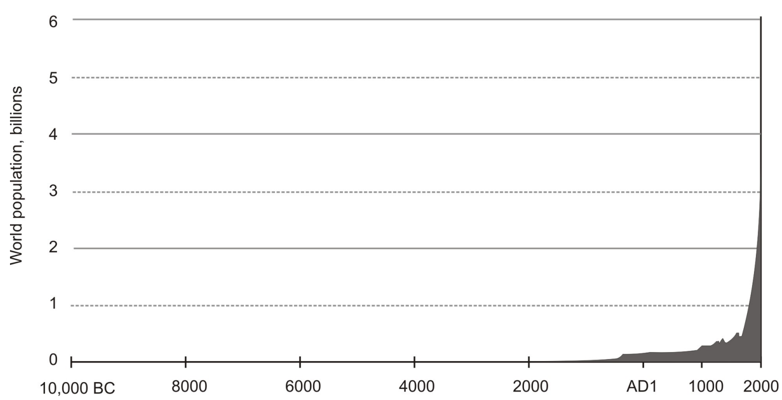

FIGURE 5.7
Worldwide human population growth from 10,000 BCE through today

On the other hand, if you look at human population growth in specific countries, you may see a different pattern. On the level of a country, the history of human population growth can be divided into five stages, as described in **Table** 5.1.

TABLE 5.1: The Stages of Human Population Growth

Stage of Human Population Growth	Description
Stage 1	Birth and death rates are high and population growth is stable. This occurred in early human history.
Stage 2	Significant drop in death rate, resulting in exponential growth. This occurred in 18th and 19th century Europe.
Stage 3	Population size continues to grow.
Stage 4	Birth rates equal death rates and populations become stable.
Stage 5	Total population size may level off.

The United Nations and the U.S. Census Bureau predict that by 2050, the Earth will be populated by 9.4 billion people. Other estimates predict 10 to 11 billion.

The Cornucopians believe that a larger population is good for technology and innovation. The 5-stage model above predicts that when all countries are industrialized, the human population will eventually reach a carrying capacity. But many scientists and other Neo-Malthusians believe that humans have already gone over the Earth's carrying capacity for resources and habitat. If this is true, then human overpopulation will lead to a lack of food, disease, or war. These things will cause the population of humans to crash, or cause humans to go extinct.

For additional information, see this 2010 video: http://whoknew.news.yahoo.com/?vid=21435088.

Which of the above theories makes sense to you? Why?

Lesson Summary

- A population is made of organisms belonging to the same species, all living in the same area and interacting with each other
- One measure of a population's health is the dispersion of individuals within a population
- The population growth rate shows how the population size changes per population member per unit of time.
- Birth rate, death rate, and migration affect population growth rate.
- In an ideal environment, populations show exponential growth. In nature, limiting factors cause logistic growth.
- There are two major beliefs about human population growth. Neo-Malthusians believe that human population growth is limited, and that overpopulation could have serious consequences. Cornucopians believe that human population growth can continue because of natural resources and technology.

Review Questions

Recall

1. Name two ways ecologists know that a population is healthy.

2. Define Birth Rate.

3. Define Death Rate.

4. What is the equation that calculates growth rate in a population, include information on migration?

5. What are three factors that affect reproduction within a population?

Apply Concepts

6. How does a limiting factor such as food supply limit population size?

7. Give two examples of environmental crises that support the idea that our human population has already grown beyond the carrying capacity resulting in environmental degradation.

8. What is the difference between Neo-Malthusian beliefs and Cornucopian beliefs about human population growth?

Critical Thinking

9. In the altricial reproductive strategy used by robins and hummingbirds, the birds hatch helpless and naked. Parents spend little energy in just a few small eggs. It is important these offspring survive because there are not very many of them. What strategies might parents use to make sure their young survive?

10. In human history, major advances in technology caused our population to increase rapidly. What do you think these major advances were?

Further Reading / Supplemental Links

- http://www.brainpop.com/science/ourfragileenvironment/populationgrowth/preview.weml
- http://eelink.net/pages/EE+Activities+-+Population
- http://mathforum.org/t2t/faq/census.html
- http://en.wikipedia.org/wiki/Population_ecology

Points to Consider

- Now that you understand what makes up a population, what do you think makes up a community?
- You have learned about some of the factors that limit populations. What do you think are some interactions that affect the community?

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5. . MSLS-23-08-barnacle-geese-migration.
6. . MSLS-23-09-population-growth-graphs.
7. . MSLS-23-10-human-pop-growth-history.

CHAPTER 6 Communities

Lesson Objectives

- Define community.
- Describe community interactions.
- Explain how competition affects the community.
- Describe predation and how it affects prey density.
- Explain what symbiosis is and give examples of different kinds of symbiosis.

Check Your Understanding

- What is a population?
- How do limited resources encourage competition?

Vocabulary

- camouflage
- character displacement
- commensalism
- competition
- competitive exclusion principle
- keystone species
- mutualism
- parasitism
- predation
- symbiosis

What is a Community?

From populations, we are moving to the next level of ecology: the community level. In a community, different species that live in the same area interact with each other. The term "community" can be used in different ways. You can study populations in different areas of during different time periods. For example, you may study the fish community in Lake Ontario. But you could also study fish in a lake during a particular time period, like after 1990.

Community Interactions

Community interactions can be either:

1. Intraspecific: Interactions between members of the same species.
2. Interspecific: Interactions between members of different species.

There are a number of different types of interactions, but we will look at three different types:

1. Competition.
2. Predation.
3. Symbiosis.

Competition

Competition occurs when organisms compete for limited resources, and the "fitness" of one individual is lowered by competing with another individual. The interaction can be between organisms of the same species (intraspecific) or different species (interspecific).

Intraspecific competition happens when members of the same species compete for the same resources. They can compete for food, nutrients, space, or light. For example, two trees may grow close together and compete for light. One may out-compete the other by growing taller to get more available light. The organism that is better adapted to that environment gets to survive. In this case, it is the taller tree.

Interspecific competition happens when individuals of different species share a limited resource in the same area. One species will have lowered reproductive success, growth, or survival. For example, cheetahs and lions feed on similar prey. If prey is limited, then lions may catch more prey than cheetahs. This will force the cheetahs to either leave the area or suffer a decrease in population.

Looking at different types of competition, ecologists developed the **competitive exclusion principle**. The principle states that species less suited to compete for resources will either adapt, move from the area, or die out. This is similar to what happens within a species. Evolutionary theory says that competition for resources within and between species plays an important role in natural selection (**Table** 6.1).

In order for two species within the same area to adapt, they may develop different specializations in order to coexist. This is known as **character displacement**. An example of character displacement is when different birds adapt to eating different types of food. They can develop different types of bills, like Darwin's Finches (**Figure** 6.1).

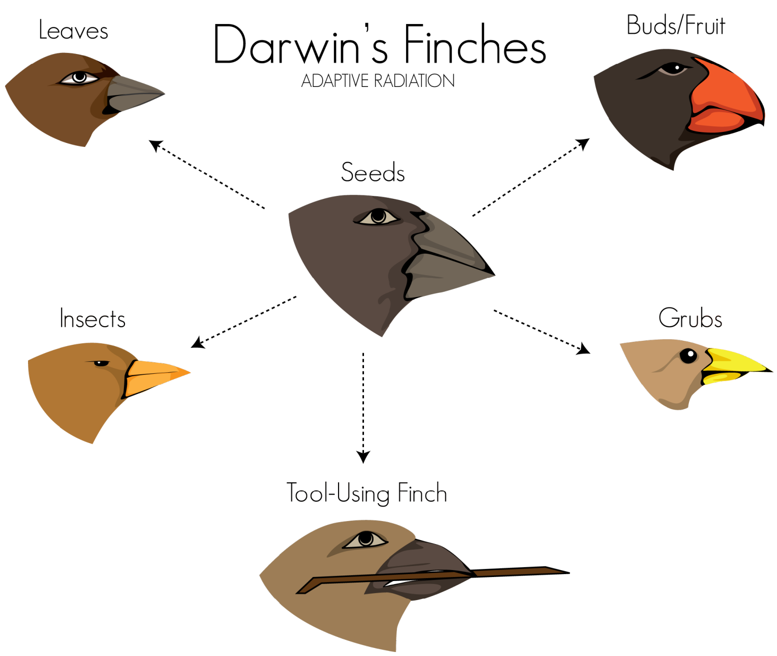

FIGURE 6.1
An example of character displacement, showing different types of bill for eating different types of foods, in Darwin

TABLE 6.1: Main Features of Competition

Type of Competition	Description of Competition
Intraspecific Competition	Occurs when members of the same species compete for the same resources, like food, nutrients, space, or light
Interspecific Competition	Occurs when individuals of different species share a limiting resource in the same area

Predation

Predation happens when a predator organism feeds on another living organism or organisms, known as prey. The predator always lowers the prey's fitness. It does this by keeping the prey from surviving, reproducing, or both.

There are different types of predation, including:

- True predation.
- Grazing.
- Parasitism.

True predation happens when a predator kills and eats its prey. Some predators of this type, such as jaguars, kill large prey. They tear it apart and chew it before eating it (**Figure** 6.2). Others, like bottlenose dolphins or snakes, may eat their prey whole. In some cases, the prey dies in the mouth or digestive system of the predator. Baleen whales, for example, eat millions of plankton at once. The prey is digested afterward. True predators may hunt actively for prey, or they may sit and wait for prey to get within striking distance.

