

Chapter Outline

49.1 Climate and the Biosphere

A. Climate

1. Climate is the prevailing weather conditions in a region over time.
2. Climate is primarily dictated by temperature and rainfall which is influenced by two factors:
 - a. variations in solar radiation due to the tilt of the spherical earth, and
 - b. other effects such as topography and whether a body of water is nearby.

B. Effect of Solar Radiation

1. The earth is a sphere; therefore the sun's rays are more direct near the equator and spread out near the poles.
2. The tropics are therefore warmer than temperate areas.
3. The tilt of the earth's axis as it rotates about the sun causes one pole to be more directly exposed to sunlight.
4. Cold air is heavy and sinks; hot air is lighter and rises.
 - a. Therefore if the earth was standing still, equatorial air would rise and move toward the poles.
 - b. This would replace heavy polar air that sinks and flows toward the equator, now a low pressure area.
 - c. In a world that stood still, this would produce high winds moving toward the poles and surface winds moving toward the equator.
5. The Earth's Rotation Has an Effect
 - a. The wet equatorial air loses its moisture as it rises and cools near the equator.
 - b. By the time it moves 30° to the north, the air descends, reheats and is dry; this is a zone of deserts.
 - c. Because of the earth's rotation, from the equator to 30° north and south, surface winds blow from east-southeast in the Southern Hemisphere and from the east-northeast in the Northern Hemisphere making east coasts wet.
 - d. Between 30° and 60° north and south, strong winds called the westerlies blow from west to east.
 - e. The west coasts of continents in these latitudes are wet as is the Pacific Northwest.
 - f. Weaker polar easterlies blow from east to west between 60° north or south and the respective poles.
 - g. The earth's rotation, continents, and oceans alter the three circulation cells between the equator and poles.

C. Other Effects

1. Topography is the physical features or "lay" of the land.
2. Mountains cause rain and rain shadows.
 - a. Air blowing up over a mountain range rises and cools; the windward side therefore receives more rainfall.
 - b. The leeward side of the mountain range receives dry air; it is in a **rain shadow**.
 - c. The Hawaiian Islands experience over 750 cm of rain on the windward side but only average 50 cm in the rain shadow.
 - d. The western side of the Sierra Nevada Mountains is lush; the eastern side is a semidesert.
3. Coastal Breezes
 - a. Since the land heats up and cools down faster than oceans, it causes a daily pattern.
 - b. In the day, land heats up and warm air rises; then cool sea breezes blow inland to replace the rising air.
 - c. At night, the land cools first and the cold air sinks and blows out to sea.
4. Monsoon Climates
 - a. The India and south Asia climate generates wet ocean winds for almost half the year.
 - b. The land heats more rapidly than the waters of the Indian Ocean during spring.
 - c. The difference in temperature causes a gigantic circulation of air with warm air rising and cooler air continuously coming in from the ocean to replace it.
 - d. As the warm air rises, it loses its moisture and the monsoon season begins.

5. The “Lake Effect”
 - a. Winter Arctic winds blowing across the Great Lakes become warm and moisture laden.
 - b. When these winds rise and lose their moisture, a large amount of snow falls.

49.2 Terrestrial Communities

A. Biome Distribution

1. The biosphere is divided into large biogeographic units called **biomes**.
2. A biome has a particular mix of plants and animals adapted to live under certain environmental conditions.
3. The average temperature and rainfall influences where the different biomes are found on the surface of the earth.
4. Climate, and mainly solar radiation and topography, is the principle determinant of the distribution of biomes.
5. A latitude temperature gradient is also seen when we consider altitude; the rain forest–deciduous forest–coniferous forest–tundra sequences are also seen when ascending a mountain.
 - a. The mountain coniferous forest is a **montane coniferous forest**.
 - b. The tundra near the peak is an **alpine tundra**.

