BIOMES OF THE WORLD

Introduction :

The movement of matter and flow of energy are common to all ecosystems on Earth. Yet Earth is a very large and diverse place. Environments range from the ice of Antarctica to the heat and rain of the Amazon. Differences in temperature and rainfall create a vast array of conditions on the surface of Earth. Life has adapted to almost all of these environments.

The ecosystems of Earth can be divided into several broad categories. *A major type of ecosystem with distinctive temperature, rainfall, and organisms is called a* **biome**. Biomes are either terrestrial (on land) or aquatic (in water). On land, the type of biome that occurs in a given area depends on the average temperature and amount of precipitation the area receives. The type of aquatic biome is determined by water depth, nutrients, and nearness to land.

The biome is the largest category scientists use to classify ecosystems. Because each biome is a general category, the conditions in a biome may vary from place to place. The many ecosystems within a biome have different habitats with different conditions and organisms. Every habitat on Earth is different, so any attempt to classify these habitats involves generalization. But the concept of the biome is useful as a way to talk about sets of related habitats.

All the biomes you have read about so far have had one thing in common. They are all land, or terrestrial, biomes. But land covers less than 30 percent of Earth's surface. With water covering so much of Earth, it is not surprising that many of Earth's organisms live in aquatic habitats. An *aquatic habitat* is one in which the organisms live in or on water. Aquatic biomes are not grouped geographically the way terrestrial biomes are, and it is difficult to show them on a map. Aquatic biomes and their ecosystems are scattered and are often determined by depth rather than location.

The characteristics used to describe aquatic biomes are different from those used to describe terrestrial biomes. Recall that temperature and rainfall and important factors in distinguishing one terrestrial biome from another. While these factors do have some effect, the temperature in large bodies of water

is more stable than the temperature on land. Also, rainfall has less effect on many aquatic biomes than on terrestrial biomes because the organisms are already underwater. For aquatic biomes, two of the most important factors are the amount of dissolved salts in the water and the depth of the water. The rate of flow and the amount of dissolved oxygen in the water are also important factors in determining the types of organisms that live in an aquatic ecosystem.

Aquatic biomes can be divided into two main groups, based on the amount of dissolved minerals in the water: saltwater and freshwater. Although all bodies of water contain some dissolved salts and other minerals, ocean water has a good deal more than the water in most lakes, ponds, and streams. *The amount of dissolved salts in a sample of water is called* **salinity**.

Salinity is measured in parts per thousand, or the number of units of salt in a thousand units of water. The salinity of ocean water is about 30 parts per thousand. The salinity of fresh water is 0.5 parts per thousand or less. Water that is more saline than fresh water, but less saline than ocean water, is called brackish water. Brackish water is common in areas such as river deltas and coastal marines, where fresh water meets the ocean.

The ecosystem present in a body of water, whether deep or shallow, is greatly influenced by the amount of sunlight that penetrates to the bottom. The amount of sunlight is important in determining the types and amounts of plants that can grow at various depths. As the producers in the ecosystem, plants form the base of the food web.

Bodies of water can be divided into depth zones. *The top layer of water, which receives sunlight, is called the* **photic zone**. The depth of the photic zone depends on how clear or cloudy the water is. In the open ocean, the photic zone is up to 200 m deep. Although sunlight reaches the bottom of the photic zone, the amount of light available decreases steadily as the depth increases. Below the photic zone is the aphotic zone. Sunlight never reaches the aphotic zone. Only the ocean and very deep lakes have aphotic zones.

The floor of a body of water is called the **benthic zone**. The benthic zone of the open ocean supports microscopic decomposes and scavengers. In shallow water, sunlight reaches the benthic zone and plants can grow. Common freshwater benthic animals include insect larvae, snails, catfish and turtles.

Standing-water ecosystems

Freshwater biomes can be divided into two main types – standing water ecosystems and flowing water ecosystems. Lakes and ponds are the most common types of standing water ecosystems. Standing water ecosystems also include many types of wetlands such as bogs, prairie potholes, swamps, and freshwater marshes.

Although there is little net flow of water in and out of most standing water ecosystems, there is usually a characteristic flow of water circulating through the system. This flow helps to distribute warmth, oxygen, and nutrients throughout the system.

Many standing water ecosystems have several levels of habitat. Organisms that live in the upper levels of water are different from those that live in the middle and bottom levels. The upper levels of the water are warmer and better sunlit than the lower levels.

The top level of a standing water ecosystem supports the plankton community. *Plankton* is a general term for organisms that drift in the water. Most freshwater planktons are about the size of dust particles. There are two main types of plankton: phytoplankton and zooplankton. *Planktons that carry out photosynthesis are called* **phytoplankton**. Although they are usually too small to see without a microscope, phytoplanktons are the main producers in most aquatic biomes.

Planktons that do not carry out photosynthesis are called **zooplankton**. Zooplanktons include microscopic animals and protests. Because zooplanktons are unable to carry out photosynthesis, they are consumers in the ecosystem. Zooplankton feed on phytoplankton. Small fish feed on plankton and insects on the surface of the water. Larger fish feed on smaller fish, and so on. As you can see, plankton are an essential part of the aquatic food web.