FIGURE 6.2
This example of a true predator shows a lioness actively hunting warthogs in the western corridor of the Serengeti, in Africa.

In grazing, the predator eats part of the prey, but does not usually kill it. You may have seen cows grazing on grass. The grass they eat grows back, so there is no real effect on the population. In the ocean, kelp (a type of seaweed) can regrow after being eaten by fish. Starfish can regenerate lost arms when they are eaten.

Predators play an important role in an ecosystem. For example, if they did not exist, then a single species could become dominant over others. Grazers on a grassland keep grass from growing out of control. Predators can be **keystone species**. These are species that can have a large affect on the balance of organisms in an ecosystem. For example, if all of the wolves are removed from a population, then the population of deer may increase. If there are too many deer, then they may decrease the amount of plants or grasses in the ecosystem.

The act of predation can be broken down into four stages:

1. Predator senses the prey.
2. Predator attacks the prey.
3. Predator captures the prey.
4. Predator eats the prey.

At each stage, predators have adaptations for getting the prey. Prey also have adaptations for avoiding predators. (**Table** 6.2).

Prey sometimes avoid detection by using camouflage (**Figure** 6.3). **Camouflage** means that species have an appearance (color, shape or pattern) that helps them blend into the background. Mimicry is a related adaptation where a species uses appearance to copy another species. For example, a non-poisonous dart frog may evolve to look like a poisonous dart frog. Why do you think this is an adaptation for the non-poisonous dart frog? Mimicry can be used by both predators and prey (**Figure** 6.4).

TABLE 6.2: Main Features of Predation

Type of Predation	Description of Predation
True Predation	Predator kills and eats its prey
Grazing	Predator eats part of the prey, but rarely kills it

FIGURE 6.3
Camouflage by the dead leaf mantis makes it less visible to both its predators and prey. If alarmed, it lies motionless on the rainforest floor of Madagascar, Africa, camouflaged among the actual dead leaves. It eats other animals up to the size of small lizards.

FIGURE 6.4
An example of Batesian mimicry, where the Viceroy butterfly (right) mimics the unpalatable Monarch butterfly (left). Both species are avoided by predators to a greater degree than either one would be otherwise.

Symbiosis

Symbiosis describes a close and long-term interaction between different species. At least one species will benefit in a symbiotic relationship. There are three types of symbiotic relationships:

1. **Mutualism**: Both species benefit.
2. **Commensalism**: One species benefits while the other is not affected.
3. **Parasitism**: The parasitic species benefits, while the host species is harmed.

An example of a mutualistic relationship is between herbivores (plant-eaters) and the bacteria that live in their intestines. The bacteria get a place to live while they also help the herbivore to digest food. Both species benefit, so it is a mutualistic relationship.

The *Ocellaris* clownfish and the *Ritteri* sea anemones also have a mutualistic relationship. The clownfish protects the anemone from anemone-eating fish, and the stinging tentacles of the anemone protect the clownfish from predators (**Figure** 6.5).

Commensal relationships may involve an organism using another for transportation or housing. For example, spiders build their webs on trees. The spider gets to live in the tree, but the tree is unaffected.

An example of a parasite is a hookworms. Hookworms live inside of humans and cause them pain, but the hookworms must live inside of a host in order to survive. Parasites may even kill the host they live on. Parasites are found in animals, plants, and fungi.

FIGURE 6.5

A mutualistic relationship between the Ocellaris clownfish and the Ritteri sea anemone. Myako Island, Japan. The fish protects the anemone from anemone-eating fish, while the anemone protects the clownfish from its predators, with its stinging tentacles. The clownfish has a special mucus which protects it from the tentacles.

Lesson Summary

- A community is a collection of populations of different species interacting with one another in the same area.
- Community interactions include competition, predation, and symbiosis.
- Intraspecific and interspecific competition occur when individuals share a limiting resource in the same area.
- The competitive exclusion principle plays an important role in natural selection.
- Types of predation include true predation, grazing, and parasitism.
- Prey use different adaptations to avoid detection, attack and capture by predators.
- Symbiosis includes mutualism, commensalism, and parasitism.

Review Questions

Recall

1. Define competition.

2. What is the difference between intraspecific and interspecific competition?

3. Name three different types of predation.

4. In the mutualistic relationship between the *Ocellaris* clownfish and the *Ritteri* sea anemones, what benefit does the fish get?

Apply Concepts

5. If two similar species do not live in the same area, would you expect the two species to compete? Why or why not?

6. How might a predator lower a prey's fitness?

7. In most types of grazing, does the predator lower a prey's fitness? Why or why not?

8. A drone fly looks a lot like a bee, yet it is completely harmless, as it cannot sting at all. What anti-predator mechanism is the drone fly using? Would you expect predators to always avoid drone flies?

Critical Thinking

9. Choose one of the symbiotic relationships: mutualism, parasitism, or commensalism. Think of an example of that type of symbiosis. Explain why it is that type.

Further Reading / Supplemental Links

en.wikipedia.org/wiki/Symbiosis

- http://www.nclark.net/CommunitiesBiomes
- http://www.ecokidsonline.com/pub/index.cfm

Points to Consider

- How do you think predation helps a species to survive?

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2. . MSLS-23-12-lioness-hunting-warthogs.
3. . MSLS-23-13-mantis-camouflage.
4. . MSLS-23-14-butterfly-mimicry.
5. . MSLS-23-15-clownfish-anemone.

CHAPTER 7 Ecosystem Change

Lesson Objectives

- Explain the process of ecological succession.
- Distinguish between secondary and primary succession.
- Describe a climax community.

Check Your Understanding

- What is a biome?
- What is the most abundant element in living things?
- How do humans obtain nitrogen?

Vocabulary

- climax community
- ecological succession
- pioneer species
- primary succession
- secondary succession

Ecosystems Change

When you see an older forest, it's easy to picture that the forest has been there forever. This is not the case.

Ecosystems are "dynamic." This means that ecosystems change over time. That forest may lie on land that was once covered by an ocean millions of years ago. Or the forest may have been cut down at one point for agricultural use, then abandoned and allowed to re-grow over time. During the ice ages, glaciers once covered areas that are tropical rainforests today. Both natural forces and human actions cause ecosystems to change.

If there is a big ecosystem change caused by natural forces or human actions, the plants and animals that live there may be destroyed. Or they may be forced to leave. Over time, a new community will develop, and then that community may be replaced by another. You may see several changes in the plant and animal composition of the community over time. **Ecological succession** is the constant replacement of one community by another. It happens after a big change in the ecosystem.

Primary Succession

Primary succession is the type of ecological succession that happens on lands without plants or animal life. It can take place after a lava flow or a glacier. Since the land that results from these processes is often completely new land, soil must be produced.

Primary succession always starts with a **pioneer species**. This is the species that first lives in the disturbed area.

If life wants to begin on rocks without life, the pioneer species could be a lichen (**Figure** 7.1). A lichen is actually not one species, but two. There is a symbiotic relationship between a fungus and an algae or cyanobacteria. The fungus is able to absorb minerals and nutrients from the rock, while algae supplies the fungus with sugars. Since lichens can photosynthesize and do not rely on soil, they can live in environments where other organisms cannot. As a lichen grows, it breaks down the rock, which is the first step of soil formation.

FIGURE 7.1
Primary succession on a rock often begins with the growth of lichens. What do lichens help create?

The pioneer species is soon replaced by other communities. Mosses and grasses will be able to grow in the newly created soil. During early succession, plant species like grasses that grow and reproduce quickly will take over the landscape. Over time, these plants improve the soil and a few shrubs can begin to grow. Slowly, the shrubs are replaced by trees. Since trees are more successful at competing for resources than shrubs and grasses, a forest may be the end result of primary succession.

Secondary Succession

Sometimes ecological succession happens where there are already soil and organisms.

Secondary succession is the type of succession that happens after something destroys the community. Abandoning a field that was once used for agriculture can lead to secondary succession (**Figure** 7.2). In this case, the pioneer species would be the grasses that first appear. Slowly, the field would return to the natural state and look like it used to look before the humans used it for agriculture.

Another event that results in secondary succession is a forest fire (**Figure** 7.3, and **Figure** 7.4). Although the area will look devastated at first, the seeds of new plants are underground. They are waiting for their chance to grow. Just like primary succession, the burned forest will go through a series of communities, starting with small grasses, then shrubs, and finally bigger trees.

Climax Communities

Climax communities (**Figure** 7.5) are the end result of ecological succession. They are a stable balance of all organisms in an ecosystem. The climax community will remain stable unless a disaster strikes. After the disaster, succession will start all over again. Depending on the climate of the area, the climax community will look different. In the tropics, the climax community might be a tropical rainforest. At the other extreme, in northern parts of the world, the climax community might be a coniferous forest.

FIGURE 7.2
This land was once used for growing crops. Now that the field is abandoned, secondary succession has begun. Pioneer species, such as grasses, appear first, and then shrubs begin to grow.

FIGURE 7.3
The early stages of succession after a forest fire are shown in these pictures. Taken four years after the fire, they show the charred remains of the original forest as well as the small grasses and shrubs that are beginning to grow back in the area.

Lesson Summary

- Ecological succession is the continual replacement of one community by another that happens after big changes in the ecosystem.
- Primary succession happens in disturbed areas that have little or no soil.
- Secondary succession happens in disturbed areas that previously supported life.
- Climax communities develop as the last stage of succession, when the ecosystem is again stable.

