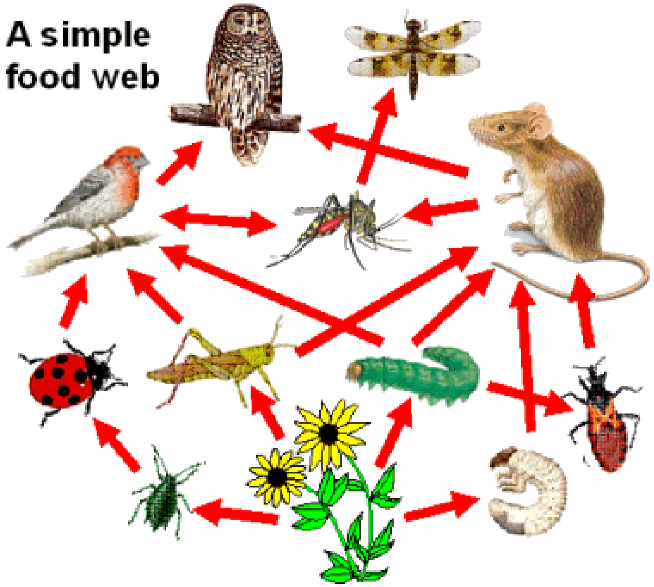
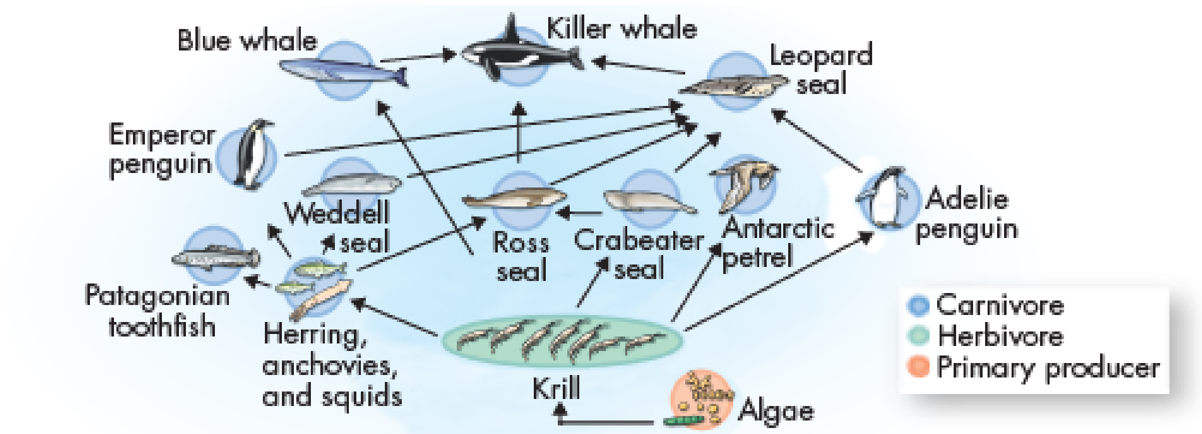
Biology EOC Review

Ecology and Environmental Science



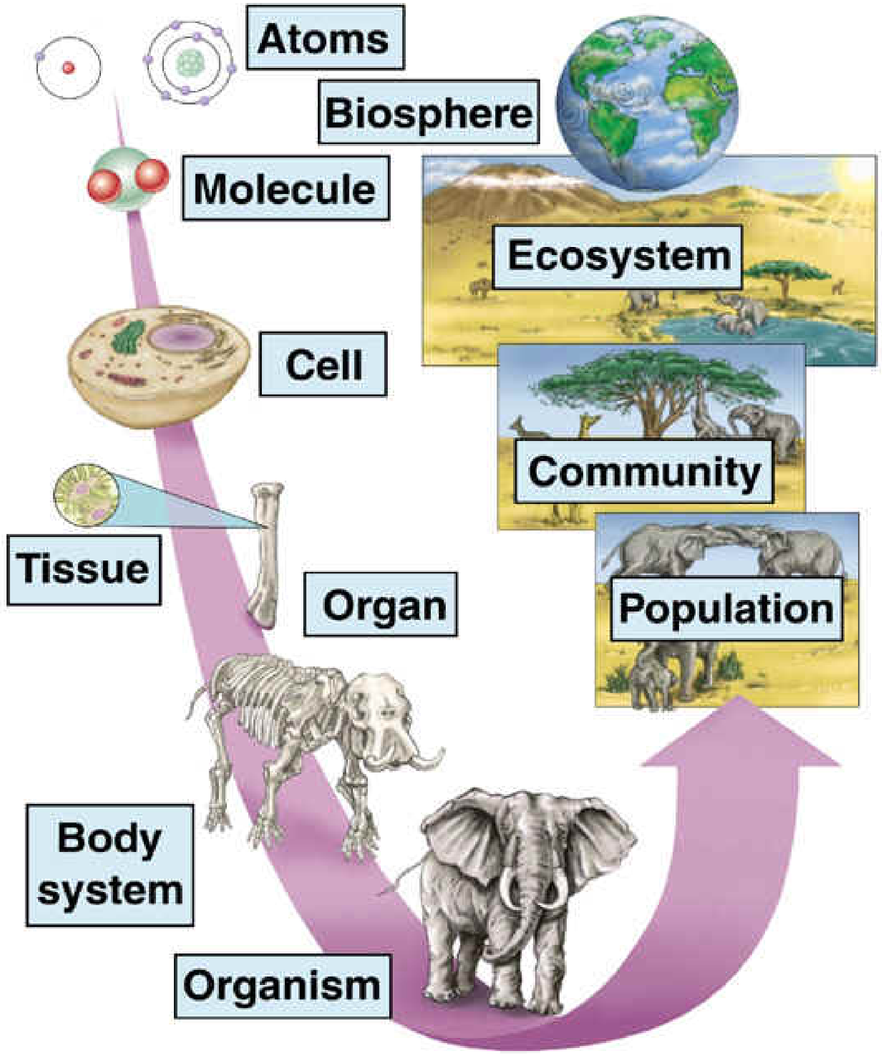
The Science of Ecology

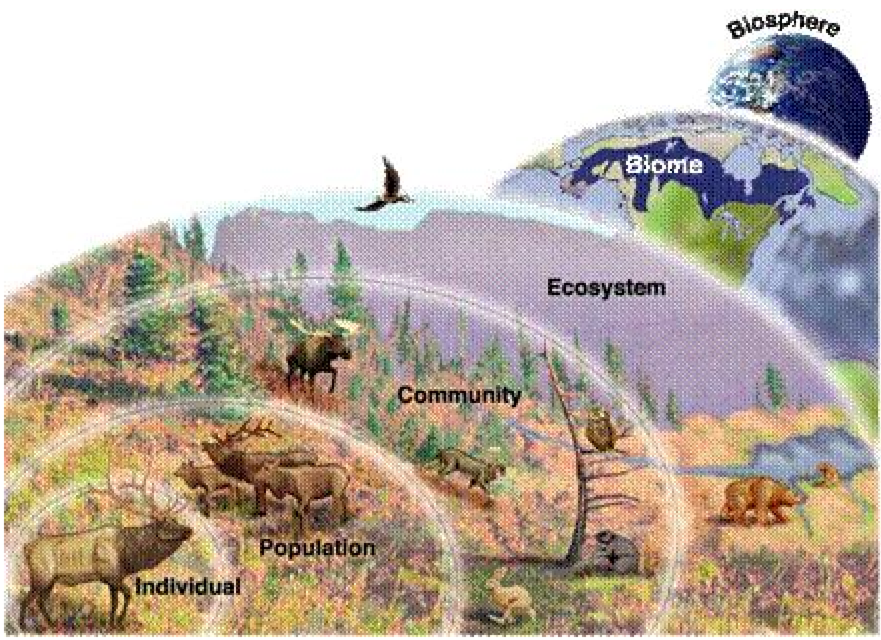
- **Ecology** is the scientific study of interactions among and between organisms and their physical environment.
- Interactions within the biosphere produce a web of interdependence between organisms and the environments in which they live.



Lesson Overview What is Ecology?

Raven/Berg, Environment, 3/e
Figure 4.1





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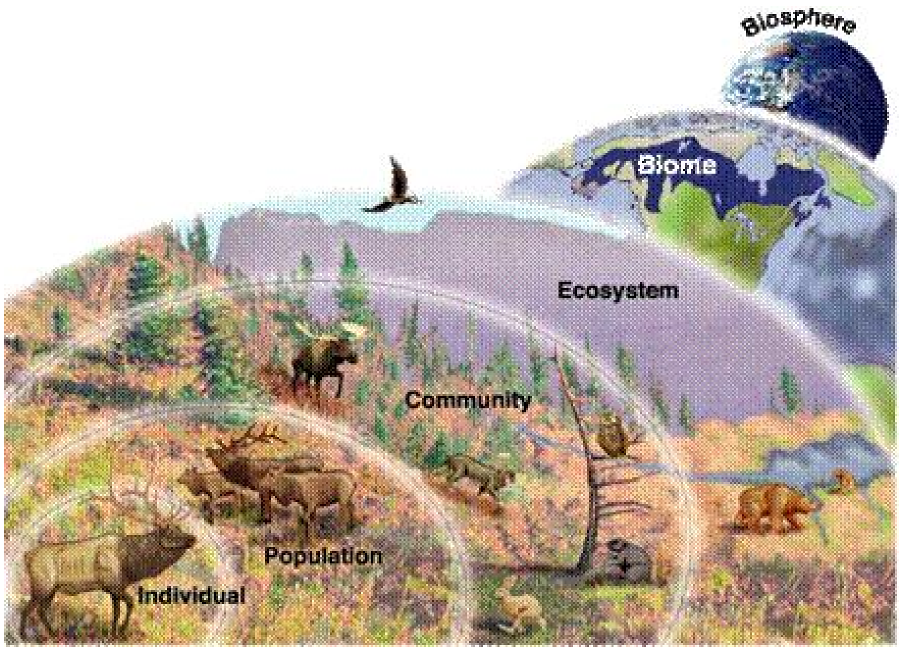
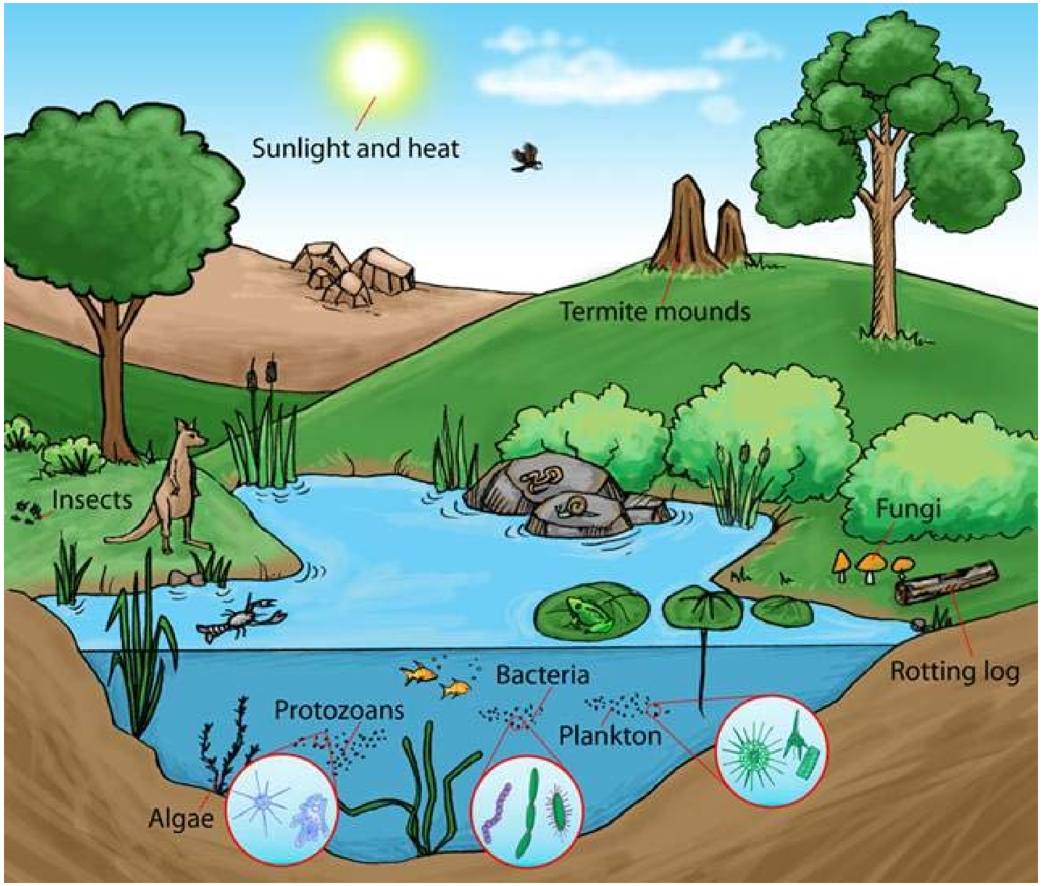
Levels of Organization

- Ecological studies may focus on **levels of organization** that include the following:
- **Individual organism**
- **Population**—a group of individuals that belong to the same species and live in the same area
- **Community**—an assemblage of different populations that live together in a defined area
- **Ecosystem**—all the organisms that live in a place, together with their physical environment
- **Biome**—a group of ecosystems that share similar climates and typical organisms
- **Biosphere—**our entire planet, with all its organisms and physical environments

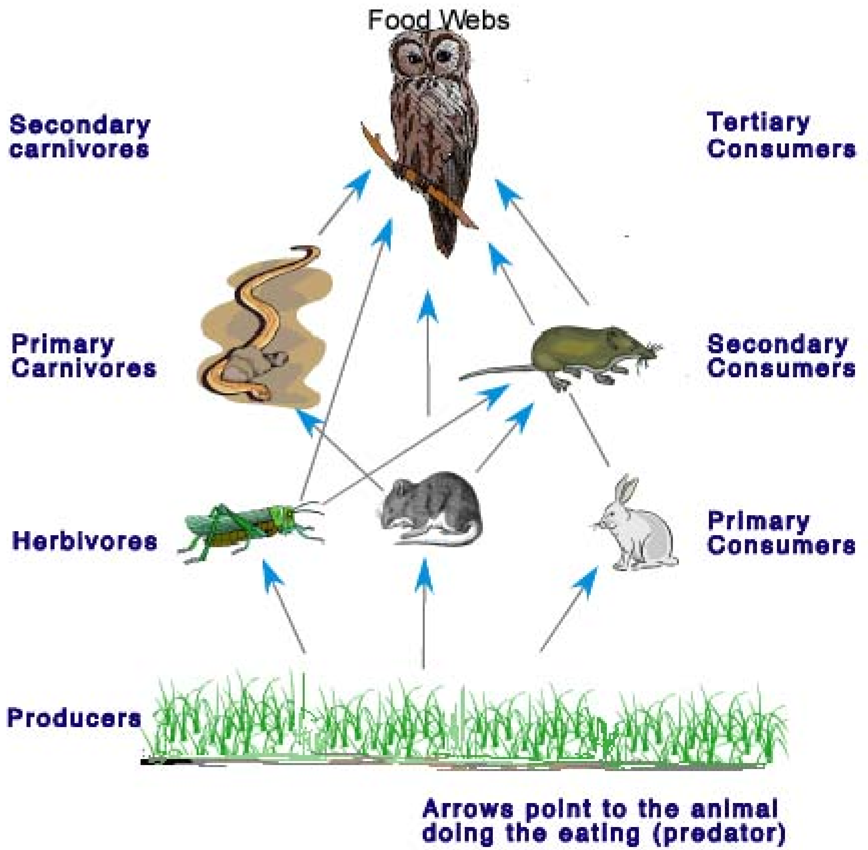


Biotic / Abiotic Factors

- A **biotic factor** is any living part of the environment with which an organism might interact, including animals, plants, mushrooms and bacteria.
- **Biotic factors** relating to a bullfrog might include algae it eats as a tadpole, the herons that eat bullfrogs, and other species competing for food or space.
- An **abiotic factor** is any nonliving part of the environment, such as sunlight, heat, precipitation, humidity, wind or water currents, soil type, etc.
- For example, a bullfrog could be affected by abiotic factors such as water availability, temperature, and humidity.



Energy, Producers, and Consumers



http://www.eelsinc.org/id64.html

Primary Producers

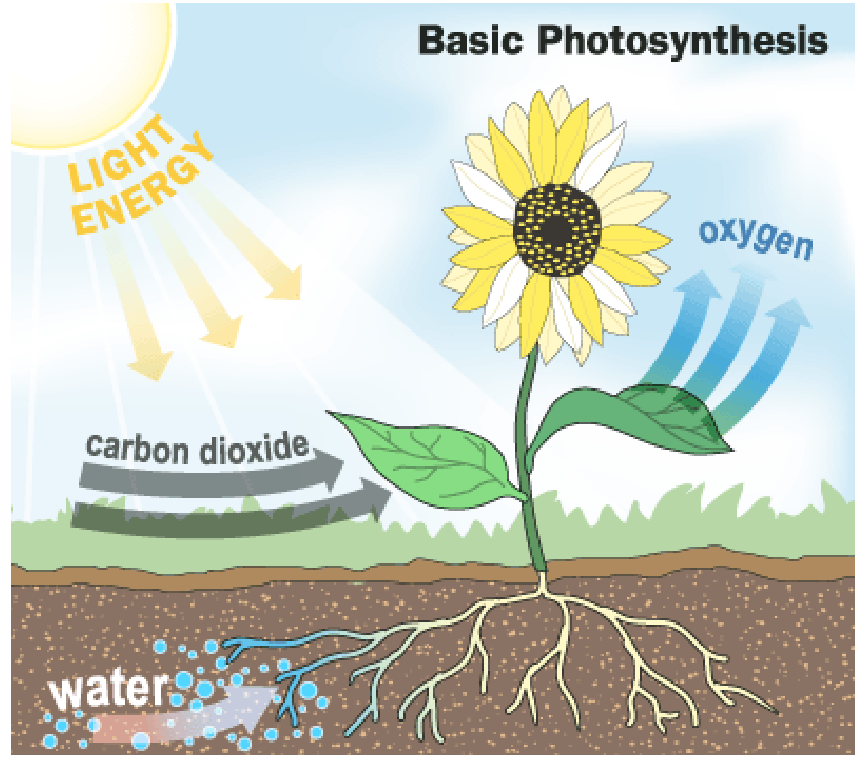
Organisms need energy for growth, reproduction, and metabolic processes.

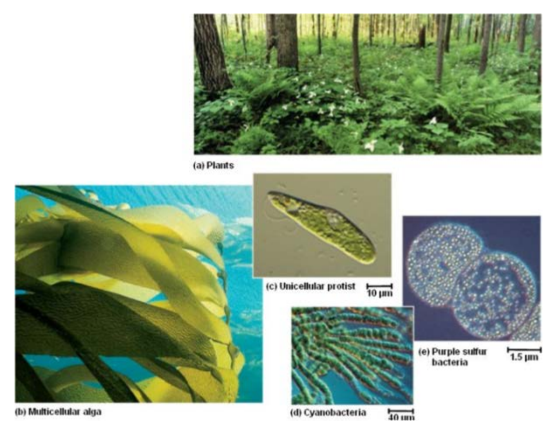
No organism can create **energy—organisms can only use energy from other sources.**

For most life on Earth, **sunlight is the ultimate energy source.**

Plants, algae, and certain bacteria can capture energy from sunlight or chemicals and convert it into forms that living cells can use. These organisms are called **<u>autotrophs</u>.**

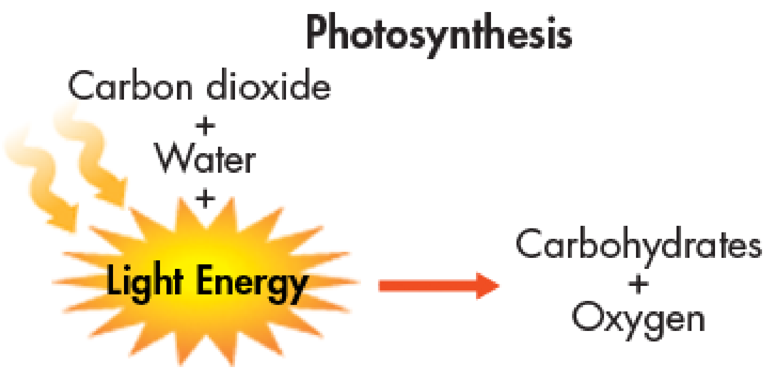
Autotrophs are also called **<u>primary producers.</u>**

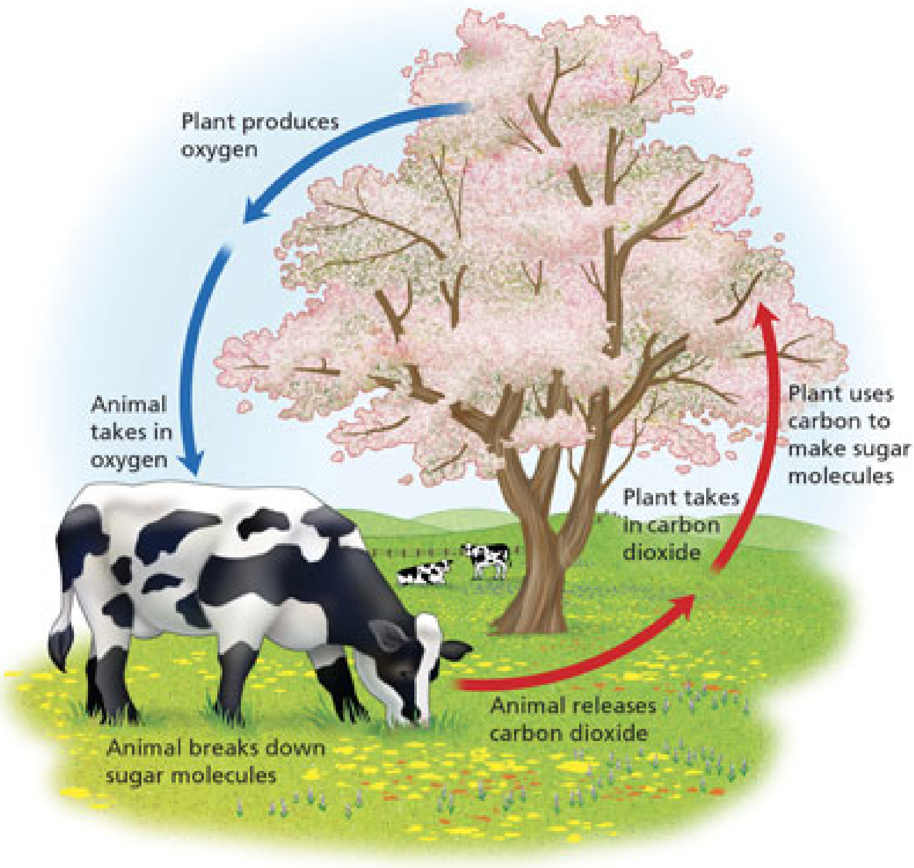




Energy From the Sun

The best-known and most common primary producers harness solar energy through the process of **photosynthesis.**





Consumers

Organisms that must acquire energy from other organisms by ingesting in some way are known as **heterotrophs.**

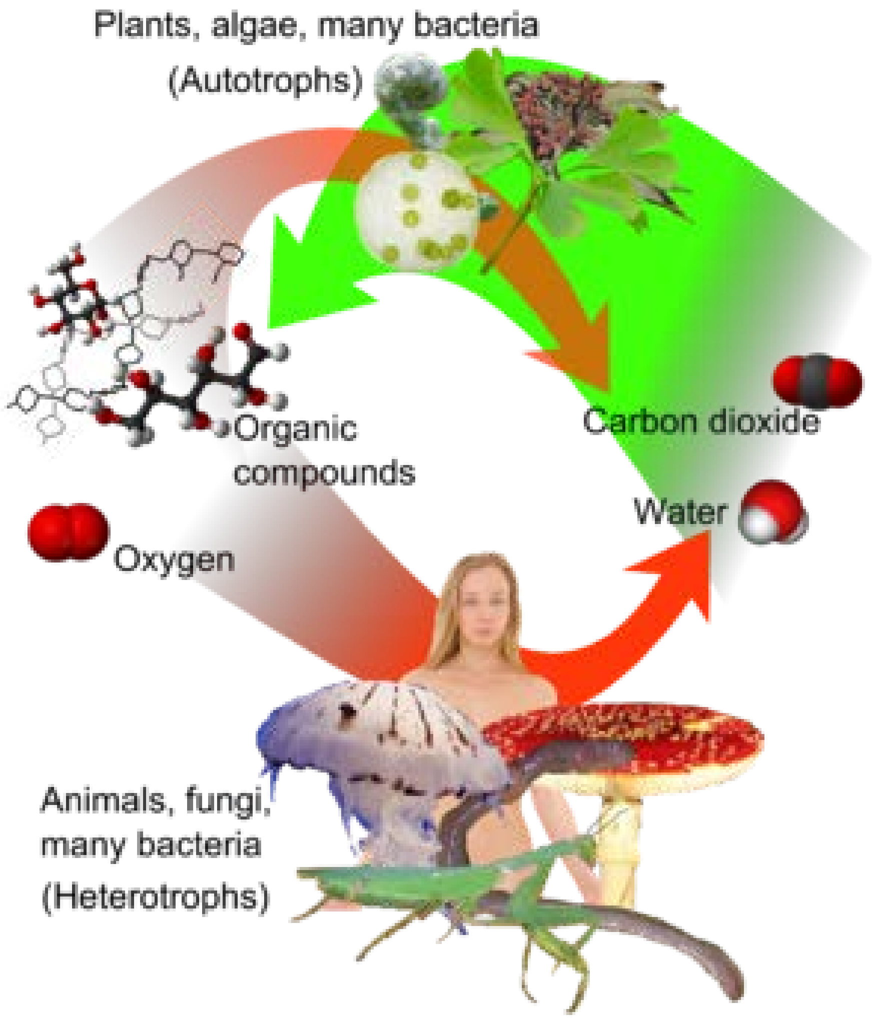
Heterotrophs are also called **consumers.**

Types of Consumers

Herbivore – eats plants, examples include; cows, grasshoppers, deer

Carnivore – eats animals, examples include; lions, tigers, sharks

Omnivore – eats both plants and animals, examples include; humans, pigs, bears, raccoons

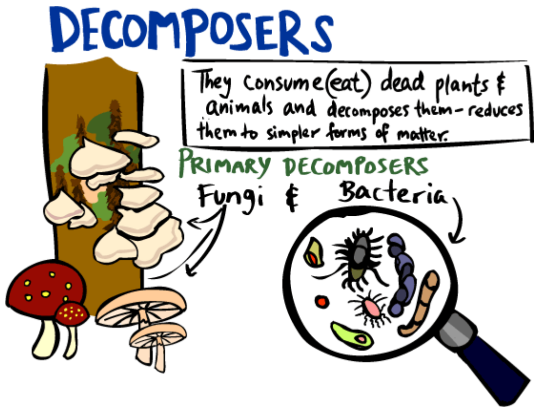


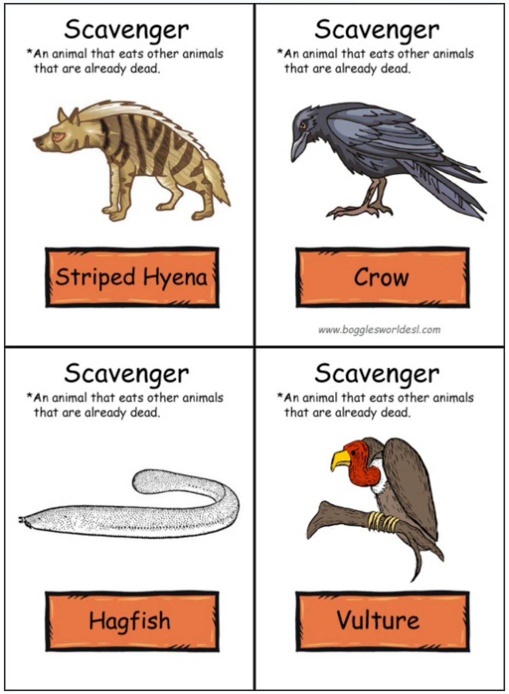
Types of Consumers

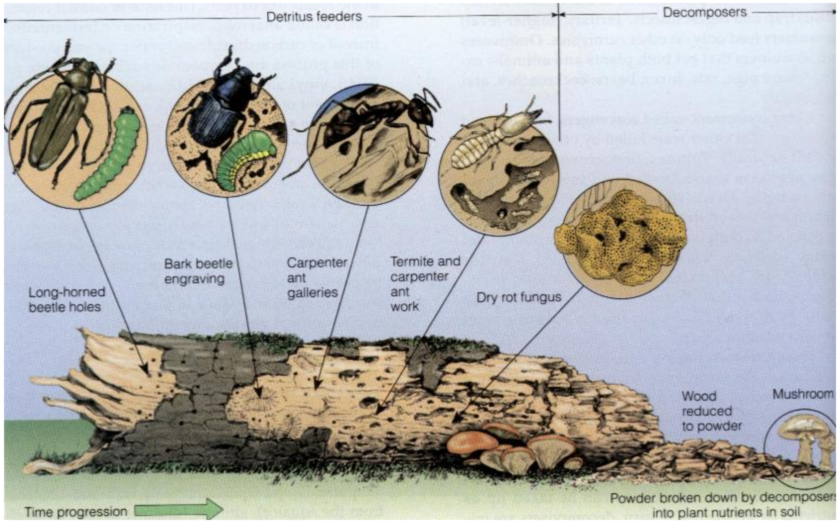
Scavengers, like a king vulture, are animals that consume the carcasses of other animals that have been killed by predators or have died of other causes.

