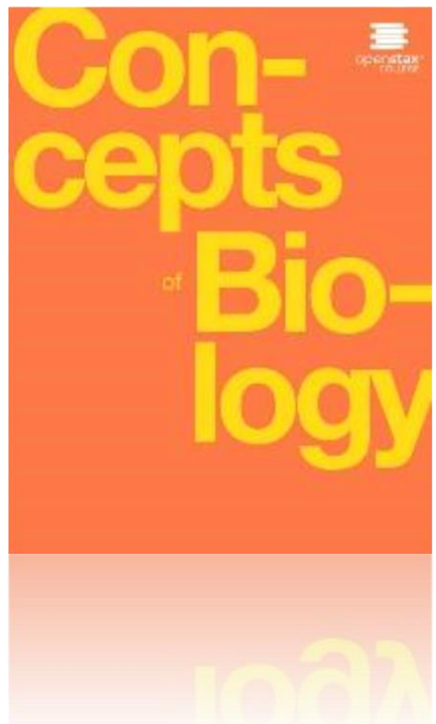
CONCEPTS OF BIOLOGY

Chapter 20 ECOSYSTEMS AND THE BIOSPHERE

PowerPoint Image Slideshow



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INTRODUCTION

- The **ecosystem** comprises all the **biotic** components (living things) and **abiotic** components (non-living things) in a particular geographic area.
    - Some of the abiotic components include air, water, soil, and climate.
- Wild lupine and Karner blue butterflies live in an oak-pine barren habitat in portions of North America (Figure 20.1).
    - This habitat is characterized by natural disturbance in the form of fire and nutrient poor soils that are low in nitrogen—important factors in the distribution of the plants that live in this habitat.

FIGURE 20.1 KARNER BLUE BUTTERFLY AND WILD LUPINE

The (a) Karner blue butterfly and (b) wild lupine live in oak-pine barren habitats in North America. (credit a: modification of work by John & Karen Hollingsworth, USFWS)

ENERGY FLOW THROUGH ECOSYSTEMS (20.1)

- Ecosystems can be small, such as the tide pools found near the rocky shores of many oceans, or large, such as those found in the tropical rainforest of the Amazon in Brazil (Figure 20.2).
- There are three broad categories of ecosystems based on their general environment: freshwater, marine, and terrestrial.
    - Within these three categories are individual ecosystem types based on the environmental habitat and organisms present.

FIGURE 20.2 ECOSYSTEMS

(a) (b)

A (a) tidal pool ecosystem in Matinicus Island, Maine, is a small ecosystem, while the (b) Amazon rainforest in Brazil is a large ecosystem. (credit a: modification of work by Jim Kuhn; credit b: modification of work by Ivan Mlinaric)

ECOLOGY OF ECOSYSTEMS 1 OF 2 (20.1)

- Life in an ecosystem often involves competition for limited resources, which occurs both within a single species and between different species.
    - Organisms compete for food, water, sunlight, space, and mineral nutrients.
- Freshwater ecosystems are the least common (1.8 percent of Earth's surface). These systems comprise lakes, rivers, streams, and springs.
    - They are quite diverse, and support a variety of organisms.
- Marine ecosystems are the most common (75 percent of Earth's surface)
    - Consists of three basic types: shallow ocean, deep ocean water, and deep ocean bottom.
- Terrestrial ecosystems, also known for their diversity, are grouped into biomes (Figure 20.3) .
    - A **biome** is a largescale community of organisms, primarily defined on land by the dominant plant types that exist in geographic regions of the planet with similar climatic conditions.

FIGURE 20.3 DESERT ECOSYSTEMS

(a) (b)

Desert ecosystems, like all ecosystems, can vary greatly. The desert in (a) Saguaro National Park, Arizona, has abundant plant life, while the rocky desert of (b) Boa Vista island, Cape Verde, Africa, is devoid of plant life. (credit a: modification of work by Jay Galvin; credit b: modification of work by Ingo Wölbern)

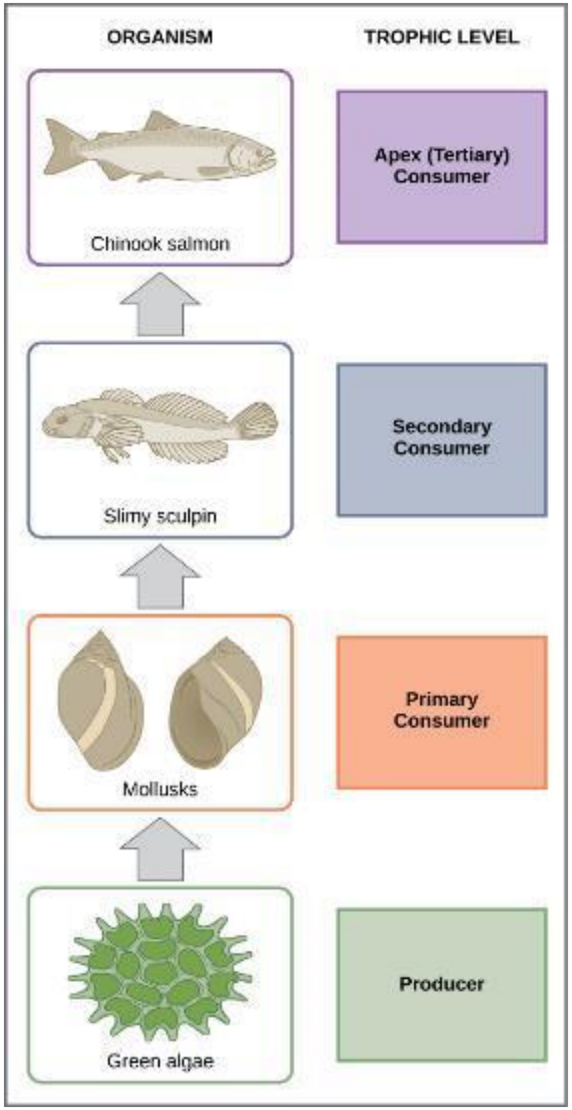
ECOLOGY OF ECOSYSTEMS 2 OF 2 (20.1)

- Ecosystems are complex with many interacting parts. They are routinely exposed to various disturbances.
- Many disturbances are a result of natural processes.
- The impact of environmental disturbances caused by human activities is now as significant as the changes caused by nature.
- Equilibrium is a dynamic state of an ecosystem in which, despite changes in species numbers and occurrence, biodiversity remains somewhat constant. Two parameters are used to measure changes in ecosystems:
    - The ability of an ecosystem to remain at equilibrium in spite of disturbances is called **resistance**.
    - The speed at which an ecosystem recovers equilibrium after being disturbed is called **resilience.**

FOOD CHAINS AND FOOD WEBS 1 OF 3 (20.1)

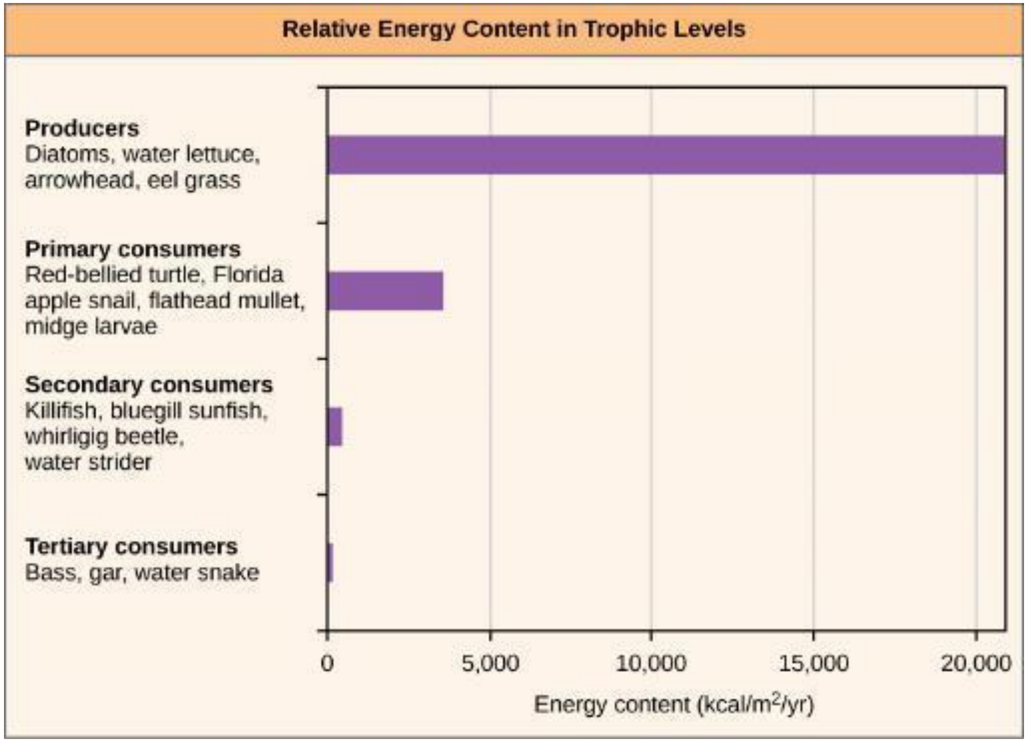
- A **food chain** is a linear sequence of organisms through which nutrients and energy pass as one organism eats another.
- Each organism in a food chain occupies a specific **trophic level** (energy level), its position in the food chain or food web (Figure 20.4) .
    - **Producers** (photosynthetic organisms like plants or phytoplankton), are the base, or foundation, of the food chain.
    - **Primary consumers** are the herbivores--organisms that consume the producers.
    - **Secondary consumers** are usually carnivores that eat the primary consumers.
    - **Tertiary consumers** are carnivores that eat other carnivores.
    - Higher-level consumers feed on the next lower trophic levels, and so on, up to the organisms at the top of the food chain: the **apex consumers.**