FIGURE 7.4
In 1988, a forest fire destroyed much of Yellowstone National Park. This photo, taken 17 years later, shows that the forest is gradually growing back. Small grasses first grew here and are now being replaced by small trees and shrubs. This is an example of the later stages of secondary succession.

FIGURE 7.5
These ancient redwood trees are part of a climax community, the end result of a series of community replacements during succession.

Review Questions

Recall

1. What is the term for a continuous replacement of one community by another following a disturbance?

2. What type of succession occurs in areas where there is no soil?

3. What type of succession occurs in areas where soil is present?

4. What is the term for the final stage of succession, when the community becomes stable?

Apply Concepts

5. Imagine a forest fire destroyed a forest. The forest will slowly re-establish itself, which is an example of what kind of succession?

6. A glacier slowly melts, leaving bare rock behind it. As life starts establishing itself on the newly available land, what kind of succession is this?

7. Does the climax community look the same in all parts of the world?

Critical Thinking

8. An area covered with lava is going through primary succession. Explain in detail all of the stages of succession up until the climax community. Also, describe the complex community.

Further Reading / Supplemental Links

- http://www.scribd.com/doc/529104/Ecological-Succession
- http://www.biologycorner.com/worksheets/succession.html
- http://ecolibrary.cs.brandeis.edu/general_search.php?id=CS_Succession@Secondary%20succession&page=links
- http://en.wikipedia.org/wiki

Points to Consider

- Think about what would happen if dangerous toxins were illegally dumped near a river.
- Discuss why it is important to seek alternative energy sources.
- Do we have an infinite supply of fossil fuels, or will we run out some day?

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3. . MSLS-24-13-Succession-1.
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CHAPTER 8 Biomes and the Biosphere

Lesson Objectives

- Explain what biomes are.
- Describe terrestrial biomes.
- Describe aquatic biomes.
- Describe the features of the biosphere and list specific systems.

Check Your Understanding

- What is an ecosystem?
- How do ecosystems relate to humans?

Vocabulary

- aquatic biomes
- elevation
- GAIA hypothesis
- humidity
- latitude
- terrestrial biomes

What are Biomes?

The biome is the highest level of organization in ecology. Biomes include populations, communities, and ecosystems. A biome is an area with similar geography and climate that includes similar communities of plants and animals.

There are into two major groups of biomes:

1. Terrestrial biomes (land).
2. Aquatic biomes (water).

Different biomes are habitats for different organisms. For example, one may find algae only in the part of the ocean where there is light, while conifers may be mostly found in mountains.

The diversity of animals and plants that can live in a specific biome is determined by the abiotic factors. For example, where there is more land, there are more species. Near the equator, there is also more biodiversity, probably because there is more water caused by high humidity levels.

Biomes are classified in terms of two factors:

1. Latitude.
2. Humidity.

Using these two factors, the World Wildlife Fund (WWF) identified fourteen biomes. They then divided those 14 biomes into 825 terrestrial ecoregions.

Biomes are often given local names. For example, a "temperate grassland" biome is known as "steppe" in central Asia, "prairie" in North America, and "pampas" in South America.

Terrestrial Biomes

Different **terrestrial biomes** are defined in terms of their plant structures (such as trees, shrubs, and grasses), leaf types (such as broadleaf and needleleaf), and plant spacing (forest, woodland, savanna). Climate also affects what type of terrestrial biomes will exist in a specific area. The following factors affect biome type:

- **Latitude** means how far a biome is from the equator. Moving from the poles to the equator, you will find Arctic, boreal, temperate, subtropical, tropical biomes.
- **Humidity** is the amount of water in the air. Air with a high concentration of water will be called humid. Moving away from the most humid climate, biomes will be called semi-humid, semi-arid, or arid (the driest).
- **Elevation** measures how high land is above sea level. Higher elevations have a similar affect on biomes as increasing latitude.

This is summarized in **Table** 8.1.

Terrestrial biomes (**Figure** 8.1) lying within the Arctic and Antarctic Circles do not have very much plant or animal life. Biomes with the highest amount of diversity are near the equator (**Figure** 8.2).

FIGURE 8.1
One of the terrestrial biomes, taiga, is a coniferous evergreen forest of the subarctic, covering extensive areas of northern North America and Eurasia. This taiga is along the Denali Highway in Alaska. The Alaska Range is in the background.

FIGURE 8.2
Another terrestrial biome is tropical rainforest. The one pictured here is located in the Amazon basin north of Manaus, Brazil. The image was taken within 30 minutes of a rain event, and a few white clouds above the canopy are indicative of rapid evaporation from wet leaves after the rain.

TABLE 8.1: Characteristics of Terrestrial Biome

Characteristics of Terrestrial Biome	Description of Characteristics
Plant structures	Trees, shrubs, grasses
Leaf types	Broadleaf, needleleaf
Plant spacing	Forest, woodland, savanna
Latitude from poles towards the equator	Arctic, boreal, temperate, subtropical, tropical
Humidity	Humid, semi-humid, semi-arid, arid
Elevation	Increasing elevation causes habitat types similar to that of increasing latitude

Aquatic Biomes

Aquatic biomes can be defined according to:

- Size.
- Depth.
- Vegetation, such as a kelp forest.
- Animal communities.

According to the WWF scheme, freshwater biomes can be classified as the following:

- Large lakes (**Figure** 8.5).
- Large river deltas.
- Polar freshwaters.
- Montane freshwaters (in mountain areas).
- Temperate coastal rivers.
- Temperate floodplain rivers and wetlands.
- Temperate upland rivers.
- Tropical and subtropical coastal rivers.
- Tropical and subtropical floodplain rivers and wetlands.
- Tropical and subtropical upland rivers.
- Xeric (dry habitat) freshwaters and endorheic (interior drainage) basins.
- Oceanic islands.

The WWF classifies marine (salt or ocean water) biomes according to:

- Polar habitat types.
- Temperate seas.
- Temperate upwelling.
- Tropical upwelling.
- Tropical coral.

Other marine habitat types include:

- Continental shelf.
- Littoral/intertidal zone.
- Coral reef.
- Kelp forest (**Figure** 8.3).
- Pack ice (**Figure** 8.4).
- Hydrothermal vents.

- Cold seeps.
- Benthic zone.
- Pelagic zone.
- Neritic zone.

FIGURE 8.3
An example of an aquatic marine biome, a kelp forest, located near Santa Cruz Island, Channel Islands National Park, California.

FIGURE 8.4
An example of an aquatic marine biome, pack ice.

The Biosphere

The highest level of ecology is the biosphere. It is the part of the Earth, including the air, land, surface rocks, and water, where you can find life.

The biosphere interacts with the:

- Lithosphere: sphere of soils and rocks.

FIGURE 8.5
Lake Tahoe in Northern California is a freshwater biome.

- Hydrosphere: water.
- Atmosphere: air.

The biosphere includes an area between 11,000 meters below sea level to 15,000 meters above sea level. It overlaps with the above three spheres.

The **GAIA hypothesis** states that the biosphere is its own living organism. The hypothesis explains how biotic and abiotic factors interact in the biosphere.

The atmosphere, hydrosphere and lithosphere are cooperating systems that produce a biosphere full of life.

Lynn Margulis, a microbiologist, added to the hypothesis, specifically noting the ties between the biosphere and other Earth systems. For example, when carbon dioxide levels increase in the atmosphere, plants grow more quickly. As their growth continues, they remove more carbon dioxide from the atmosphere.

For a better understanding of how the biosphere works and various dysfunctions related to human activity, scientists have simulated the biosphere in small-scale models. Biosphere 2 (**Figure** 8.6) is a laboratory in Arizona that contains 3.15 acres of closed ecosystem. BIOS-3 was a closed ecosystem in Siberia, and Biosphere J is located in Japan.

Direct human interactions with ecosystems, including agriculture, city development and other land uses, affect the health of the biosphere and their ecosystems. In terms of the human impact on biomes and ecosystems, the study of ecology is now more important than ever. Scientists that study ecology will move us toward an understanding of how best to live in and manage our biosphere.

Lesson Summary

- A biome is an area with similar geography and climate that contains ecologically similar communities of plants and animals.
- Biomes are classified in different ways, sometimes according to differences in the physical environment, and sometimes according to latitude and humidity.
- Biodiversity of each biome is determined by abiotic factors, such as water and temperature.
- Terrestrial biomes are classified based on various plant factors and on climate.
- Aquatic biomes are classified based on various factors and divided into freshwater and marine biomes.
- The biosphere is a global ecological system.
- The biosphere is itself a living organism, as explained by the GAIA hypothesis.
- Humans have changed global patterns of biodiversity and ecosystem processes.

FIGURE 8.6
Biosphere 2, in Arizona, contains 3.15 acres of closed ecosystem and is a small-scale model of the biosphere.

Review Questions

Recall

1. Define biome.
2. What is the difference between a terrestrial and an aquatic biome?
3. Name a type of biome based on the physical environment.
4. Name the aquatic biomes classified according to depth.
5. What is the GAIA hypothesis?

Apply Concepts

6. Where would you expect to find more biodiversity, in a rainforest on the equator, or in a desert? Explain why.
7. As you climb a mountain, you will see the vegetation a habitat type change as you gain elevation. What kind of change will result in a similar change in habitat?
8. Name one way that human activity has affected the biosphere (maybe you have heard something on the news?)

Critical Thinking

9. Water is recycled between the hydrosphere, lithosphere, atmosphere, and biosphere in regular cycles. Why do you think oceans are important for this type of water recycling?