The benthic community of a standing-water ecosystem is quite different from the community at the surface. Many benthic organisms are scavengers, feeding on the remains of other organisms. This is particularly true of deep lakes, where sunlight does not reach the benthic zone. The benthic community depends on a steady rain of organic material that drifts down from the top. The decomposers of standing-water ecosystems are also members of the benthic community.

Wetlands

There is no single definition for wetlands that all scientists and government officials agree upon. As the name suggests, wetlands are found where water and land come together. *In general,* **wetlands** *are ecosystems in which the roots of plants are submerged under water at least part of the year*. Marshes, swamps, and bogs are just a few of the many types of wetlands. Wetland soils are soaked with water and contain very little dissolved oxygen. The water in most types of wetlands is standing water that may be fresh or brackish. However, there are also wetlands with flowing water and salt water.

Flowing-water ecosystems

Flowing freshwater environments have many names: *rivers, streams, creeks*, and *brooks* all refer to water that flows over land. To most people, the different names suggest bodies of water of different sizes. Even though they are under the ground, there is some life in aquifers. Some aquifers contain fish and other animals. In these cases, the aquifers are the animals habitats.

Stream Organisms

Organisms that live in flowing-water habitats are adapted to the rate of the water's movement. Some organisms such as insect larvae have hooks that enable them to grab hold of plants. Others have suckers that anchor them to rocks. One type of animals that has adapted to life in freshwater streams is the fish of the salmon and trout families. Salmon and related fish breed and grow in freshwater streams but spend their adult lives in the oceans. When the fish mature and are ready to breed, they swim upstream and return to the very same spot in which they hatched.

Major ocean zones based on their relationship to the shore

The Oceanic Zone

The open ocean, or **oceanic zone**, *is by far the largest zone in the ocean*. It occupies over 90 percent of the surface area of the world ocean. The oceanic zone is very deep, ranging from about 200 m along continental slopes to as deep as 11,000 m below the surface. Sunlight does not penetrate very deeply into the oceanic zone.

The photic zone accounts for a layer at the surface of the ocean up to 200 m deep. Therefore, the only producers of the open ocean ecosystem are phytoplankton. It may seem that microscopic planktons are

too small to support much life. But each year, the phytoplankton in the world ocean convert CO2 into billions of ions of organic carbon, the basic material of living tissue that forms the base of the food web. Within the photic zone, zooplankton feed on phytoplankton, and small fishes feed on both types of plankton. Planktons are a major food source for many larger animals of the oceanic zone as well. Despite their enormous size, baleen whales, such as the humpback whale feed primarily on plankton.

In terms of biomass, the aphotic zone of the open ocean can be thought of as the desert of the marine biome. Just as the lack of rain in the desert limits the number and types of organisms that live there, the absence of sunlight limits the diversity of the deep ocean. Deep ocean organisms have adapted to the cold, dark, deep waters. Many organisms in the deep ocean feed on pieces of dead organic material that drift down from the surface. *Tiny pieces of dead organic material that are food for organisms at the base of an aquatic food web are called* **detritus**. Benthic organisms that feed on detritus in many types of aquatic habitats include invertebrates such as clams, worms, and sponges.

Ocean Water

Although all the oceans of the world are connected, not all ocean waters have the same characteristics. Differences in the amount of energy received from the sun cause oceans in different parts of the world to vary in temperature, salinity, and density. Water near Earth's equator receives more energy from the sun than water elsewhere. This increased energy causes the water to be warmer and evaporate more rapidly in the tropics. As a result of the evaporation, the water in the ocean near the equator tends to be more saline and have a higher mineral content that average. In contrast, the ocean in the Polar Regions is fed by melting glaciers and polar ice. Because of the influx of frozen water, the ocean near the poles is less salty and colder than elsewhere. Low temperatures make the water near the poles denser than water elsewhere as well.

The water in the ocean flows in characteristics patterns called *ocean currents*. Although ocean currents vary somewhat during the year and from one year to the next, certain patterns are quite stable. Ocean currents are driven mostly by winds. Because of these currents, one mass of water can be very different from an adjacent mass. Fish and other ocean organisms often travel within specific water masses, following the pattern of currents over large distances.

Because of the vastness of the ocean, people have dumped various pollutants at sea for many years, believing that they would be diluted to safe levels. However, many pollutants can become concentrated in fish eaten by humans. The Ocean Dumping Act (1988) banned the disposal of industrial wastes at sea.

Neritic zones

The edges of continents do not drop suddenly into the ocean. Instead, the major landmasses are surrounded by an area of relatively shallow water. *The shallow border that surrounds the continents is called the* **continental shelf**. The continental shelf is the area between the shore and about 200 m below the surface of the water. The width of the continental shelf varies among the different continents and coasts.

The ocean region between the edge of the continental shelf and the low tidemark is called the **neritic zone**. Because the continental shelf is usually shallow enough to be within the photic zone, the waters in the neritic zone receive enough sunlight for photosynthesis to occur. Although the neritic zone accounts for only about 10 percent of the ocean, these shallow, warmer waters are the most productive part of the ocean. Two types of very productive neritic ecosystems are reefs and estuaries.