Detritivores, like giant earthworms, feed on detritus particles, often chewing or grinding them into smaller pieces. Detritivores commonly digest decomposers that live on, and in, detritus particles.

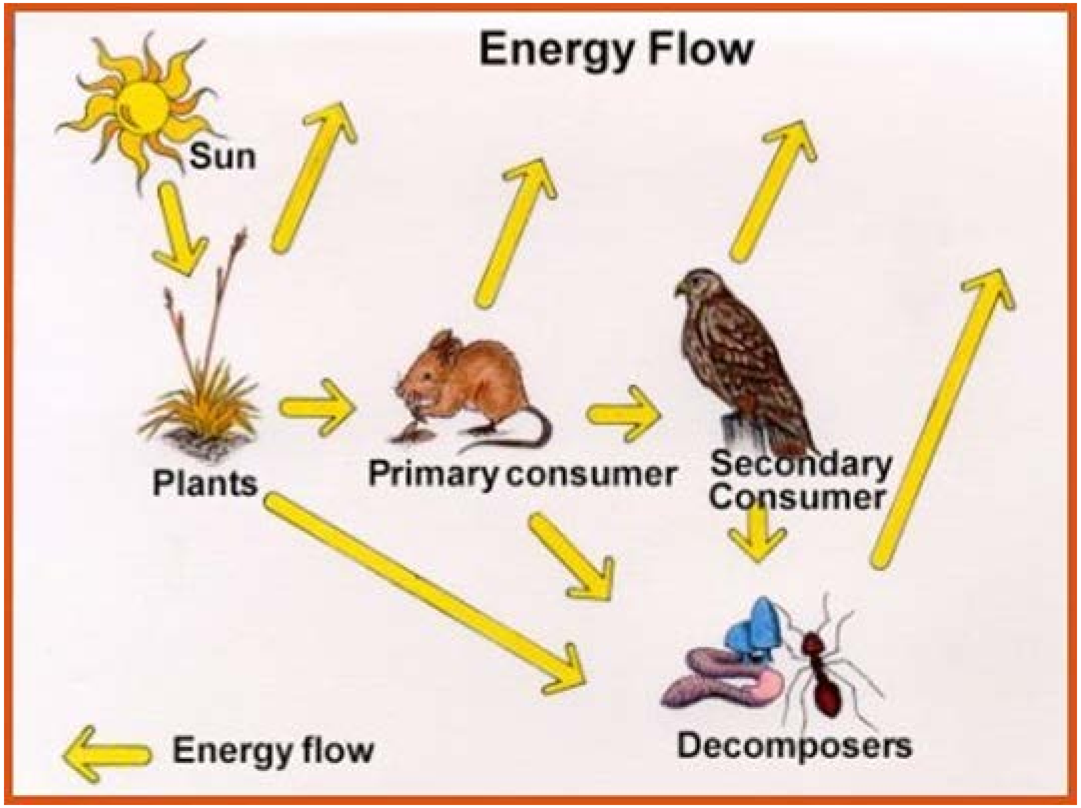
Decomposers, such as bacteria and fungi, feed by chemically breaking down organic matter. The decay caused by decomposers is part of the process that produces detritus—small pieces of dead and decaying plant and animal remains.







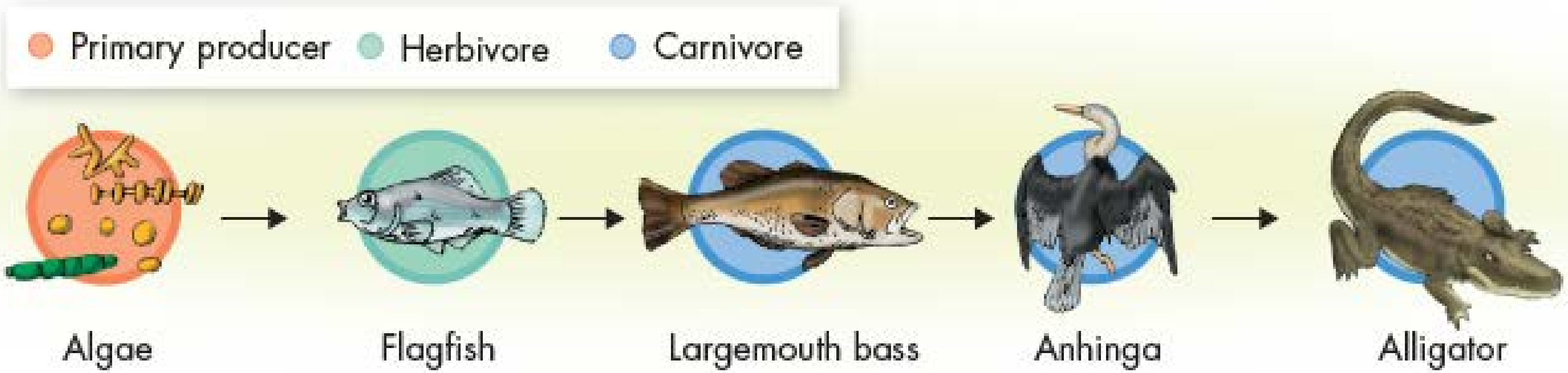
Energy Flow in Ecosystems



Food Chains

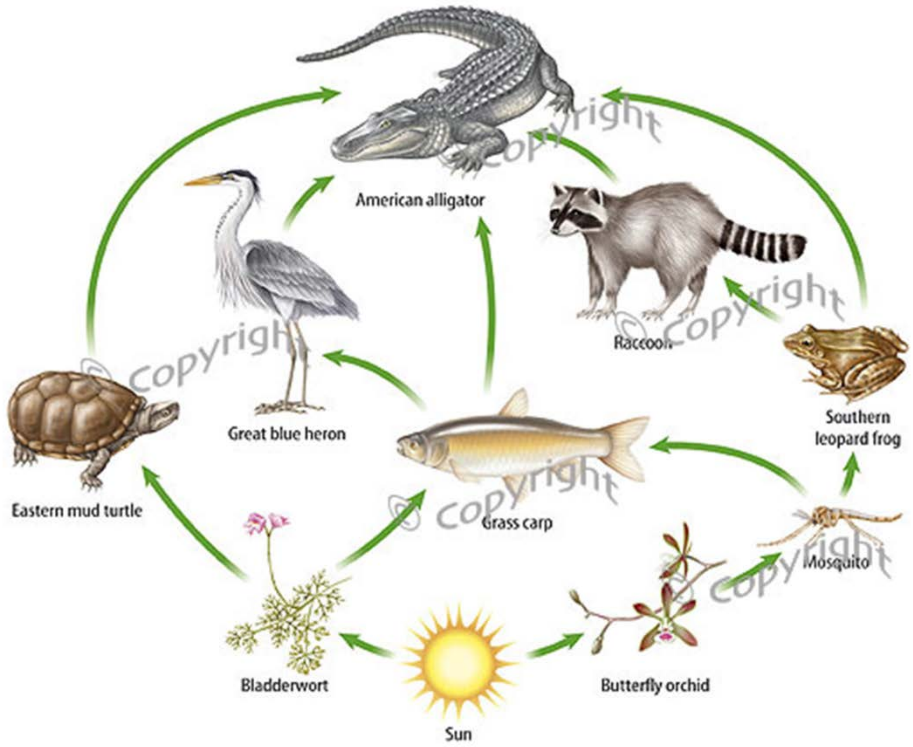
A **food chain** is a series of steps in which organisms transfer energy by eating and being eaten.

Food chains can vary in length. An example from the Everglades is shown.



Food Webs

In most ecosystems, feeding relationships are much more complicated than the relationships described in a single, simple chain because many animals eat more than one kind of food. Ecologists call this network of feeding interactions a **food web.**



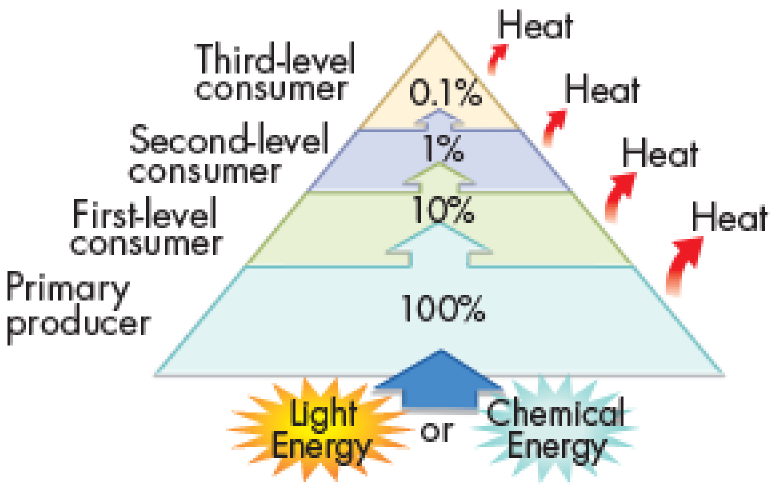
Trophic Levels and Ecological Pyramids

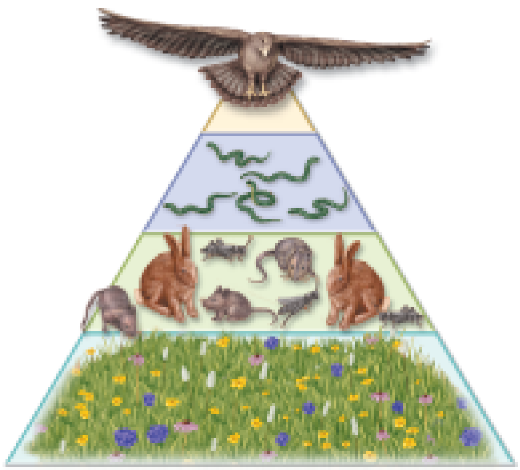
Each step in a food chain or food web is called a **trophic level.**

Primary producers always make up the first trophic level.

Various consumers occupy every other level. Some examples are shown.

Ecological pyramids show the relative amount of energy or matter contained within each trophic level in a given food chain or food web.





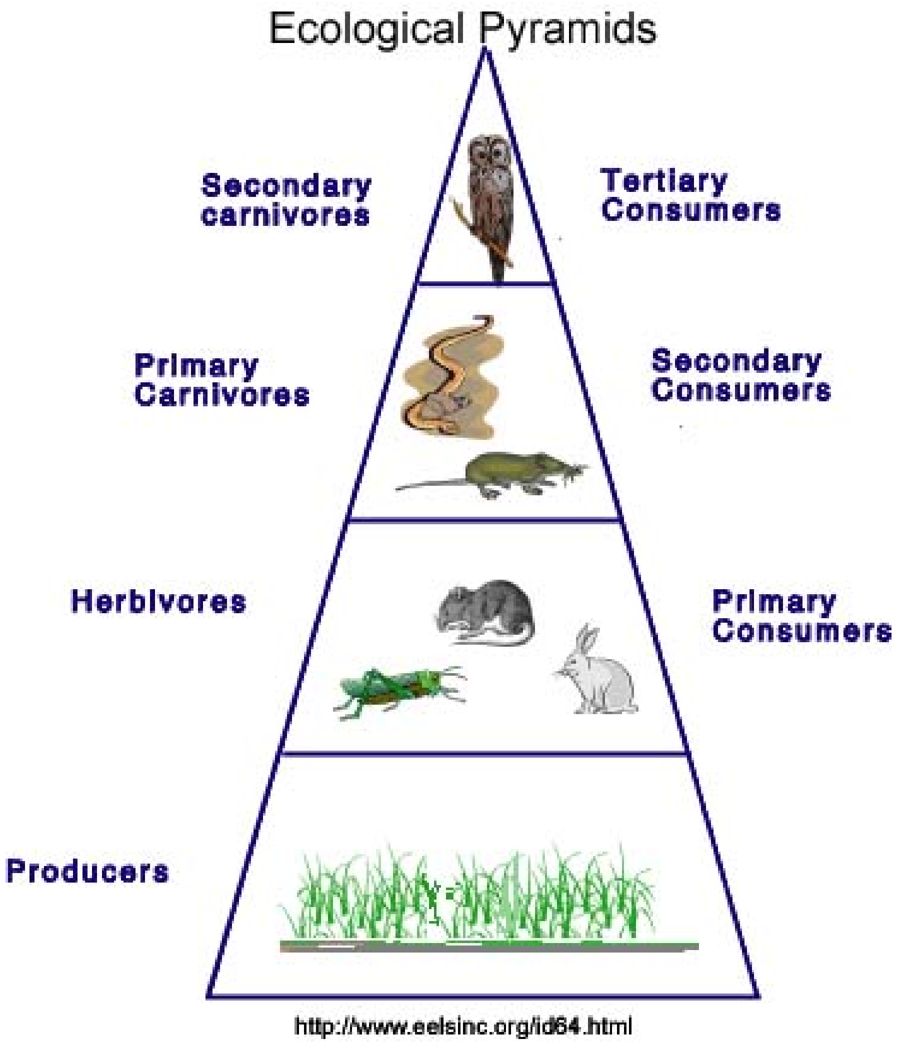
Pyramids of Energy

There is theoretically no limit to the number of **trophic levels** in a food web or the number of organisms that live on each level.

However, only a small portion of the energy that passes through any given trophic level is ultimately stored in the bodies of organisms at the next level.

Organisms expend much of the energy they acquire on life processes, such as respiration, movement, growth, and reproduction.

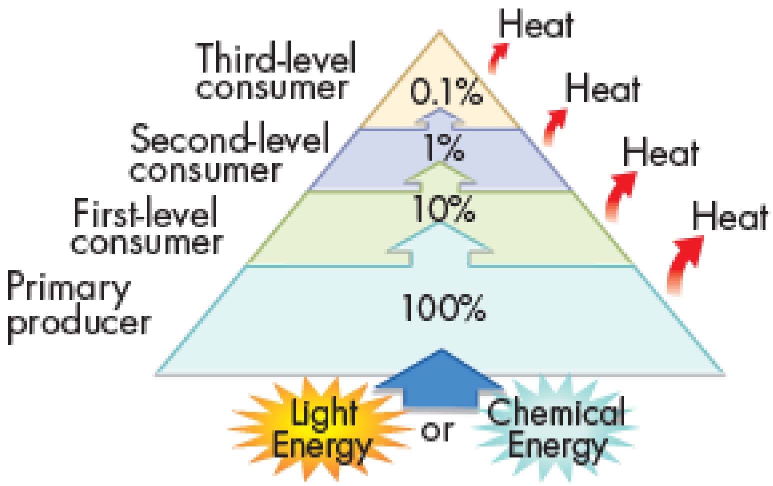
Most of the remaining energy is released into the environment as heat—a byproduct of these activities.



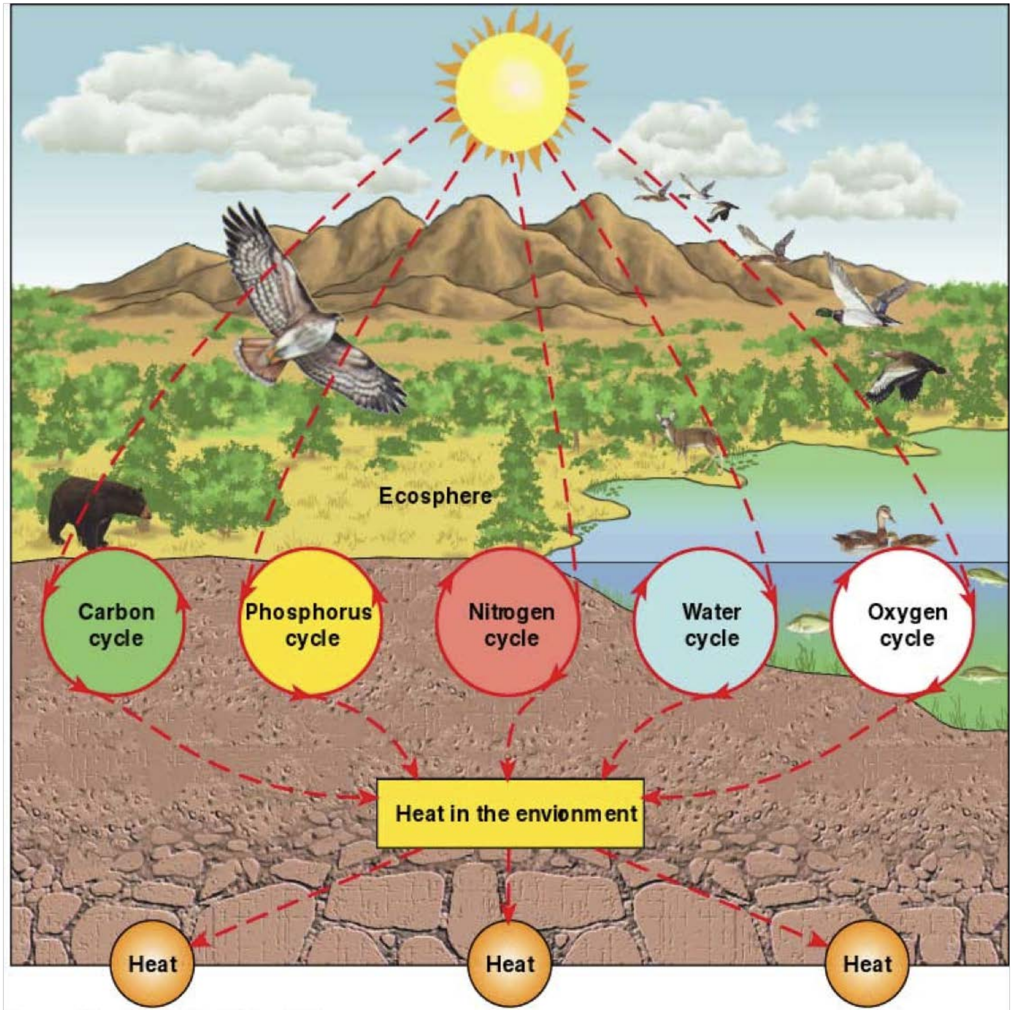
Pyramids of Energy

On average, about 10 percent of the energy available within one trophic level is transferred to the next trophic level.

The more levels that exist between a producer and a consumer, the smaller the percentage of the original energy from producers that is available to that consumer.



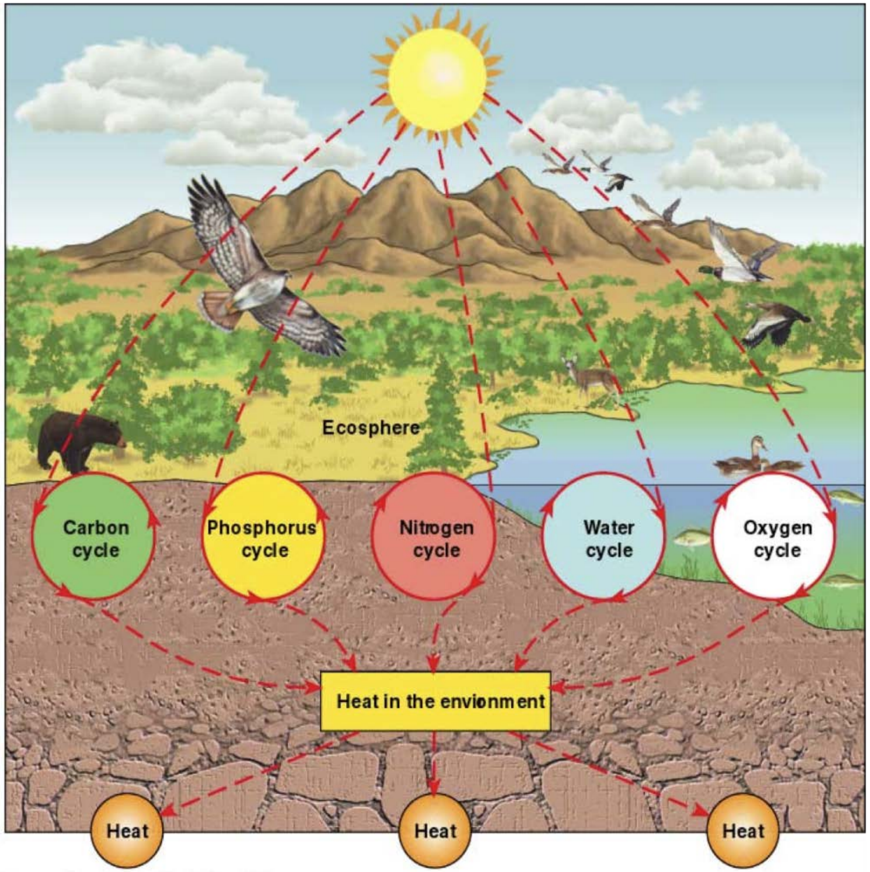
Cycles of Matter



Recycling in the Biosphere

Unlike the one-way flow of energy, matter is recycled within and between ecosystems.

Elements pass from one organism to another and among parts of the biosphere through closed loops called **biogeochemical cycles**, which are powered by the flow of energy.



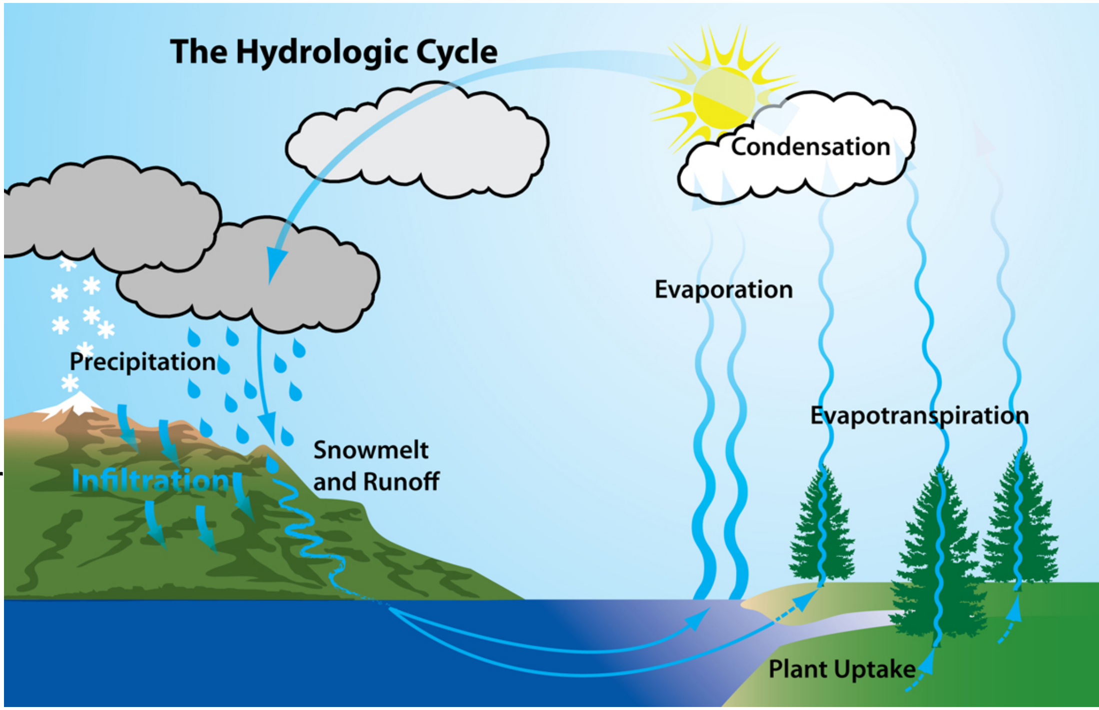
The Water Cycle

Water molecules typically enter the atmosphere as water vapor when they **evaporate** from the ocean or other bodies of water.

Water can also enter the atmosphere by evaporating from the leaves of plants in the process of **transpiration.**

If the air carrying it cools, water vapor **condenses** into tiny droplets that form clouds.

When the droplets become large enough, they fall to Earth's surface as **precipitation** in the form of rain, snow, sleet, or hail.