B. Tundra

1. The Arctic tundra encircles the earth south of the ice-covered polar seas in the Northern Hemisphere.
2. Arctic tundra covers 20% of the earth’s land surface; it is cold and dark much of the year.
3. The tundra receives about 20 cm of rainfall annually; this would constitute a desert but the melting snow provides water during summer and very little evaporates.
4. Only the topmost layer of earth thaws; the **permafrost** beneath is always frozen.
5. Trees are not found in the tundra because
 - a. the growing season is too short,
 - b. their roots cannot penetrate the permafrost, and
 - c. trees cannot become anchored in the boggy soil of summer.
6. In the summer, the ground is covered with sedges and short-grasses with patches of lichens and mosses.
7. Dwarf woody shrubs flower and seed quickly while there is sunlight for photosynthesis.
8. Only a few animals adapted to cold live in the tundra year-round (e.g., lemming, ptarmigan, and musk-ox).
9. During the summer, the tundra contains many insects, birds, and migratory animals (e.g., shore birds, waterfowl, caribou, reindeer, and wolves).

C. Coniferous Forests

1. Conifer forests are found in three locations: taiga, montane coniferous forests, and temperate coniferous forests.
2. **Taiga** is coniferous forest extending across northern Eurasia and North America.
3. Near a mountain top is a similar conifer forest called a montane coniferous forest.
4. On the Pacific Coast from Canada down to California is part of the temperate rain forest.
5. Conifer forests contain great stands of spruce, fir, hemlock, and pine; these trees have thick protective leaves or needles and bark.
6. The needlelike leaves can withstand the heavy weight of snow.
7. There is a limited understory of plants; the floor is covered by low-lying mosses and lichens beneath the layer of needles.
8. Birds harvest the seeds of conifers; bears, deer, moose, beaver and muskrat live around the cool lakes and streams.
8. Major carnivores include wolves, wolverine, and mountain lion.
9. The temperate rain forest along the Pacific Coast has the largest trees in existence, some as old as 800 years.

D. Temperate Deciduous Forests

1. Temperate deciduous forests are found south of taiga in eastern North America, eastern Asia, and much of Europe.
2. Climate in these areas is moderate with a relatively high annual rainfall (75–150 cm).
3. The seasons are well-defined with a growing season that ranges between 140 and 300 days.
4. The trees of a deciduous forest (e.g., oak, beech, and maple) have broad leaves which they lose in the fall and grow again in the spring.

5. Enough sunlight penetrates the canopy to support a well-developed understory composed of shrubs, a layer of herbaceous plants, and a ground cover of mosses and ferns.
6. Stratification beneath the canopy provides a variety of habitats for insects and birds.
7. Deciduous forest contains many rodents that provide food for bobcats, wolves, foxes.
8. Deciduous forest also contains deer and black bears.
9. Compared to the taiga, the winters are milder and allow many amphibians and reptiles to survive.
10. Minerals are washed fr into the ground and eventually brought back up by deep roots of trees.

E. **Tropical Forests**

1. Tropical rain forests are found in South America, Africa, and the Indo-Malayan region near the equator.
2. The climate is warm (20E–25EC) and rainfall is plentiful with a minimum of 190 cm per year.
3. This is probably the richest biome, both in number of species and in their abundance.
4. A tropical rain forest has a complex structure, with many levels of life.
5. Although there is animal life on the ground (e.g., pacas, agoutis, peccaries, and armadillos), most of the animals live in the trees.
6. Insects are abundant in tropical rain forests; the majority have not been identified.
7. Termites are critical in the decomposition of woody plant material.
8. Various birds tend to be brightly colored.
9. Amphibians and reptiles are represented by many species of frogs, snakes, and lizards.
10. Lemurs, sloths and monkeys feed on fruits.
11. The largest carnivores are cats (e.g., jaguars in South America and leopards in Africa and Asia).
12. Epiphytes are air plants that grow on other plants.
 - a. They have roots of their own to absorb moisture and minerals leached from the canopy.
 - b. Others catch rain and debris in hollows of overlapping leaf bases.
 - c. Common epiphytes are related to pineapples, orchids and ferns.
13. Tropical forests in India, Southeast Asia, West Africa, West Indies, Central and South America are seasonal.
 - a. They have deciduous trees that shed leaves in the dry season; layers of undergrowth are below.
 - b. Certain of these forests contain elephants, tigers and hippopotami.
14. A year-long growing season and high temperatures mean productivity is high.
15. But the warm, moist climate that supports high productivity also promotes rapid recycling of litter..
16. The soil is called laterite and the iron and aluminum oxides give it a red color and a brick texture when it bakes in the hot sun.
17. Consequently the soil is relatively poor because the nutrients are rapidly cycled into the biomass; this makes a poor agricultural soil.