Further Reading / Supplemental Links

- http://library.thinkquest.org/11353/ecosystems.htm
- http://earthobservatory.nasa.gov/Laboratory/Biome
- http://www.worldbiomes.com/biomes_map.htm

- http://www.mbgnet.net/sets/index.htm
- http://www.mbgnet.net/fresh/index.htm
- http://www.mbgnet.net/salt/index.htm
- http://www.kidsgeo.com/geography-for-kids/0153-biosphere.php
- http://www.geography4kids.com/files/land_intro.html

Points to Consider

You now have a general idea of what a biome is and how the diversity of a biome is related to other factors. The next chapter, on ecosystem dynamics, will give you a greater understanding of how energy flow, cycling of matter, and succession vary from one biome to another.

- One of the aquatic biomes, the hydrothermal vents, is not dependent on sunlight but on bacteria, which utilize the chemistry of the hot volcanic vents. Can guess where these bacteria fit into the flow of energy in such an ecosystem?

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3. . MSLS-23-24-Kelp-forest.
4. . MSLS-23-25-pack-ice.
5. . MSLS-23-26-tahoe.
6. . MSLS-23-27-biosphere-2.

Chapter 9 Air Pollution

Lesson Objectives

- Discuss the types of outdoor pollution and what causes them.
- Describe the effects of outdoor pollution on the environment.
- Discuss where indoor air pollutants come from and what they are.
- Describe the health hazards of both indoor and outdoor pollutants.
- Discuss how you can protect yourself from air pollution.

Check your Understanding

- What is pollution?
- What is global warming?

Vocabulary

- acid rain
- greenhouse gases
- outdoor air pollution
- primary pollutants
- secondary pollutants

Pollution of Outdoor Air

Air is all around us. Air is essential for life. Sometimes, humans can pollute the air. For example, releasing smoke and dust from factories or cars can cause air pollution. This pollution affects entire ecosystems around the world. Pollution can also cause many human health problems and sometimes death.

You may be familiar with outdoor air pollution, but air pollution can also be found indoors. Air in its unpolluted state cannot be seen, smelled or tasted. Yet the gases in air are very important for life. For example:

- Nitrogen helps build proteins and nucleic acids.
- Oxygen helps to power life.
- Carbon dioxide provides the carbon to build bodies.
- Water supports most forms of life.

Outdoor air pollution is made of chemical particles. When smoke or other pollutants enter the air, the particles found in the pollution mix with the air. Air is polluted when it contains many large toxic particles. Outdoor air pollution changes the natural characteristics of the atmosphere.

Primary pollutants are added directly to the atmosphere. Fires are direct pollutants. Particles released from the fire directly enter the air and cause pollution (**Figure** 9.1). Burning of fossil fuels also directly pollutes the air (**Figure** 9.2).

Secondary pollutants are formed when primary pollutants interact with sunlight, air, or each other. They do not directly cause pollution. However, when they interact with other parts of the air, they do cause pollution. For example, ozone is created when some pollutants interact with sunlight. High levels of ozone in the atmosphere can cause problems for humans (see below). Both types can hurt the environment or human health.

FIGURE 9.1
Wildfires, either natural or human-caused, release particles into the air, one of the many causes of air pollution.

FIGURE 9.2
A major source of air pollution is the burning of fossil fuels from factories, power plants, and motor vehicles.

Most air pollutants can be traced to the burning of fossil fuels. Fossil fuels are burned during the following processes:

- In power plants to create electricity.
- To make machinery run.
- To power stoves and furnaces for heating.
- In transportation, such as cars, trains, and planes.
- In waste facilities.

Another word for "human-caused" is anthropogenic. Anthropogenic air pollution can be caused by agriculture, such as cattle ranching. The use of fertilizers and pesticides can also cause air pollution. Other sources of air pollution include:

- Production of plastics, refrigerants, and aerosols.
- Nuclear power and defense.
- Landfills.
- Mining.

- Biological warfare.

Environmental Effects of Outdoor Air Pollution

Many outdoor air pollutants may hurt the health of plants and animals, including humans. There are many specific problems caused by the burning of fossil fuels. These include acid rain and global warming.

Acid Rain

Sulfur oxides are chemicals that are released from coal-fired power plants. Nitrogen oxides are released from motor vehicle exhaust. Sulfur oxides and nitrogen oxides can both cause **acid rain** (**Figure** 9.3). Acid rain has a very low pH. When the rain hits forests, freshwater habitats, or soils, it can kill insects and aquatic life.

FIGURE 9.3
A forest in the Jizera Mountains of the Czech Republic shows effects caused by acid rain. What do you observe?

Global Warming

Global warming is an increase in the earth's temperature. It is thought to be caused mostly by the increase of **greenhouse gases** like carbon dioxide. Greenhouse gases can be released by factories that burn fossil fuels.

Over the past 20 years, burning fossil fuels has produced about three-quarters of the carbon dioxide from human activity. The rest of the carbon dioxide is caused by deforestation, or cutting down trees (**Figure** 9.4). Trees absorb carbon dioxide, so when trees are cut down, they cannot remove carbon dioxide from the air.

This increase in global temperature will cause the sea level to rise. It is also expected to cause an increase in extreme weather events. It may also change the amount of precipitation. Global warming may also cause food shortages and species extinction.

Pollution of Indoor Air

Lack of indoor air movement causes air pollution to stay in places where people often spend a majority of their time. Some indoor pollutants include:

FIGURE 9.4
Deforestation, shown here as a result of burning for agriculture in southern Mexico, has produced significant increases in carbon dioxide emissions over the past 20 years.

- Radon gas, released from the Earth in certain locations and then trapped inside buildings.
- Formaldehyde gas, emitted from building materials, such as carpeting and plywood.
- Volatile organic compounds (VOCs), given off by paint and solvents as they dry.

Other air pollutants include air fresheners, incense, and other scented items. Wood fires in stoves and fireplaces can produce significant amounts of smoke particles in the air. Use of pesticides and other chemical sprays indoors can be another source of indoor pollution.

Other sources of air pollution include the following:

- Carbon monoxide (CO) is often released by faulty vents and chimneys or by the burning of charcoal indoors.
- Problems with plumbing can release of sewer gas and hydrogen sulfide.
- Dry cleaning fluids, such as tetrachloroethylene, can be released from clothing days after dry cleaning.
- The use of asbestos in factories and in homes in the past has left a very dangerous material in many buildings (**Figure** 9.5). Asbestos can cause cancer and other lung diseases.

Biological sources of air pollution are also found indoors. These are produced from:

- Pet dander.
- Dust from tiny skin flakes and decomposed hair.
- Dust mites.
- Mold from walls, ceilings, and other structures.
- Air conditioning systems can incubate certain bacteria and mold.
- Pollen, dust, and mold from houseplants, soil, and surrounding gardens.

Health Hazards of Air Pollution

The World Health Organization (WHO) reports that 2.4 million people die each year from causes directly related to air pollution. 1.5 million of these deaths are caused by indoor sources. Worldwide, there are more deaths linked to air pollution per year than to car accidents. Research by WHO also shows that the worst air quality is in countries with high poverty and population rates, such as Egypt, Sudan, Mongolia, and Indonesia.

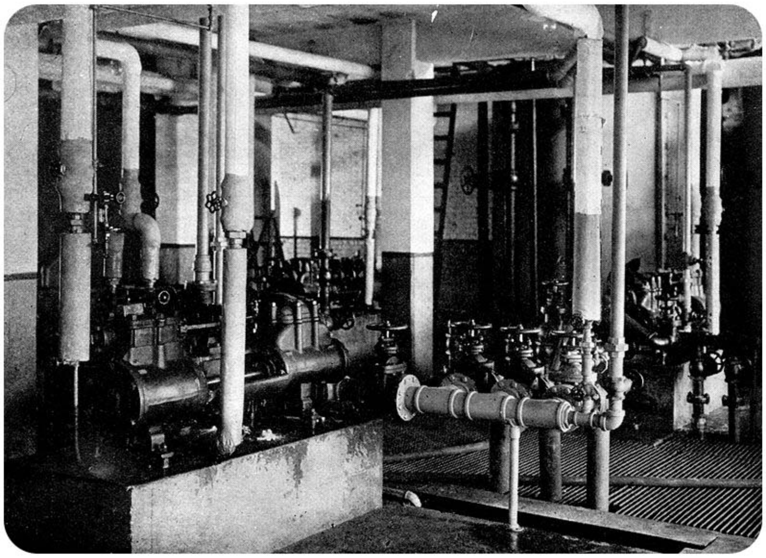

FIGURE 9.5
The use of asbestos in industry and domestic environments in the past, as in the asbestos-covered pipes in the oil-refining plant pictured here, has left a potentially very dangerous material in many businesses.

Direct causes of air-pollution related deaths include:

- Asthma.
- Bronchitis.
- Emphysema.
- Lung and heart diseases.
- Respiratory allergies.

Certain respiratory conditions can be made worse in people who live closer to or in large cites. Some studies have shown that patients in urban areas suffer lower levels of lung function and more chronic bronchitis and emphysema. Air pollution can also cause an increase in cancer, eye problems, and other conditions. For example, use of certain agricultural herbicides and pesticides, such as DDT and PCBs, can all cause cancer.

Effects of Smog on Health

If you live in a city, you have seen smog. It is a low-hanging, fog-like cloud that seems to never leave the city. Smog is caused by coal burning, and by ozone produced by motor vehicle exhaust. Smog can cause eye irritation and respiratory problems. Carbon monoxide from motor vehicle exhaust and from charcoal burning indoors can also cause poisoning and deaths.