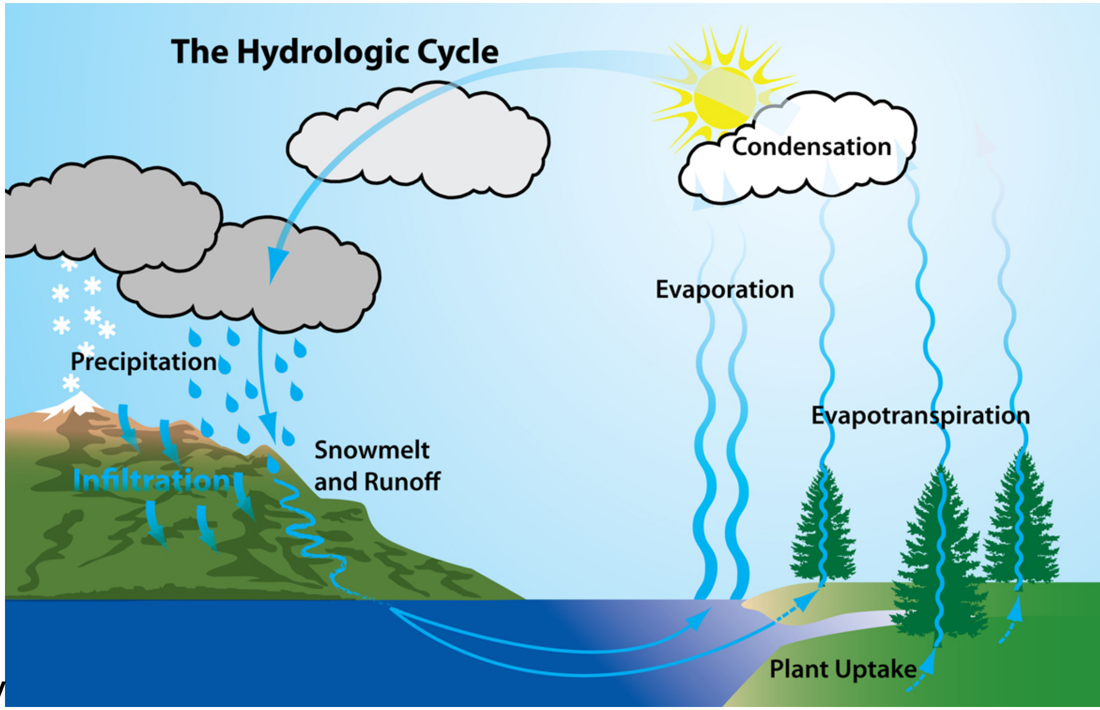
The Water Cycle

On land, some **precipitation** flows along the surface in what scientists call **runoff**, until it enters a river or stream that carries it to an ocean or lake.

Precipitation can also be absorbed into the soil, and is then called groundwater.

Groundwater can enter plants through their roots, or flow into rivers, streams, lakes, or oceans.

Some groundwater penetrates deeply enough into the ground to become part of underground reservoirs.

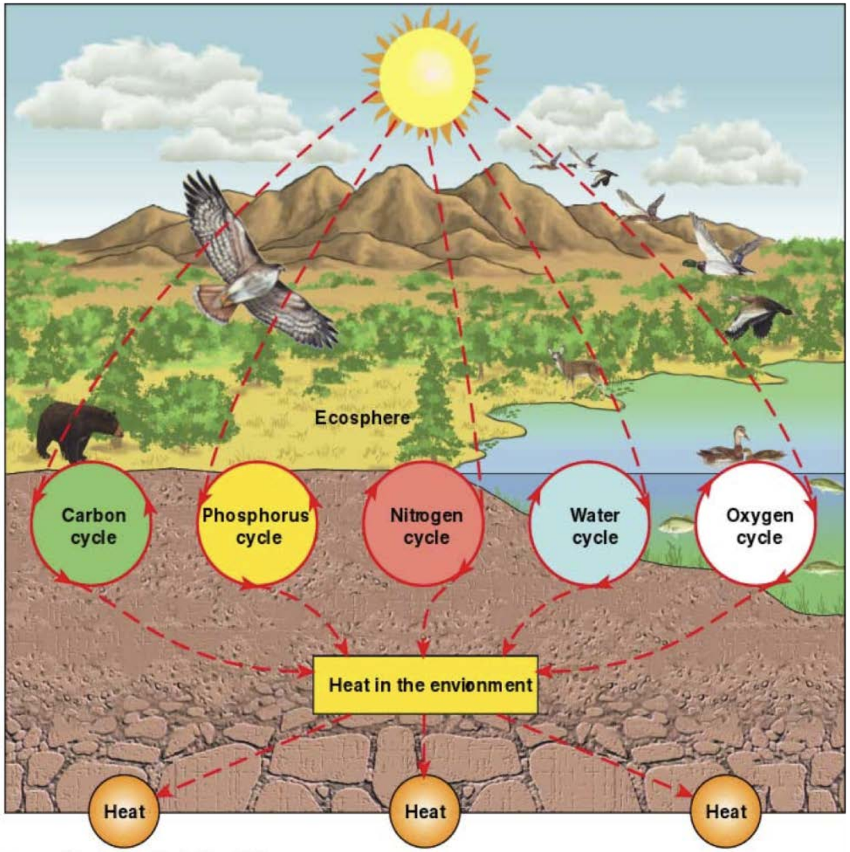


Nutrient Cycles

The chemical substances that an organism needs to sustain life are called **nutrients.**

Every organism needs nutrients to build tissues and carry out life functions.

Nutrients pass through organisms and the environment through biogeochemical cycles.



The Carbon Cycle

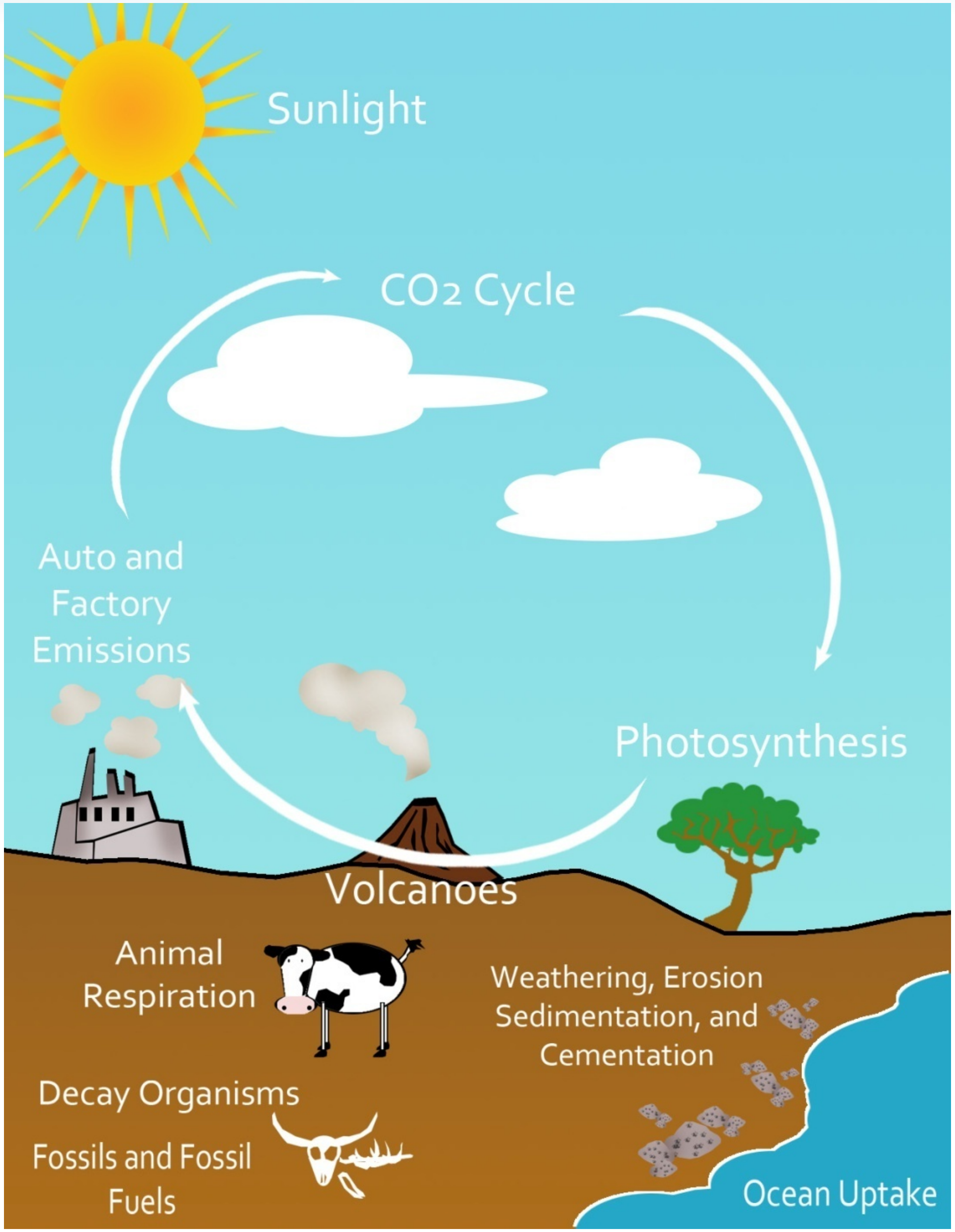
Carbon is a major component of all organic compounds, including carbohydrates, lipids, proteins, and nucleic acids.

Carbon dioxide is continually exchanged through chemical and physical processes between the atmosphere and oceans.

Plants take in carbon dioxide during **photosynthesis** and use the carbon to build carbohydrates.

Carbohydrates then pass through food webs to consumers.

Organisms release carbon in the form of carbon dioxide gas by **respiration.**

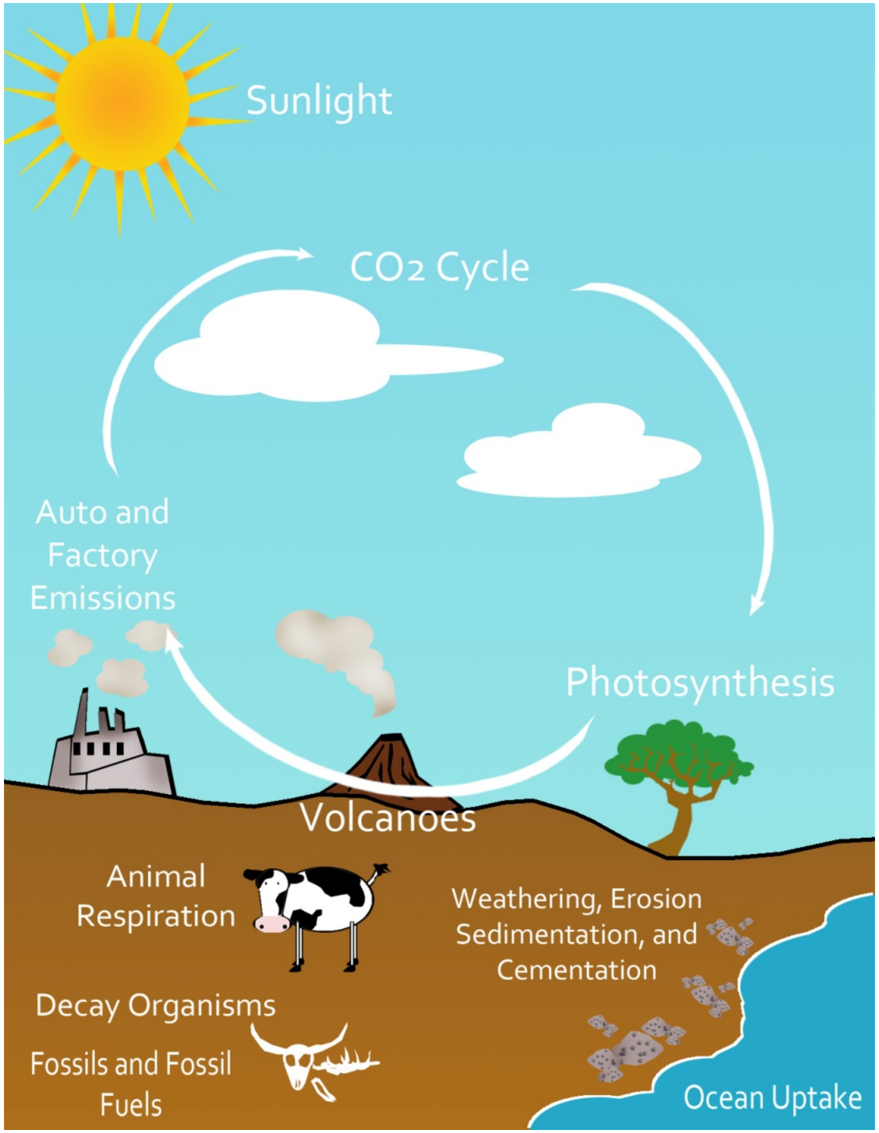


The Carbon Cycle

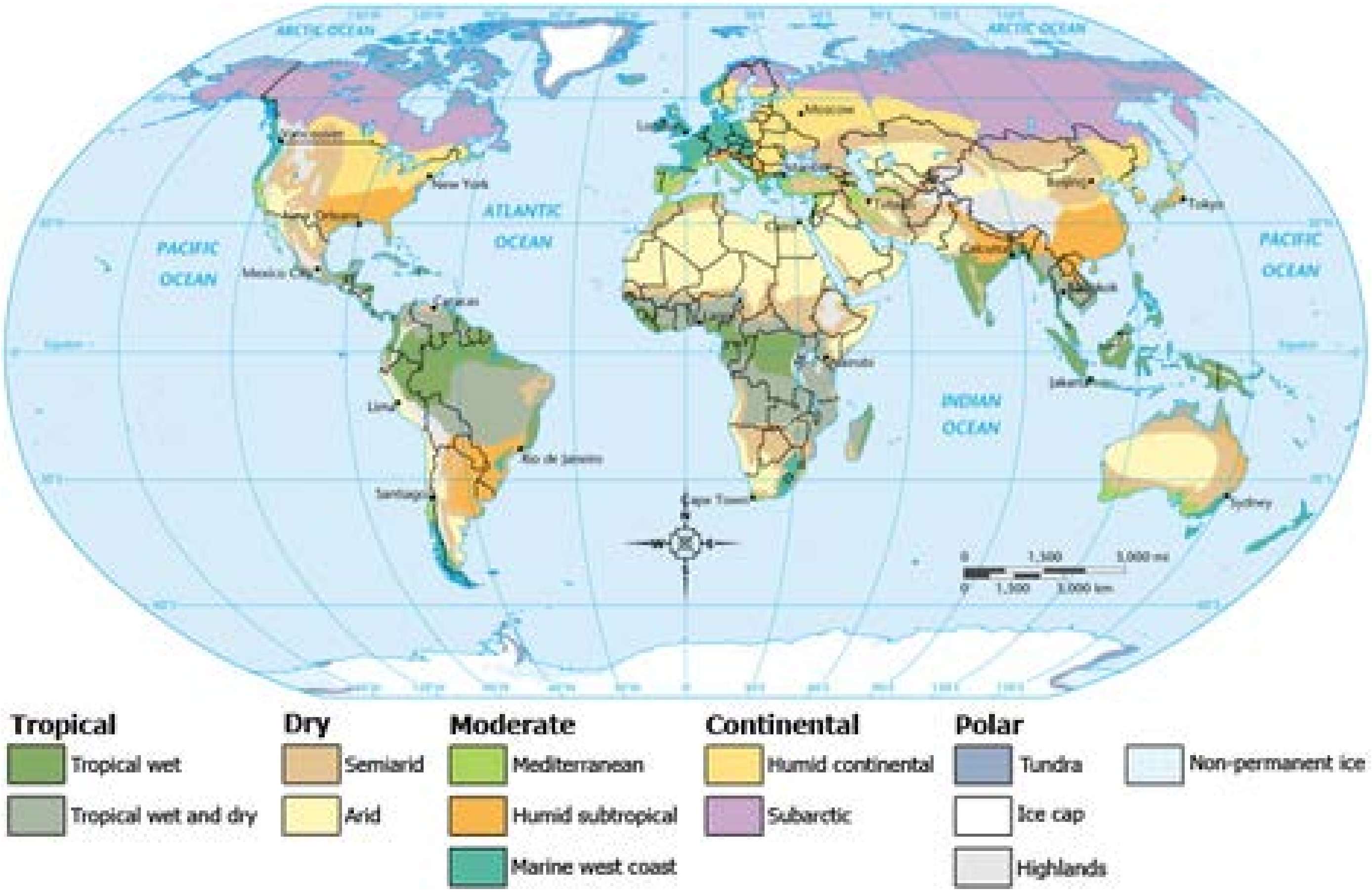
When organisms die, **decomposers** break down the bodies, releasing carbon to the environment.

Geologic forces can turn accumulated carbon into carbon-containing rocks or **fossil fuels**.

Carbon dioxide is released into the atmosphere by **volcanic activity** or by **human activities**, such as the burning of fossil fuels and the clearing and burning of forests.



Climate


ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
New York
Rio de Janeiro
Cape Town
Tokyo
Sydney
Tropical
Tropical wet
Tropical wet and dry
Dry
Semiarid
Arid
Moderate
Mediterranean
Humid subtropical
Marine west coast
Continental
Humid continental
Subarctic
Polar
Tundra
Ice cap
Highlands
Non-permanent ice

Weather and Climate

Weather is the day-to-day condition of Earth's atmosphere.

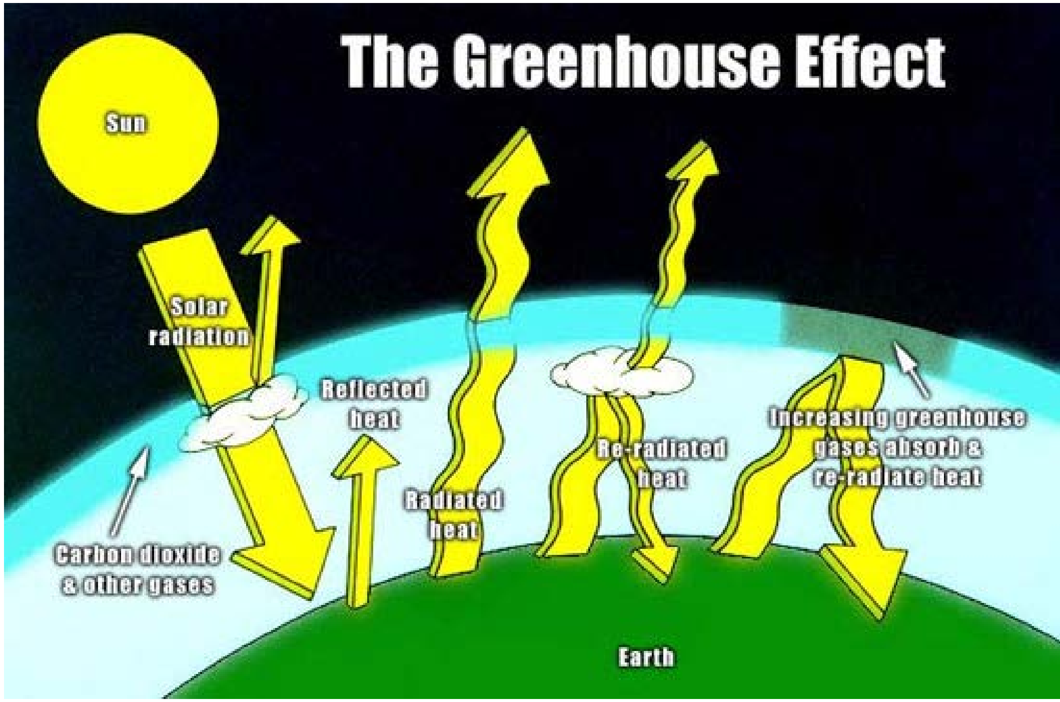
Climate refers to average conditions over long periods and is defined by year-after-year patterns of temperature and precipitation.

Climate is rarely uniform even within a region. Environmental conditions can vary over small distances, creating **microclimates.**

For example, in the Northern Hemisphere, south-facing sides of trees and buildings receive more sunlight, and are often warmer and drier, than north-facing sides. These differences can be very important to many organisms.

Solar Energy and the Greenhouse Effect

The main force that shapes our climate is solar energy that arrives as sunlight that strikes Earth's surface.

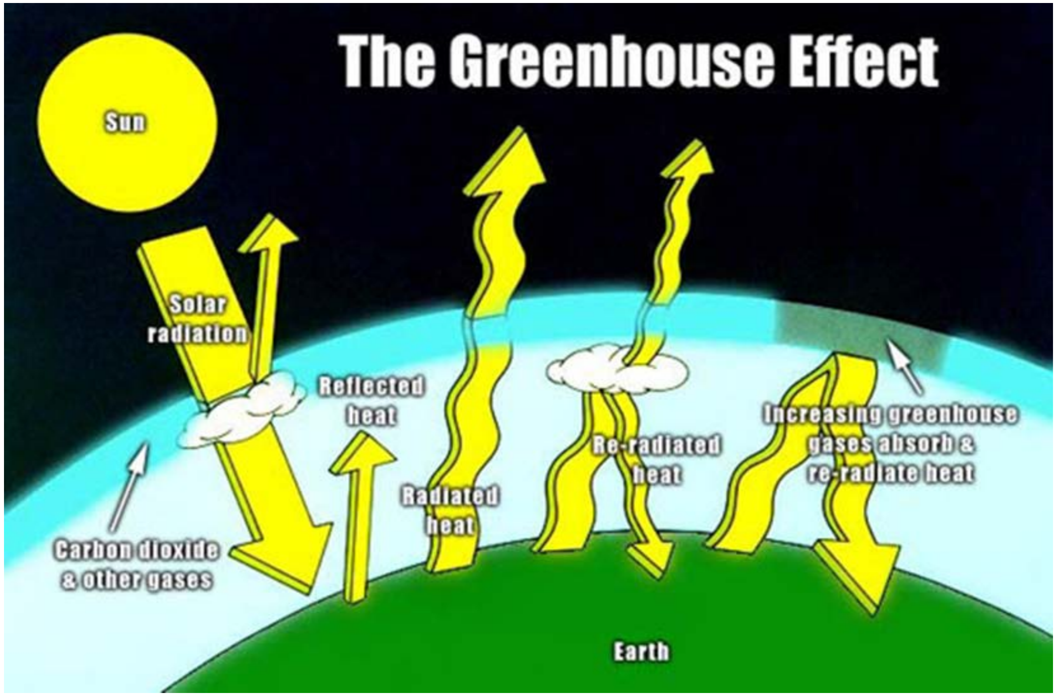


Some of that energy is reflected back into space, and some is absorbed and converted into heat.

Solar Energy and the Greenhouse Effect

Some of the heat also radiates back into space, and some is trapped in the biosphere.

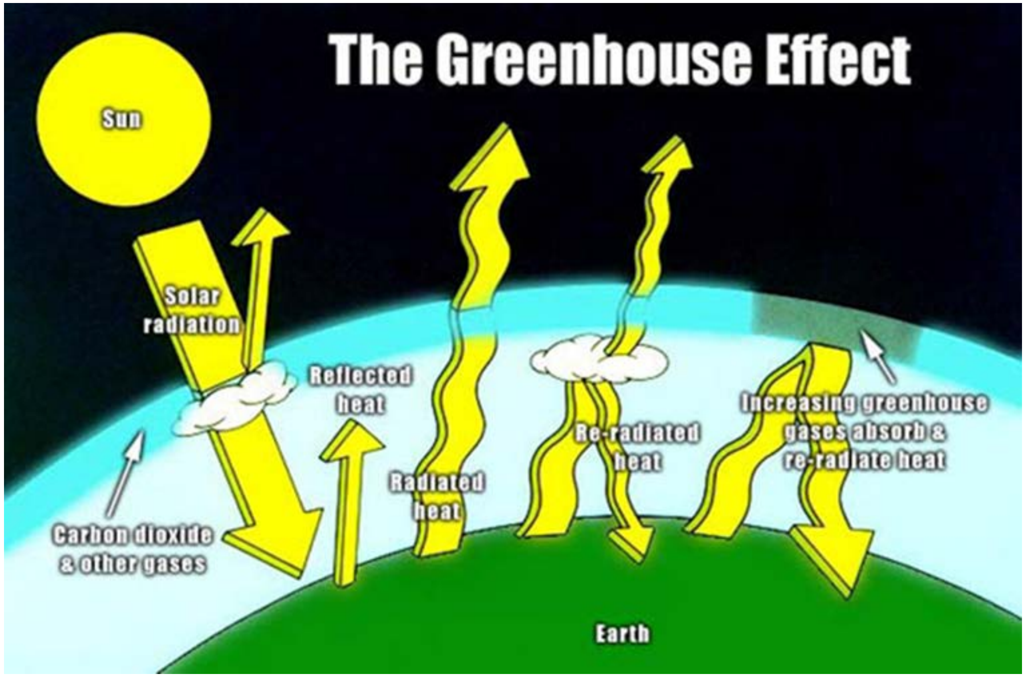
The balance between heat that stays in the biosphere and heat lost to space determines Earth's average temperature.



Solar Energy and the Greenhouse Effect

Earth's temperature is largely controlled by concentrations of three atmospheric **gases—carbon dioxide, methane, and water vapor.**

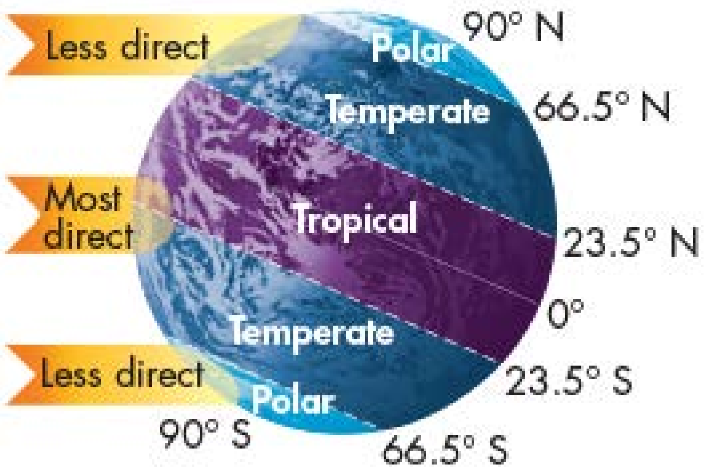
These **"greenhouse gases"** function like glass in a greenhouse, allowing visible light to enter but trapping heat through a phenomenon called the **greenhouse effect.**

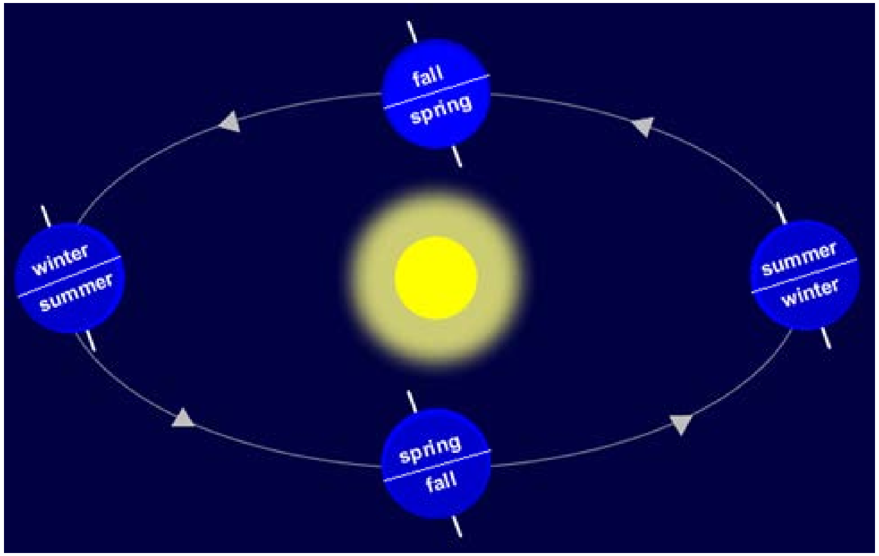


Latitude and Solar Energy

Near the equator, solar energy is intense, as the sun is almost directly overhead at noon all year. That's why equatorial regions are generally so warm.