FIGURE 20.4 FOOD CHAIN



These are the trophic levels of a food chain in Lake Ontario at the United States–Canada border. Energy and nutrients flow from photosynthetic green algae at the base to the top of the food chain: the Chinook salmon. (credit: modification of work by National Oceanic and Atmospheric Administration/NOAA)

FIGURE 20.5 RELATIVE ENERGY



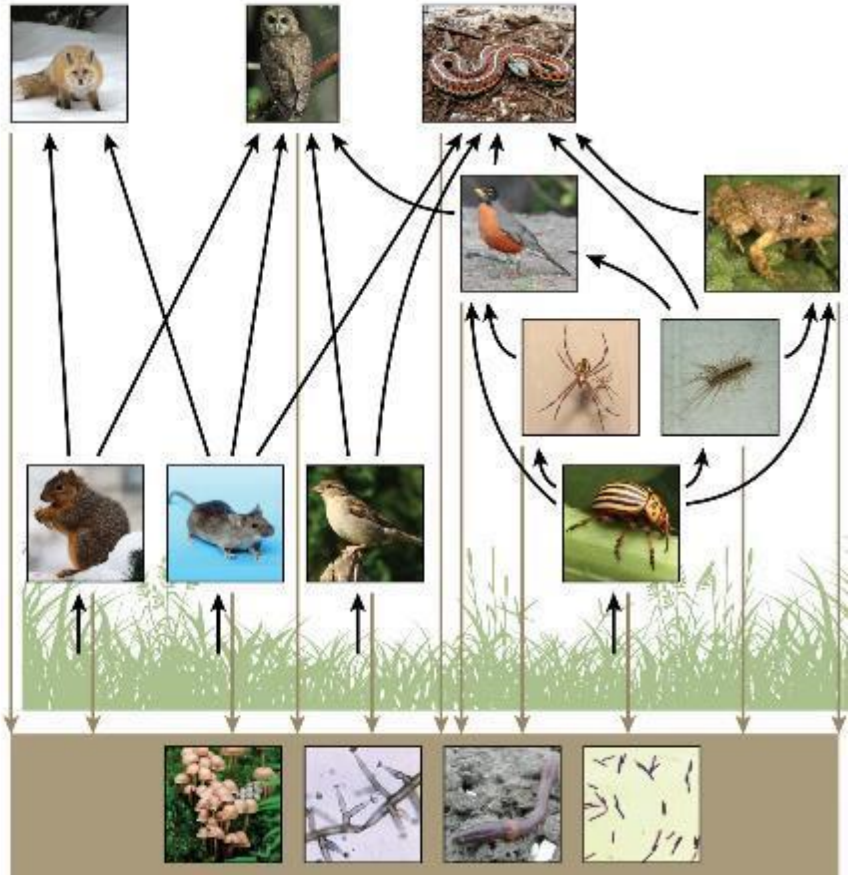
The relative energy in trophic levels in a Silver Springs, Florida, ecosystem is shown. Each trophic level has less energy available, and usually, but not always, supports a smaller mass of organisms at the next level.

FOOD CHAINS AND FOOD WEBS 2 OF 3 (20.1)

- There are problems with using food chains:
  - Some organisms can feed on more than one trophic level
  - Some organisms can also be fed on from multiple trophic levels
  - Species feed on and are eaten by more than one species.
- A **food web** is a concept that accounts for the multiple trophic (feeding) interactions between each species and the many species it may feed on, or that feed on it.
- The matter and energy movements of virtually all ecosystems are more accurately described by food webs (Figure 20.6).

FIGURE 20.6
A FOOD WEB

This food web shows the interactions between organisms across trophic levels. Arrows point from an organism that is consumed to the organism that consumes it. All the producers and consumers eventually become nourishment for the decomposers (fungi, mold, earthworms, and bacteria in the soil). (credit “fox”: modification of work by Kevin Bacher, NPS; credit “owl”: modification of work by John and Karen Hollingsworth, USFWS; credit “snake”: modification of work by Steve Jurvetson; credit “robin”: modification of work by Alan Vernon; credit “frog”: modification of work by Alessandro Catenazzi; credit “spider”: modification of work by “Sanba38”/Wikimedia Commons; credit “centipede”: modification of work by “Bauerph”/Wikimedia Commons; credit “squirrel”: modification of work by Dawn Huczek; credit “mouse”: modification of work by NIGMS, NIH; credit “sparrow”: modification of work by David Friel; credit “beetle”: modification of work by Scott Bauer, USDA Agricultural Research Service; credit “mushrooms”: modification of work by Chris Wee; credit “mold”: modification of work by Dr. Lucille Georg, CDC; credit “earthworm”: modificationof work by Rob Hille; credit “bacteria”: modification of work by Don Stalons, CDC)



FOOD WEB CONCEPT IN ACTION

Head to this online interactive simulator to investigate food web function.

In the Interactive Labs box, under Food Web, click Step 1. Read the instructions first, and then click Step 2 for additional instructions. When you are ready to create a simulation, in the upper-right corner of the Interactive Labs box, click OPEN SIMULATOR.

[Launch Interactive]

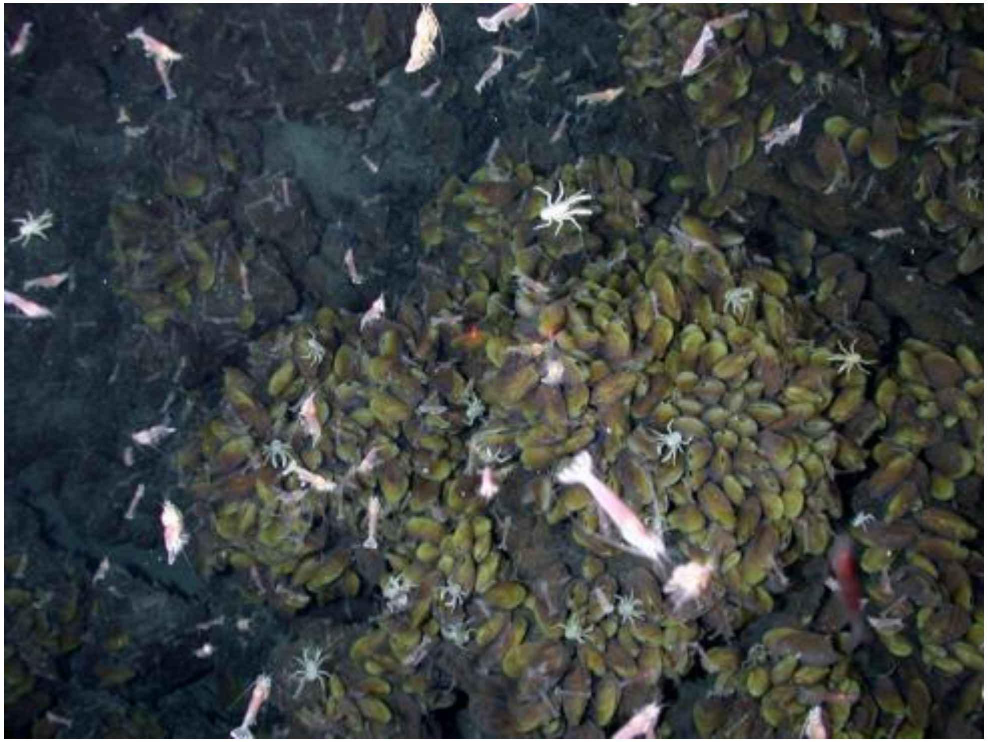
FOOD CHAINS AND FOOD WEBS 3 OF 3 (20.1)

- Two general types of food webs are often shown interacting within a single ecosystem:
  - A **grazing food web** has plants or other photosynthetic organisms at its base, followed by herbivores and various carnivores.
  - A **detrital food web** consists of a base of organisms that feed on decaying organic matter (dead organisms), including decomposers (which break down dead and decaying organisms) and detritivores (which consume organic detritus). These organisms are usually bacteria, fungi and invertebrates.

HOW ORGANISMS ACQUIRE ENERGY IN A FOOD WEB (20.1)

- All living things require energy in one form or another.
- Energy is acquired by living things in two ways:
- **Autotrophs** harness light or chemical energy
  - Photoautotrophs use sunlight as an energy source to photosynthesize. This group includes some bacteria, algae, and plants.
  - Chemoautotrophs use inorganic molecules as an energy source and are found rare places where sunlight is not available (Figure 20.7). This group includes bacteria and archaea.
- **Heterotrophs** acquire energy through the consumption and digestion of other living or previously living organisms.
- The rate at which photosynthetic producers incorporate energy from the Sun is called **gross primary productivity**.
- **Net primary productivity** is the energy that remains in the producers after accounting for these organisms' respiration and heat loss.