Protecting Yourself from Air Pollution

After reading the above sections, you may be confused as to where the air is healthier, outdoors or indoors. As for outdoor air pollution, if you hear in the news that the outdoor air quality is particularly bad, then it might make sense to wear a mask outdoors (**Figure** 9.6 or to stay indoors.

Because you have more control over your indoor air quality than the outdoor air quality, there are some simple steps you can take indoors to make sure the air quality is less polluted:

- Make sure that vents and chimneys are working properly, and never burn charcoal indoors.
- Carbon monoxide detectors can be placed in the home.

- Keep your home as clean as possible from pet dander, dust, dust mites, and mold.
- Make sure air conditioning systems are working properly

Are there any other ways you can think of to protect yourself from air pollution?

FIGURE 9.6
Many people take to wearing masks in public to help maintain their health.

Lesson Summary

- Outdoor air pollution can change the natural characteristics of the atmosphere and cause unwanted changes to the environment and to human health.
- There are two kinds of pollutants: primary and secondary pollutants.
- There are many sources of human-caused air pollution, the most common being the burning of fossil fuels.
- Outdoor air pollutants cause many environmental effects, among them global warming, global dimming, and ozone depletion.
- Indoor air pollutants are either chemical or biological in nature.
- Both outdoor and indoor pollutants cause many health problems, ranging from respiratory and cardiac to cancer, eye problems, and poisoning.
- While it is not always possible to protect yourself from poor air quality outdoors, there are a number of measures you can take to protect yourself from poor indoor air quality.

Review Questions

Recall

1. Define outdoor air pollution.

2. What is the difference between primary and secondary pollutants?

3. Give three examples of indoor air pollutants.

Apply Concepts

4. Most air pollutants can be traced to the burning of fossil fuels. What are the sources of some of these pollutants?
5. Why does deforestation increase the effects of global warming?
6. Explain why one of the environmental effects of global dimming may result in less food at all trophic levels.
7. Name two environmental effects of ozone depletion.
8. Give an example of air pollutant and explain why is it bad for human health.

Critical Thinking

9. Even though we have a hole in the ozone layer of the atmosphere, why is it ozone still considered a pollutant?

Further Reading / Supplemental Links

- Unabridged Dictionary, Second Edition, Random House, New York, 1998.
- http://www.epa.gov/acidrain/education/site_students/
- http://www.koshlandscience.org/exhibitgcc/index.jsp

Points to Consider

- One of the effects of outdoor air pollution is to cause global warming. How do the effects of global warming affect water pollution?
- How do outdoor air pollutants cause acid rain?

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3. . MSLS-25-03-acid-rain-effects.
4. . MSLS-25-04-mexico-deforestation.
5. . MSLS-25-05-asbestos.
6. . MSLS-25-06-Masks.

CHAPTER 10 Water Pollution and Waste

Lesson Objectives

- Describe water pollution sources.
- Explain how water pollution affects living organisms.
- Discuss how to prevent water pollution.
- Discuss ways you can save water

Check your Understanding

- What are water resources?
- What is the demand for water?
- What are the sources of fresh water?

Vocabulary

- algal bloom
- ocean acidification
- waterborne diseases
- water pollution

Sources of Water Pollution

While water may seem limitless and everywhere, it is actually a limited resource. A limited resource is one that we use faster than we can remake it. Unpolluted water is even harder to find (**Figure** 10.1).

FIGURE 10.1
Water pollution can cause harmful effects to ecology and human health.

Water pollution happens when contaminants enter water bodies. Contaminants are any substances that harm the health of the environment or humans. Most contaminants enter the water because of humans.

Natural events, like storms, algal blooms, volcanoes, and earthquakes can cause major changes in water quality. But human-caused contaminants have a much greater impact on the quality of the water supply. Water is considered polluted either when it does not support a human use, like clean drinking water, or a use for other animals and plants.

The main sources of water pollution can be grouped into two categories:

- Point source pollution results from the contaminants that enter a waterway or water body through a single site. Examples of this include untreated sewage, wastewater from a sewage treatment plant, and leaking underground tanks.
- Nonpoint source pollution is contamination that does not come from a single point source. Instead, it happens when there is a buildup of small amounts of contaminants that collect from a large area. Examples of this include fertilizer runoff from farms into groundwater or streams.

Specific contaminants causing water pollution include different types of chemicals and pathogens. A small amount of any chemical may not be toxic, but large amount of chemicals in a waterway can cause a lot of damage.

Effects of Water Pollution on Living Things

Water pollutants can have an effect on both the ecology of ecosystems and on human health.

Pollution Problem: Eutrophication

Eutrophication is an increase in chemical nutrients, specifically compounds containing nitrogen or phosphorus, in an ecosystem. It occurs when run-off from lawn or farm fertilizers gets into natural waters, such as rivers or coastal waters.

Since there are such high levels of plant nutrients in the water, algae will grow, forming **algal blooms**. The algae grows so large and so fast that when it dies, it sucks the oxygen out of the water. Without oxygen, fish and shellfish cannot live (**Figure** 10.2).

As a result, humans cannot use the waterway for recreation, fishing or hunting. Drinking water can be affected if the toxic water enters the groundwater. Toxins created during the algal bloom can enter shellfish. If humans eat these shellfish, then they can get shellfish poisoning. This can cause neurological problems in humans.

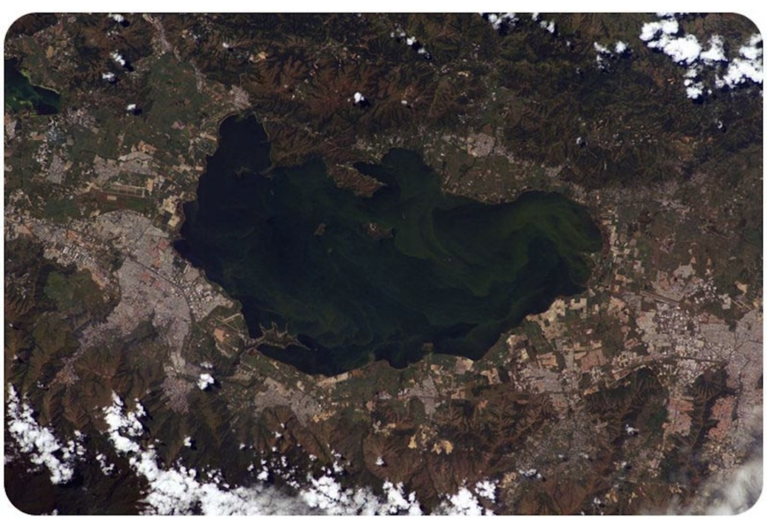

FIGURE 10.2
Lake Valencia, Venezuela, showing green algal blooms. How did the algal bloom form? What will it do to the lake over time?

Pollution Problem: Ocean Acidification

Ocean acidification occurs when carbon dioxide released by human factories into the atmosphere causes the oceans to become acidic. Burning fossil fuels leads to an increase in carbon dioxide into the atmosphere. This carbon dioxide is then absorbed by the oceans.

Ocean acidification can kill corals and shellfish. It may also cause marine organisms to reproduce less, which could harm other organisms in the food chain. As a result, there may be fewer marine organisms that humans consume.

Pollution Problem: Aquatic Debris

Aquatic debris is trash that gets into fresh and saltwater waterways. It comes from shipping accidents, landfill erosion, or the dumping of trash.

Debris can be very dangerous to aquatic wildlife. Some may swallow plastic bags, while other organisms can be strangled by plastic six-pack rings. Wildlife can also get tangled in nets (**Figure** 10.3). This may decreases the amount of fish available for human consumption.

FIGURE 10.3
Marine trash can harm different types of aquatic life. Pictured here is a marine turtle entangled in a net. How can you keep this from happening?

According to the World Health Organization (WHO), diarrheal disease is responsible for the deaths of 1.8 million people every year. It was estimated that 88% of cases of diarrheal disease are caused by unsafe water supply. Such **waterborne diseases** can be caused by protozoa, viruses, bacteria, and intestinal parasites. Protozoal infections can be caused by sewage, non-treated drinking water, animal manure, poor disinfection, and groundwater contamination.

Preventing Water Pollution

In the U.S., concern over water pollution resulted in the enactment of state anti-pollution laws in the latter half of the 1800s, and federal legislation in 1899. The laws prohibit the disposal of any waste into the nation's rivers, lakes, streams, and other bodies of water, unless a person first had a permit. In 1948, the Water Pollution Control Act was passed and gave power to the Surgeon General to reduce water pollution. Growing public awareness and concern for controlling water pollutants led to enactment of the Federal Water Pollution Control Act Amendments of 1972, also known as the Clean Water Act. The Clean Water Act set water quality standards. It also limits the pollution that can enter the waterways. Other countries are also actively preventing water pollution and purifying water (**Figure** 10.4).

FIGURE 10.4
A water purification system at Bret Lake, Switzerland. Contaminants are removed to make clean water.

Ways to Save Water

Saving water can help make sure we have clean water for future use. Preventing water pollution is one way of saving precious water resources. One way to make sure that water is kept clean and conserved is the use of wastewater reuse or cycling systems. This means that wastewater can be purified at a water treatment plant (**Figure** 10.5). When wastewater is recycled, waterborne diseases caused by sewage and non-treated drinking water can be prevented.

There are various means of removing contaminants from water. Atmospheric water generation is one technology that can provide high quality drinking water. It involves extracting water from the air by cooling the air and turning it back into a liquid.