Coral Reefs

A **reef** *is a natural structure built on a continental shelf.* The structures are made from products of the reef organisms. Coral reefs are found in warm, tropical waters. Kelp forests, also called kelp beds, are common in colder waters.

Coral reefs can be thought of as the tropical rain forests of the marine biome. Coral reefs are not only productive ecosystems, as are rain forests, but are also home to a huge variety of organisms. The coral reef ecosystem is extremely important to both the ocean organisms and the human populations living near the reef. Coral reefs are the breeding and feeding grounds for many economically important types of fish. In fact, one-third of all bony fish live on or depend on coral reefs. The reef itself protects the shoreline from erosion. Like the species of the rain forests, many coral reef organisms may have medicinal value that has not yet been identified. And like the rain forests, the delicate coral reef ecosystems of the world are vulnerable to human activities.

The ecology of the coral reef is unique and fragile. The reef itself is made of the calcium carbonate skeletons of millions of tiny corals. Only the top layer of the reef is alive. Corals depend on a symbiotic relationship with a form of alga, called **zooxanthellae**, that lives inside the tissues of the coral. The algae carry out photosynthesis and provide corals with food. Like all photosynthetic organisms, the algae that live inside corals require an adequate amount of sunlight and cannot grow below a certain depth.

Human activities can harm coral reefs in many ways. The reef is often blasted with dynamite to make harbors and shipping channels. The coral itself is often harvested and sold for jewelry. Many of the bright, colorful fishes that inhabit coral reefs are popular for use in home aquariums. The methods used to collect the fish, however, can damage the reefs.

Estuaries

An **estuary** *is a region where a freshwater source, usually the mouth of a river, meets the salt water of the ocean.* Estuaries are subject to the rise and fall of ocean tides that mix the nutrient-rich waters and sediments. The water in estuaries is usually brackish, but the salinity varies with depth, time of year, flow rate, and tide. Many marine organisms, including commercially important food species, use estuaries as spawning grounds. Humans use estuaries for recreational activities, such as boating, hunting, and fishing. Estuaries function as important buffer zones, filtering sediments and pollutants from the water. They also ease the effects of storms and floods by showing the flow of water.

Terrestrial ecosystems

The **terrestrial ecosystems** of Earth can be divided into nine major biomes. Two of these biomes – the *desert* and the *tundra* – receive very little water and support only a small amount of biomass. Desert, for example, covers 25 percent of Earth's land surface but contains only 1 percent of Earth's biomass. The lack of water in the desert and in the tundra makes plant life scarce in these areas.

Forest biomes contain 75 percent of Earth's biomass. There are three forest biomes: the *coniferous forest*, the *deciduous forest*, and the *rain forest*. Forests receive abundant precipitation. Rain forest covers only 6 percent of Earth's land surface, but contains more than 50 percent of all Earth's biomass. The rainforest biome is also the most diverse biome. The destruction of the rain forests is a serious environmental problem.

Rain forests are found in tropical regions where there is abundant rainfall year-round. In some parts of the tropics, however, a rainy season is followed by a dry season. In these regions, a biome called tropical dry forest occurs. During the dry season, nearly all the trees drop their leaves to conserve water. Tropical dry forests are found in parts of Africa, South and Central America, Mexico, India, Australia, and tropical islands.

Another biome in which precipitation is highly seasonal is temperate woodland and shrubland. Regions in this biome have hot, dry summers and cool, rainy winters. Worldwide, there are only 5 areas of temperate woodland and shrubland: California, central Chile, the region around Cape Town, South Africa, southwestern Australia, and the lands bordering the Mediterranean Sea.

The landscapes of the temperate woodland shrubland biome are made up a mix of shrub communities and open woodlands. In California, for example, oak woodlands are interspersed with large areas of grasses and wildflowers such as poppies. Another type of community in this biome, called chaparral, is dominated by shrubs. Chaparral is made up of densely growing, low plants that contain flammable oils. Some of these plants are woody evergreen shrubs with small, leathery leaves. Others are fragrant oily herbs that grow during winter and die in summer. These plants, as well as the grasses of the open woodland, catch fire easily during the dry season. The plants, however, are adapted to recurrent fires. Some types of plants grow back quickly after the fires, while others have seeds that must be exposed to fire in order to germinate. Thus fire plays an important part in maintaining the ecosystems of this biome.

Some land areas cannot easily be classified as belonging to a particular biome. High mountains, for example, have lower temperatures and receive more precipitation that surrounding areas. For this reason, the plants and animals found in mountain regions can be quite different from those in nearby lowlands. In Earth's polar regions, life is largely absent from the thick icecaps that cover much of Greenland and Antarctica. But where there is exposed land, mosses and lichens can grow, and seabirds and mammals are abundant in coastal areas.

Desert biomes

Deserts in different parts of the world have different characteristics and are home to different organisms. All deserts have one thing in common, however. They all receive very little rain during the course of a year.