FIGURE 20.7 A HYDROTHERMAL VENT

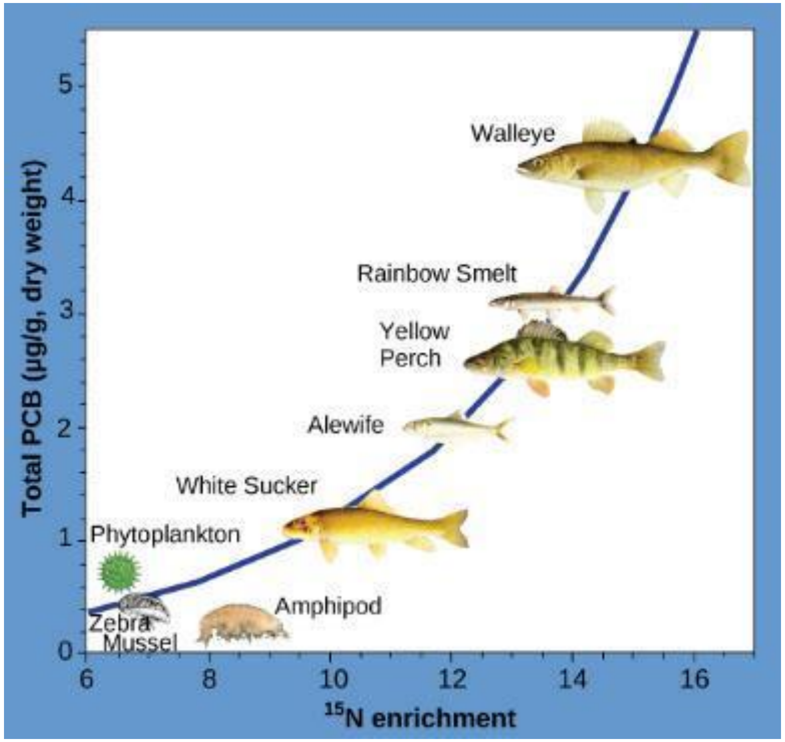


Swimming shrimp, a few squat lobsters, and hundreds of vent mussels are seen at a hydrothermal vent at the bottom of the ocean. As no sunlight penetrates to this depth, the ecosystem is supported by chemoautotrophic bacteria and organic material that sinks from the ocean’s surface. This picture was taken in 2006 at the submerged NW Eifuku volcano off the coast of Japan by the National Oceanic and Atmospheric Administration (NOAA). The summit of this highly active volcano lies 1535 m below the surface.

CONSEQUENCES OF FOOD WEBS: BIOLOGICAL MAGNIFICATION (20.1)

- **Biomagnification** is the increasing concentration of persistent, toxic substances in organisms at each successive trophic level.
- These are substances that are fat soluble, not water soluble, and are stored in the fat reserves of each organism.
- For example, DDT was a commonly used pesticide before its dangers to apex consumers, such as the bald eagle, became known.
    - The birds accumulated sufficient amounts of DDT to cause fragility in their eggshells.
    - The use of DDT was banned in the United States in the 1970s.
- Other substances that biomagnify are polychlorinated biphenyls (PCB), which were used as coolant liquids in the United States until their use was banned in 1979, and heavy metals, such as mercury, lead, and cadmium.
    - Figure 20.8 shows a study of PCB concentrations. Notice that the fish in the higher trophic levels accumulate more PCBs than those in lower trophic levels.

FIGURE 20.8 BIOMAGNIFICATION



This chart shows the PCB concentrations found at the various trophic levels in the Saginaw Bay ecosystem of Lake Huron. Notice that the fish in the higher trophic levels accumulate more PCBs than those in lower trophic levels. (credit: Patricia Van Hoof, NOAA)

BIOGEOCHEMICAL CYCLES (20.2)

- The matter that makes up living organisms is conserved and recycled.
- The recycling of inorganic matter between living organisms and their nonliving environment is called a biogeochemical cycle.
- The six most common elements associated with organic molecules are—carbon, nitrogen, hydrogen, oxygen, phosphorus, and sulfur.
    - The cycling of these elements is interconnected.
- Water, which contains hydrogen and oxygen, is essential to all living processes. The **hydrosphere** is the area of Earth where water movement and storage occurs.

BIOGEOCHEMICAL CYCLES CONCEPT IN ACTION

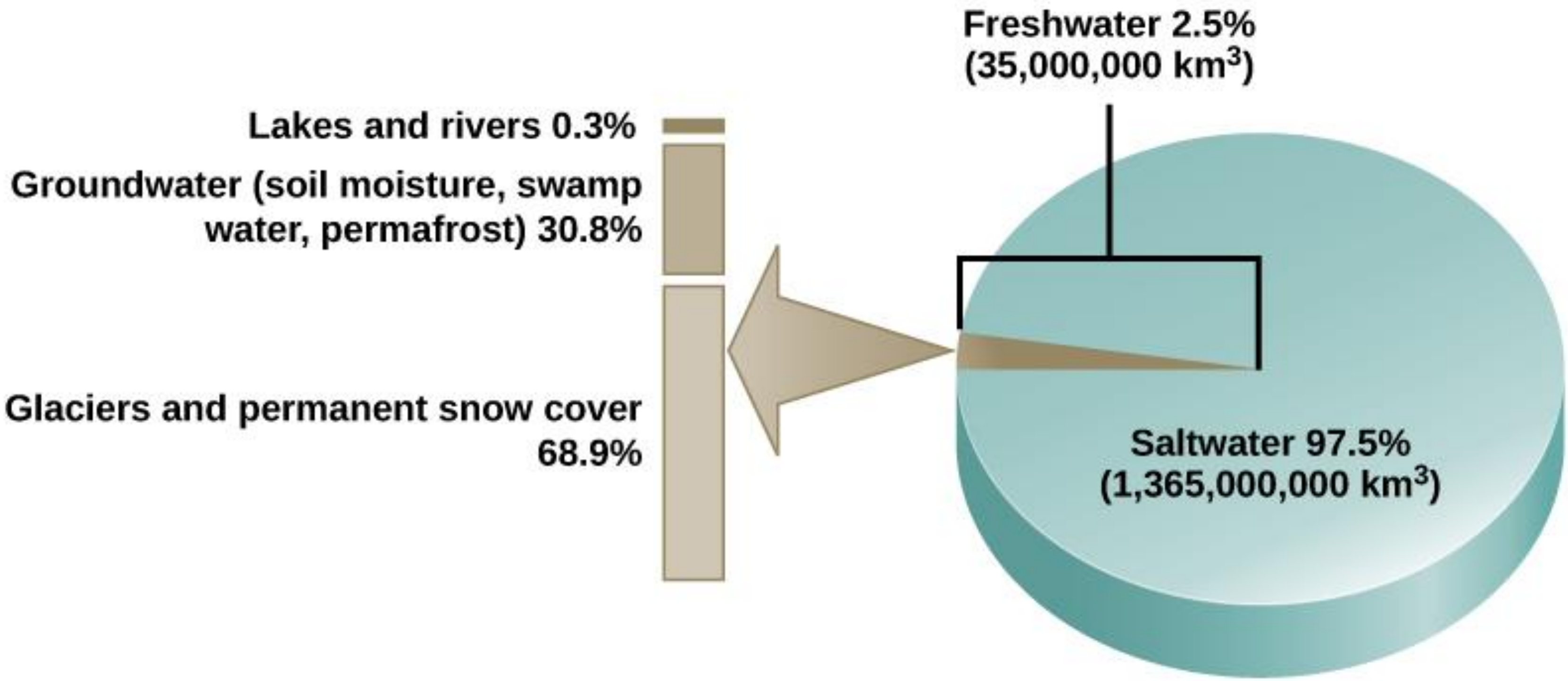
Head to this website to learn more about biogeochemical cycles.