FIGURE 10.5
Sand processing mill near Provodin, Czech Republic. Water is used to wash mined sand, then is drained into tanks, filtered, and recycled.

Both developed and developing countries can increase protection of ecosystems, especially wetlands, in order to save clean water.

What are some ways you can save water in your own house or community in order to increase the resource of clean water, to be made available to everyone?

Lesson Summary

- There are two primary sources of water pollution, point sources and nonpoint sources.
- Specific contaminants causing water pollution include chemicals and pathogens.
- Water pollution can affect both ecology and human health.
- One effect of water pollution is eutrophication, which can harm aquatic ecosystems as well as on human life, including health.
- Water pollution also causes ocean acidification.
- Contaminated groundwater can lead to poisoned drinking water and various health problems, including cancer.
- A variety of water pollutants can cause waterborne diseases.
- Various legislation has regulated contaminants entering into water resources.
- Different ways of saving water can also have an impact on our clean water supply.

Review Questions

Recall

1. When is water considered polluted?

2. What is point source pollution?

3. Name some sources of nonpoint source pollution.

4. Name some sources of pollutants that can cause waterborne diseases.

Apply Concepts

5. Why are nonpoint sources of pollution so difficult to regulate?

6. Why might floating plastic debris be a problem for marine life?

7. What can you do to save clean water?

Critical Thinking

8. Lakes often become polluted when sewage plants release phosphorous into the water. By what process would the release of phosphorus affect a lake's plant growth? How could this affect water quality and fish and shellfish populations?

Further Reading / Supplemental Links

- http://www.cdli.ca/CITE/water.htm
- http://en.wikipedia.org

Points to Consider

- Even though water is a renewable resource, there is not always availability of clean water. Control of water pollution, such as removal of phosphorus or creating buffer zones near farms, helps to preserve this renewable resource for the future.

- Methods such as wastewater reuse, atmospheric water generation, reclaiming water, catchment management, and protection of aquatic systems can all contribute towards the dual goals of keeping water clean and also available for future generations.

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3. . MSLS-25-09-marine-trash.
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CHAPTER 11 Natural Resources

Lesson Objectives

- Define natural resource.
- Describe renewable resources.
- Define nonrenewable resource.
- Discuss the use of fossil fuels as an energy source.
- List alternative uses to fossil fuels.
- Discuss how reducing, reusing, and recycling can help conserve resources.

Check your Understanding

- What are our natural resources?
- What is the difference between a renewable and nonrenewable resource?

Vocabulary

- erosion
- hydropower
- natural resources
- nonrenewable resource
- nuclear power
- recycling
- reducing
- renewable resources
- solar power
- wind power

What are Natural Resources?

A **natural resource** is a naturally occurring substance that is necessary for the support of life. What resources do you use on a daily basis? You may think of air and water. What else is absolutely necessary to your survival? The food you eat. Can you survive with just air, water, and food? Are other resources, like the land you live on, the house you live in, the gasoline your parents put in the car and the tools you use at home or at school resources, too? Yes.

Renewable Resources

A resource is *renewable* if it is remade by natural processes at the same rate that humans use it up. Sunlight and wind are **renewable resources** because they will not be used up (**Figure** 11.1 and **Figure** don't purge me). Tides are another example of a resource in unlimited supply.

Based on what you learned in the last two lessons, would you say air and water are renewable resources? Your knowledge about air and water pollution would tell you that clean air and water are not always available.

Soils are often considered renewable, but **erosion** sometimes makes it nonrenewable. Erosion occurs when the nutrient-rich top levels of soil are removed because of wind or bad farming techniques (**Figure** 11.3).

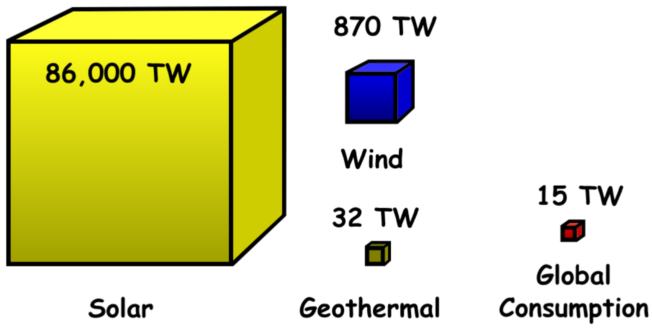

FIGURE 11.1
The figure shows you how much of each type of energy source is used worldwide. TW stands for terrawatt, which is a very large unit for measuring energy. Solar radiation and wind energy are considered renewable resources because both can be created just as fast as we use them.

FIGURE 11.2
Wind power, another renewable resource, shown here in a modern wind energy plant.

Living things, like forests and fish, are considered renewable because they can reproduce to replace individuals lost to human consumption. But over-using these resources can lead to species extinction.

Also, metals and other minerals are sometimes considered renewable because they can be recycled.

If something can be renewed, but at great cost economically or ecologically, should that resource still be considered renewable?

For example, energy resources from living things, such as ethanol, plant oils, and methane, are called renewable. But these can have harmful effects on the environment. For example, too much methane in the atmosphere can increase global warming.

Sustainable means that a resource is used in a way that meets the needs of the present without keeping future generations from meeting their needs. People can sustainably harvest wood, cork, and bamboo. Farmers can also grow crops sustainably by not planting the same crop in their soil year after year. Planting the same crop can suck all of the nutrients out of a soil.

FIGURE 11.3
Soil as a resource, showing a mixture of eroded rock, minerals, ions, water, air, roots, fungi, animals, and microorganisms, formed over thousands or possibly millions of years.

Nonrenewable Resources

A **nonrenewable resource** is a natural resource that is consumed or used up faster than it can be made by nature. Two main types of nonrenewable resources are fossil fuels and nuclear power.

- Fossil fuels, such as petroleum, coal, and natural gas, formed from plant and animal remains over periods from 50 to 350 million years ago! It has been estimated that 20 metric tons of phytoplankton produce one liter of gasoline. Humans save been consuming fossil fuels for less than 200 years, yet remaining reserves of oil can supply our needs for only 45 years. Gas can only supply us for another 72 years. Coal can only supply us for 252 years.

- **Nuclear power** is power developed from atoms in certain elements, such as uranium. Currently, there are limited uranium fuel supplies, which will last about 70 years at current rates of use. New technologies could make some uranium fuel reserves more useful.

Population growth, especially in developing countries, should make us think about how fast we are consuming resources. Developing nations will also increase demands on natural resources as they build more factories (**Figure** 11.4).

Improvements in technology, conservation of resources, and controls in population growth could all help to decrease the demand on natural resources.

Fossil Fuels and Alternative Energy Sources

As you learned in the section on nonrenewable resources, fossil fuels are non-renewable resources. They take millions of years to form naturally, and cannot be replaced as fast as they are consumed.

It was estimated in 2005 that 86% of energy produced in the world came from burning fossil fuels. Wars have been fought over fossil fuels like oil. Producing and burning fossil fuels also harms the environment.

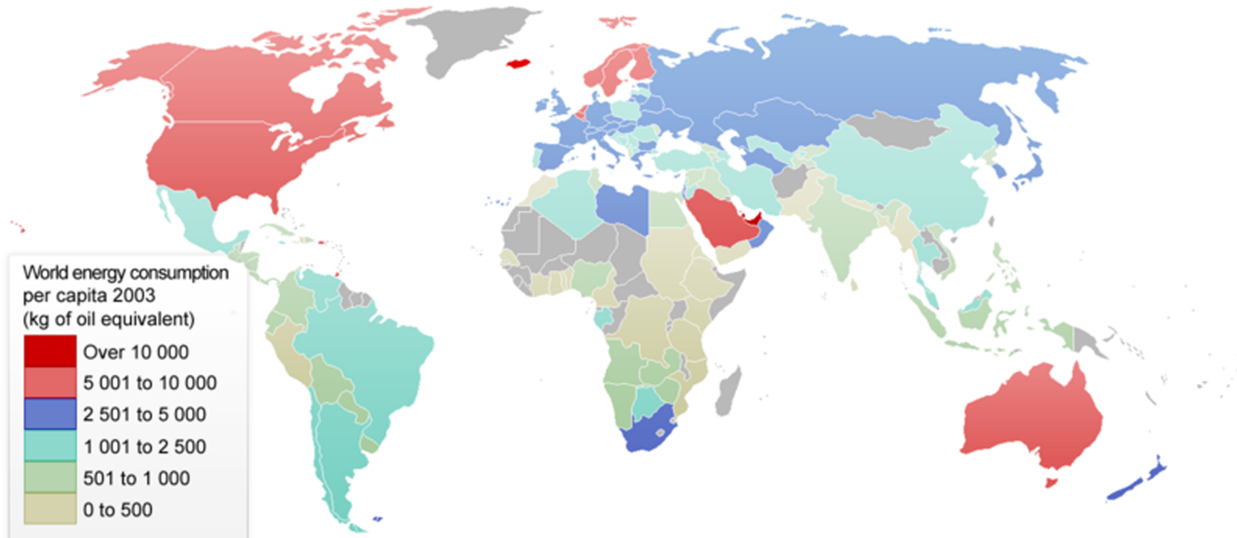

FIGURE 11.4
Per capita energy consumption (2003) shows the unequal distribution of wealth, technology, and energy use.

Alternative energy resources are being developed so we do not need to be dependent on fossil fuels anymore. Below are examples of sustainable alternative energy resources:

- **Solar power** uses solar cells to turn sunlight into electricity (**Figure** 11.5). The electricity can be used to power anything that uses normal coal-generated electricity.