Desert soils tend to be rich in minerals but poor in organic material. *Rainwater moving through soil carries minerals deeper into the soil in a process called* **leaching**. Because deserts do not receive much rainfall, there is very little leaching of the soil. As a result, the upper layers of desert soil are rich in minerals. The dryness of a desert prevents many plants from living there. The lack of rainfall also slows the decay or organic material. Because decayed organic matter is an important part of topsoil, deserts do not have much topsoil.

Loose, dry desert soil is easily blown away by wind. *If the loose soil is removed, a lower layer of soil called* **pavement** becomes exposed. The pavement is the desert floor. The desert floor is made mostly of hard-baked sand, bare rock particles, or both.

Deserts can be divided into two main types: cool deserts and hot deserts. Cool and hot deserts result from variations in elevation and latitude that affect their winter and summer climates.

Deserts rarely get more than 25 cm of precipitation in any single year. The lack of precipitation in a desert determines the kinds of plants that can live in the region. Because plants are at the base of the food web, the types of plants determine the types of animals in the area as well. The lack of precipitation, therefore, is the limiting factor of the desert biome.

The lack of moisture also affects desert temperatures. Moisture in the atmosphere has a stabilizing effect on a region's temperature. It acts as a blanket over the ground, absorbing heat during the day and holding in the warmth at night. Because desert air contains so little moisture, temperatures can rise and fall dramatically, with very hot days followed by very cold nights.

Organisms that live in the desert are adapted to survive two challenges: lack of water and extreme temperatures. Some of the adaptations that enable organisms to live in the desert involve physical structures. Other adaptations involve behaviors. Although the challenge of living in the desert may seem great, deserts are actually species-rich, complex ecosystems.Plants that live in the desert must be able to absorb water from the ground. They must also prevent the loss of water from their tissues. The spines of a cactus are a familiar adaptation for preventing water loss. Cactus spines are actually the leaves of the plant. The spines reduce the loss of water by reducing the surface area from which water can evaporate.

Cacti are also able to store water in their tissues. *Plants such as cacti, which have thick, water-filled tissues, are called* **succulents**. The stored water in succulents enables the plants to survive long dry periods. Because cacti contain stored water, they are an attractive source of both food and water for desert animals. The spines of the cactus help protect the plant from being eaten by most animals.

Although cacti are native only to the American continents, deserts elsewhere also have succulents. Aloe Vera is a succulent native to Africa. Cacti and aloe are not related, but both types of plants have similar adaptations that include the presence of succulent tissues surrounded by protective spines.

Adaptations to the dryness of a desert can also be seen in the roots of desert plants. Some desert plants have very shallow roots that grow over a wide area. These roots maximize the amount of rain the plant can absorb during the infrequent rainstorms. The desert is home to many types of animals, including insects, reptiles, birds, and mammals. Most desert animals get the water they need from their foods. Like plants, desert animals face the challenge of reducing water loss.

All insects and reptiles have an outer coating that reduces water loss. The shells of insects and the scales of reptiles evolved as these animals adapted to life on land. The protective coverings make insects and reptiles well equipped to survive the dryness of a desert.

Animals that are active at night and sleep during the day are called **nocturnal** animals. Many of the animals in the desert are nocturnal.

Tundra

The tundra is a cold, windy, dry region. The tundra is located in the Northern Hemisphere just south of the polar ice caps in Alaska, Canada, Greenland, Iceland, Scandinavia, and Russia. In the Southern Hemisphere, the region that would be the tundra is covered by oceans.

The tundra is one of the largest biomes, making up almost 10 percent of Earth's surface. However, fewer types of organisms live in the tundra than in any other biome. The lack of biodiversity makes tundra ecosystems very fragile and unstable if disturbed.

The tundra receives little precipitation. In fact, the tundra usually receives less than 25 cm of precipitation each year. The main difference between deserts and tundra is temperature. In the tundra, air temperature rarely reaches above 10° C, even in summer. Because temperatures in the tundra are

below freezing almost all year, most precipitation falls as ice and snow. Temperature, therefore, is the limiting factor in the tundra.

Summer days are long and cool in the tundra. Because of low temperatures, only the top layer, or active zone, of soil thaws during the summer months. The active zone may be as thin as 8 cm in some areas. Beneath the active zone, the soil never thaws. *The frozen soil below the active zone is called* **permafrost**. A dense mat of mosses, grasses, and other plant life covers the active zone during summer. This mat keeps the ground insulated and prevents the permafrost from melting. Therefore, any disruption of the plants in the active zone can affect the permafrost.

Because of the short growing season and low temperatures, tundra vegetation does not recover from disruption as quickly as does vegetation in their biomes.

The tundra receives a small amount of rainfall in summer. Rain that falls during the summer months cannot drain through the permafrost. Instead, the water collects at the surface, forming bogs, marshes, ponds, and small streams. These areas serve as the breeding grounds for insects such as mosquitoes and black flies. These insects are an important link in the food web of the tundra. The permafrost is therefore an important factor in the stability of tundra ecosystem.

In spite of the cold climate and the lack of rainfall, some plants do grow in the tundra. The summer growing season lasts only about 60 days. The most common tundra plants are mousse, shrubs, grasses, and small, colorful wildflowers.