Link to Website

THE WATER CYCLE (20.2)

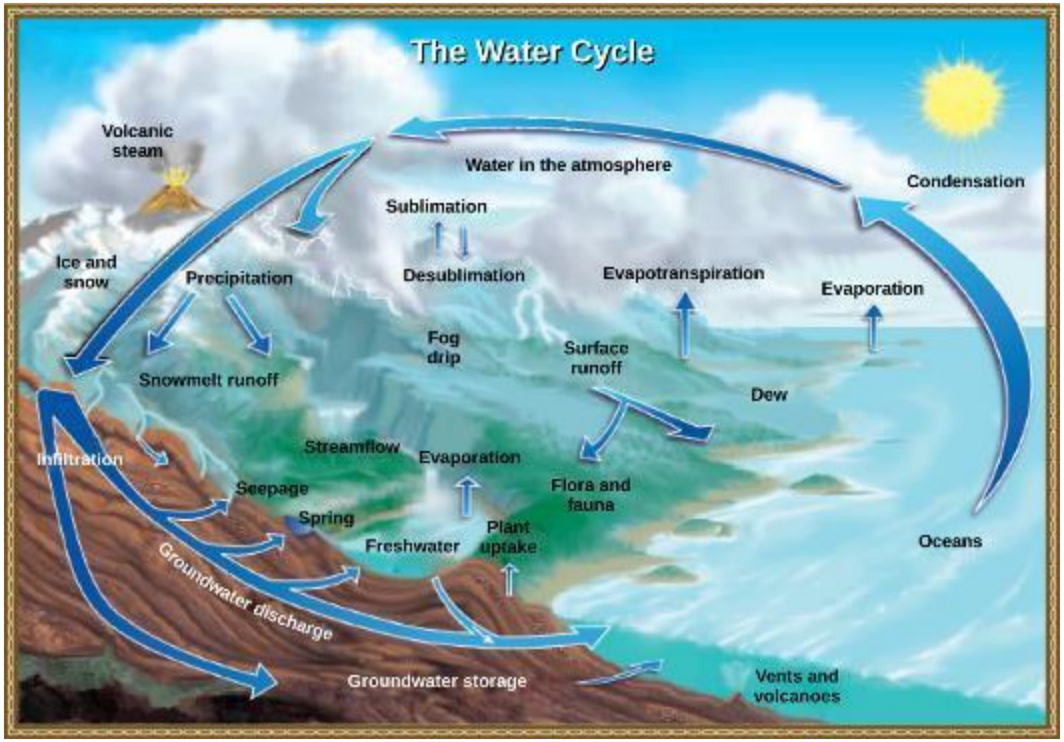
- Water is essential for all living processes. The human body is more than one-half water and human cells are more than 70% water. Thus, most land animals need a supply of fresh water to survive.
- Of the stores of water on Earth, 97.5% is salt water (Figure 20.9). Of the remaining water, 99 percent is locked as underground water or ice. Thus, less than 1% of fresh water is present in lakes and rivers.
- The various processes that occur during the cycling of water are illustrated in Figure 20.10. The processes include the following:
    - evaporation (water to water vapor) and sublimation (ice to water vapor)
    - condensation and precipitation (rain or snow)
    - subsurface water flow
    - surface runoff (flow of fresh water from rain) and snowmelt
    - streamflow

FIGURE 20.9 WATER PERCENTAGES



Only 2.5 percent of water on Earth is fresh water, and less than 1 percent of fresh water is easily accessible to living things.

FIGURE 20.10 THE WATER CYCLE

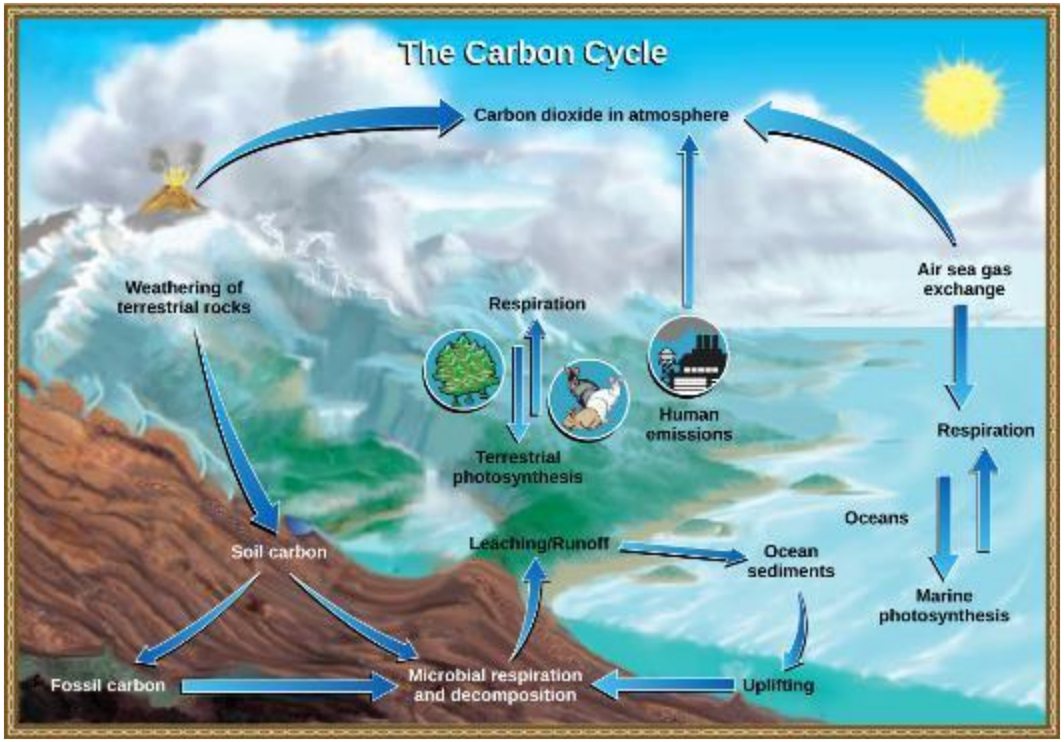


Water from the land and oceans enters the atmosphere by evaporation or sublimation, where it condenses into clouds and falls as rain or snow. Precipitated water may enter freshwater bodies or infiltrate the soil. The cycle is complete when surface or groundwater reenters the ocean. (credit: modification of work by John M. Evans and Howard Perlman, USGS)

THE CARBON CYCLE 1 OF 2 (20.2)

- Carbon is the fourth most abundant element in living organisms. Carbon is present in all organic molecules, and its role in the structure of macromolecules is of primary importance to living organisms.
- The entire carbon cycle is shown in Figure 20.11. The carbon cycle is most easily studied as two interconnected sub-cycles.
- One sub-cycle (the biological carbon cycle) deals with rapid carbon exchange among living organisms.
    - Autotrophs use carbon dioxide to build high-energy carbon compounds.
    - Heterotrophs consume autotrophs to obtain these high energy compounds.

FIGURE 20.11 THE CARBON CYCLE



Carbon dioxide gas exists in the atmosphere and is dissolved in water. Photosynthesis converts carbon dioxide gas to organic carbon, and respiration cycles the organic carbon back into carbon dioxide gas. Long-term storage of organic carbon occurs when matter from living organisms is buried deep underground and becomes fossilized. Volcanic activity and, more recently, human emissions bring this stored carbon back into the carbon cycle. (credit: modification of work by John M. Evans and Howard Perlman, USGS)

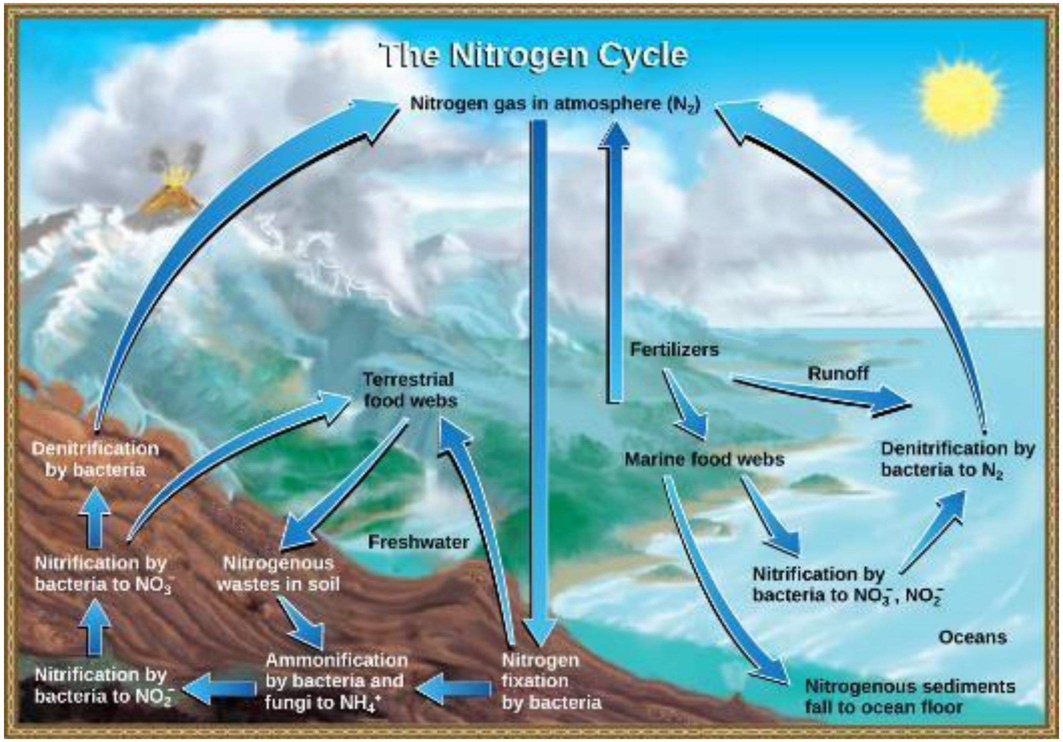
THE CARBON CYCLE 2 OF 2 (20.2)

- The other sub-cycle (the biogeochemical carbon cycle) deals with the long-term cycling of carbon through geologic processes. This is the cycling of carbon through land, water and air.
- Fossil fuels are the anaerobically decomposed remains of plants that take millions of years to form.
  - They are considered a non-renewable resource because their use far exceeds their rate of formation. A **non-renewable resource** is either regenerated very slowly or not at all.
  - Also, when fossil fuels are burned, it increases the amount of carbon dioxide in the atmosphere.
  - Another way that carbon dioxide is released into the atmosphere is due to the increased number of animals kept to feed the earth’s population. Their breathing releases carbon dioxide.
- These increases in atmospheric carbon dioxide are associated with climate change, which is a major environmental concern worldwide.