F. **Shrublands**

1. Shrubland is dominated by shrubs with small but thick evergreen leaves coated with a thick, waxy cuticle, and with thick underground stems that survive dry summers and frequent fires.
2. Shrubland is found more along the coasts in South America, western Australia, central Chile, and around the Mediterranean Sea..
3. The dense shrubland in California, where the summers are hot and very dry, is chaparral.
 - a. This Mediterranean-type shrubland lacks an understory and ground litter and is highly flammable.
 - b. Seeds of many species require heat and scarring action of fire to induce germination.
4. West of the Rocky Mountains is a cold desert region dominated by sagebrush and dependent birds

G. **Grasslands**

1. Grasslands occur where rainfall is greater than 25 cm but is insufficient to support trees.
2. In temperate areas with rainfall between 10 and 30 inches a year, grassland is the climax community; it is too wet for desert and too dry for forests.
3. Natural grasslands once covered over 40% of the earth's land surface.
4. Most grasslands now grow crops, especially wheat and corn.
5. Grasses generally grow in different seasons; therefore some grassland animals migrate and ground squirrels hibernate when there is little grass.

6. The temperate grasslands include the Russian steppes, South American pampas, and North American prairies.
7. Tall-grass prairie occurs where moisture is not sufficient to support trees.
8. Short-grass prairie survives on less moisture and is between a tall-grass prairie and desert.
9. Animal life includes mice, prairie dogs, and rabbits and the animals that feed on them, hawks, snakes, badgers, coyotes, and foxes.
10. Prairies once contained large herds of buffalo and pronghorn antelope.
11. **Savannas** are tropical grasslands that contain some trees.
 - a. The savanna occurs in regions where a relatively cool dry season is followed by a hot, rainy one.
 - b. The savanna contains the greatest variety and numbers of herbivores (e.g., antelopes, zebras, wildebeests, water buffalo, rhinoceroses, elephants, and giraffes).
 - c. Any plant litter not consumed by grazers is attacked by termites and other decomposers.
 - d. Termites also build towering nests and tend fungal gardens.
 - e. The savanna supports a large population of carnivores (e.g., lions, cheetahs, hyenas, and leopards).

H. Deserts

1. Deserts usually occur at latitudes about 30° both north and south of the equator.
2. Deserts have an annual rainfall of less than 25 cm because incoming descending winds lack moisture.
3. Lacking cloud cover, the desert days are hot and the nights are cold.
4. The Sahara and a few other deserts are nearly devoid of vegetation.
5. Most have a variety of plants, all adapted to heat and scarcity of water (e.g., succulents).
6. Animal life includes many insects, reptiles such as lizards and snakes, running birds (e.g., roadrunner), rodents (e.g., kangaroo rat), and a few larger birds and mammals such as hawks and coyotes.

49.3 Aquatic Communities

A. Classifications

1. Aquatic biomes are classified as fresh water or saltwater (marine).
2. Wetlands near the sea have mixed fresh and saltwater and are brackish.
3. Seawater evaporates and then precipitates and flows through lakes and ponds, streams and rivers, and groundwater.
 - a. The top of the saturation zone defines the **water table**.
 - b. Groundwater sometimes occurs in underground layers called aquifers.
4. Human Activities
 - a. Wandering streams are often channelized into straight channels; this eliminates storage for flood control.
 - b. The elimination of wetlands removes unique habitat for fish, waterfowl and other wildlife.
 - c. Wetlands also filter toxic wastes and use excess nutrients.