FIGURE 11.5
An example of solar power, using solar cells to convert sunlight into electricity.

- **Wind power** uses windmills to transform wind energy into electricity. It is used for less than 1% of the world's energy needs. But wind energy is growing fast. Every year, 30% more wind energy is used to create electricity.

- **Hydropower** (**Figure** 11.6) uses the energy of moving water to turn turbines (similar to windmills) or water wheels, that create electricity. This form of energy produces no waste or pollution. It is a renewable resource.

FIGURE 11.6
Small hydropower plant, Buchholz, Switzerland.

Other alternative energy sources to the burning of fossil fuels include geothermal power, biomass biofuels, tidal power, nuclear energy, and fusion power. Let's examine these briefly to see how they compare with the sources of energy we've already discussed.

- Geothermal power uses the natural flow of heat from the earth's core to produce steam. This steam is used to turn turbines which create electricity.

- Biomass production involves using garbage or other renewable resources, like corn, to create electricity. When garbage decomposes, the methane produced is captured in pipes and burned to produce electricity. Wastes from agriculture could also be recycled. Biomass is generally renewable.

- Tides in the ocean can also turn a turbine to create electricity. This energy can then be stored until needed (**Figure** 11.7).

- Nuclear power plants use nuclear energy (fission) to create energy inside of a nuclear reactor. The nuclear reactor releases heat. The released heat, heats water to create steam, which spins a turbine. Again, the spinning turbine creates electricity (**Figure** 11.8).

What type of alternative energy source do you think is the most interesting? Which type should we use instead of fossil fuels?

Reduce, Reuse, and Recycle

You may have heard people say "Reduce, Reuse, Recycle." But what do each one of those words mean?

Reducing means decreasing the amount of waste we create. That could also mean cutting down on use of natural resources. Minimizing of waste may be difficult to achieve for individuals and households, but here are some starting points that you can include in your daily routine:

FIGURE 11.7
Dam of the tidal power plant in the Rance River, Bretagne, France

FIGURE 11.8
Aerial photo of the Bruce Nuclear Generating Station near Kincardine, Ontario

- When you go shopping for items, buy quantities you know you will use without waste.
- Turn lights off when not using them.
- Replace burned out bulbs with ones that are more energy-efficient.
- Reduce water use by turning off faucets when not using water.
- Use low-flow shower heads, which save on water and use less energy.
- Use low-flush and composting toilets.
- Put kitchen and garden waste into a compost pile.
- In the summer, change filters on your air conditioner and use as little air conditioning as possible.
- n winter, make sure your furnace is working properly and make sure there is enough insulation on windows and doors.
- Mend broken or worn items instead of buying new ones.
- Walk or bicycle instead of using an automobile, in order to save on fuel costs and to cut down on pollution.

- When buying a new vehicle, check into hybrid and semi-hybrid brands to cut down on gas mileage and pollution.

Let's now look at what we can reuse. Reusing includes using the same item again for the same function and also using an item again for a new function. Reuse can have both economic and environmental benefits. New packaging regulations are helping society to move towards these goals.

Some ways of reusing resources include:

- Use gray water. Water that has been used for laundry, for example, can be used to water the garden or flush toilets.
- At the town level, purified sewage water can be used for fountains, watering public parks or golf courses, fire fighting, and irrigating crops.
- Catching rain or runoff in rain barrels next to buildings.

What are some other ways to reuse resources?

Now we move on to **recycling.** Sometimes it may be difficult to understand the differences between reusing and recycling.

Recycling means taking a used item, breaking it down, and reusing the pieces. Even though recycling requires extra energy, it does often make use of items which are broken, worn out, or cannot be reused.

The things that are commonly recycled include:

- Concrete.
- Batteries.
- Biodegradable waste.
- Electronics.
- Iron and steel.
- Aluminum (**Figure** 11.9).
- Glass.
- Paper.
- Plastic.
- Textiles, such as clothing.
- Timber.
- Old ships.
- Tires.

Each type of recyclable requires a different recycling technique.

Here are some things you can do to recycle in your home, school, or community:

- If you have recycling in your community, make sure you separate out your plastics, glass, and paper if you need to.
- See if your school recycles. If not, you and some friends could start a recycling club, or organize efforts to better recycling goals

The amount that an individual wastes is small in proportion to all the waste produced by society. Yet all small contributions, when added up, make a difference. But that also means that laws need to be created to make sure people and companies reduce, reuse, and recycle. Individuals can vote for leaders who stand for sustainable and ecological practices. They can also tell their leaders to make wise use of natural resources

You can also influence companies. If you and your family only buy from companies and restaurants that support recycling or eco-friendly packaging, then other companies will also change to be more environmentally friendly.

FIGURE 11.9
These aluminum cans are packed together in a recycling plant to be reused.

Lesson Summary

- A natural resource is a naturally occurring substance that is necessary for the support of life.
- Resources are either renewable or nonrenewable.
- Examples of renewable resources include sunlight and wind tides.
- Nonrenewable resources include fossil fuels and nuclear power.
- Burning of fossil fuels causes harmful effects in the environment and can lead to war.
- There are a number of renewable energy sources which offer alternatives to the burning of fossil fuels. They include solar radiation, wind energy, and hydropower.
- Reducing waste, as well as reusing and recycling resources, can help save natural resources.
- There are many things you can do in your household and community to reduce, reuse, and recycle.
- Consumers can influence companies to become more environmentally friendly.
- Individuals can tell their leaders to make wise use of natural resources, and to vote for those leaders who stand for sound ecological practices.

Review Questions

Recall

1. Define renewable resource.

2. Give two examples of nonrenewable resources.

3. Why is nuclear power considered a nonrenewable resource?

Apply Concepts

4. Why must some natural renewable resources, such as geothermal power, fresh water, timber, and biomass be used carefully?

5. What human activities put increasing pressure on how fast we consume such resources?

6. What are the main disadvantages to the burning of fossil fuels as an energy source?

7. What two advantages do solar power, wind power, and hydropower all have in common?

Critical Thinking

8. Pick one renewable or alternative energy resource. Explain to your mayor why you think it would be good for your community to invest in this natural resource.

Further Reading / Supplemental Links

- http://dnr.state.il.us/lands/education/index.htm
- http://www.nrcs.usda.gov/feature/education/squirm/skworm.html
- http://fossil.energy.gov/education/energylessons/index.html
- http://en.wikipedia.org/wiki/Water_conservation

Points to Consider

- Why do you think it is important to protect natural habitats?
- Discuss how the protection of natural resources may be important for biodiversity.

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7. . MSLS-25-18-tidal-power-plant.
8. . MSLS-25-19-nuclear-generating-station.
9. . MSLS-25-20-Recycling.

Chapter 12 Habitat Destruction and Extinction

Lesson Objectives

- Discuss what causes destruction of habitats.
- Explain why habitat destruction threatens species.
- Describe causes of extinction other than habitat destruction.
- Explain why biodiversity is important.
- Explain why habitat protection is important, including for maintaining biodiversity.

Check your Understanding

- What is a habitat?
- What is habitat destruction?
- What is the effect of habitat destruction?
- What is biodiversity?

Vocabulary

- biodiversity
- desertification
- extinction
- invasive species
- slash-and-burn agriculture

The Importance of Biodiversity

Some of the importance of biodiversity is shown in the following three figures (**Figure** 12.1, **Figure** 12.2, and **Figure** 12.3). In this lesson you will read about habitat destruction and the impact of this destruction on biodiversity. **Biodiversity** is a measurement of the amount of variation of the species in a given area.

Causes of Habitat Destruction

From a human point of view, a habitat is the environment where you live, go to school, go to have fun, and regularly visit. A habitat is the natural home or environment of an organism. Humans often cause habitat destruction for other organisms. Humans cause habitat destruction by land clearing (**Figure** 12.4) and by the introduction of non-native species of plants and animals. Habitat destruction can cause the extinction of species (**Figure** 12.5). **Extinction** is the complete disappearance of a species. Once a species is extinct, it can never recover.

Land Loss

Clearing habitats of plants for agriculture and development is a major cause of destruction. Within the past 100 years, the amount of total land used for agriculture has almost doubled. Land for the grazing of cattle has more than doubled.

FIGURE 12.1
A sampling of some of the wide diversity of animal species on earth.

FIGURE 12.2
Coral reefs are one of the biomes with the highest biodiversity on earth.

FIGURE 12.3
This tropical rain forest shows another biome having one of the greatest biodiversities on earth.

FIGURE 12.4
Slash-and-burn agriculture, shown here in southern Mexico, clears land for agriculture.

Agriculture alone has cost the United States half of its wetlands (**Figure** 12.6) and almost all of its tallgrass prairies (**Figure** 12.7). Native prairie ecosystems, with their thick fertile soils, deep-rooted grasses, diversity of colorful flowers, burrowing prairie dogs, and herds of bison and other animals, have virtually disappeared (**Figure** 12.8).

Slash-and-Burn Agriculture

Other habitats that are being rapidly destroyed are forests, especially tropical rainforests. The rainforest is one of the two major ecosystems with the greatest biodiversity on earth. The largest cause of deforestation today is **slash-and-burn agriculture** (**Figure** 12.4). This means that when people want to turn a forest into a farm, they cut down all of the trees and then burn them. This technique is used by over 200 million people in tropical forests throughout

FIGURE 12.5
An exotic species, the brown tree snake, hitchhiked on an aircraft to the Pacific Islands, causing the extinctions of many bird and mammal species which had evolved in the absence of predators.