THE NITROGEN CYCLE (20.2)

- Most organisms are not equipped to incorporate nitrogen from the atmosphere even though nitrogen comprises approximately 78% of the atmosphere.
- Two nitrogen atoms (N2) are bonded to each other by a very strong triple covalent bond.
- Nitrogen enters the living world via free-living and symbiotic bacteria, which incorporate nitrogen into their macromolecules through nitrogen fixation (conversion of N2).
- The nitrogen that enters living systems by nitrogen fixation is eventually converted from organic nitrogen back into nitrogen gas by bacteria (Figure 20.12).
- Human activity can release nitrogen into the environment by two primary means:
    - The combustion of fossil fuels
    - The use of artificial fertilizers

FIGURE 20.12 THE NITROGEN CYCLE

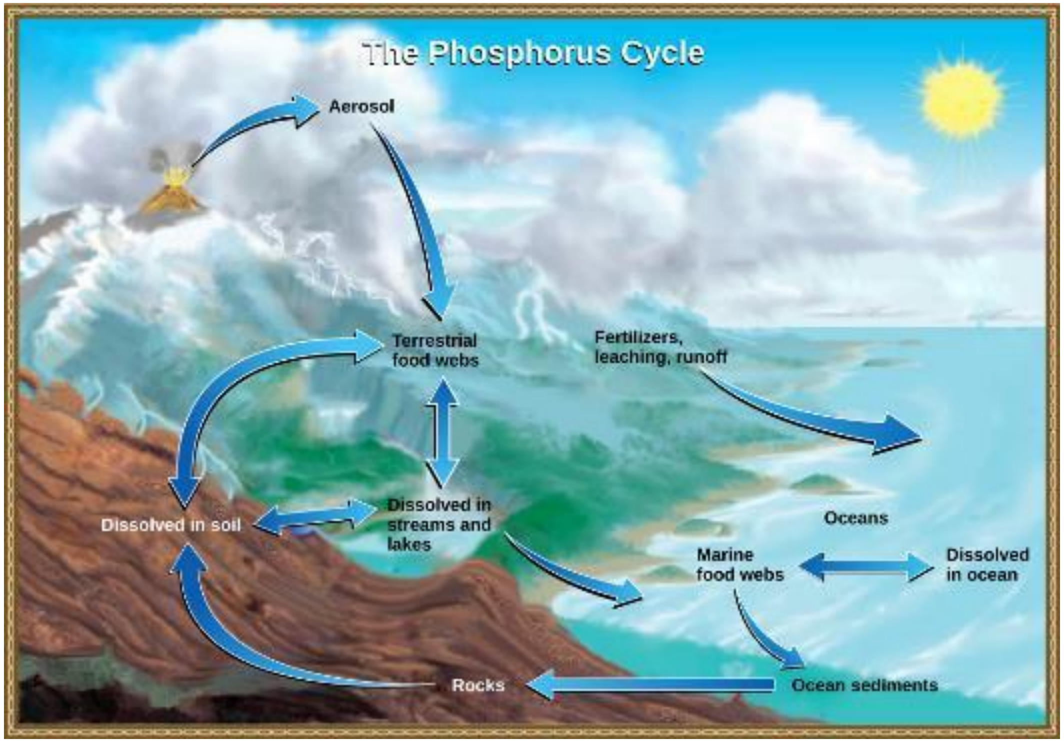


Nitrogen enters the living world from the atmosphere through nitrogen-fixing bacteria. This nitrogen and nitrogenous waste from animals is then processed back into gaseous nitrogen by soil bacteria, which also supply terrestrial food webs with the organic nitrogen they need. (credit: modification of work by John M. Evans and Howard Perlman, USGS)

THE PHOSPHOROUS CYCLE (20.2)

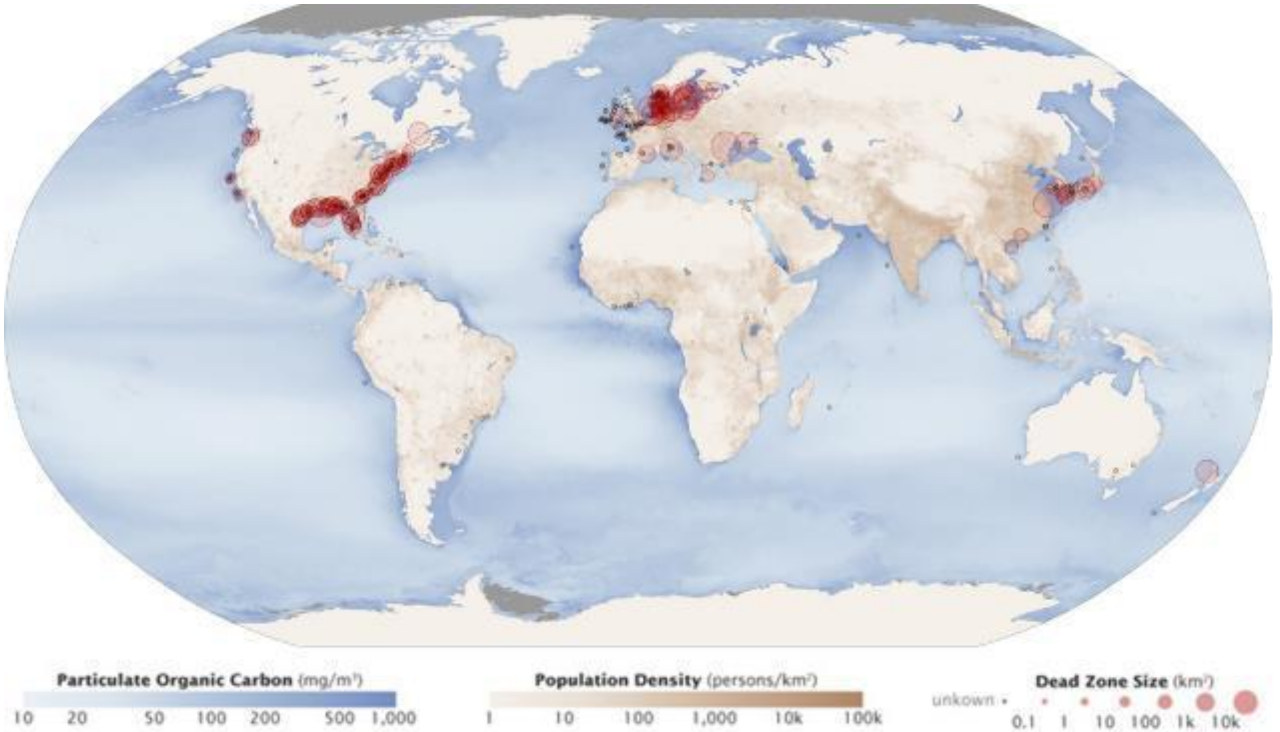
- Phosphorus is an essential nutrient for living processes
    - It is a major component of nucleic acids and phospholipids
    - It makes up the supportive components of our bones.
- Phosphorus is often the limiting nutrient (necessary for growth) in aquatic, particularly freshwater, ecosystems.
- A major effect from fertilizer runoff (excessive nitrogen and phosphorous) is **eutrophication,** a process whereby nutrient runoff causes the overgrowth of algae and a number of problems.
    - The subsequent death and decay of these organisms depletes dissolved oxygen, which leads to the death of aquatic organisms, such as shellfish and finfish.
    - This process is responsible for **dead zones** in lakes and at the mouths of many major rivers and for massive fish kills, which often occur during the summer months (Figure 20.14).