The curvature of Earth causes the same amount of solar energy to spread out over a much larger area **near the poles** than near the equator.

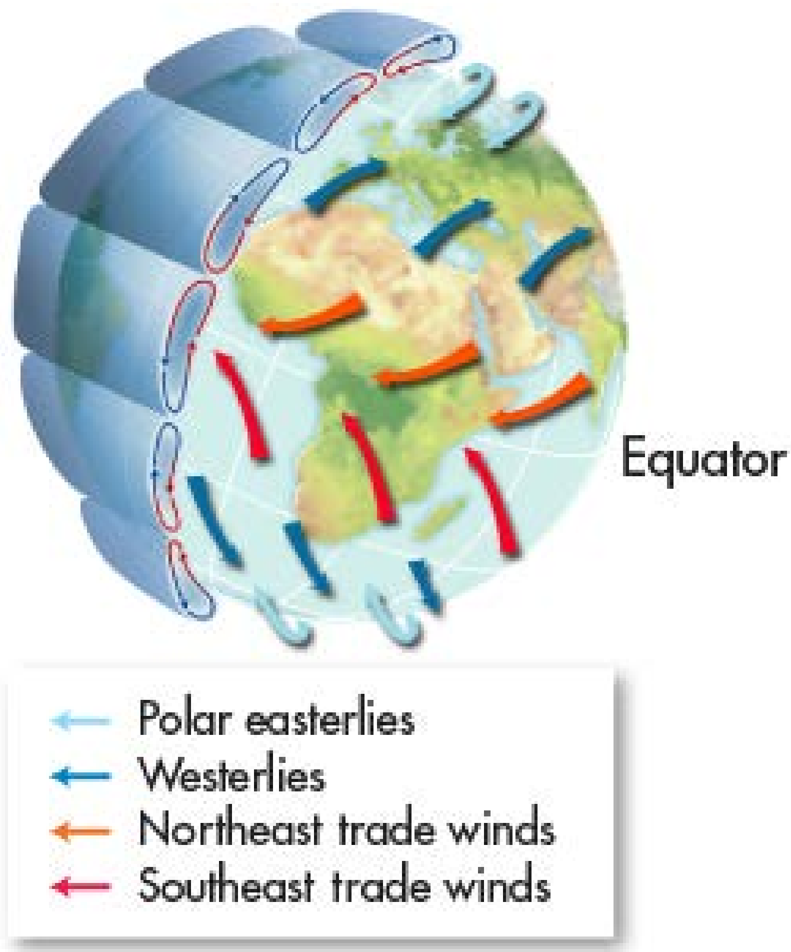




Heat Transport in the Biosphere

The unequal distribution of heat across the globe creates wind and ocean currents, which transport heat and moisture.

Earth has winds because warm air is less dense and rises, and cool air is more dense and sinks.

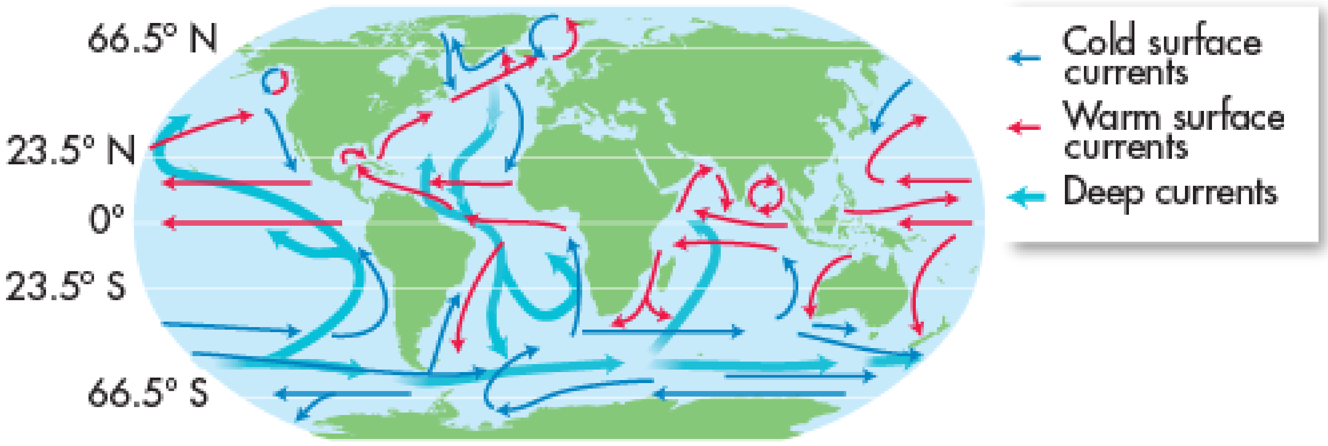


Heat Transport in the Biosphere

Similar patterns of heating and cooling occur in the oceans.

Surface water is pushed by winds.

Ocean currents, like air currents, transport enormous amounts of heat.

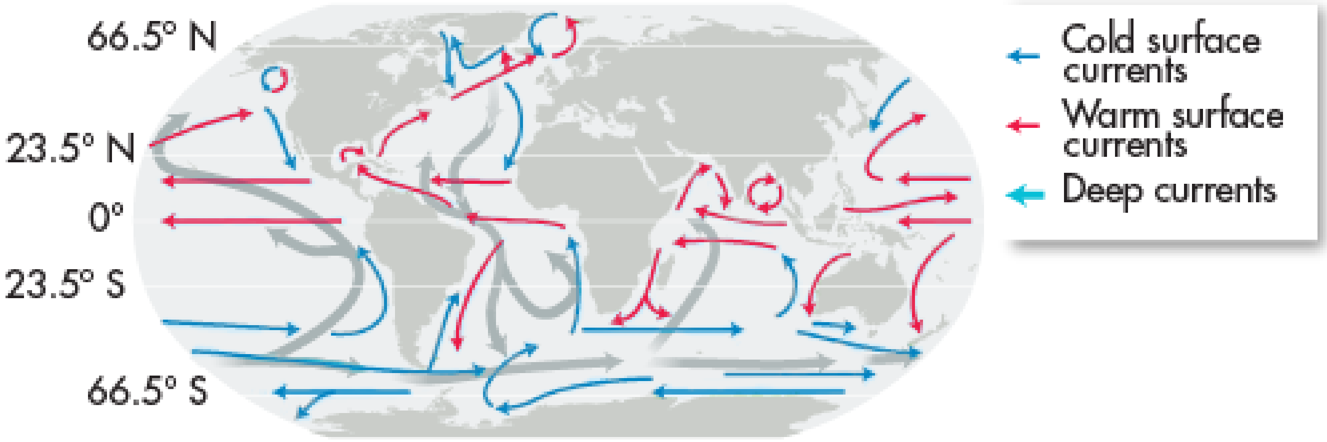


Heat Transport in the Biosphere

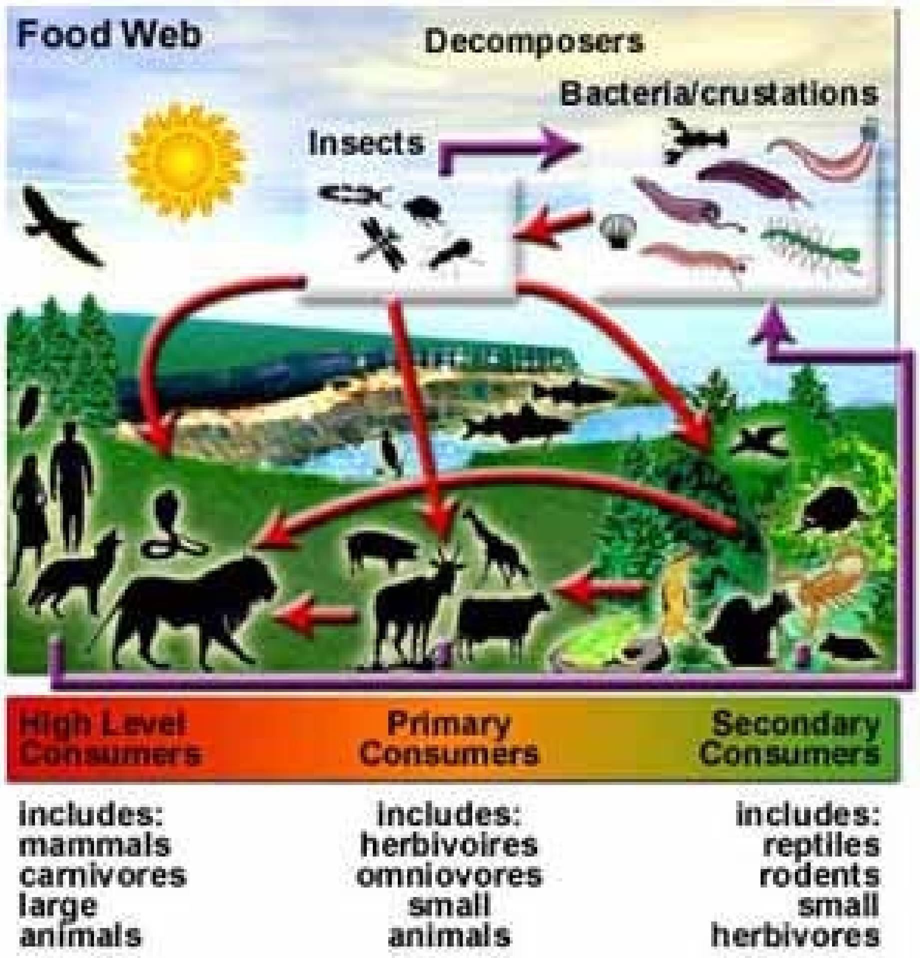
Warm surface currents add moisture and heat to air that passes over them.

Cool surface currents cool air that passes over them.

In this way, surface currents affect the weather and climate of nearby landmasses.



Niches and Community Interactions



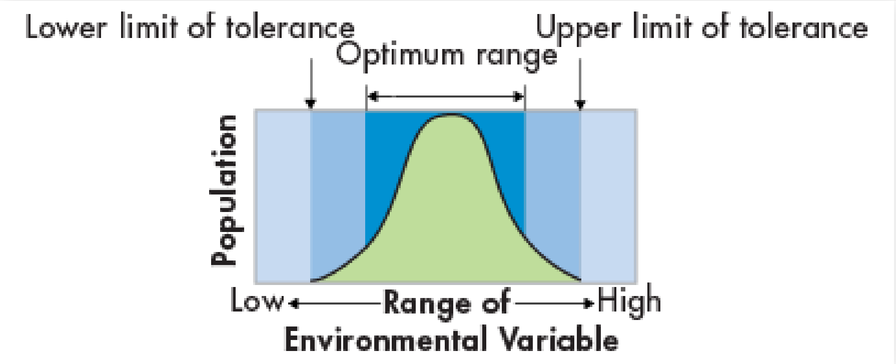
Tolerance

Every species has its own range of **tolerance**, the ability to survive and reproduce under a range of environmental circumstances.

When an environmental condition, such as temperature, extends in either direction beyond an organism's optimum range, the organism experiences stress.

The organism must expend more energy to maintain **homeostasis**, and so has less energy left for growth and reproduction.

A species' tolerance for environmental conditions, then, helps determine its **habitat** —the general place where an organism lives (its home).



Defining the Niche

An organism's **niche** describes not only the environment where it lives, but ***how* it interacts with biotic and abiotic factors in the environment.**

In other words, an organism's niche includes not only the physical and biological aspects of its environment, **but also the way in which the organism uses them to survive and reproduce (its job).**

Resources and the Niche

The term **resource** can refer to any necessity of life, such as water, nutrients, light, food, or space.

For plants, resources can include sunlight, water, and soil nutrients.

For animals, resources can include nesting space, shelter, types of food, and places to feed.

Competition

How one organism interacts with other organisms is an important part of defining its niche.

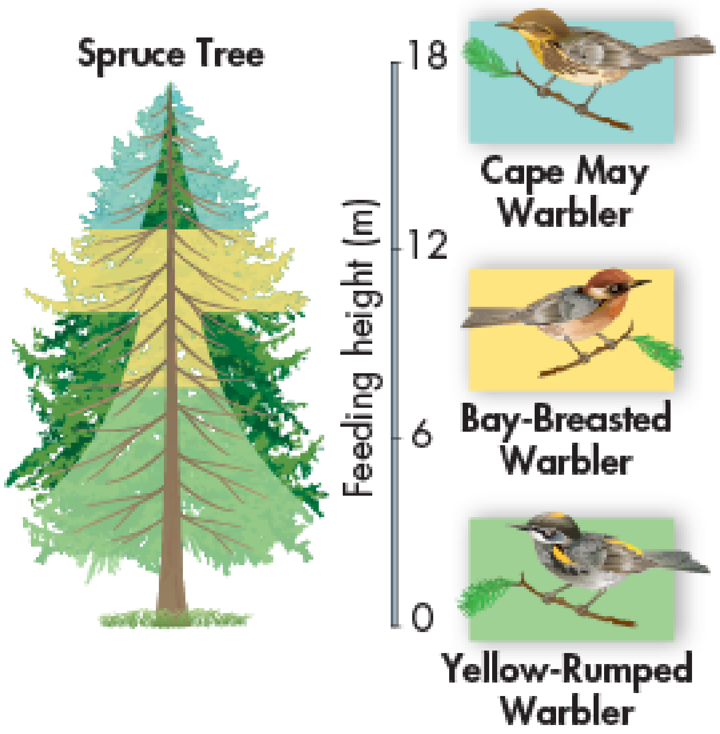
Competition occurs when organisms attempt to use the same limited ecological resource in the same place at the same time.

Dividing Resources

Instead of competing for similar resources, species usually divide them.

For example, the three species of North American warblers shown all live in the same trees and feed on insects.

But one species feeds on high branches; another feeds on low branches, and another feeds in the middle.



Predator-Prey Relationships

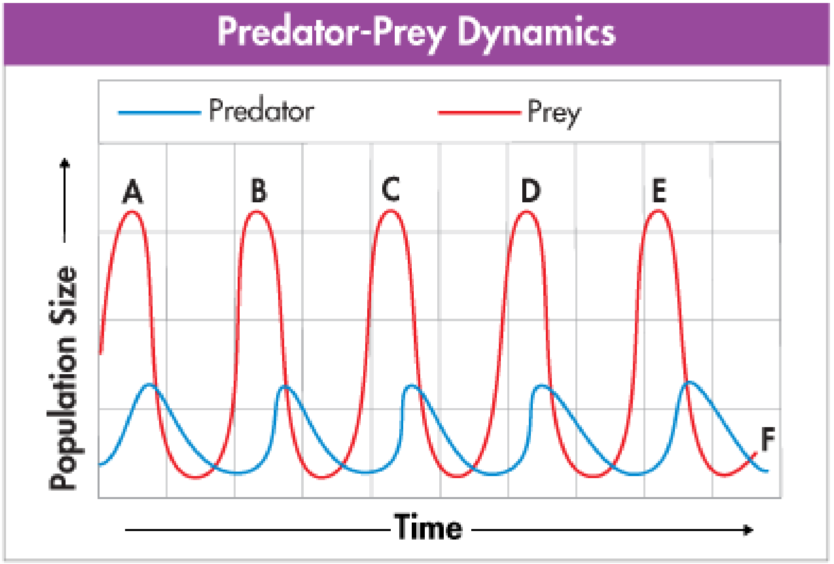
An interaction in which one animal (the predator) captures and feeds on another animal (the prey) is called **predation.**

Predators can affect the size of prey populations in a community and determine the places prey can live and feed.

Birds of prey, for example, can play an important role in regulating the population sizes of mice, voles, and other small mammals.

Predator-Prey Relationships

This graph shows an idealized computer model of changes in **predator and prey populations** over time.



Keystone Species

Sometimes changes in the population of a single species, often called a **keystone species,** can cause dramatic changes in the structure of a community.

A century ago, sea otters were nearly eliminated by hunting. Unexpectedly, the kelp forest nearly vanished.

Without otters as predators, the sea urchin population skyrocketed, and armies of urchins devoured kelp down to bare rock.

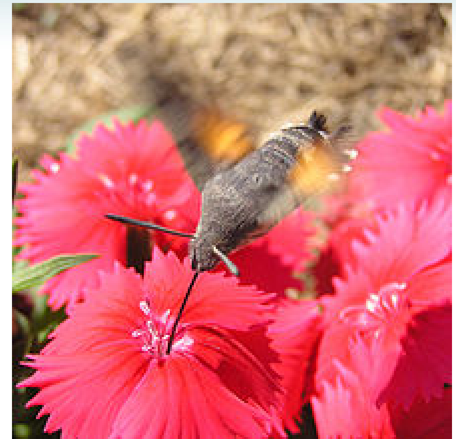
Without kelp to provide habitat, many other animals, including seabirds, disappeared.

Otters were a keystone species in this community.

Symbioses

Any relationship in which two species live closely together is called **symbiosis**, which means "living together."

The three main classes of symbiotic relationships in nature are **mutualism, parasitism**, and **commensalism**.



Mutualism

The sea anemone's sting has two functions: to capture prey and to protect the anemone from predators. Even so, certain fish manage to snack on anemone tentacles.

The clownfish, however, is immune to anemone stings. When threatened by a predator, clownfish seek shelter by snuggling deep into an anemone's tentacles.

If an anemone-eating species tries to attack the anemone, the clownfish dart out and chase away the predators.

This kind of relationship between species in which both benefit is known as **mutualism.**

Parasitism

Tapeworms live in the intestines of mammals, where they absorb large amounts of their hosts' food.

Fleas, ticks, lice, and the leech shown, live on the bodies of mammals and feed on their blood and skin.

These are examples of **parasitism,** relationships in which one organism lives inside or on another organism and harms it.

The **parasite** obtains all or part of its nutritional needs from the **host** organism.

Generally, parasites weaken but do not kill their host, which is usually larger than the parasite.

Commensalism

Barnacles often attach themselves to a whale's skin. They perform no known service to the whale, nor do they harm it. Yet the barnacles benefit from the constant movement of water—that is full of food particles—past the swimming whale.

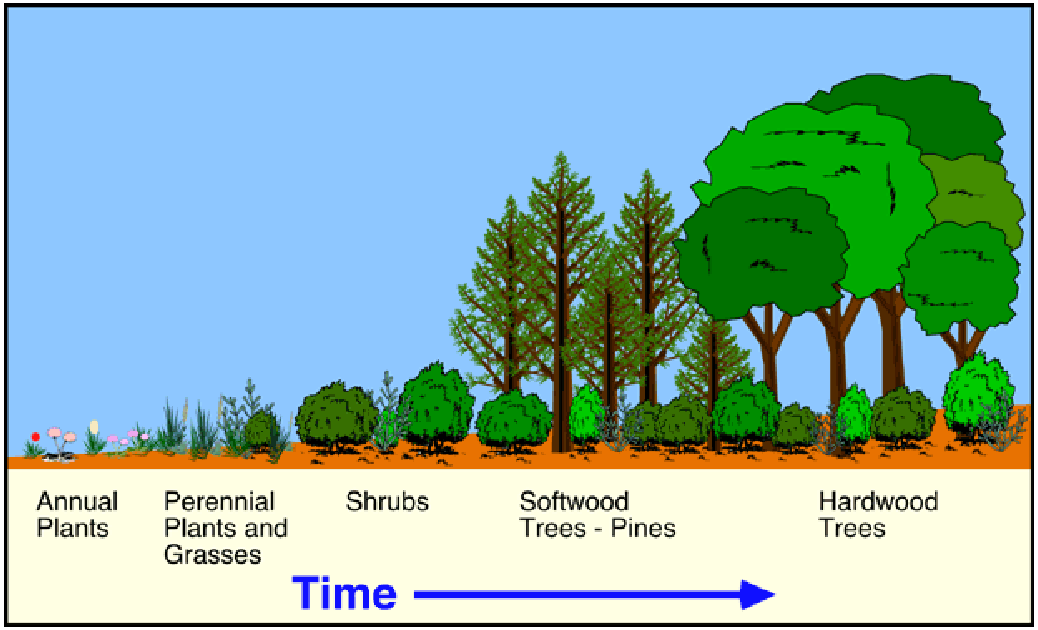
This is an example of **commensalism,** a relationship in which one organism benefits and the other is neither helped nor harmed.

Succession

<u>Ecological succession</u> is a series of more-or-less predictable changes that occur in a community over time.

Ecosystems change over time, especially after disturbances, as some species die out and new species move in.

Over the course of succession, the number of different species present typically increases



Primary Succession

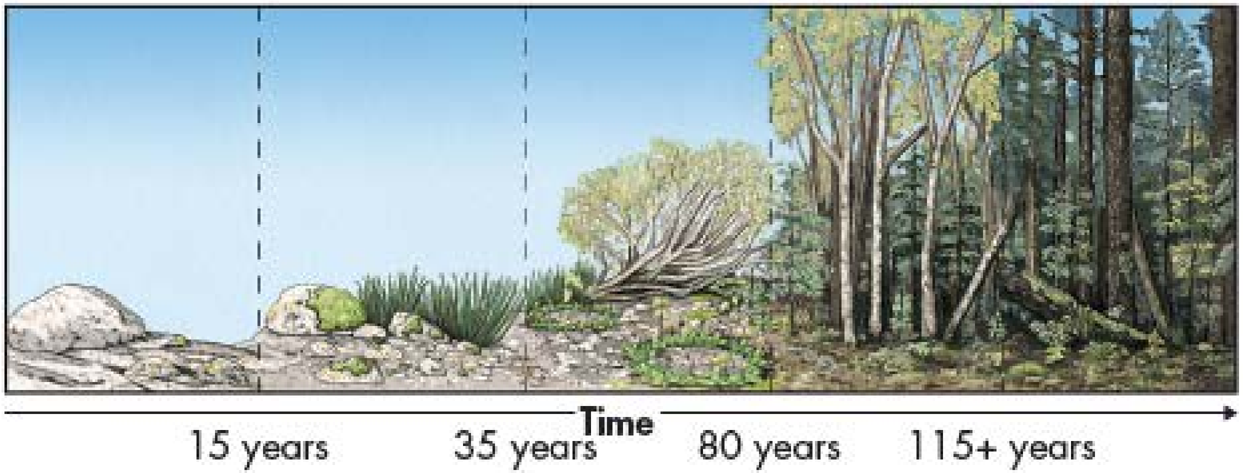
Volcanic explosions can create new land or sterilize existing areas.

Retreating glaciers can have the same effect, leaving only exposed bare rock behind them.

Succession that begins in an area with no remnants of an older community is called **primary succession.**

The first species to colonize barren areas are called **pioneer species**.

One ecological pioneer that grows on bare rock is lichen—a mutualistic symbiosis between a fungus and an alga.



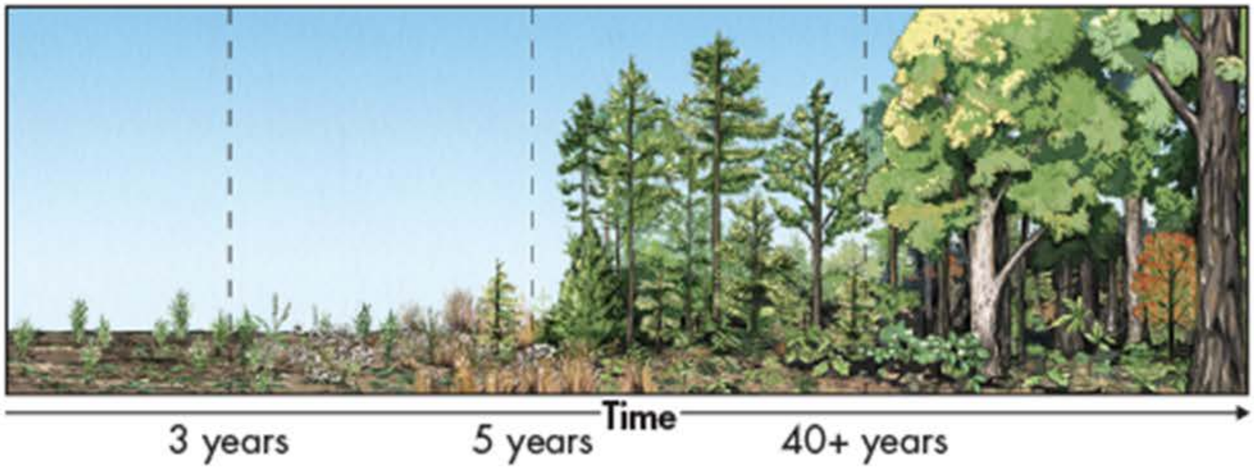
Secondary Succession

Sometimes, existing communities are not completely destroyed by disturbances. In these situations, **secondary succession** occurs.

Secondary succession often follows a wildfire, hurricane, or other natural disturbance.

We think of these events as disasters, but many species are adapted to them. Although forest fires kill some trees, for example, other trees are spared, and fire can stimulate their seeds to germinate.

Secondary succession can also follow human activities like logging and farming.



Why Succession Occurs

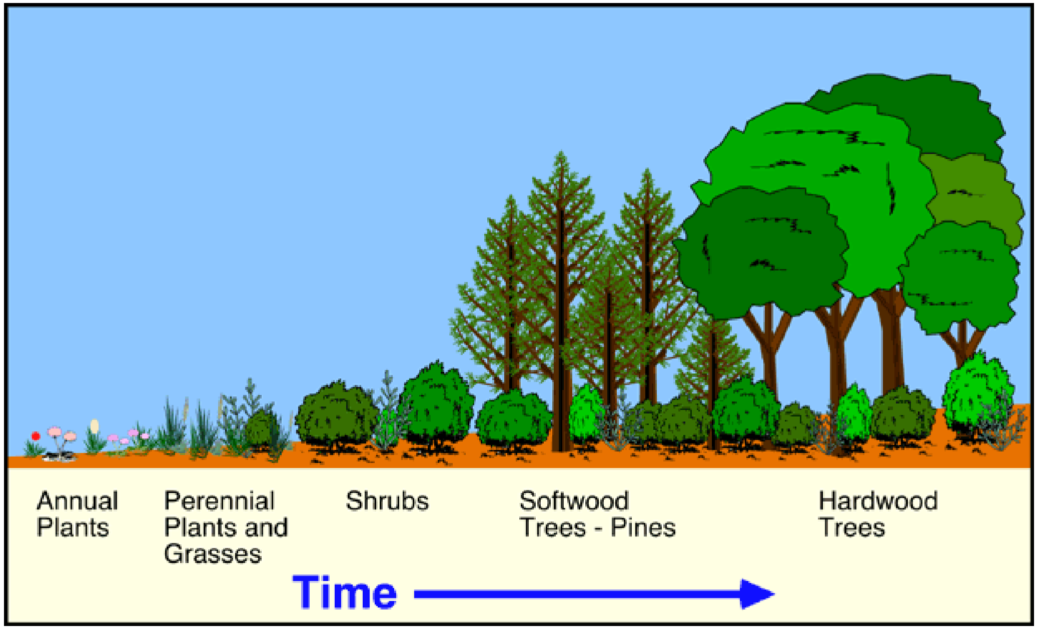
Every organism changes the environment it lives in.