Tundra Plants: The ground is warmed by radiant energy from the sun. Tundra plants tend to be small and grow close to the warm ground. The roots of tundra plants grow very close to the ground's surface because they cannot penetrate the permafrost. Trees that grow in the tundra such as willow and alder are much smaller than their relatives in warmer climates. In fact, tundra trees are usually less than 1 m tall and are more like shrubs than trees. These plants are dwarfed by the short growing season, by the limited space for roots to grow, and by strong polar winds.

Tundra Animals: Many of the animals that live in the tundra are seasonal visitors. *Seasonal travel is called* **migration**. Many species of birds, for example, migrate to the tundra during their breeding season. There are fewer predators in the tundra, which makes it a safer place than most to raise young. Migratory birds of the tundra feed mostly on the abundant flies and mosquitoes that breed in the bogs

and ponds during summer. The birds, in turn, serve as a food source for migratory predators such as the Arctic fox. Small herbivores are also common, but there are no reptiles or amphibians.

The caribou, a close relative of the reindeer, is a large migratory mammal of the tundra. The adaptations that enable caribou to live in their environment are common among tundra mammals. Like many mammals of the tundra, caribou have a thick coat. The hairs of their coat are filled with air. The air acts as insulation, reducing the loss of body heat. Caribou also have hooves to help them move easily through snow or on the muddy ground in warmer months.

Grasslands biome

A **grassland** *is an ecosystem in which there is more water than in a desert, but not enough water to support a forest.* Grasslands begin at the edges of the desert biome and stretch across the land to the forest biome. Grasslands exist in Africa, central Asia, North America, South America, and Australia.

The climate of grasslands is a little wetter than the climate of deserts. *The* **desert-grassland boundary** *is the area between deserts and grasslands where increased rainfall enables some grasses to grow*. Because rainfall is an abiotic factor affecting both deserts and grasslands, long-term changes in climate patterns can change the desert-grassland boundary.

The biotic and abiotic factors characteristic of a grassland ecosystem determine what types of organisms will be found there. Although many kinds of organisms live in the grasslands, grasses are the most common.

Grasslands have hot, dry summers, making rainfall a grassland's most significant limiting factor. Without enough rain, grasslands cannot develop.

The occasional fires common in grasslands keep the number of trees and shrubs there low. Grass fires destroy trees and saplings became most of their mass is aboveground and therefore vulnerable to fire.

Another benefit of fires is that they burn away the layer of dead grass that accumulates during the year, converting it to valuable nutrients. The nutrients act as fertilizer, giving grasslands a deep, fertile soil held in place by grass roots. Heat from fires also aids the germination of many grass seeds.

Grasses are abundant in grassland areas because of biotic factors as well as abiotic factors. Grazing animals, such as the bison and burrowing animals help maintain grasslands with their activities above and below the ground. Grazing animals act as natural lawn mowers, keeping the vegetation of grasslands close to the ground. When kept this low, tree saplings and shrubs become too damaged to grow well. With most of their growth below ground level, the grasses remain unharmed. Animals such as earthworms, prairie dogs, and insects, which aerate the soil by making tunnels and digging, also live below ground. When the soil is aerated, grasses can grow more successfully because nutrients oxygen, and water can reach their roots more quickly.

The amount of rain a grassland area receives also affects the sizes and textures of the grasses. The tall-grass prairies and short-grass prairies of the Midwestern and western United States and Canada form because of differences in rainfall and soil nutrients. Similar regions exist in the South American pampas, the South African veldt, and the steppes of central Europe and Asia. Most tall-grass prairies, where the fertile soils can support grass 2 m tall, have been cleared for crops such as corn and wheat. Short-grass prairies are now used for cattle grazing and irrigated crops.

Although the *amount* of rain an area receives is important to grassland ecosystems, *when* it rain is also important. Some grasslands experience cycles of heavy rain followed by long periods of little or no rain, called *rainy seasons* and *drought seasons*. The rainy season and drought season determine, in part, the kinds of organisms that live in the grasslands. The trees and shrubs in grasslands often grow near ponds, streams, and springs. In grasslands where months may go by without rain, many plants and trees have adaptations that make them *drought-resistant*. These trees and shrubs survive in the dry grasslands, despite small amounts of rain.

All grasslands contain large grazing animals such as antelope and bison. Their ability to run quickly across the prairie is an adaptation that helps them avoid predators. Grasshoppers and other insects feed on the seeds and leaves of grasses, as do many other small herbivores including mice, gophers, prairie dogs, and birds. Some of these animals burrow underground and are only active at night, to avoid predators and intense daytime heat. Predators in the grassland are different throughout the world. In the North American prairies, coyotes, foxes, snakes, and birds of prey are the top consumers.

Grasslands around the world vary by climate and types of organisms. Although scientists do not always agree about how to classify grasslands, one method is to divide the grasslands into three different biomes. These three biomes are called the *steppe, prairie* and *savanna*.