FIGURE 20.13 THE PHOSPHOROUS CYCLE



In nature, phosphorus exists as the phosphate ion (PO_4^{3-}). Weathering of rocks and volcanic activity releases phosphate into the soil, water, and air, where it becomes available to terrestrial food webs. Phosphate enters the oceans in surface runoff, groundwater flow, and river flow. Phosphate dissolved in ocean water cycles into marine food webs. Some phosphate from the marine food webs falls to the ocean floor, where it forms sediment. (credit: modification of work by John M. Evans and Howard Perlman, USGS)

FIGURE 20.14 DEAD ZONES



Dead zones occur when phosphorus and nitrogen from fertilizers cause excessive growth of microorganisms, which depletes oxygen and kills fauna. Worldwide, large dead zones are found in areas of high population density. (credit: Robert Simmon, Jesse Allen, NASA Earth Observatory)

FIGURE 20.15 CHESAPEAKE BAY

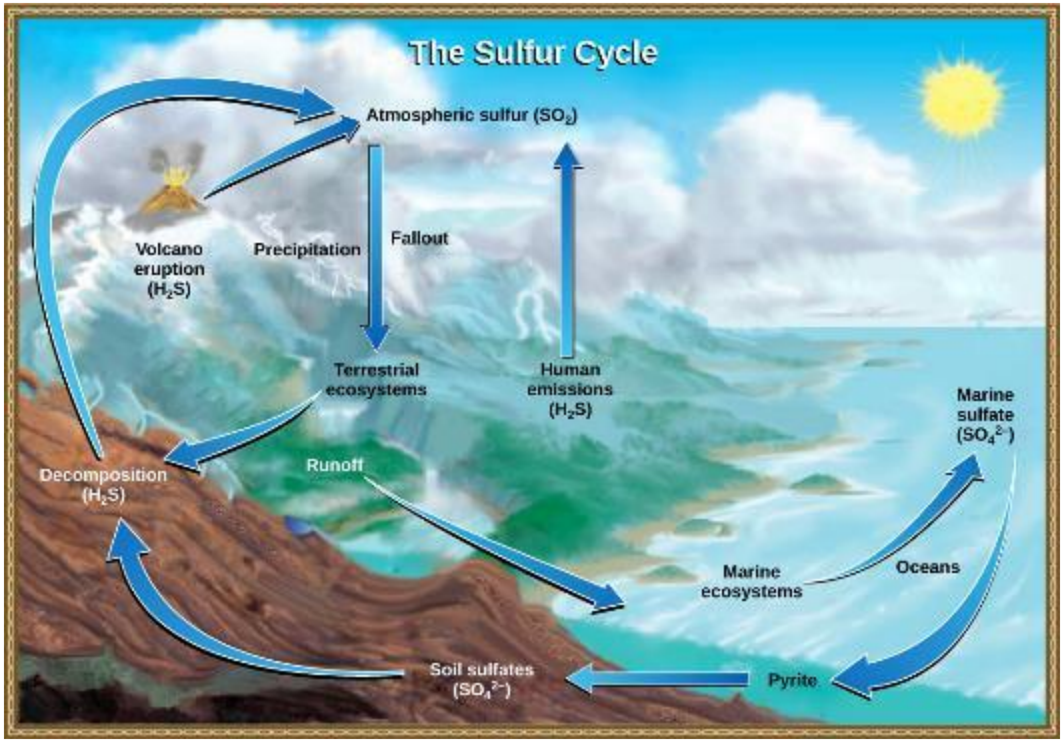
(a) (b)

This (a) satellite image shows the Chesapeake Bay, an ecosystem affected by phosphate and nitrate runoff. A (b) member of the Army Corps of Engineers holds a clump of oysters being used as a part of the oyster restoration effort in the bay. (credit a: modification of work by NASA/MODIS; credit b: modification of work by U.S. Army)

THE SULFUR CYCLE (20.2)

- Sulfur is an essential element for the macromolecules of living things. It is involved in the formation of proteins.
- Sulfur cycles between the oceans, land, and atmosphere (Figure 20.16).
- One source of sulfur on land are geothermal vents (Figure 20.17).
- The burning of large quantities of fossil fuels, especially from coal, releases larger amounts of hydrogen sulfide gas into the atmosphere.
- **Acid rain** is corrosive rain caused by rainwater falling to the ground through sulfur gas, turning it into weak sulfuric acid, which causes damage to aquatic ecosystems.

FIGURE 20.16 THE SULFUR CYCLE



Sulfur dioxide from the atmosphere becomes available to terrestrial and marine ecosystems when it is dissolved in precipitation as weak sulfuric acid or when it falls directly to Earth as fallout. Weathering of rocks also makes sulfates available to terrestrial ecosystems. Decomposition of living organisms returns sulfates to the ocean, soil, and atmosphere. (credit: modification of work by John M. Evans and Howard Perlman, USGS)

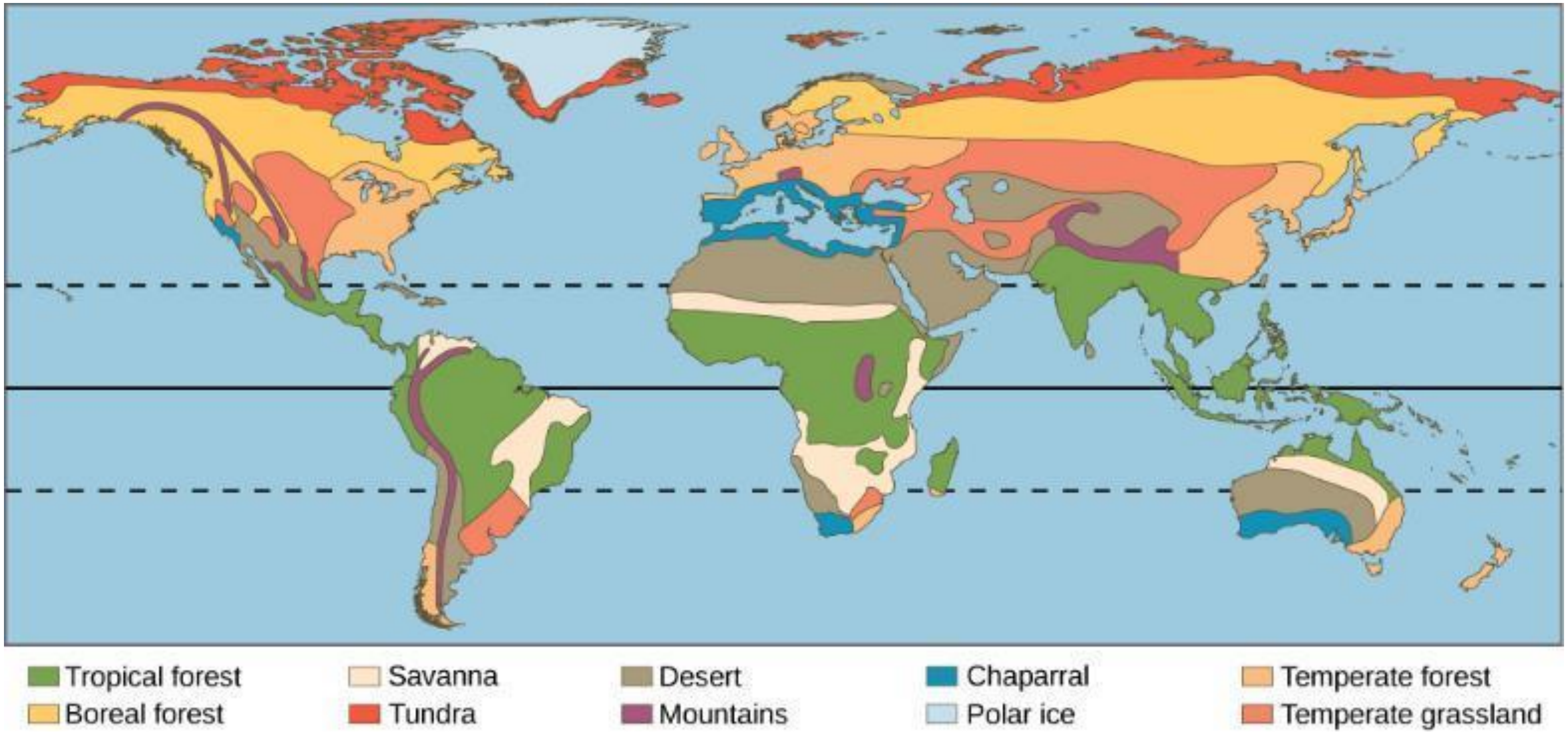
FIGURE 20.17 A GEOTHERMAL VENT

At this sulfur vent in Lassen Volcanic National Park in northeastern California, the yellowish sulfur deposits are visible near the mouth of the vent. (credit: “Calbear22”/Wikimedia Commons)

TERRESTRIAL BIOMES (20.3)

- Terrestrial biomes are based on land, while aquatic biomes include both ocean and freshwater biomes.
- The eight major terrestrial biomes on Earth are each distinguished by characteristic temperatures and amount of precipitation.
- The same biome can occur in geographically distinct areas with similar climates (Figure 20.18).
- There are also large areas on Antarctica, Greenland, and in mountain ranges that are covered by permanent glaciers and support very little life. These areas are not biomes.

FIGURE 20.18 MAJOR BIOMES



Each of the world's eight major biomes is distinguished by characteristic temperatures and amount of precipitation. Polar ice caps and mountains are also shown.

TROPICAL FOREST (20.3)

- Tropical rainforests are found in equatorial regions (Figure 20.18).
- They are the most diverse terrestrial biome. This biodiversity is under extraordinary threat primarily through logging and deforestation for agriculture.
- Tropical rainforests have also been described as nature's pharmacy because of the potential for new drugs from plants and animals.
- The temperature and sunlight profiles of tropical rainforests are stable in comparison to that of other terrestrial biomes.
- They have high net primary productivity because the annual temperatures and precipitation values support rapid plant growth (Figure 20.19).
- Tropical rainforests are characterized by vertical layering of vegetation and the formation of distinct habitats for animals within each layer.