FIGURE 12.6
Wetlands such as this one in Cape May, New Jersey, filter water and protect coastal lands from storms and floods.

the world.

These people use the soil very quickly, so nutrients are lost. This often results in people abandoning the forest within a few years. The abandonment can cause erosion and lead to desertification. **Desertification** turns forest into a desert, where it is difficult for plants to grow. Half of the earth's mature tropical forests are gone. At current rates of deforestation, all tropical forests will be gone by 2090.

Non-native Species

One of the main causes of extinction is introduction of exotic species into an environment. These exotic and new species can also be called **invasive species**. Invasive species out-compete the native species for resources. Sometimes native species are so successful at living in a certain habitat that the native species go extinct.

Recently, cargo ships have transported zebra mussels, spiny waterfleas, and ruffe (a freshwater fish) into the Great Lakes (**Figure** 12.9). These invasive species are better at hunting for food. They have caused some of the native species to go extinct.

FIGURE 12.7
Big bluestem grasses as tall as a human were one of the species of the tallgrass prairie, largely destroyed by agricultural use.

FIGURE 12.8
Herds of bison also made up part of the tallgrass prairie community.

Invasive species can disrupt food chains, carry disease, prey on native species directly, and out-compete native species for limited resources, like food. All of these effects can lead to extinction of the native species.

Other causes of habitat destruction include poor fire management, overfishing, mining (**Figure** 12.10), pollution, and storm damage.

Examples of Habitat Destruction

Wetlands

A habitat that is quickly being destroyed is the wetland. By the 1980s, over 80% of all wetlands in seven states of the U.S. were destroyed. In Europe, many wetland species have gone extinct. For example, many bogs in Scotland have been lost because of human development. Over half of the Portlethen moss in Aberdeenshire, for example, has been lost. A number of species, such as the great crested newt, have gone extinct.

FIGURE 12.9
These zebra mussels, an invasive species, live on most man-made and natural surfaces. Here they have infested the walls of the Arthur V. Ormond Lock on the Arkansas River. They have caused significant damage to American waterways, locks, and power plants.

FIGURE 12.10
Strip coal mining, pictured here, has destroyed the entire ecosystem.

Another example of species loss due to habitat destruction happened on Madagascar's central highland plateau. From 1970 to 2000, slash-and-burn agriculture destroyed about 10% of the country's total native plants. The area turned into a wasteland. Soil from erosion entered the waterways. Much of the river ecosystems of several large rivers were also destroyed. Several fish species are almost extinct. Also, some coral reef formations in the Indian Ocean are completely lost.

Other Causes of Extinction

Global Warming

Another major cause of extinction is global climate change. As we have already seen earlier in this chapter, our increasing need for coal and oil is changing the earth's climate. Any change in the climate can destroy the habitat of a species. For example, if the seas increase in temperature, it may be too warm for certain types of fish to reproduce.

Overpopulation

Human populations are on the rise. The highest population growth rates are often in developing tropical countries. These countries are also where biodiversity is highest. Development by humans can cause habitats to be destroyed. This destruction can force species to go extinct, or move somewhere else.

Pollution

Pollution adds chemicals, noise, heat, or even light to an environment. This can have many different harmful effects on all kinds of organisms. For example, the pesticide DDT destroyed the habitat of the peregrine falcon. The pesticide collected in organisms low on the food chain. When organisms high on the food chain started to consume the organisms that contained the chemical, they started to die. This caused the disappearance of the peregrine falcon from this area. DDT was then banned in the U.S.

Water pollution threatens vital freshwater and marine resources throughout the world (**Figure** 12.11). Specifically, industrial and agricultural chemicals, waste, acid rain, and global warming threaten water. As water is essential for all ecosystems, water pollution can result in extinction.

FIGURE 12.11
An oiled bird from an oil spill in San Francisco Bay. About 58,000 gallons of oil spilled from a South Korea-bound container ship when it struck a tower supporting the San Francisco-Oakland Bay Bridge in dense fog in November, 2007.

Finally, soil contamination can also result in extinction. Soil contamination can come from toxic industrial and municipal wastes (**Figure** 12.12), salts from irrigation, and pesticides from agriculture. These all degrade the soil as well. As soil is the foundation of terrestrial ecosystems and their biodiversity, this can result in extinction.

Importance of Biodiversity

Does it matter if we are losing thousands of species each year? The answer is yes. It matters even if we consider only direct benefits to humans. But there are many benefits to ecosystems.

FIGURE 12.12
Soil contamination caused by underground storage tanks containing tar.

Economic Importance

Economically, there are many direct benefits of biodiversity. In our food supply, when we grow one type of crop on large areas of farmland, it is called a monoculture. Unfortunately, when a certain type of crop is grown year after year, it becomes more likely to develop disease. Agriculture benefits from biodiversity. In 1970, a disease almost wiped out 80% of corn grown in the U.S. (**Figure** 12.13). This would not have happened if there was a diversity of corn being grown. Certain species of corn would have contracted the disease, while others would not have contracted it.

FIGURE 12.13
In order to increase the genetic diversity of corn, these unusually colored and shaped Latin American maize are bred with domestic corn lines. Such hybrids may have increased resistance to local diseases.

As many as 40,000 species of fungi, plants, and animals provide us with many varied types of clothing, shelter, and other products. These include poisons, timber, fibers, fragrances, papers, silks, dyes, adhesives, rubber, resins, skins, furs, and more. According to one survey, 57% of the most important prescription drugs come from nature. Specifically, they come from bacteria, fungi, plants, and animals. (**Figure** 12.14). But only a small amount of species with the ability to give us medicines have been explored. The loss of any species may mean the loss of new medicines.

Bionics, also known as biomimetics or biomimicry, uses organisms to inspire technology or engineering projects. For example, rattlesnake heat-sensing pits helped inspire the development of infrared sensors. Zimbabwe's Eastgate Centre (**Figure** 12.15) was inspired by the air-conditioning efficiency of a termite mound (**Figure** 12.16).

FIGURE 12.14
Aspirin comes from the bark of the white willow, pictured here.

FIGURE 12.15
Design of the Eastgate Centre, in Zimbabwe, which requires just 10% of the energy needed for a conventional building of the same size, was inspired by a biological design.

Ecological Importance

At an ecological level, biodiversity has many benefits. Biodiversity makes ecosystems more stable. Biodiversity helps keep the nutrients in the soil. For example, a diversity of organisms in the soil allows nitrogen fixation and nutrient recycling to happen. Biodiversity allows plants to be pollinated by different types of insects. Also, different

FIGURE 12.16
The air-conditioning efficiency of this termite mound was the inspiration for the Eastgate Centre.

species of fungi are necessary to recycle wastes from dead plants and animals. These are just a few of the many examples of how biodiversity is important for ecosystems.

Biodiversity is critically important for us and for the earth. What can you do to help protect habitats?

Protecting Habitats

There are lots of things we can do to protect biodiversity:

- Reduce, reuse, and recycle all resources.
- Do not introduce invasive species.
- Practice sustainable development of land.
- Learn more about biodiversity and its importance.
- Vote for lawmakers who make sure biodiversity is protected.

You can also support areas that protect habitats, like national parks, nature reserves, state parks, and even community and town parks.

Think about sustainable management even at the level of your own backyard. What does your household do with organic waste? Do you have a compost pile, or would you or your family consider starting one? What kinds of trees and shrubs are planted in your yard? Are they native or invasive species? Are they drought-tolerant?

Research some of the vegetation you can plant that will attract native bird, mammal, and other species. Put out bird feeders, especially in the winter in areas where birds may have trouble finding food.

Remember that in addition to all the actions you can take, learning about biodiversity and ecology is an important part of valuing and protecting the diversity of life. Pass on what you learn to others.

Lesson Summary

- There are a number of causes of habitat destruction, including clearing of land, introduction of invasive species, overfishing, mining, pollution, and storm damage.
- Some habitats affected by destruction include tropical rainforests, wetlands, and coral reefs.
- Biodiversity is important because it directly benefits humans and ecosystems.

- Because of the importance of biodiversity and habitats, it is important that we do what we can as citizens to protect habitats.

Review Questions

Recall

1. What are two major causes of habitat destruction?
2. What is the largest cause of deforestation today?

Apply Concepts

3. How can habitat destruction through pollution kill a species over a long period of time?
4. Why do introduced exotic species have unexpected and negative effects in the new ecosystems?
5. Why is it important to grow different species of the same type of plant?
6. What are some of the things you can do to have a sustainably managed backyard?

Critical Thinking

7. Explain how biological magnification played a role in the disappearance of the peregrine falcon from the eastern U.S.

8. Pick an environment near where you live that is a natural ecosystem (like a wetland or other area). Explain to a law-maker why it is important to maintain biodiversity in that particular environment.

Further Reading / Supplemental Links

- http://www.epa.gov/owow/oceans/kids.html
- http://ology.amnh.org/biodiversity
- http://www.biodiversity911.org
- http://en.wikipedia.org

Points to Consider

- Global warming and climate change are frequently in the news these days, with reports of glaciers melting, and possible effects on species, such as the polar bear. Keep aware of these news trends and learn what you can about what species are becoming threatened.
- Our purchasing decisions may affect biodiversity: be more aware of the natural resources used to make and transport any product you buy; Buy recycled products whenever possible; when you buy fish for food, check to be sure that commercial species are not from overharvested areas.

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