Steppes and Prairies biome

Steppes are similar to deserts in many ways. **Steppes** *are grasslands of short bunchgrasses that get less than 50 cm of rain a year*. Rainfall is very low and plant life is sparse. Because of such similarities, some scientists consider steppes to be semiarid deserts rather than grasslands. In the United States, steppes are located at the western and southwestern edges of the grasslands. Large areas of steeps exist within the wetter areas of the deserts of the Southwest and the Great Basin. Steppes are also located within drier areas of the prairies.

Prairies make up most of the grasslands in the United States. **Prairies** *are grasslands characterized by rolling hills, plains, and sod-forming grasses*. In the United States, the prairies are often called the Great Plains. The Russian steppes in central Eurasia and the veldt in South Africa are local names for prairies in those locations. The prairies in Argentina are known as the Pampas. The pariries of the world are large, fertile areas where the human population gets most of its food. Because breads and cereals come from grains grown on the prairies, the prairies are sometimes called "breadbaskets".

To distinguish between a steppe and a desert, scientists define a desert as a region that gets less than 25 cm of rain a year and a steppe as receiving 25 cm or more. Most of the rain on the steppes evaporates very quickly or reaches only the upper 25 cm of soil. High winds and high temperatures across the steppes are responsible for rapid evaporation. Throughout the year, temperatures on the steppes can fall to -5° C or rise as high as 30° C.

The amount of rain in the prairies is about 50 to 75 cm a year. Occasionally, however, prairies get up to twice that much rain in a year.

Soil in the prairie can hold water very well because soil organisms create air spaces that can hold water. Most of the grasses of the prairie have roots that form a mat in the soil. The mat of soil and roots is called *sod*. *Grasses that form a mat of soil and roots are called* **sod-forming grasses**. Lawns are an example of sod-forming grasses. The roots of the sod-forming grasses hold the soil together.

When the soil is held together, it does not dry out very quickly, and it does not blow away in strong winds. *As plants and animals decompose, they form a layer of organic matter called* **humus**. The humus helps hold moisture and provides additional nutrients and food for grasses and other organisms to grow.

Steppes are sometimes referred to as short-grass prairies. The grasses of the steppes are mostly bunchgrasses. **Bunchgrasses** *are short, fine-bladed grasses that grow in a clump*. Clumping helps save water by holding the water in a small root area, under the shade of the grass. The short, fine blades of the bunchgrasses prevent them from losing moisture in the dry climate. The roots of the steppe grasses may grow only as deep as 50 cm. At that shallow depth, the roots can absorb as much as the scarce rainwater as possible before it evaporates.

Animals of the steppes and prairies have adapted to the changing conditions of these grasslands by migrating, hibernating, or burrowing underground. The grasses and small shrubs also have adaptations that use the energy of the wind. The wind carries the grasses' seeds and pollen over wide areas of land. With the aid of the wind, grasses can cover large areas rapidly. However, when one area of the prairie or steppe gets very dry or cold, the grasses cannot grow very well.

In colder areas, some of the animals of the steppe hibernate to save energy. Others migrate to other areas in search of more food and warmer temperatures. During hot periods, many small animals, like the prairie dogs remain in their burrows to keep from overheating. A cluster of prairie dog burrows, knows as towns, can be as large as several hundred square kilometers. Except during winter, the cooler nights are ideal times for burrowing animals to come aboveground to eat. Many of these animals eat at night or in the early or late parts of the day.

The steppe and prairie grasses are only slightly affected by the feeding habits of migrating grazers, because these animals move from place to place. But poor farming and ranching practices can cause extensive damage to the grasses of the steppes and prairies. One harmful practice is concentrating the feeding of sheep and cattle in small areas. When grazing animals eat too much in one place, they destroy most of the grass in a process called overgrazing.

Savannas

Savannas *are tropical or subtropical grasslands ranging from dry scrubland to wet, open woodland*. Savannas occur in Asia, from India to Southeast Asia, and in Africa, from the Sahara and Kalahari deserts to the southern tip of Africa. The Llanos of Venezuela and the Campos of Brazil are regions of savanna in South America.

Rainy seasons and long periods of drought are typical of savannas. The amount of rain in a savanna can be as high as 150 cm a year, but most of it falls heavily during thunderstorms in the short rainy season. In Africa, the rainy season usually lasts from January to April. During the rest of the year, the savanna may be very dry. The extreme climate demands a wide range of adaptations in the organisms of the savanna.

In order to survive, the grasses, shrubs, and trees of the savanna must be resistant to drought, fires, and grazing animals. Many plants of the savanna grow runners or rhizomes. **Runners** *are long horizontal stems above ground*. Rhizomes are roots that grow horizontally underground. Runners are used by some plants to reproduce; they spread quickly and can extend for several meters. When a fire occurs, the underground rhizomes are protected.

Savanna grasses grow in tufts. **Tufts** *are large clumps of tall, coarse grasses*. The savanna trees and shrubs have thorns or sharp leaves that keep them from being eaten by grazing animals, such as gazelles. Another adaptation of savanna plants is the ability to grow rapidly. This adaptation enables the plants to recover quickly from the damage caused by fire and animals. Growing quickly also enables plants to use the water available during the rainy season.