FIGURE 20.19 TROPICAL FOREST

Species diversity is very high in tropical wet forests, such as these forests of Madre de Dios, Peru, near the Amazon River. (credit: Roosevelt Garcia)

SAVANNA AND CHAPARRAL (20.3)

- Savannas are grasslands with scattered trees.
  - They are found in Africa, South America, and northern Australia (Figure 20.18).
  - Savannas are hot, tropical areas with an extensive dry season and consequent fires.
  - They are dominated by grasses and small flowering plants.
- The chaparral is also called scrub forest.
  - It is found in California, along the Mediterranean Sea, and along the southern coast of Australia (Figure 20.18).
  - Summers are very dry and the majority of the rain falls in the winter.
  - The chaparral is dominated by shrubs.
  - Many chaparral plants are dormant during the summer time.

FIGURE 20.20 SAVANNA

Although savannas are dominated by grasses, small woodlands, such as this one in Mount Archer National Park in Queensland, Australia, may dot the landscape. (credit: “Ethel Aardvark”/Wikimedia Commons)

FIGURE 20.22 CHAPARRAL

The chaparral is dominated by shrubs. (credit: Miguel Vieira)

DESERTS (20.3)

- Subtropical deserts are centered on the Tropic of Cancer and the Tropic of Capricorn (Figure 20.18).
- They are frequently located on the downwind side of mountain ranges, which create a rain shadow after prevailing winds drop their water content on the mountains.
- Subtropical deserts are very dry; evaporation typically exceeds precipitation.
- The low species diversity of this biome is closely related to its low and unpredictable precipitation. Desert species exhibit fascinating adaptations to the harshness of their environment.
- Perennial plants in deserts are characterized by adaptations that conserve water (Figure 20.21).
- There are also cold deserts that experience freezing temperatures during the winter and any precipitation is in the form of snowfall.

FIGURE 20.21 DESERT

Many desert plants have tiny leaves or no leaves at all to reduce water loss. The leaves of ocotillo, shown here in the Chihuahuan Desert in Big Bend National Park, Texas, appear only after rainfall and then are shed. (credit "bare ocotillo": "Leaflet"/Wikimedia Commons)

TEMPERATE GRASSLANDS (20.3)

- Temperate grasslands are found throughout central North America, where they are also known as prairies, and in Eurasia, where they are known as steppes (Figure 20.18).
- Temperate grasslands have pronounced annual fluctuations in temperature with hot summers and cold winters.
- The dominant vegetation tends to consist of grasses.
- They have very few trees which is maintained by low precipitation, frequent fires, and grazing (Figure 20.23).
- Fires, which are a natural disturbance in temperate grasslands, can be ignited by lightning strikes.

FIGURE 20.23 TEMPERATE GRASSLANDS

The American bison (*Bison bison*), more commonly called the buffalo, is a grazing mammal that once populated American prairies in huge numbers. (credit: Jack Dykinga, USDA ARS)

TEMPERATE FORESTS (20.3)

- Temperate forests are the most common biome in eastern North America, Western Europe, Eastern Asia, Chile, and New Zealand (Figure 20.18).
- Temperate forests have defined growing seasons during the spring, summer, and early fall.
- Precipitation is relatively constant throughout the year.
- **Deciduous trees** are the dominant plant in this biome with fewer evergreen conifers. Deciduous trees lose their leaves each fall and remain leafless in the winter.
- Temperate forests show far less diversity of tree species than tropical rainforest biomes.

FIGURE 20.24 TEMPERATE FORESTS

Deciduous trees are the dominant plant in the temperate forest. (credit: Oliver Herold)

BOREAL FORESTS (20.3)

- The boreal forest, also known as taiga or coniferous forest, is found across most of Canada, Alaska, Russia, and northern Europe (Figure 20.18).
- This biome has cold, dry winters and short, cool, wet summers.
- The precipitation usually takes the form of snow.
- The major vegetation are **evergreen** coniferous trees like pines, spruce, and fir, which retain their needle-shaped leaves year-round.
- Species diversity is less than that seen in temperate forests and tropical rainforests.
- When conifer needles are dropped, they decompose slowly; therefore, fewer nutrients are returned to the soil to fuel plant growth (Figure 20.25).

FIGURE 20.25 BOREAL FOREST

The boreal forest (taiga) has low lying plants and conifer trees. (credit: L.B. Brubaker, NOAA)

TUNDRA (20.3)

- The Arctic tundra lies north of the subarctic boreal forests and is located throughout the Arctic regions of the Northern Hemisphere (Figure 20.18).
- Tundra also exists at elevations above the tree line on mountains.
- Winters are very cold and there is low annual precipitation.
- Plants in the Arctic tundra are generally low to the ground and include low shrubs, grasses, lichens, and small flowering plants (Figure 20.26).
- There is little species diversity, low net primary productivity, and low aboveground biomass.
- The soils of the Arctic tundra may remain in a perennially frozen state referred to as **permafrost**.

FIGURE 20.26 TUNDRA

Low-growing plants such as shrub willow dominate the tundra landscape during the summer, shown here in the Arctic National Wildlife Refuge. (credit: Arctic National Wildlife Refuge, USFWS)

BIOMES CONCEPT IN ACTION

Watch this Assignment Discovery: Biomes video for an overview of biomes.

To explore further, select one of the biomes on the extended playlist: desert, savanna, temperate forest, temperate grassland, tropic, tundra.

Link to Video

AQUATIC AND MARINE BIOMES (20.4)

- The abiotic factors important in aquatic habitats include:
  - Light→ the depth to which light can penetrate the water is important because it controls productivity through photosynthesis
  - Temperature→ water temperature affects the organisms' rates of growth and the amount of dissolved oxygen available for respiration
  - Flow regime→ regular currents and tides impact availability of nutrients, food resources, and the presence of the water itself
  - Dissolved solids→ all natural water contains dissolved solids, or salts ranging from fresh water (little dissolved) to ocean water (much dissolved)

MARINE BIOMES 1 OF 2 (20.4)

- The ocean is categorized by several zones (Figure 20.28).
  - All of the ocean’s open water is referred to as the **pelagic zone**.
  - The **benthic zone** extends along the ocean bottom from the shore line to the deepest parts of the ocean floor.
  - From the surface to the bottom or the limit to which photosynthesis occurs is the **photic zone**.
  - The **aphotic zone** is the area into which light cannot penetrate.
- The ocean is also categorized into different zones based on how far light reaches into the water. These are listed on the next slide.
- Each zone has a distinct group of species adapted to the biotic and abiotic conditions particular to that zone (Figure 20.28).

MARINE BIOMES 2 OF 2 (20.4)

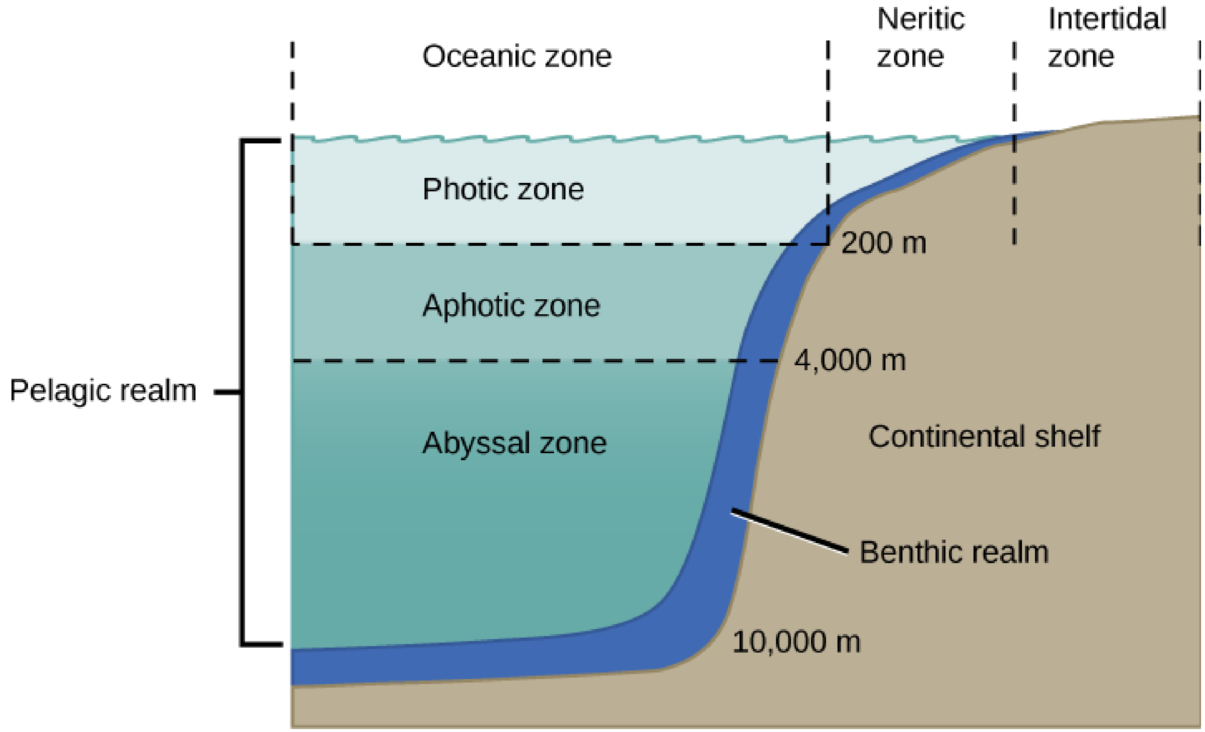
- The **intertidal zone** (Figure 20.27) is the region that is closest to land. The intertidal zone is often a sandy beach, but it can also be rocky, muddy, or dense.
- The **neritic zone** extends from the margin of the intertidal zone to depths of about 200 m at the edge of the continental shelf. This zone has the highest productivity and biodiversity of the ocean, including algae, bacteria, shrimp and small fish.
- Beyond the neritic zone is the open ocean area known as the **oceanic zone**. Abundant plankton support populations of fish and whales.
- Beneath the pelagic zone is the **benthic zone**. Because of its high level of nutrients, a diversity of fungi, sponges, sea anemones, marine worms, sea stars, fishes, and bacteria exists.
- The **abyssal zone** is the deepest part of the ocean. It is very cold and has very high pressure, high oxygen content, and low nutrient content. There are a variety of invertebrates and fishes found in this zone, but no photosynthetic organisms.