One model of succession suggests that as one species alters its environment, other species find it easier to compete for resources and survive.

For example, as lichens add organic matter and form soil, mosses and other plants can colonize and grow.

As organic matter continues to accumulate, other species move in and change the environment further.

Over time, more and more species can find suitable niches and survive.



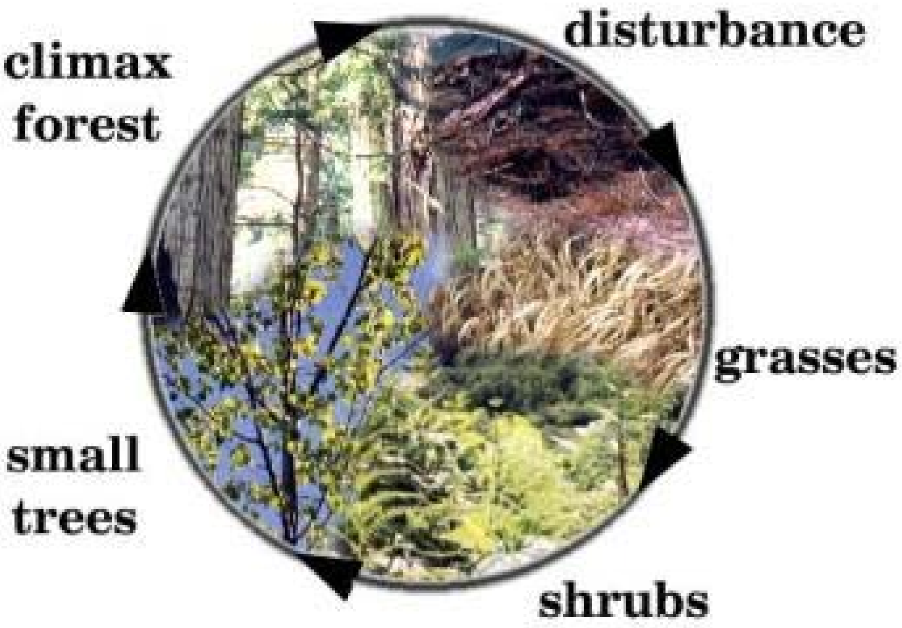
Climax Communities

Ecologists used to think that succession in a given area always proceeds through the same stages to produce a specific and stable climax community.

Recent studies, however, have shown that succession doesn't always follow the same path, and that climax communities are not always uniform and stable.

Often, they have areas in varying stages of secondary succession following multiple disturbances that took place at different times.

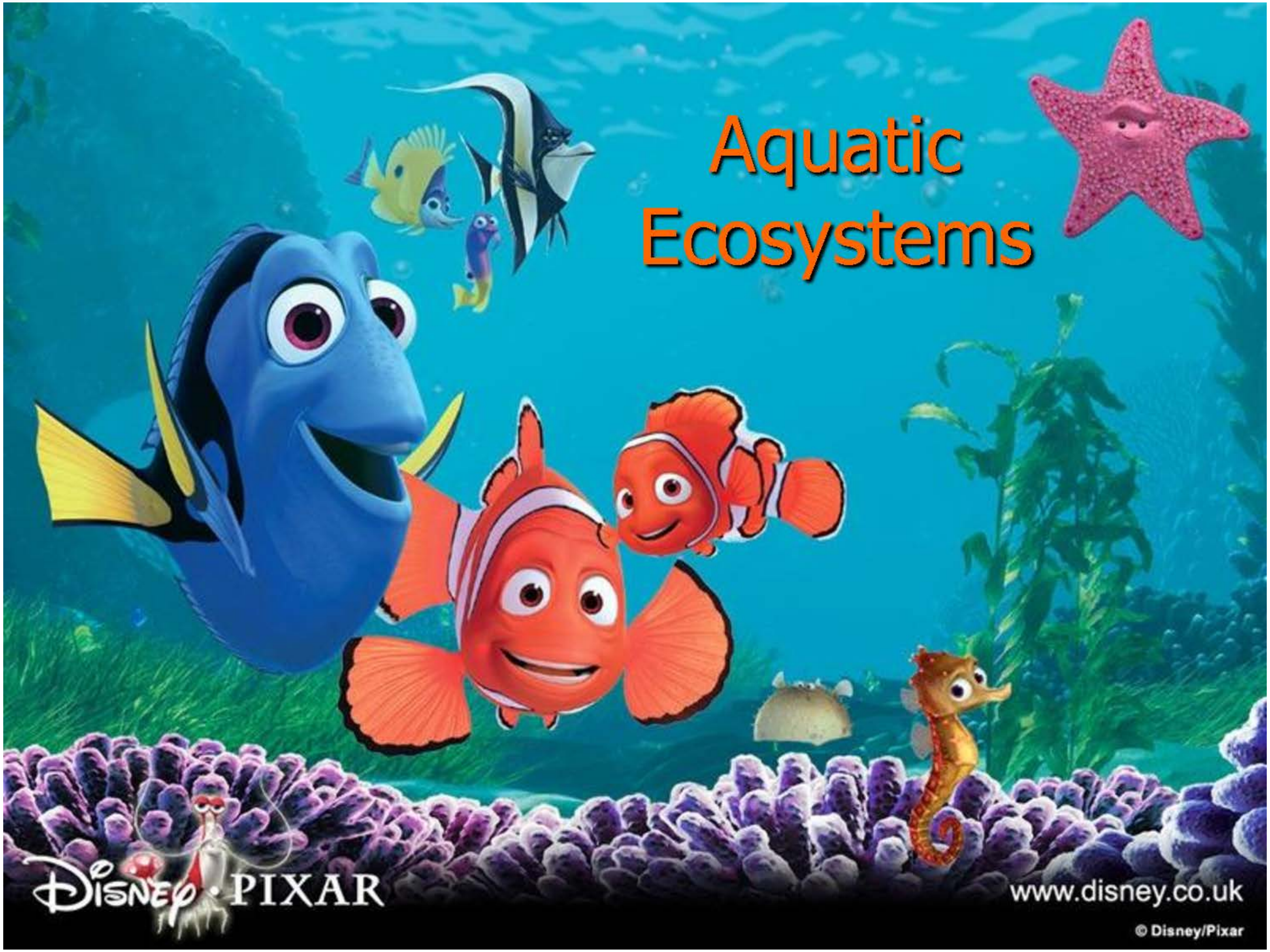
Some climax communities are disturbed so often that they can't really be called stable.



Succession After Human-Caused Disturbances

Ecosystems may or may not recover from extensive human-caused disturbances.

Clearing and farming of tropical rain forests, for example, can change the <u>microclimate</u> and soil enough to prevent regrowth of the original community.


Aquatic Ecosystems
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Water Depth

Water depth strongly influences aquatic life because sunlight penetrates only a relatively short distance through water.

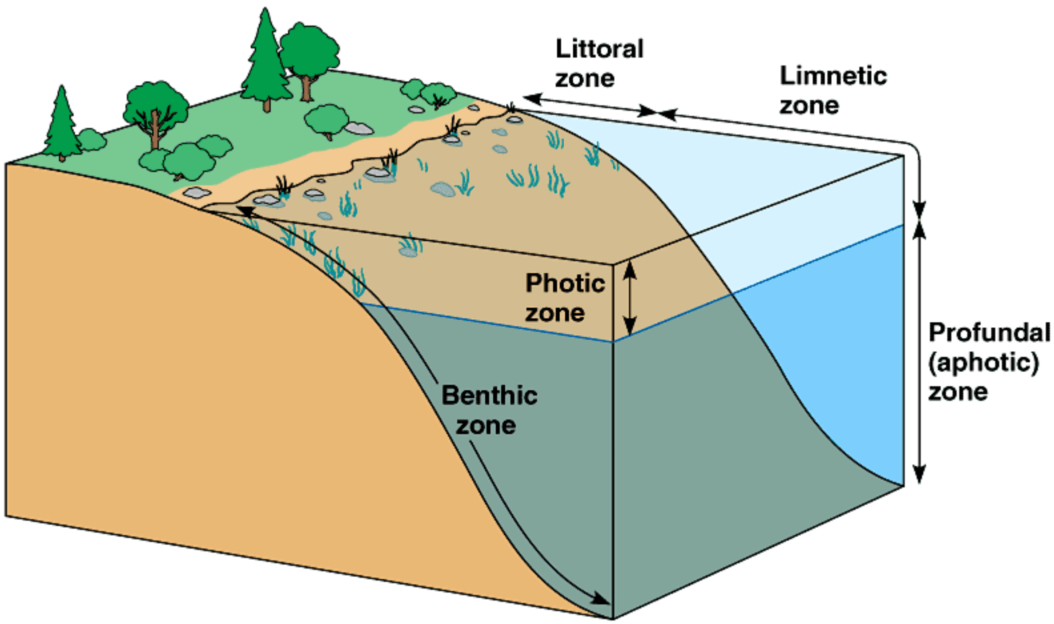
The sunlit region near the surface in which photosynthesis can occur is known as the **photic zone.**

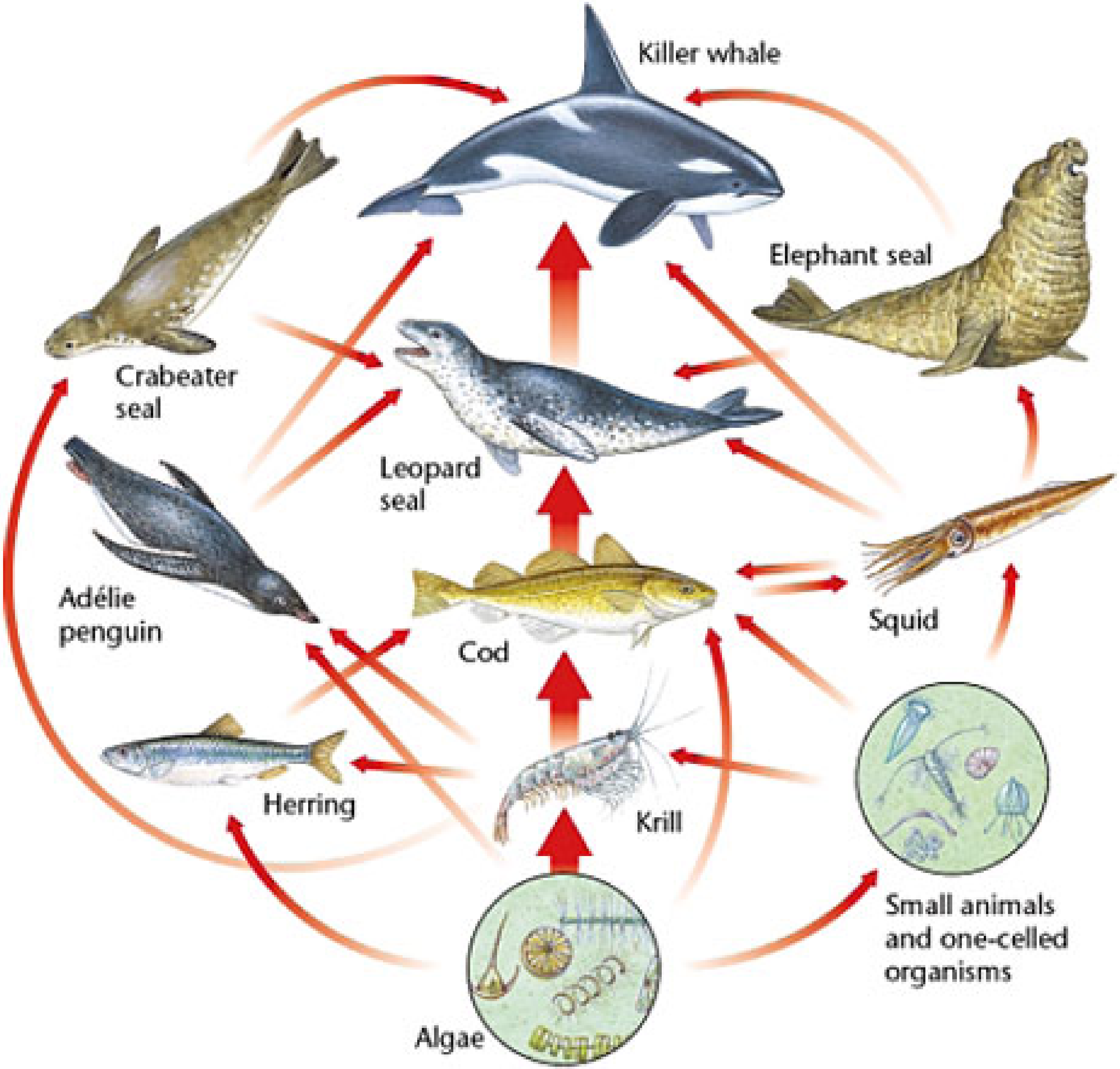
The **photic zone** may be as deep as 200 meters in tropical seas, but just a few meters deep or less in rivers and swamps.

Photosynthetic algae, called **phytoplankton**, live in the **photic zone**.

Zooplankton—tiny free-floating animals—eat phytoplankton. This is the first step in many aquatic food webs.

Below the photic zone is the dark **aphotic zone,** where photosynthesis cannot occur.




Killer whale
Elephant seal
Crabeater seal
Leopard seal
Adélie penguin
Cod
Squid
Herring
Krill
Small animals and one-celled organisms
Algae

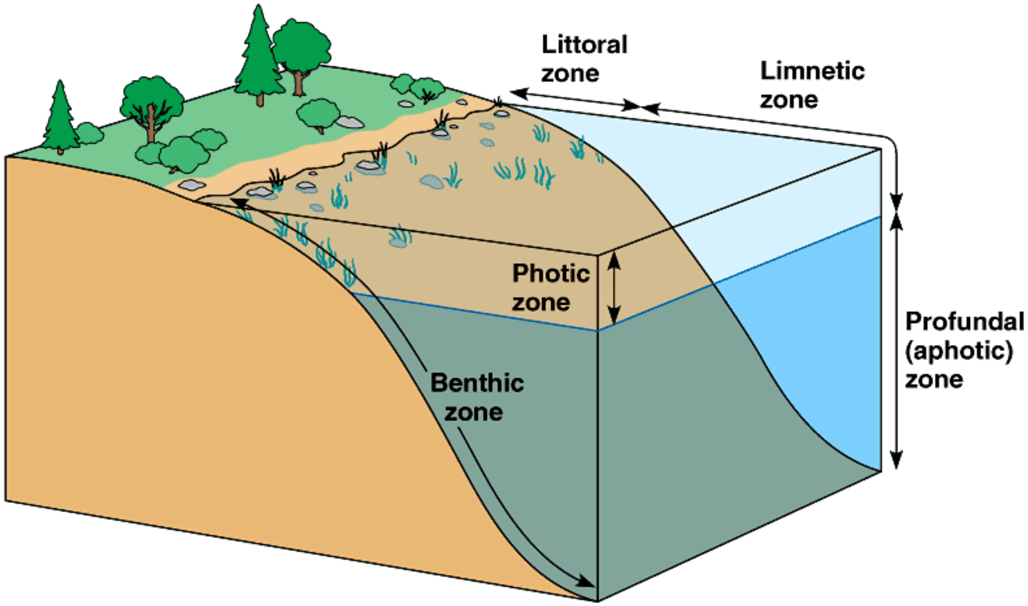
Water Depth

Many aquatic organisms live on, or in, rocks and sediments on the bottoms of lakes, streams, and oceans.

These organisms are called the **benthos**, and their habitat is the **benthic zone**.

When the water is shallow enough for the benthic zone to be within the photic zone, algae and rooted aquatic plants can grow.

When the benthic zone is below the photic zone, **chemosynthetic** autotrophs are the only primary producers.



Temperature and Currents

Aquatic habitats are warmer near the equator and colder near the poles.

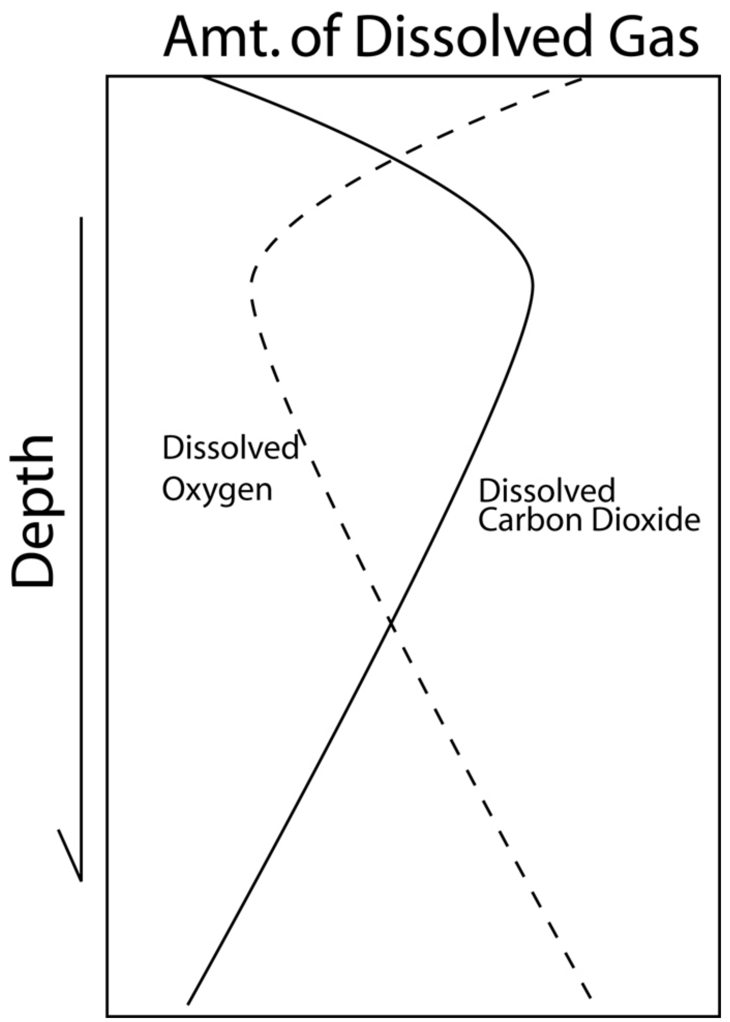
Temperature in aquatic habitats also often varies with depth. The deepest parts of lakes and oceans are often colder than surface waters.

Currents in lakes and oceans can dramatically affect water temperature because they can carry water that is significantly warmer or cooler than would be typical for any given latitude, depth, or distance from shore.

Nutrient Availability

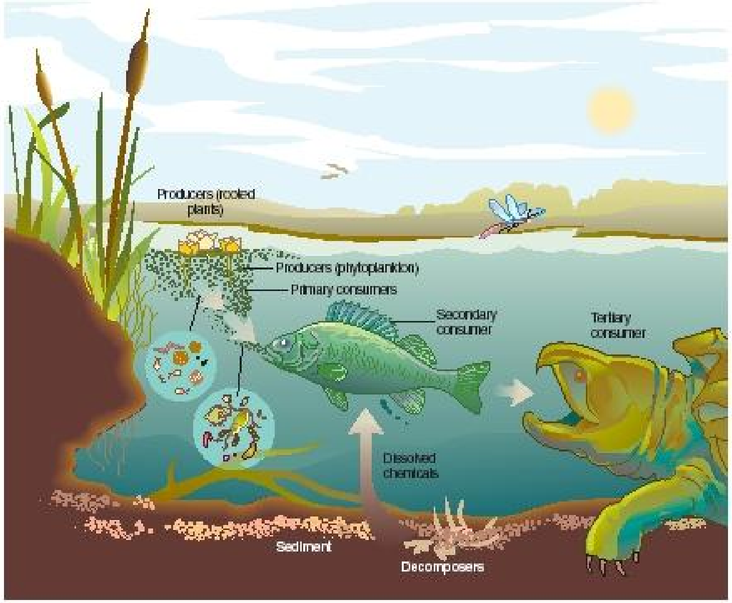
Organisms need certain substances to live, such as oxygen, nitrogen, potassium, and phosphorus.

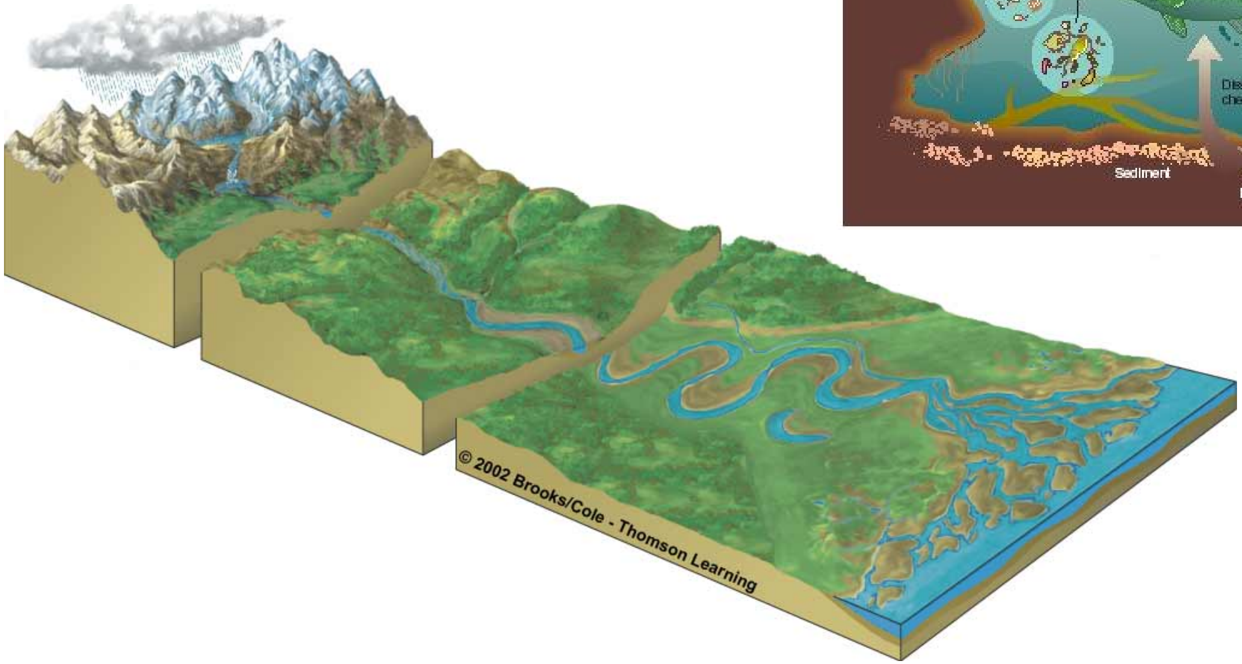
The type and availability of these dissolved substances vary within and between bodies of water, greatly affecting the types of organisms that can survive there.



Freshwater Ecosystems

Freshwater ecosystems include rivers, streams, lakes, and freshwater wetlands (bogs, swamps, and marshes).





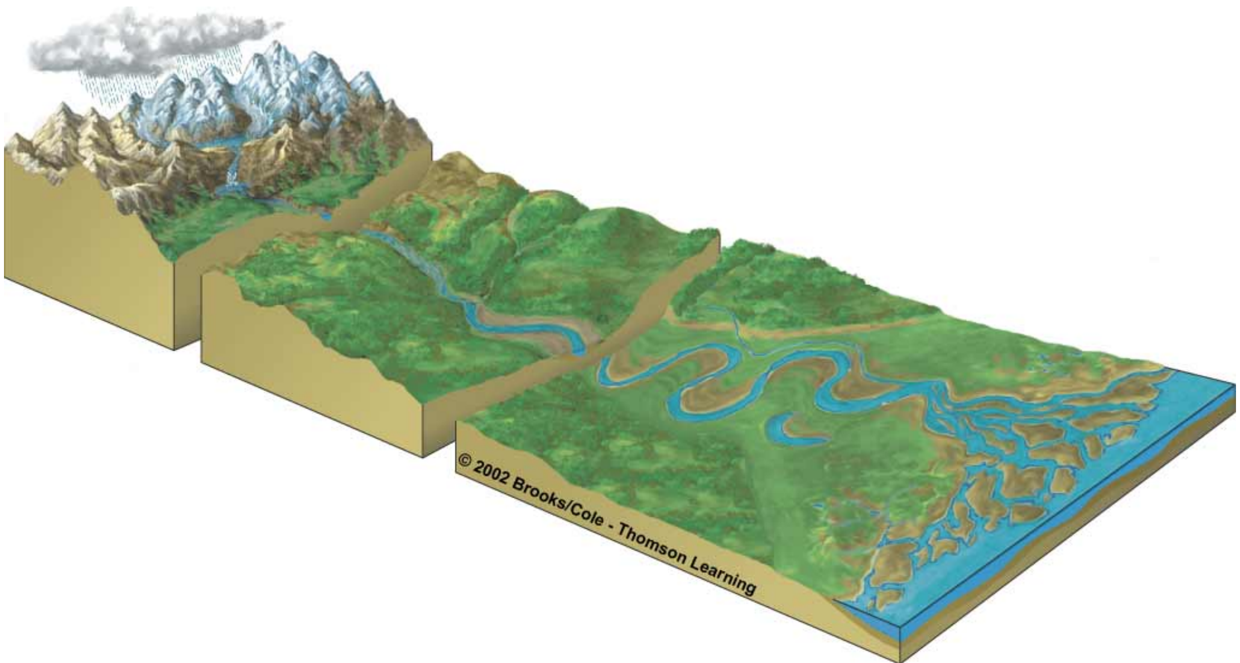
Rivers and Streams

Rivers, streams, creeks, and brooks often originate from underground water sources in mountains or hills.

Near a **source**, water has plenty of dissolved oxygen but little plant life.

Downstream, sediments build up and plants establish themselves. Farther downstream, water may meander slowly through flat areas.

Animals in many rivers and streams depend on terrestrial plants and animals that live along their banks for food.