The concentration of animal populations in smaller areas around streams and watering holes is also influenced by the rainy season of the savanna. Because of this concentration, some animals are adapted to make use of the available food in what is called a vertical feeding pattern. *In a* **vertical feeding pattern**, *animals eat vegetation at different heights*. Vertical feeding patterns enable animals with different eating habits to feed in the same area without competing for food. The pattern allows more animals to live on limited resources because the animals can have smaller, more specific niches.

As in the prairie, many larger animals migrate to areas of the savanna where rain has fallen, often traveling great distances to find water. In Africa, lions, cheetahs, and other predators prey on

migrating herds of wildebeest, zebras, and various species of antelope. Sometimes habitat loss due to human activities disrupts the migration patterns of these animals. Survival for many species depends on wildlife preserves and global conservation efforts.

Coniferous forests

The coniferous forest biome is located primarily in the subarctic regions of North America, Europe and Asia. The summers are warm, lasting 2 to 5 months. The winters are long, cold, and dry, and there is very little sunlight. Precipitation falls as rain during summer and as snow during winter. Coniferous forests receive 40 to 200 cm of precipitation a year. In the Southern Hemisphere, coniferous forests are generally found on high mountains, where conditions are similar to high northern latitudes.

Coniferous trees or **conifers** *are trees that produce seed cones*. The cones hold the seeds of the tree. Conifers share an unusual type of leaf called a needle. These leaves are long and thin and covered in a thick, waxy substance. The needles help the trees conserve water. Most conifers are also evergreen, meaning they do not lose all their leaves at a given time each year. Conifers lose and replace their leaves slowly throughout the year. The needles of conifers help the trees shed snow during winter.

Species of pine, hemlock, fir, spruce, and cedar are common in coniferous forests. Some broad-leafed trees, such as aspen and birch, are also present. Coniferous forests are not diverse, and most contain only a few species of trees. The trees must be able to survive during winter, when the soil moisture is frozen and unavailable. The soil is poor and acidic because conifer needles are acidic and decompose slowly. Harsh winters and nutrient-poor soils are limiting factors in the coniferous forest. Ferns, lichens, and sphagnum moss are plants that can grow in the dim light of the forest floor.

The heavy winter snow that falls in most coniferous forests is important to the ecosystem. The snow acts like an insulating blanket, trapping heat and preventing the ground from forming permafrost. This insulating effect protects the roots of the forest trees. Small animals such as mice that would freeze to death above the snow can also survive underneath the ground.

Many animals in the coniferous forest are adapted to the cold winters, and to life in the conifers. Most small herbivores are seed eaters, such as mice, squirrels, jays, and other rodents and birds. Insects are common during summer, when the soil is moist and poorly drained.

Larger herbivores, such as moose, elk, beaver, and snowshoe hares, feed on plants and bark. These herbivores are pursued by predators, such as grizzly bears, wolves, and lynxes. All these animals have adaptations that enable them to survive the long winters. Many species migrate, while some hibernate or live under the snow. All have thick body coverings to protect them from the cold.

Vast stretches of coniferous forest cover the northern parts of Russia and North America. Because of the harsh climate, these have not been logged as extensively as other forest types. However, the growing need for wood has led to tree harvesting and large areas of forest have been lost in some regions.

Deciduous forests

Forests also grow at lower latitudes than the coniferous forest. These latitudes are called the temperate zone. Temperate zones have climates with four well-defined seasons. The forests in the temperate zone are made up largely of deciduous trees. *A* **deciduous** *tree is a tree that sheds its leaves during a particular season of the year.* These trees are the basis of deciduous forest biomes.

Temperature varies greatly in deciduous forests. Temperatures in summer can be as high as 30° C, while in the winter they can fall to -30° C. Precipitation falls as rain or snow, depending on the temperature and season. Deciduous forests receive 50 to 300 cm of precipitation a year. Precipitation falls fairly regularly throughout the year.

Deciduous trees are adapted to the highly variable climate of the temperate zone. The growing season lasts about 6 months. During the growing season, a tree grows quickly and produces and stores large amounts of food. In autumn, the shortening daylight and cooling temperatures trigger changes in the tree. The tree sheds its leaves and becomes dormant. The loss of leaves is an adaptation that enables a tree to conserve water during the cold winter months. Photosynthesis stops, and the tree no longer makes food. The tree survives winter by consuming food stored in its trunk, branches, and roots. The tree grows new leaves in spring. Photosynthesis begins again preparation for the next winter.

Maple, oak, beech, ash, hickory, and birch are examples of deciduous trees. The inhabitants of deciduous forests are more diverse than those in coniferous forests. The forest has three distinct vegetation layers, and each layer has its own group of plant species.

The highest layer of a deciduous forest is called the *canopy*. The canopy is made up of the upper branches and leaves of tall trees. The canopy captures most of the sun's direct light, but some filters down to the forest's lower levels. Beneath the canopy is the understory. The *understory* is made up of trees that are younger and smaller than those of the canopy. A layer of shrubs also grows in the understory, while mosses, ferns, and other plants grow on the forest floor.

The leaves that fall from forest trees enrich the soil. The leaves decay quickly during the warm, humid summer months. The decaying leaves produce a deep, rich layer of soil called humus. The humus and fallen leaves are home to many insects and other invertebrates that feed on the abundant organic matter.