B. Lakes

1. Lakes are freshwater bodies classified by their nutrient status.
 - a. **Oligotrophic** (nutrient-poor) lakes have low organic matter and therefore low productivity.
 - b. **Eutrophic** (nutrient-rich) lakes are highly productive from natural nutrients or agricultural runoff.
 - c. **Eutrophication** occurs when added nutrients change an oligotrophic lake to eutrophic.
2. In the temperate zone, deep lakes are stratified in summer and winter.
 - a. Epilimnion is the surface layer warmed from solar radiation; it soon becomes nutrient-poor but photosynthesis keeps oxygen levels high.
 - b. At the thermocline, there is an abrupt drop in temperature.
 - c. The hypolimnion is the lower cold region; it becomes depleted in oxygen but is nutrient rich from detritus falling from above.
 - d. The less dense epilimnion floats on the heavier cold hypolimnion; this prevents mixing.
3. Fall and Spring Overturns
 - a. In the fall, the upper epilimnion waters become cooler than the hypolimnion.
 - b. This causes the surface water to sink and deep water to rise.
 - c. The **fall overturn** continues until the temperature is uniform.
 - d. In the winter, ice forms on top because ice is lighter; this provides an insulating cover and organisms can live through a harsh winter in this moderate water.
 - e. In spring, the ice melts and the cooler water on top sinks below the warmer water on the bottom.

- f. After the **spring overturn**, water returns to a more uniform temperature and sun warms the surface.
- g. Fish and other aquatic life are adapted to the strata and seasonal changes; for instance, cold water fish move deeper in the summer.

C. Life Zones

1. **Plankton** includes freshwater and marine microscopic organisms that freely drift in fresh or saltwater.
2. **Phytoplankton** are the photosynthetic plankton, including algae.
3. **Zooplankton** are animals that feed on phytoplankton.
4. The **littoral zone** is shallow and closest to shore; plants root in this zone and harbor some animals.
5. The **limnetic zone** is open sunlit layer of body of a lake; it contains plankton, a few insect larvae, and fish.
6. The **profundal zone** is that portion of a lake below any significant sunlight penetration; it contains zooplankton and fishes that feed on the debris that falls from above.
7. The **benthic zone** is at the soil-water interface with the bottom-dwelling organisms; it includes worms, mollusks, and crustaceans.

D. Coastal Communities

1. The mouth of a river develops into
 - a. a salt marsh in temperate zones, and
 - b. a mangrove swamp in subtropical zones.
2. Silt carried by rivers forms mudflats.
3. An **estuary** is a partially enclosed body of water at the end of a river where the fresh water and sea water mix.
 - a. Not many organisms are tolerant of this mix of fresh river water and salty tidal water.
 - b. For organisms suited to the rapid changes in salinity, estuaries provide abundant nutrients.
 - c. Estuaries are a nutrient trap since nutrients are
 - 1) delivered by the river,
 - 2) brought in from the sea by tides, and
 - 3) released from decaying vegetation.
 - d. Estuaries are a nursery estimated as spawning and rearing of over half of all marine fishes.
4. Seashores are constantly bombarded by tidal seas.
 - a. The littoral zone is between high and low tide and is covered and uncovered daily.
 - b. The upper littoral is covered by barnacles.
 - c. The midportion harbors brown algae that may overlie barnacles.
 - d. The lower portion has oysters and mussels attached to rock by byssal threads; various snails hide in crevices or seaweed.
 - e. Below the littoral zone, seaweeds are the main photosynthesizers and are anchored to rocks by holdfasts.
 - f. Sandy beaches have no anchor holds; therefore permanent beach organisms are burrowing or tube-living.