FIGURE 20.27 INTERTIDAL ZONE

Sea stars, sea urchins, and mussel shells are often found in the intertidal zone, shown here in Kachemak Bay, Alaska. (credit: NOAA)

The shore of the intertidal zone is also repeatedly struck by waves and the organisms found there are adapted to withstand damage from the pounding action of the waves.

FIGURE 20.28 ZONES OF THE OCEAN

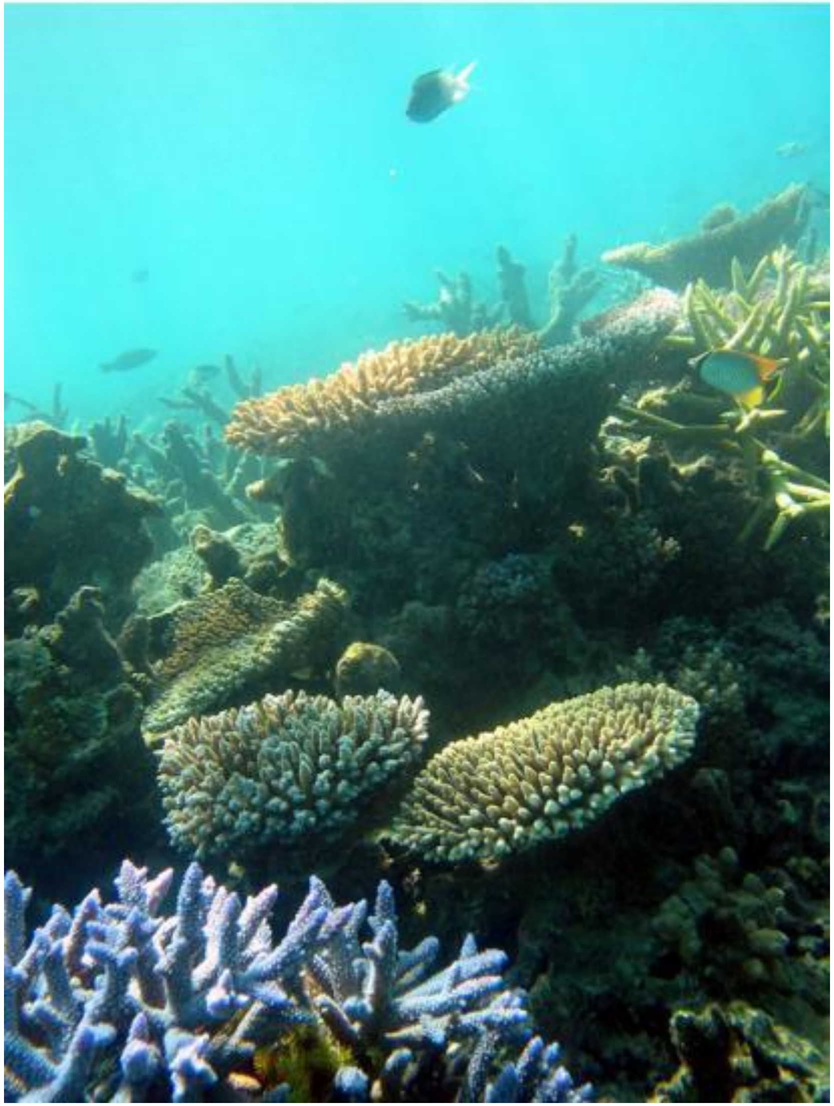


The ocean is divided into different zones based on water depth, distance from the shoreline, and light penetration.

CORAL REEFS (20.4)

- Coral reefs are ocean ridges formed by marine invertebrates living in warm shallow waters within the photic zone of the ocean.
- The Great Barrier Reef is a well-known reef system located several miles off the northeastern coast of Australia.
- The coral-forming colonies of organisms secrete a calcium carbonate skeleton. These calcium-rich skeletons slowly accumulate, thus forming the under water reef.
- Coral reefs are one of the most diverse biomes (Figure 20.29).
- Climate change and human activity pose threats to the survival of the world’s coral reefs. The main cause of killing of coral reefs is warmer-than-usual surface water caused by global warming.
- Rising levels of atmospheric carbon dioxide further threaten corals by raising acidity and interfering with the corals ability to build their skeletons.

FIGURE 20.29 A CORAL REEF



Coral reefs are formed by the calcium carbonate skeletons of coral organisms, which are marine invertebrates in the phylum Cnidaria. (credit: Terry Hughes)

CORAL ORGANISMS CONCEPT IN ACTION

In this National Oceanic and Atmospheric Administration (NOAA) video, marine ecologist Dr. Peter Etnoyer discusses his research on coral organisms.

Link to Video

ESTUARIES (20.4)

- Estuaries are biomes that occur where a source of fresh water, meets the ocean (Figure 20.30).
- Both fresh water and salt water mix which results in a diluted (brackish) salt water.
- Estuaries form protected areas where many of the offspring of crustaceans, mollusks, and fish begin their lives.
- Organisms that inhabit estuaries must be able to tolerate salinity fluctuations.

FIGURE 20.30 AN ESTUARY

As estuary is where fresh water and salt water meet, such as the mouth of the Klamath River in California, shown here. (credit: U.S. Army Corps of Engineers)

FRESHWATER BIOMES 1 OF 2 (20.4)

- Humans rely on freshwater biomes to provide aquatic resources for drinking water, crop irrigation, sanitation, recreation, and industry.
- Freshwater biomes include lakes, ponds, and wetlands (standing water) as well as rivers and streams (flowing water).
- Lakes and ponds:
    - Temperature is an important abiotic factor affecting living things in lakes and ponds. During the summer in temperate regions, thermal stratification of deep lakes occurs when the upper layer of water is warmed by the Sun and does not mix with deeper, cooler water.
    - Nitrogen and phosphorus are important limiting nutrients. When there is a large input of nitrogen and phosphorus, the growth of algae skyrockets, resulting in **algal blooms**. The blooms lower oxygen and can kill fish and other organisms.

FIGURE 20.31
AN ALGAL BLOOM

The uncontrolled growth of algae in this waterway has resulted in an algal bloom.

FRESHWATER BIOMES 2 OF 2 (20.4)

- Rivers and streams:
  - Rivers and then streams that feed into the rivers are continuously moving bodies of water that carry water from the source or headwater to the mouth at a lake or ocean.
  - The largest rivers include the Nile River in Africa, the Amazon River in South America, and the Mississippi River in North America (Figure 20.32).
  - Streams begin at a point referred to as **source water**. The source water is usually cold, low in nutrients, and clear. The **channel** (the width of the river or stream) is narrower here than at any other place along the river or stream.
  - As the river or stream flows away from the source, the width of the channel gradually widens, the current slows, and the temperature characteristically increases.
  - When a river reaches the ocean or a large lake, the water typically slows dramatically and any silt in the river water will settle.

FIGURE 20.32 RIVERS

(a) (b)

Rivers range from (a) narrow and shallow to (b) wide and slow moving. (credit a: modification of work by Cory Zanker; credit b: modification of work by David DeHetre)

WETLANDS (20.4)

- Wetlands are environments in which the soil is either permanently or periodically saturated with water.
- Wetlands exhibit a near continuous cover of emergent vegetation. **Emergent vegetation** consists of wetland plants that are rooted in the soil but have portions of leaves, stems, and flowers extending above the water's surface.
- There are several types of wetlands including marshes, swamps, bogs, mudflats, and salt marshes (Figure 20.33).

FIGURE 20.33 WETLANDS

Located in southern Florida, Everglades National Park is vast array of wetland environments, including sawgrass marshes, cypress swamps, and estuarine mangrove forests. Here, a great egret walks among cypress trees. (credit: NPS)

VOCABULARY

- Ecosystem
- Biotic
- Abiotic
- Biome
- Resistance
- Resilience
- Food chain
- Trophic level
- Food web
- Autotroph
- Heterotroph
- Gross primary productivity
- Net primary productivity
- Biomagnification
- Hydrosphere
- Non-renewable resource
- Eutrophication
- Dead zones
- Acid rain
- Evergreen
- Deciduous
- Permafrost
- Algal blooms
- Source water
- Channel
- Emergent vegetation