Because the deciduous forest produces abundant food and has many different habitats, it supports a diverse community of animals and other organisms. Fungi and other decomposers, along with insects and invertebrates, are common in the leaf litter and on fallen trees. These organisms are preyed upon by birds, mice, and small mammals. White-tailed deer are common. Reptiles and amphibians are present in warmer forests. Predators such as wolves, mountain lions, birds of prey, and foxes fill the higher trophic levels in this ecosystem. Migratory birds come to feed and breed in the summer.

The deciduous forest has been changed drastically by human activity. This biome once stretched across Europe and Asia and covered the eastern United States. Today, very little of the original deciduous forest still stands worldwide.

Two factors have driven the human consumption of the deciduous forest. The first is rich soil. The humus in deciduous forest soil makes it deep and fertile, and the soil makes excellent farmland if the trees above it are cleared. Many forests were celared to provide land for fruit trees and other crops. The second reason for the consumption of the deciduous forest is the trees themselves. Deciduous trees generally have harder wood than conifers, making the wood a better material for making furniture and flooring. The wood is also used as fuel.

Some of the world's deciduous forests have been replanted. But a forest ecosystem is not just a group of trees. The ecosystem does not simply reappear when new trees are planted. The forest ecosystem regenerates slowly because the many species that were dependent on the trees have also disappeared. These species must migrate back into the ecosystem or new species must adapt to empty niches. Also,

the tree and plant diversity in most replanted forests is very low. Planted forests are usually monocultures of a particular species. Monocultures are often very productive but have very low biodiversity and are highly susceptible to diseases, parasites, and pollution damage.

Rain forests

The *tropical zone* is located at latitudes near the equator. Because the tropical zone is near the equator, it receives direct rays from the sun during most of the year. As a result, temperature in the tropical zone average about 25° C all year long. The wide temperature ranges between summer and winter in the temperate latitudes are absent in the tropical zone. The growing season can last 12 months. Precipitation falls as rain except on the tops of high mountains. The amount of precipitation varies from 200 to 450 cm a year. With an almost unchanging climate, water and temperature are not limiting factors.

The constant warmth and abundant rain in the tropical zone have given rise to the rain forest. It is the most diverse terrestrial biome on Earth. *A* **rain forest** *is a biome with a dense canopy of evergreen, broadleaf trees supported by at least 200 cm of rain each year*. Rain forests may contain as much as 70 percent of all the terrestrial species on Earth. Though they cover only 6 percent of Earth's land surface, rain forests hold 50 percent of Earth's land biomass. The rain forest has great biodiversity and shows the vast evolutionary possibilities present here as in no other biome.

Trees are the basis of the rain forest. Thousands of species of cypress, balsa, teak, mahogany, and other trees grow in this biome. The trees in a rain forest are amazingly diverse. Many of these trees reach heights of 50 or 60 m, where their leafy tops form a dense canopy. The canopy captures almost 99 percent of the light falling on the forest. The 1 percent of sunlight that filters through supports and lower levels of vegetation. Vegetation on the forest floor is sparse because there is not enough sunlight or nutrients to support many plants.

The dead organic matter than enriches the soil in other biomes does not last in the rain forest. It is decomposed and recycled in days or weeks instead of years. The warm temperatures and constant moisture of the rain forest are ideal conditions for decomposers such as insects, fungi, and bacteria. Nutrients that fall to the forest floor are quickly recycled and lifted back up into the trees. The rain

forest as an ecosystem contains as many nutrients as other biomes, but most of these nutrients exist in living organisms

Because most of the rain forest's matter is held in its organisms, the topsoil is thin and poor. Nearly all of the available soil nutrients are in the top 5 cm of soil. As a result, rainforest tree trunks widen at their bases, with ridges of wood called buttresses that support the trees. Tree roots must be shallow to take advantage of the thin top soil. Woody vines called lianas grow up the sides of tree trunks to reach the sunlight in the canopy. Other plants called epiphytes, such as orchids and bromeliads, live entirely on the trunks of limbs of trees, absorbing airborne nutrients and moisture.

Most of the activity in the rain forest occurs in the trees. The canopy supports countless species. Each species occupies a niche in the trees. Many of these *arboreal*, or tree-dwelling organisms live their whole lives without ever touching the ground.

The amazing animal diversity in the rain forest is caused by two factors. The first is the diversity of rainforest plants. Each species of tree or plant provides niches for specialized pollinators and herbivores. High plant diversity leads to high animal diversity. The second factor is the wide variety of habitats that exist in the different forest levels. Conditions high in the canopy are different than conditions lower down, and different communities evolve to occupy each habitat.

Habitats in the rain forest vary from tree to tree and from one part of a tree to another. The result is a complex, three-dimensional mosaic of habitats with a tremendous variety of organisms. The food webs that join these organisms are complex, with many specially adapted species and interrelationships.

Scientists are not sure how many species may live in the rain forest. American biologist E.O. Wilson found 43 species of ants on a single rainforest tree. British ecologist Terry Erwin estimates there may be over 30 million species of animals, plants, bacteria, and fungi.