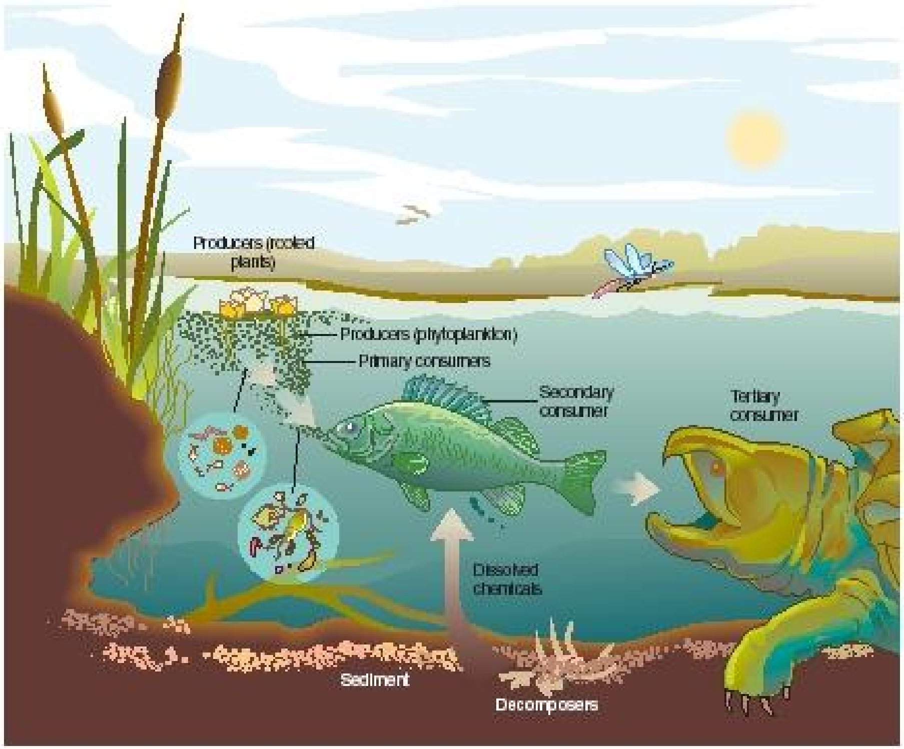


Lakes and Ponds

The food webs in lakes and ponds often are based on a combination of plankton and attached algae and plants.

<u>**Plankton**</u> is a general term that includes both phytoplankton and zooplankton.

Water flows in and out of lakes and ponds and **circulates between the surface and the benthos, distributing heat, oxygen, and nutrients.**



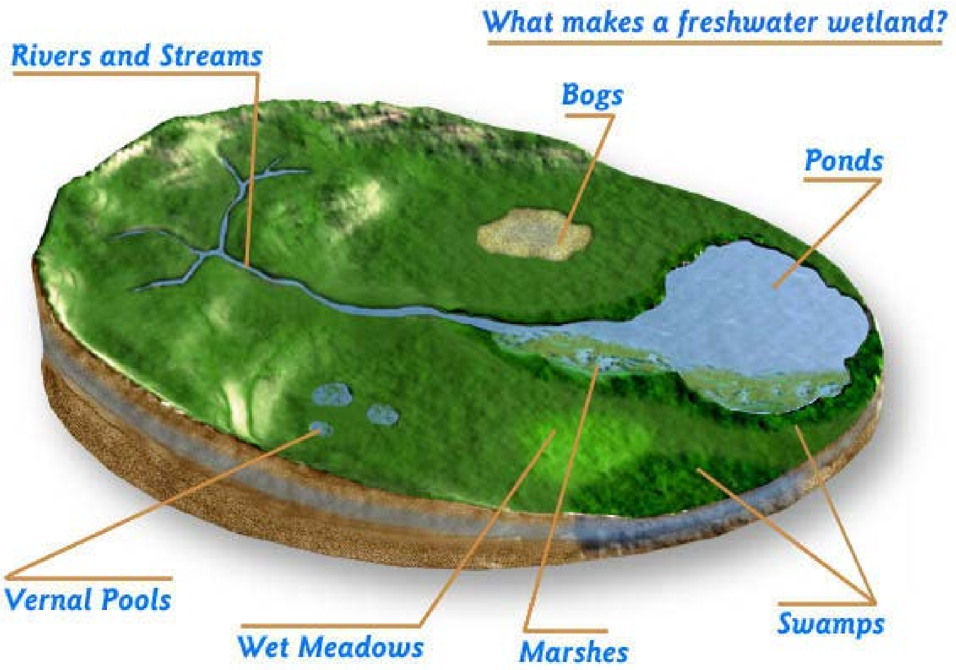
Freshwater Wetlands

A **<u>wetland</u>** is an ecosystem in which water either covers the soil or is present at or near the surface for at least part of the year.

Wetlands are often nutrient-rich, highly productive, and serve as breeding grounds for many organisms.

Freshwater wetlands purify water by filtering pollutants and help to prevent flooding by absorbing large amounts of water and slowly releasing it.

Three main types of freshwater wetlands are **freshwater bogs, freshwater marshes, and freshwater swamps.**



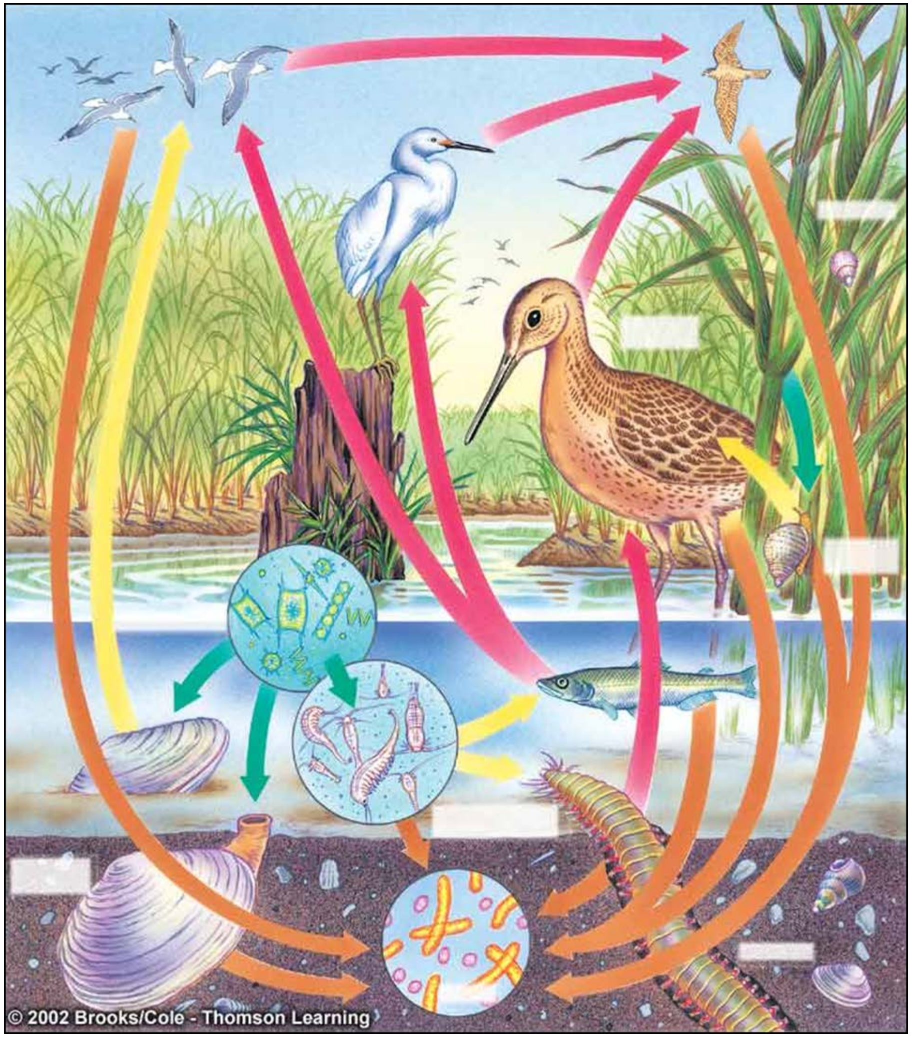
Estuaries

An **estuary** is a special kind of wetland, formed where a river meets the sea.

Estuaries contain a mixture of fresh water and salt water, and are affected by the rise and fall of ocean tides.

Many are shallow, which means that enough sunlight reaches the benthos to power photosynthesis.

Estuaries serve as spawning and nursery grounds for many ecologically and commercially important fish and shellfish species including bluefish, striped bass, shrimp, and crabs.



Estuaries

<u>Salt marshes</u> are temperate estuaries that have salt-tolerant grasses above the low-tide line and seagrasses below water.

One of the largest salt marshes in America surrounds the Chesapeake Bay in Maryland.

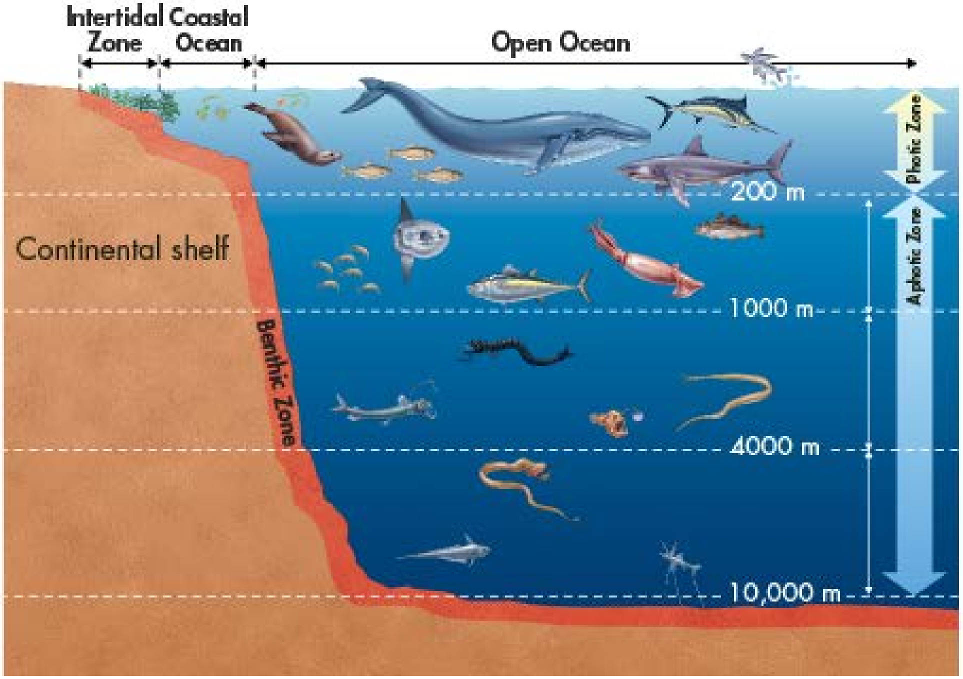
<u>Mangrove swamps</u> are tropical estuaries that have several species of salt-tolerant trees, collectively called mangroves.

The largest mangrove area in America is in Florida's Everglades National Park.

Marine Ecosystems

Ecologists typically divide the ocean into zones based on depth and distance from shore.

Starting with the shallowest and closest to land, marine ecosystems include the **intertidal zone**, the **coastal ocean**, and the **open ocean**.



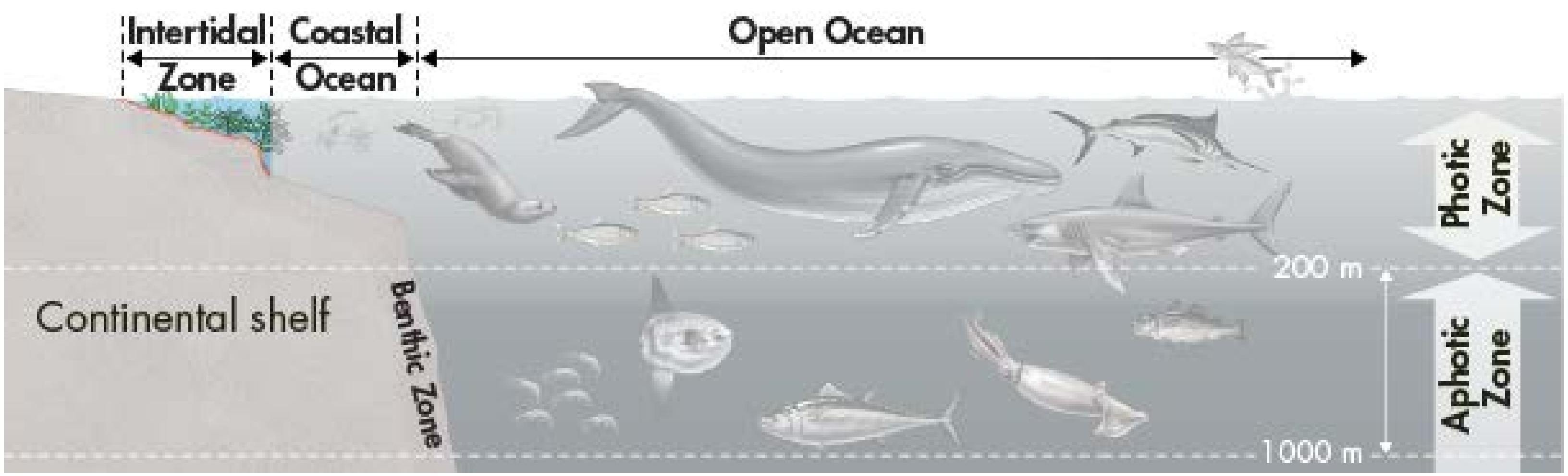
Intertidal Zone

Organisms in the **intertidal zone** are submerged in seawater at high tide and exposed to air and sunlight at low tide.

These organisms are subjected to regular and extreme changes in temperature and are often battered by waves and currents.

A typical **rocky intertidal** community exists in temperate regions where exposed rocks line the shore.

There, barnacles and seaweed permanently attach themselves to the rocks.

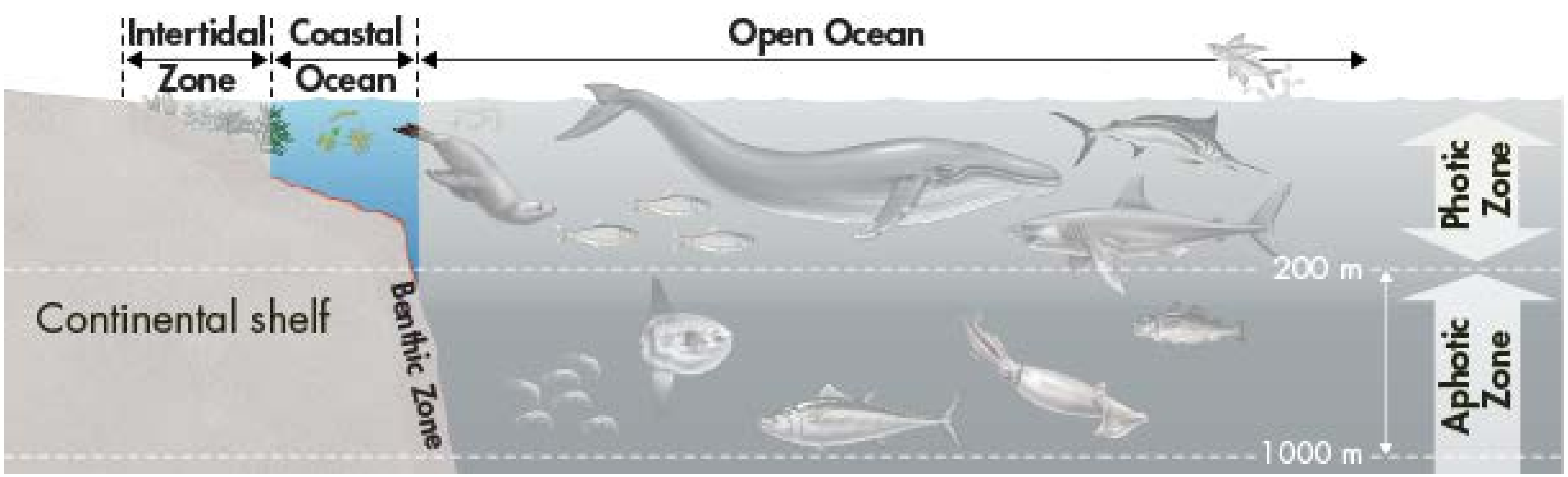


Coastal Ocean

The **coastal ocean** extends from the low-tide mark to the outer edge of the continental shelf—the relatively shallow border that surrounds the continents.

Water in the coastal ocean is brightly lit, and is often supplied with nutrients by freshwater runoff from land. As a result, coastal oceans tend to be highly productive.

Kelp forests and **coral reefs** are two important coastal communities.



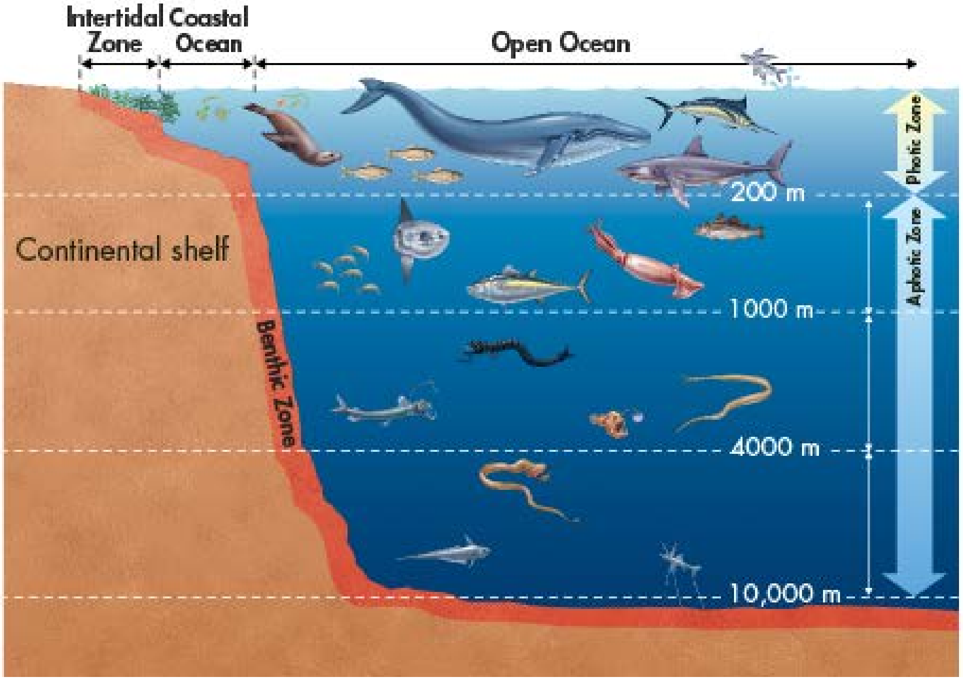
Open Ocean

The **open ocean** begins at the edge of the continental shelf and extends outward.

More than 90 percent of the world's ocean area is considered open ocean.

Depth ranges from 500 m along continental slopes to more than 10,000 m in ocean trenches.

The open ocean is divided into two zones based on light penetration—the **photic** and **aphotic.**

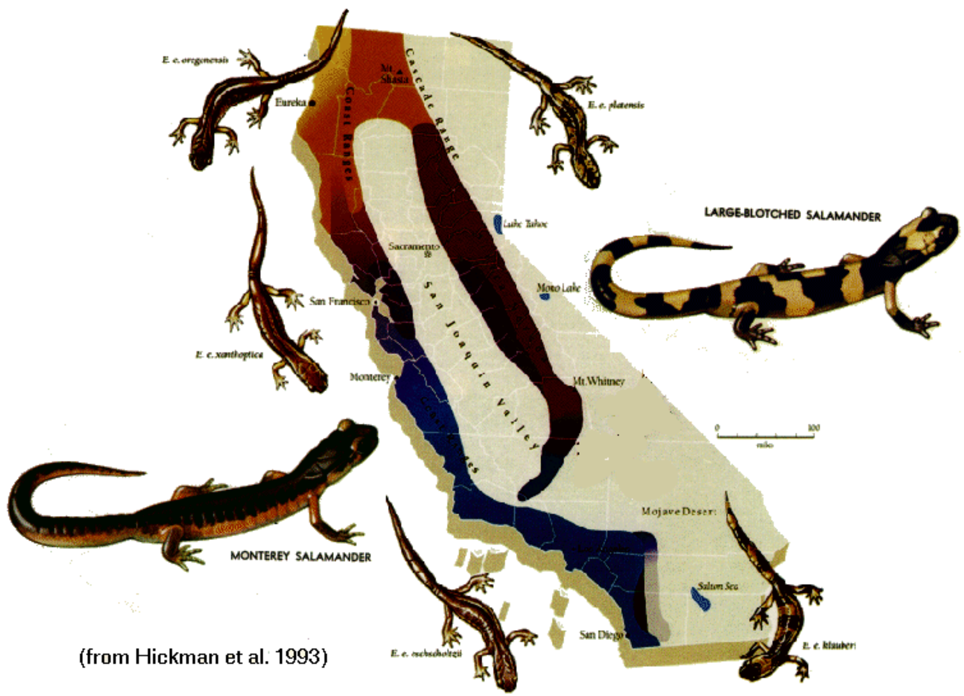


How Populations Grow

Geographic Range

The area inhabited by a population is called its <u>geographic range</u>.

A population's range can vary enormously in size, depending on the species. A bacterial population in a rotting pumpkin may have a range smaller than a cubic meter, whereas the population of cod in the western Atlantic covers a range that stretches from Greenland down to North Carolina.



(from Hickman et al. 1993)

Density and Distribution

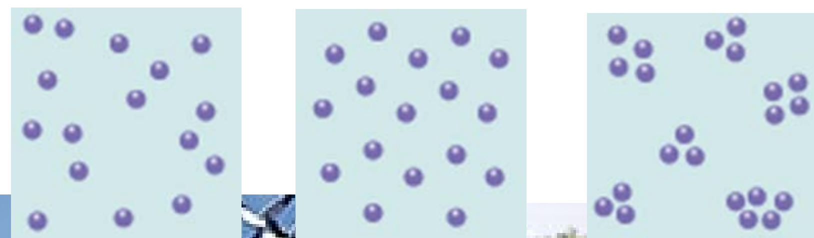
<u>Population density</u> refers to the number of individuals per unit area.

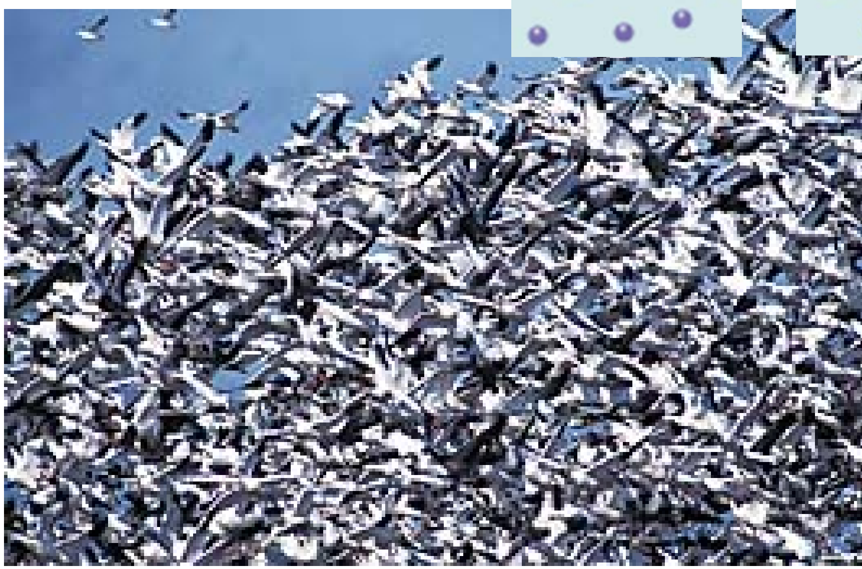
Populations of different species often have very different densities, even in the same environment.

A population of ducks in a pond may have a low density, while fish and other animals in the same pond community may have higher densities.

Density and Distribution

<u>Distribution</u> refers to how individuals in a population are spaced out across the range of the **population—randomly, uniformly, or mostly concentrated in clumps.**





Population Growth

A population will increase or decrease in size depending on how many individuals are added to it or removed from it.

The factors that can affect population size are the **birthrate**, **death rate**, and the rate at which individuals **enter or leave the population.**

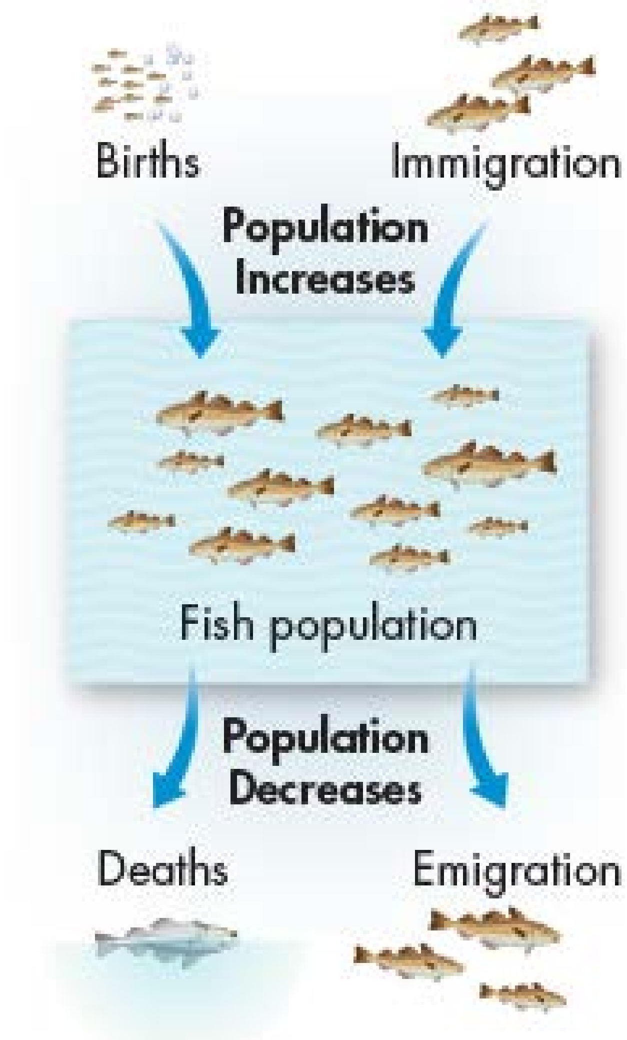
A population can grow when its birthrate is higher than its death rate.

If the birthrate equals the death rate, the population may stay the same size.

If the death rate is greater than the birthrate, the population is likely to shrink.