E. Oceans

1. Moisture that evaporates into the air carries the heat used to evaporate it with it.
2. Water is warm at the equator and cold at the poles due to the distribution of the sun's rays.
3. Air takes on the temperature of the water below and warm air moves from the equator toward the poles.
4. Therefore, the oceans make winds blow.
5. Oceans hold heat or remain cool longer than landmasses.
6. Winds generate ocean currents due to friction at the ocean surface.
7. Since ocean currents are bounded by land, they move in a circular path, counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.
8. Ocean currents take heat from the equator to the polar regions.
 - a. The **Gulf Stream** brings warmer tropical Caribbean water to the east coast of North America and to upper western Europe.
 - b. Without the Gulf Stream, Great Britain would be as cold as Greenland.
 - c. A major Atlantic ocean current warms the eastern coast of South America.
 - d. The **Humboldt Current** in the Pacific flows toward the equator off the west coast of South America.

9. **Upwellings** occur when cold nutrient-rich water rises to supplant warm nutrient-poor water.
 - a. The Humboldt Current brings rich nutrients north; the uprising that occurs near Christmas is called “El Niño.”
 - b. This supports rich marine life and the fisheries of Peru and northern Chile.
 - c. Seabirds deposit droppings on land (guano) where it is a major source of phosphorus mining.
 - d. Failure of El Niño results in stagnation, poor fishing, and global climate pattern changes.
- F. The **Pelagic Division** includes the neritic and oceanic provinces.
1. The **neritic province** lies over the continental shelf.
 - a. This contains a greater concentration of organisms than are in the oceanic province.
 - b. It is a more productive part of the ocean because of the concentration of sunlight and nutrients.
 - c. It provides the base of the food web leading to commercially valuable fishes (e.g., herring, cod, and flounder).
 2. The **oceanic province** lies over the continental slope and the abyssal plane.
 - a. The **epipelagic zone** extends from the surface to the maximum depth that photosynthesis significantly occurs.
 - 1) It does not have a high concentration of phytoplankton because it lacks nutrients.
 - 2) However, the numbers of producers in this zone still support a large assembly of zooplankton, which support large numbers of other marine organisms, when the entire ocean is considered.
 - 3) The epipelagic animals include mackerels, tunas, and sharks.
 - b. The **mesopelagic zone** extends below maximum depth at which photosynthesis significantly occurs.
 - 1) This zone is dominated by carnivores adapted to the absence of light (e.g., luminescent shrimps, squids, and fishes).
 - 2) Organisms here tend to be translucent or red colored.
 - c. The **bathypelagic zone** is in absolute darkness except for occasional flash of bioluminescent light.
 - 1) Animals here are carnivores and scavengers.
 - 2) This level supports a variety of very strange carnivores.
- G. **Benthic Division**
1. The **benthic division** includes all organisms that live on or in the soil of the ocean floor, including the continental shelf, continental slope, and the abyssal plain.
 2. The **sublittoral zone** is located on the continental shelf up to the low tide mark on the coast.
 - a. It supports a mixed food web with seaweeds and filter-feeding organisms as the first trophic level.
 - b. The seaweeds comprise the first trophic level for a grazing food web; the detritivores (e.g., clams and worms) comprise the first trophic level for a detrital food web.
 - c. Starfishes, lobsters, crabs, brittle stars, and some bottom-dwelling fish occupy the upper trophic levels.
 3. The **bathyal zone** is located on the continental slope and extends through mesopelagic and bathypelagic depths.
 - a. It contains a detrital food web with detritivores (e.g., clams and worms) as the first trophic level.
 - b. Again, starfishes, crabs, brittle stars, and some bottom-dwelling fish occupy the upper trophic levels.
 4. The **abyssal zone** is located on and immediately above the abyssal plane.
 - a. This is a region of extreme cold and intense pressure.
 - b. It contains a detrital food web in which the detritivores (e.g., sponges, worms, tube worms, sea cucumbers, sea lilies, and sea urchins) comprise the first trophic level.
 - c. Starfishes, crabs, brittle stars, and some bottom-dwelling fish occupy the upper trophic levels.
 5. **Hydrothermal vents** are areas where seawater percolates through cracks.
 - a. The water is heated to about 350°C.
 - b. This causes sulfate to react with water to form hydrogen sulfide (H₂S).
 - c. Chemosynthetic bacteria obtain energy by oxidizing hydrogen sulfide.
 - d. These communities are not based on light energy but support huge tube worms and clams.