A population may grow if individuals move into its range from elsewhere, a process called **immigration.**

A population may decrease in size if individuals move out of the population's range, a process called **emigration.**



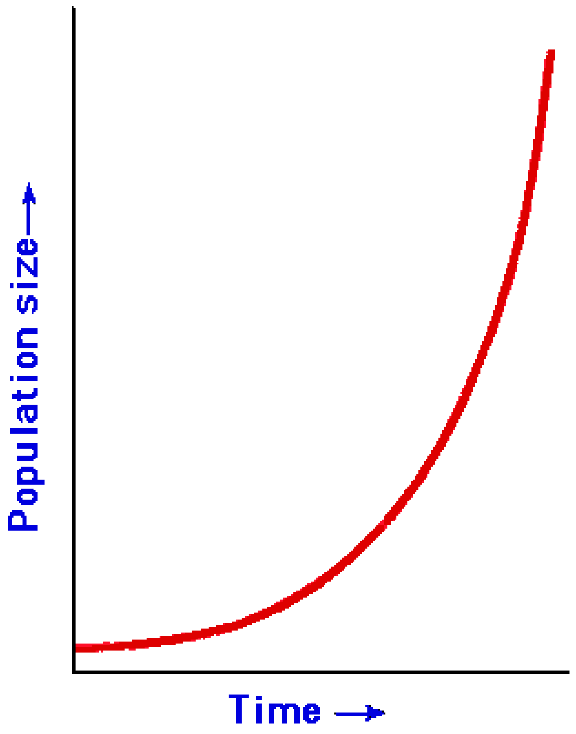
Exponential Growth

If you provide a population with all the food and space it needs, protect it from predators and disease, and remove its waste products, the population will grow.

The population will increase because members of the population will be able to produce offspring, and after a time, those offspring will produce their own offspring.

Under ideal conditions with unlimited resources, a population will grow exponentially.

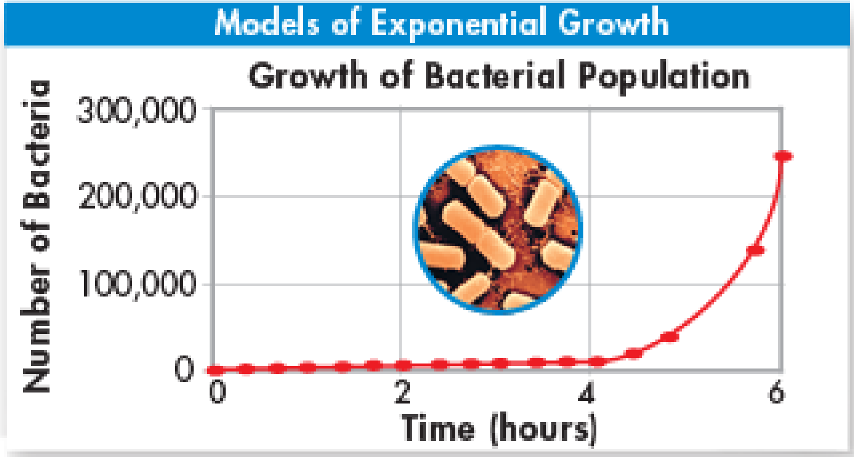
In <u>exponential growth</u>, the larger a population gets, the faster it grows. The size of each generation of offspring will be larger than the generation before it.



Organisms That Reproduce Rapidly

If you plot the size of this population on a graph over time, you get a **J-shaped curve that rises slowly at first, and then rises faster and faster.**

If nothing were to stop this kind of growth, the population would become larger and larger, faster and faster, until it approached an infinitely large size.

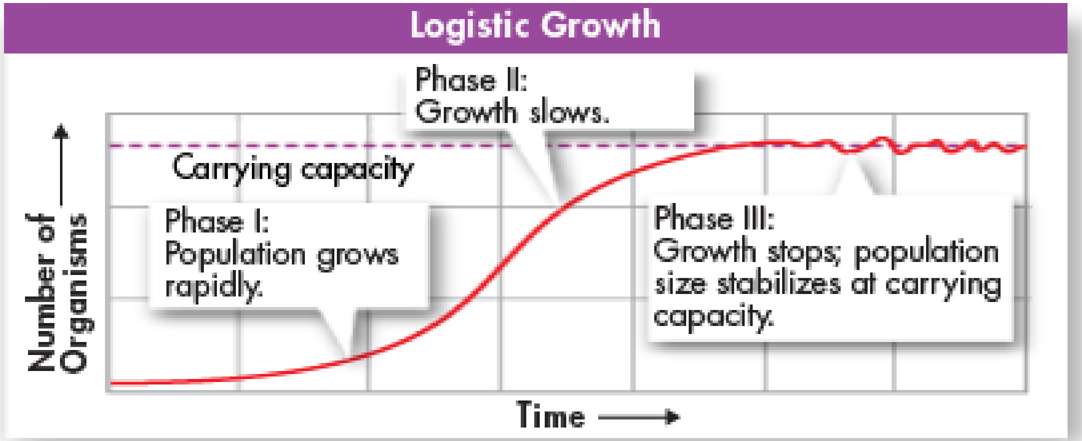


The Logistic Growth Curve

This curve has an **S-shape** that represents what is called **logistic growth.**

Logistic growth occurs when a population's growth slows and then stops, following a period of exponential growth.

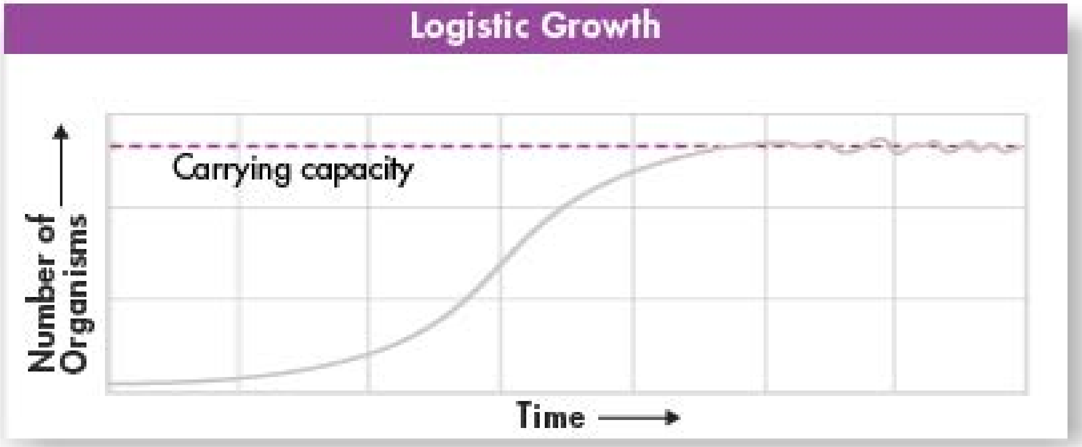
Many familiar plant and animal populations follow a logistic growth curve.



Carrying Capacity

<u>Carrying capacity</u> is the maximum number of individuals of a particular species that a particular environment can support.

Once a population reaches the **carrying capacity** of its environment, a variety of factors act to stabilize it at that size.



Limits to Growth

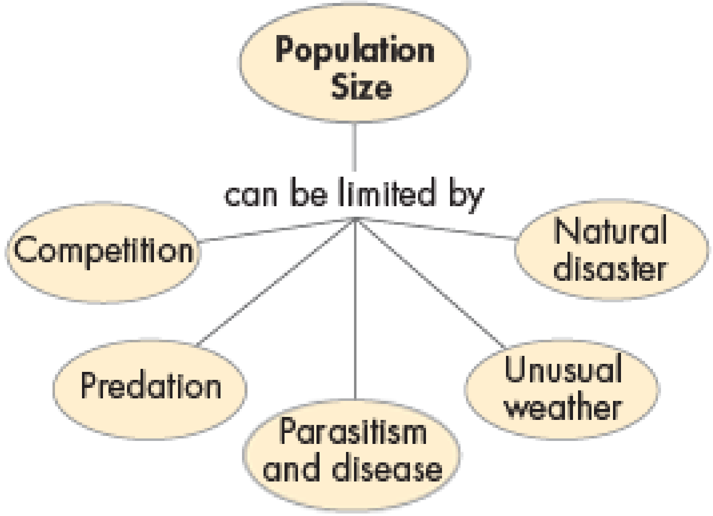
Limiting Factors

A <u>limiting factor</u> is a factor that controls the growth of a population.

There are several kinds of limiting factors.

Some—such as competition, predation, parasitism, and disease—depend on population density.

Others—including natural disasters and unusual weather—do not depend on population density.



Density-Dependent Limiting Factors

Density-dependent limiting factors operate strongly only when population density—the number of organisms per unit area—reaches a certain level. These factors do not affect small, scattered populations as much.

Density-dependent limiting factors include competition, predation, herbivory, parasitism, disease, and stress from overcrowding.

Density-Independent Limiting Factors

Density-independent limiting factors affect all populations in similar ways, regardless of population size and density.

Unusual weather such as hurricanes, droughts, or floods, and natural disasters such as wildfires, can act as density-independent limiting factors.

A Changing Landscape

Agriculture

Modern agricultural practices have enabled farmers to double world food production over the last 50 years.

Monoculture, for example, is the practice of clearing large areas of land to plant a single highly productive crop year after year. Monoculture enables efficient sowing, tending, and harvesting of crops using machines.

However, **agriculture impacts natural resources**, including fresh water and fertile soil. Fertilizer production and farm machinery also consume large amounts of fossil fuels.

Development

As modern society developed, many people chose to live in cities. Then, as urban centers became crowded, people moved to suburbs.

This development has environmental effects. Dense human communities produce lots of wastes that, if not disposed of properly, can affect air, water, and soil resources.

In addition, development consumes farmland and divides natural habitats into fragments. Development in Florida, for example, has lead to fragmentation of the forests there.

Industrial Growth

The conveniences of modern life require a lot of energy to produce and power. Most of this energy is obtained by burning **fossil fuels—coal, oil, and natural gas—and** that affects the environment.

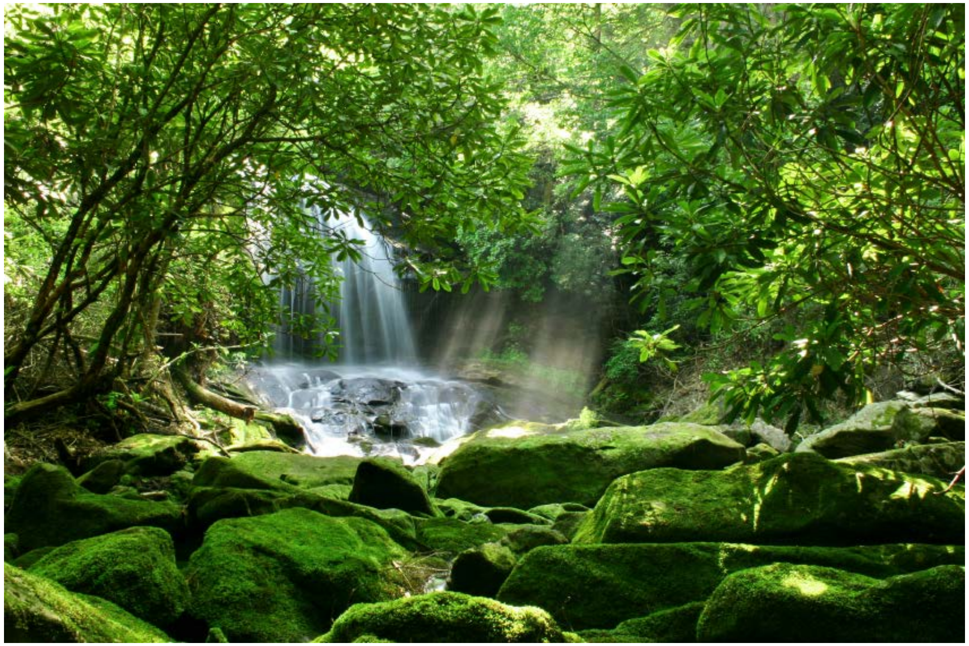
In addition, **industries have traditionally discarded wastes from manufacturing and energy production directly into the air, water, and soil.** **Smog,** for example, is formed by chemical reactions among pollutants released into the air by industrial processes and automobile exhaust.

Ecosystem Goods and Services

Healthy ecosystems provide many goods and services naturally and largely free of charge, like **breathable air and drinkable water.**

But, if the environment can't provide these goods and services, society must spend money to produce them.

In many places, for example, drinkable water is provided naturally by streams, rivers, and lakes, and filtered by wetlands.

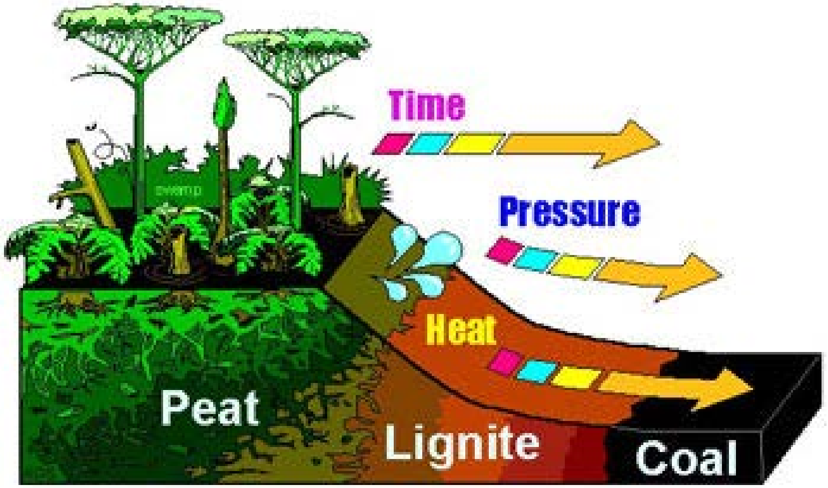


Renewable and Nonrenewable Resources

Ecosystem goods and services are classified as either renewable or nonrenewable.

A **renewable resource** can be produced or replaced by a healthy ecosystem. Wind is a renewable resource.

Some resources are **nonrenewable resources** because natural processes cannot replenish them within a reasonable amount of time. Fossil fuels like coal, oil, and natural gas are nonrenewable resources formed from buried organic materials over millions of years.



Sustainable Resource Use

Using natural resources in a way that does not cause long-term environmental harm is called **sustainable development.**

Sustainable development should cause no long-term harm to the soil, water, and climate on which it depends. It should consume as little energy and material as possible.

Sustainable development must be flexible enough to survive environmental stresses like droughts, floods, and heat waves or cold snaps.

Sustainable development must also take into account human economic systems as well as ecosystem goods and services.

Using Resources Wisely

Soil Resources

The mineral- and nutrient-rich portion of soil is called topsoil.

Good topsoil absorbs and retains moisture yet allows water to drain. It is rich in organic matter and nutrients, but low in salts. Good topsoil is produced by long-term interactions between soil and the plants growing in it.

Topsoil can be a renewable resource if it is managed properly, but it can be damaged or lost if it is mismanaged.

Years of poorly managed farming in addition to severe drought in the 1930s badly eroded the once-fertile soil of the Great Plains. The area essentially turned to desert, or a "dust bowl."

Soil Erosion

The dust bowl of the 1930s was caused, in part, by conversion of prairie land to cropland in ways that left soil vulnerable to erosion.

Soil erosion is the removal of soil by water or wind.

Soil erosion is often worse when land is plowed and left barren between plantings. When no roots are left to hold soil in place, it is easily washed away.

When soil is badly eroded, organic matter and minerals that make it fertile are often carried away with the soil. Deforestation, or the loss of forests, can have a negative effect on soil quality. More than half of the world's old-growth forests (forests that had never been cut) have been lost to deforestation.

Healthy forests hold soil in place, protect the quality of fresh water supplies, absorb carbon dioxide, and help moderate local climate.

In some areas, forests can regrow after cutting, but it takes centuries for succession to produce mature, old-growth forests.

In some places, forests don't grow back at all after logging. This is why old-growth forests are usually considered nonrenewable resources.

Soil Erosion

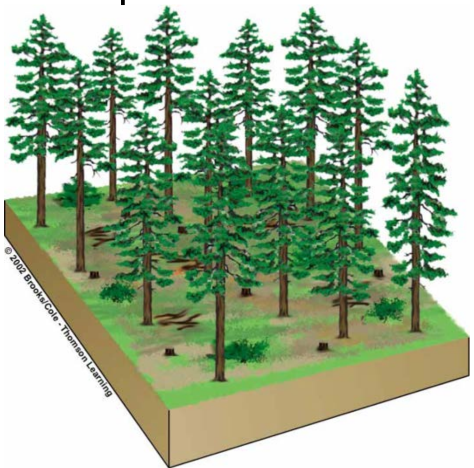
Deforestation can lead to severe erosion. Grazing or plowing after deforestation can permanently change local soils and microclimates in ways that prevent the regrowth of trees.

For example, when tropical rain forests are cleared for timber or for agriculture, their soil is typically useful for just a few years. After that the areas become wastelands. The thin topsoil and high heat and humidity prevent regrowth.

Soil Use and Sustainability

Selectively harvesting mature trees can promote the growth of younger trees and preserve the forest ecosystem, including its soil.

A well-managed tree farm both protects the soil and makes the trees themselves a renewable resource.



Freshwater Resources

Humans depend on fresh water and freshwater ecosystems for goods and services, including drinking water, industry, transportation, energy, and waste disposal. Some farmland relies heavily on irrigation, in which fresh water is brought in from other sources.

Some sources of fresh water are not renewable. The Ogallala aquifer, for example, spans eight states from South Dakota to Texas. The aquifer took more than a million years to collect and is not replenished by rainfall today. So much water is being pumped out of the Ogallala that it is expected to run dry in 20 to 40 years.

Only 3 percent of Earth's water is fresh water—and most of that is locked in ice at the poles.

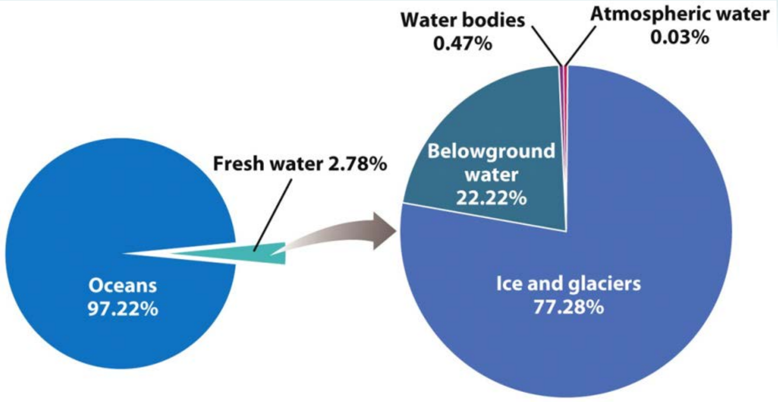
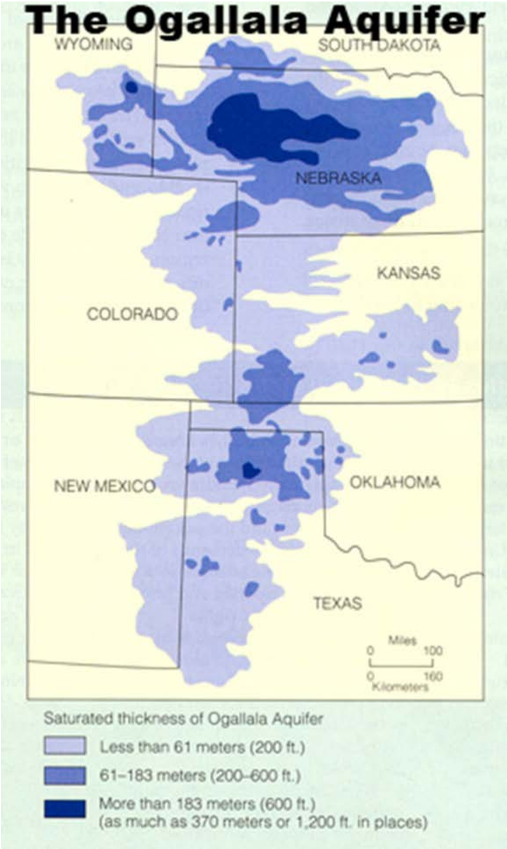


Figure 9.1
Environmental Science



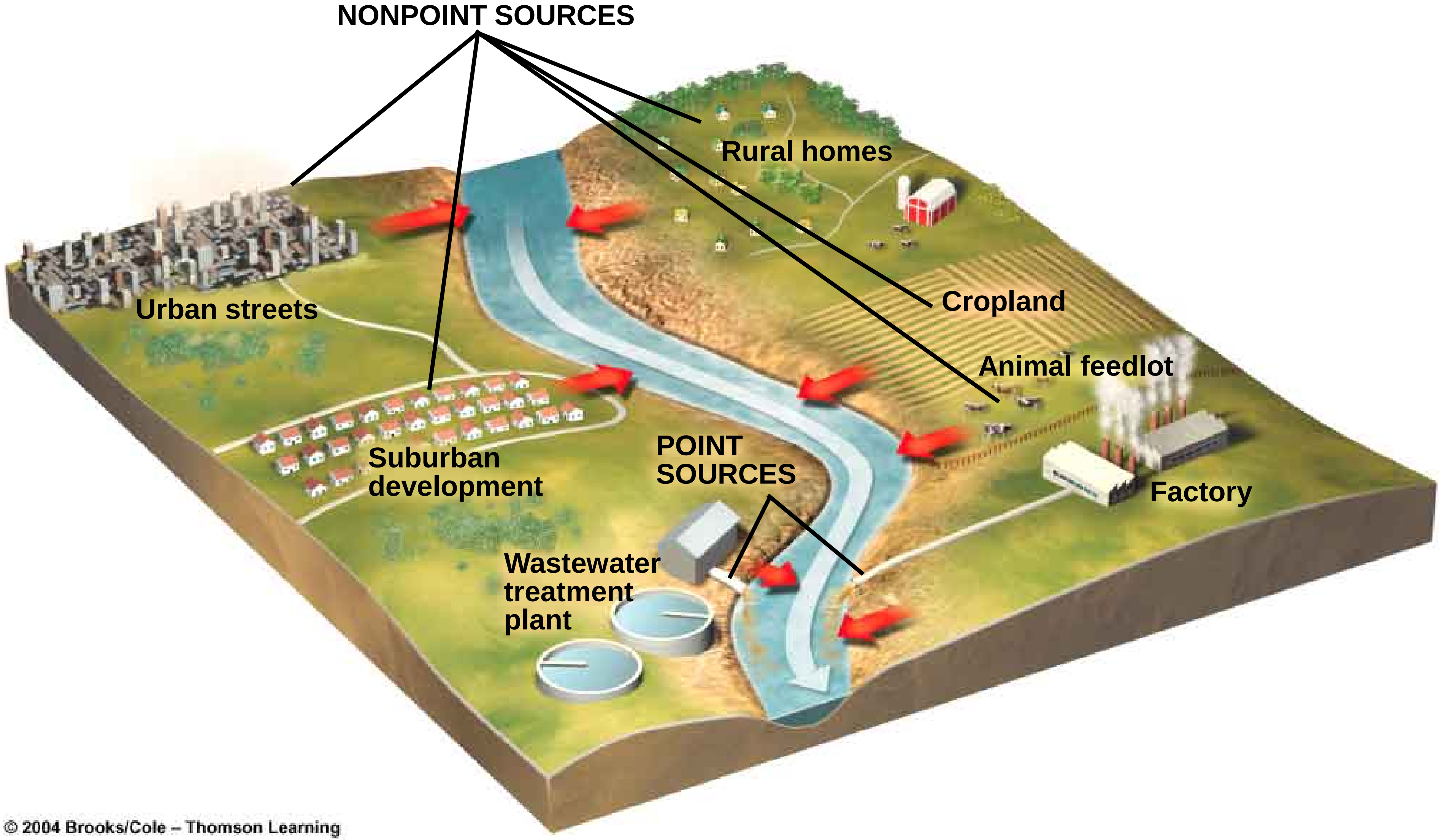
Water Pollution

Freshwater sources can be affected by different kinds of pollution. A **pollutant** is a harmful material that can enter the biosphere.

Pollutants that enter water supplies from a single source—a factory or an oil spill, for example—are called **point source pollution**.

Pollutants that enter water supplies from many smaller sources—the grease and oil washed off streets by rain or the chemicals released into the air by factories and automobiles, for example—are called **nonpoint source pollution.**

Point and Nonpoint Sources



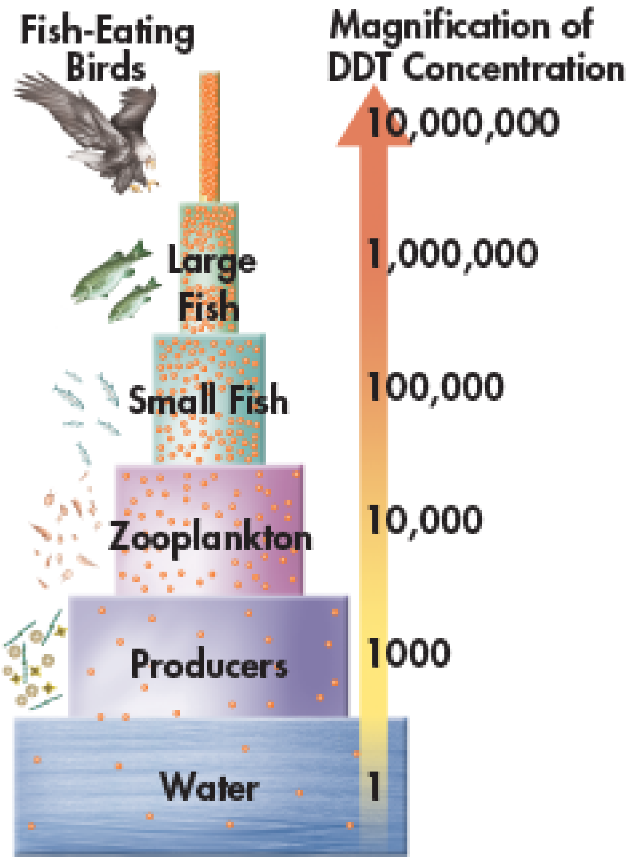
Industrial and Agricultural Chemicals

In the process of **biological magnification,** primary producers pick up a pollutant from the environment.

Herbivores that eat those producers concentrate and store the compound. Pollutant concentrations in herbivores may be more than ten times the levels in producers.

When **carnivores** eat the herbivores, the compound is still further concentrated.

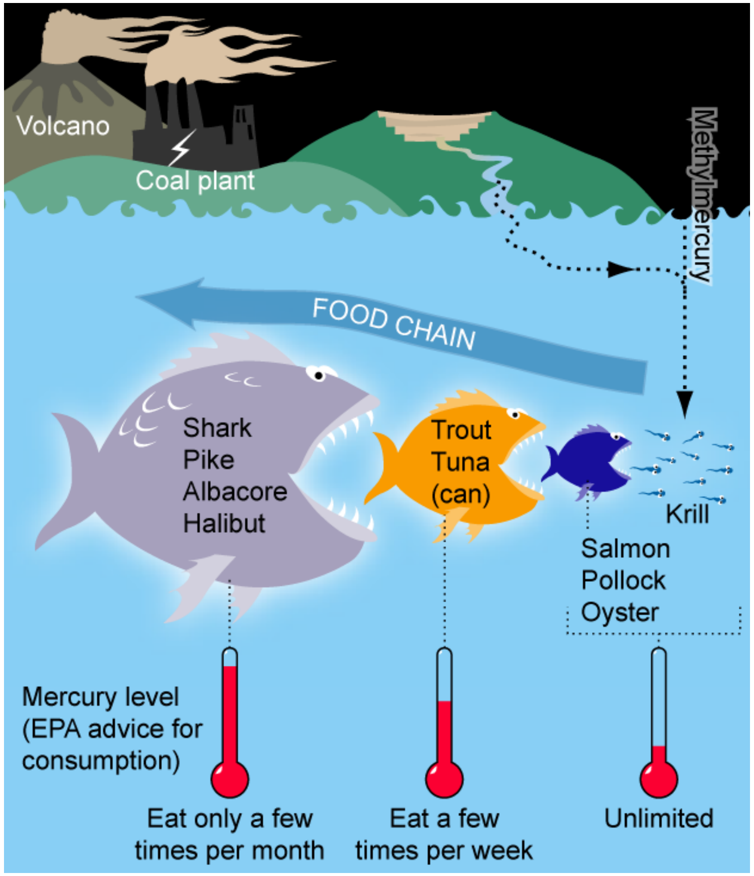
In the highest trophic levels, pollutant concentrations may reach 10 million times their original concentration in the environment.



Industrial and Agricultural Chemicals

These high concentrations can cause serious problems for wildlife and humans. Widespread DDT use in the 1950s threatened fish-eating birds like pelicans, osprey, falcons, and bald eagles. **It caused females to lay eggs with thin, fragile shells, reducing hatching rates and causing a drop in birth populations. Since DDT was banned in the 1970s, bird populations are recovering.**

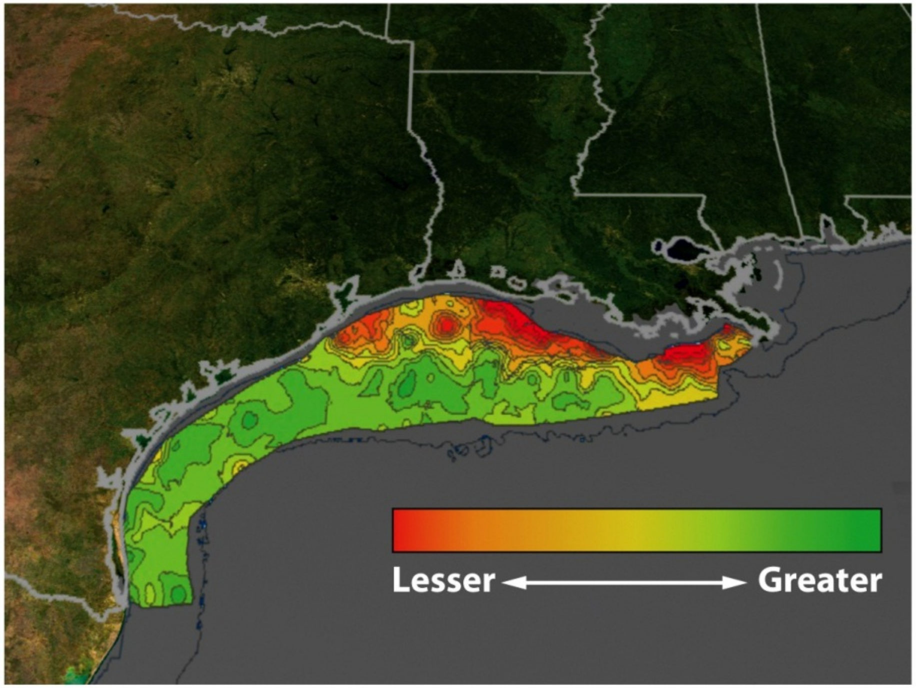
Still a concern is mercury, which accumulates in the bodies of certain marine fish such as tuna and swordfish**.**



Residential Sewage

Sewage contains lots of nitrogen and phosphorus. Large amounts of sewage can stimulate blooms of bacteria and algae that rob water of oxygen. **Oxygen-poor areas called "<u>dead zones"</u> can appear in both fresh and salt water.**

Raw sewage also contains microorganisms that can spread disease.



Oxygen concentrations in Gulf Coast waters

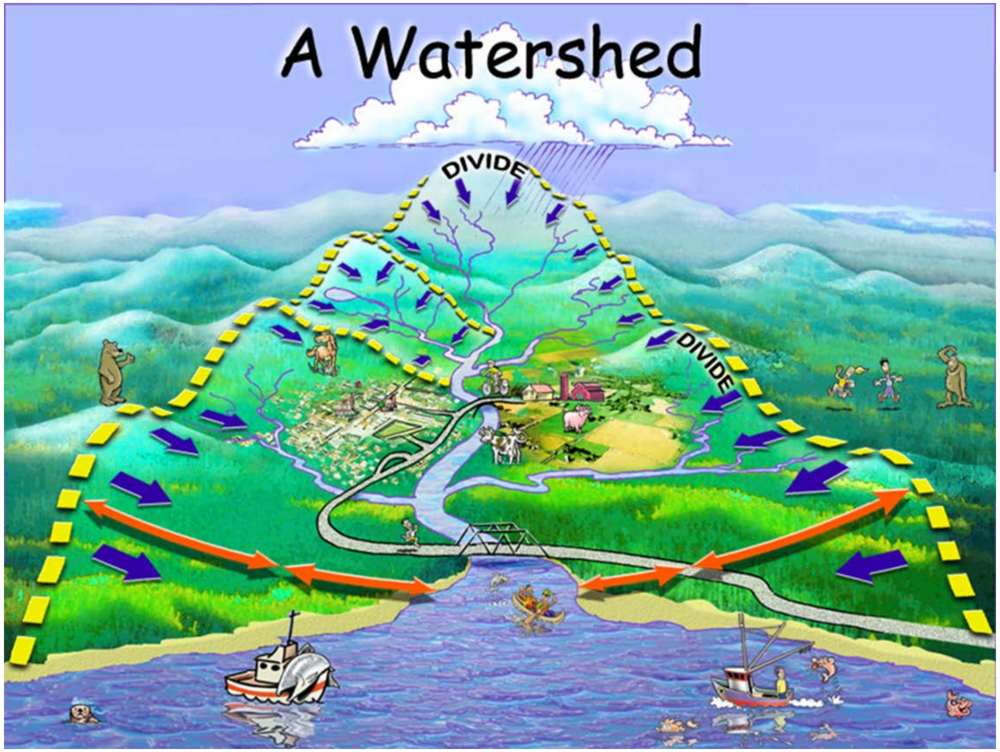
Figure 14.3a
Environmental Science

Water Quality and Sustainability

One key to sustainable water use is to protect the natural systems involved in the water cycle. Protecting these ecosystems is a critical part of watershed conservation.

A **watershed** includes all the land whose groundwater, streams, and rivers drain into the same place—such as a large lake or river.

Pollution control can have direct and positive effects on the water quality in a watershed.



Water Quality and Sustainability

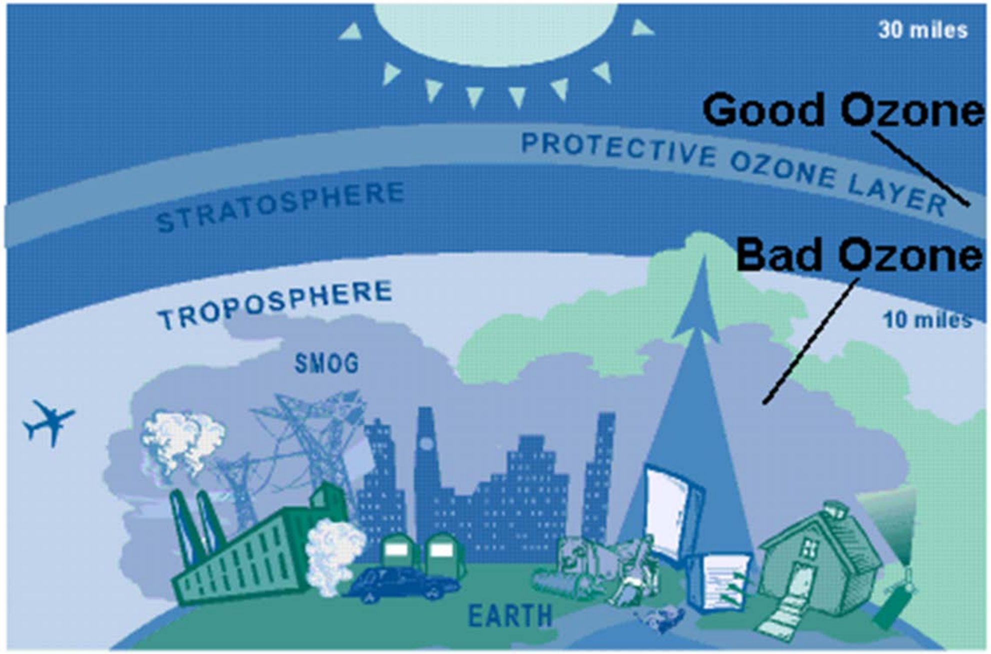
Conserving water is also important. One example of water conservation in agriculture is **drip irrigation,** which delivers water drop by drop directly to the roots of plants. Tiny holes in water hoses allow farmers to deliver water only where it's needed.

Atmospheric Resources

The atmosphere, which provides the oxygen we breathe, is a common resource whose quality has direct effects on health.

<u>Ozone</u>, a form of oxygen that is found naturally in the upper atmosphere, absorbs harmful ultraviolet radiation from sunlight before it reaches Earth's surface. The **<u>ozone layer</u>** protects our skin from damage that can cause cancer.

The atmosphere's <u>greenhouse gases</u>, including carbon dioxide, methane, and water vapor, regulate global temperature. Without the greenhouse effect, Earth's average temperature would be about 30° Celsius cooler than it is today.

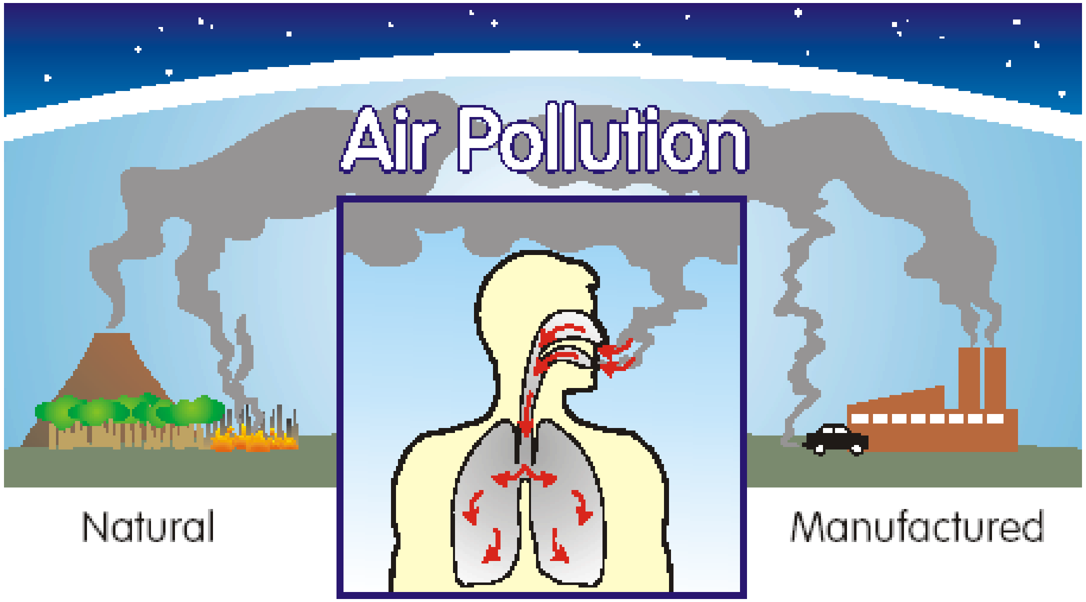


Air Pollution

When the quality of Earth's atmosphere is reduced, **respiratory illnesses** such as asthma are made worse and skin diseases tend to increase.

Globally, **climate patterns may be affected.**

Industrial processes and the burning of fossil fuels can release pollutants of several kinds. Common forms of air pollution include **smog, acid rain, greenhouse gases, and particulates.**



Smog

Smog is a gray-brown haze formed by chemical reactions among pollutants released into the air by industrial processes and automobile exhaust. Ozone is one product of these reactions.

At ground level, **ozone** and other pollutants threaten the health of people, especially those with respiratory conditions.

Acid Rain

Burning fossil fuels releases nitrogen and sulfur compounds. When those compounds combine with water vapor in the air, they form nitric and sulfuric acids. These airborne acids can drift for many kilometers before they fall as **acid rain.**

Acid precipitation can dissolve and release mercury and other toxic elements from soil, freeing those elements to enter other parts of the biosphere.

In some areas, acid rain kills plants by damaging their leaves and changing the chemistry of soils and surface water.

Acid rain can also cause damage to stone statues

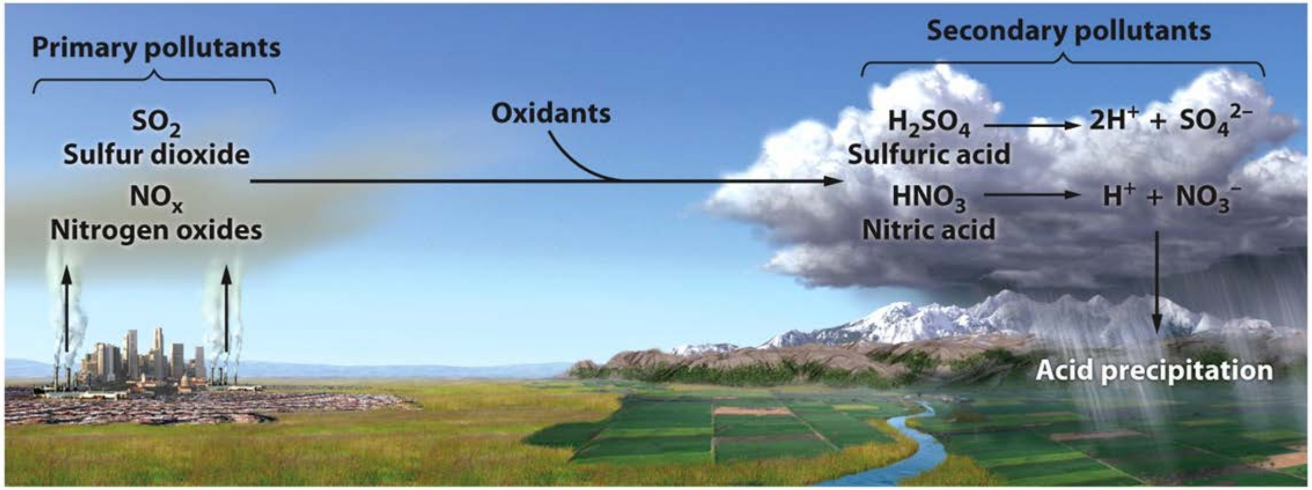
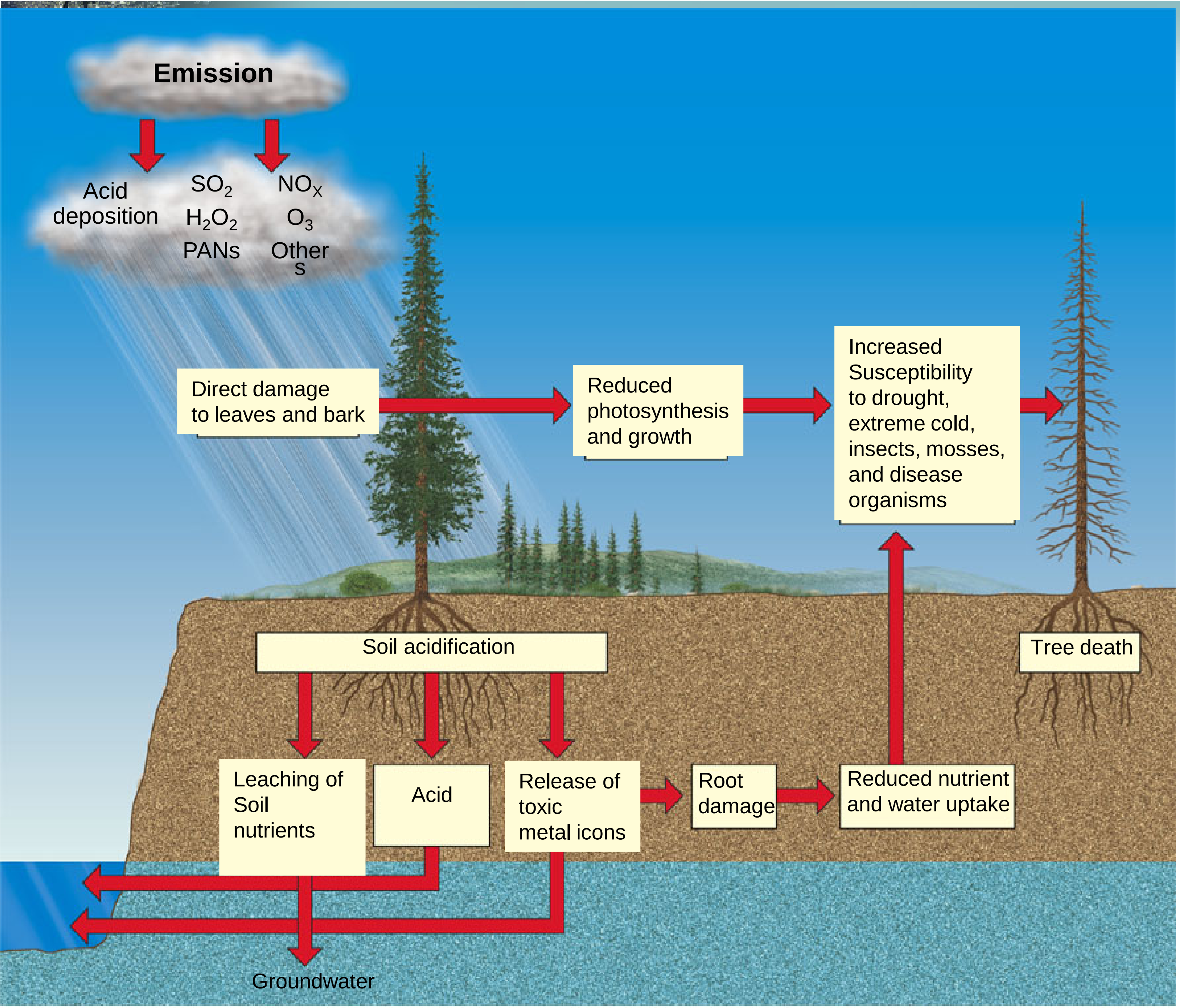
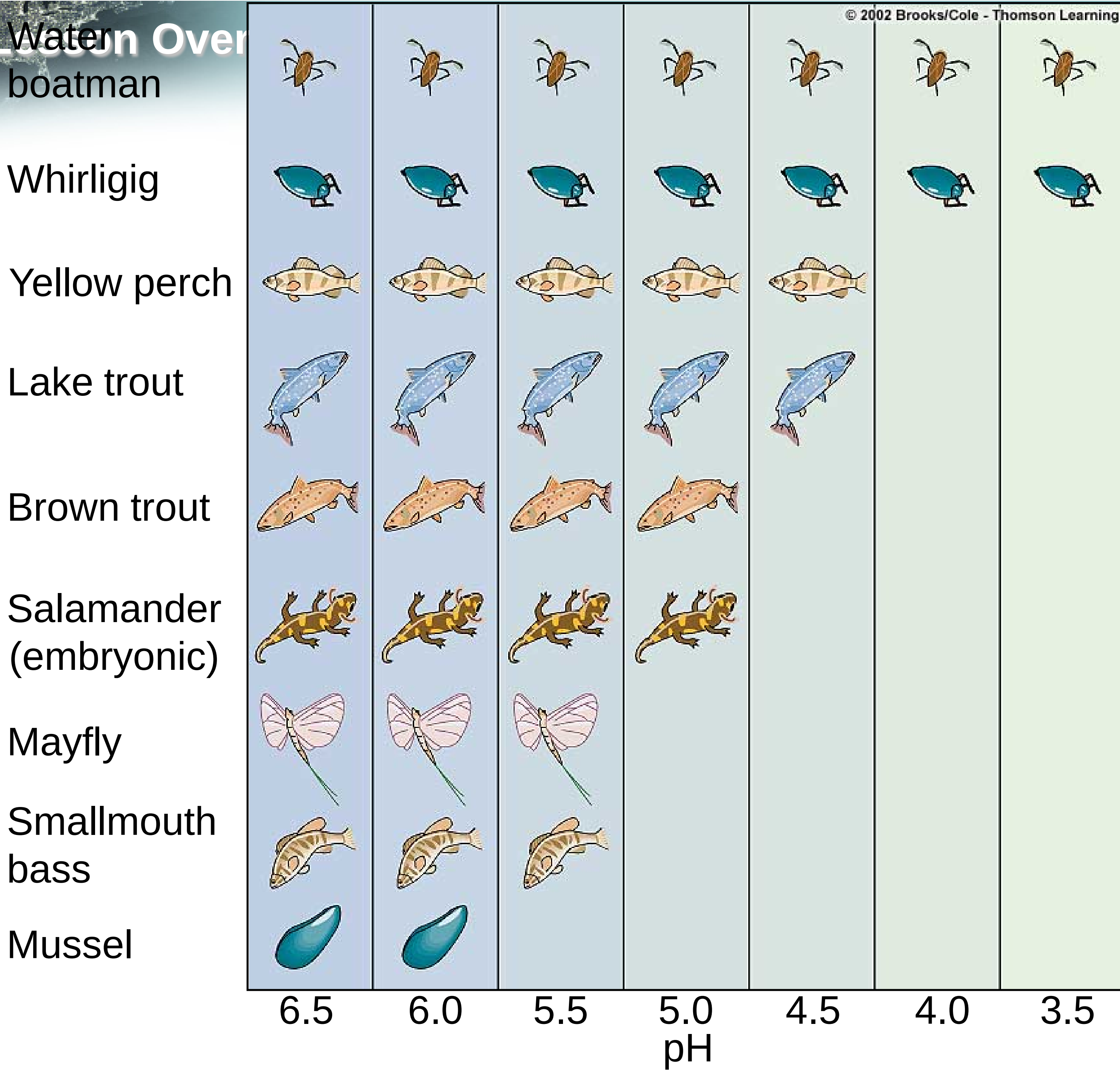


Figure 15.9
Environmental Science


Emission
Acid deposition
SO2
H2O2
PANs
NOX
O3
Other s
Direct damage to leaves and bark
Reduced photosynthesis and growth
Increased Susceptibility to drought, extreme cold, insects, mosses, and disease organisms
Soil acidification
Tree death
Leaching of Soil nutrients
Acid
Release of toxic metal icons
Root damage
Reduced nutrient and water uptake
Groundwater

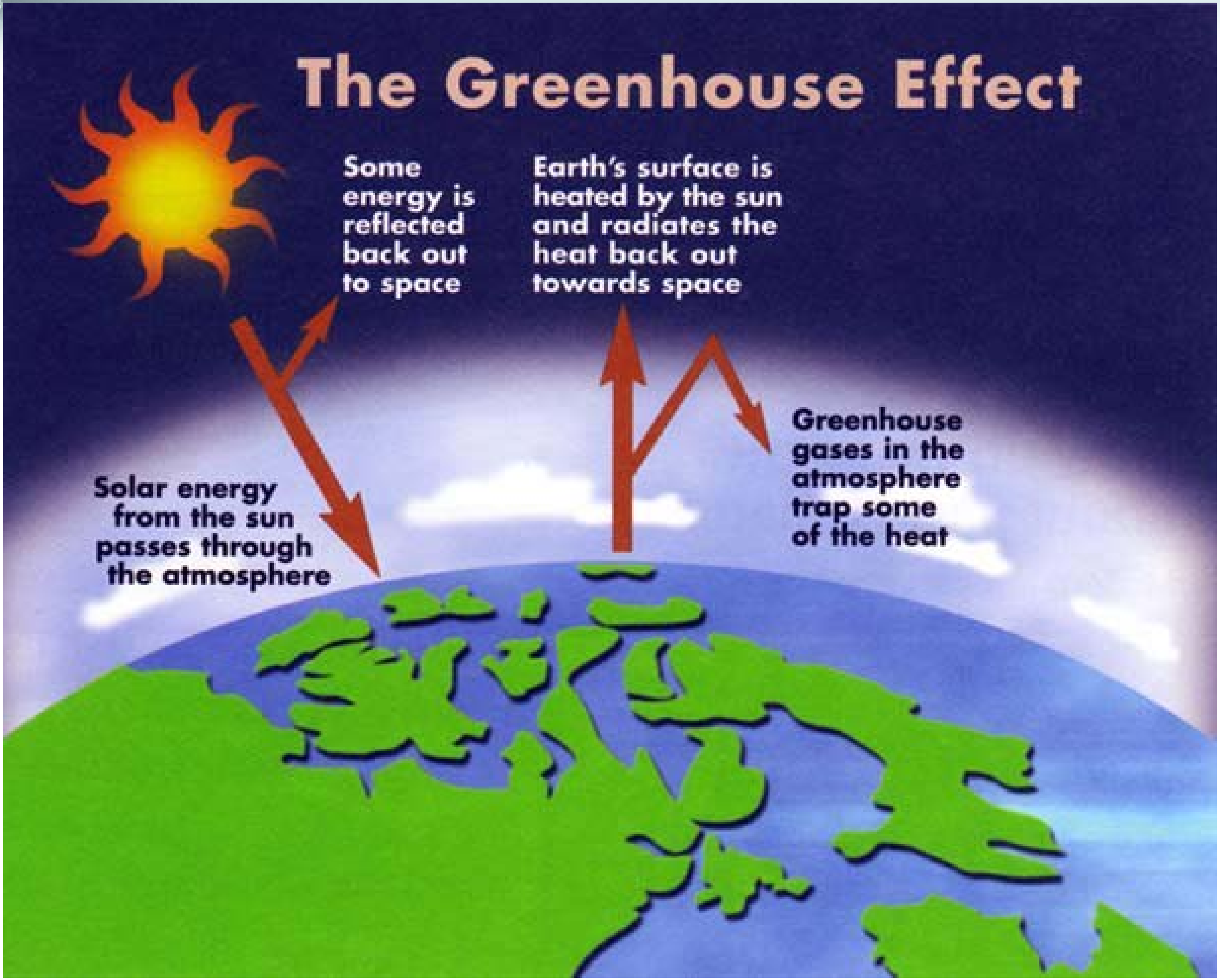

© 2002 Brooks/Cole - Thomson Learning
Water boatman
Whirligig
Yellow perch
Lake trout
Brown trout
Salamander (embryonic)
Mayfly
Smallmouth bass
Mussel
6.5
6.0
5.5
5.0
4.5
4.0
3.5
pH

Greenhouse Gases

Burning fossil fuels and forests releases stored carbon into the atmosphere as **carbon dioxide**, a greenhouse gas.

Agricultural practices release **methane,** another greenhouse gas.

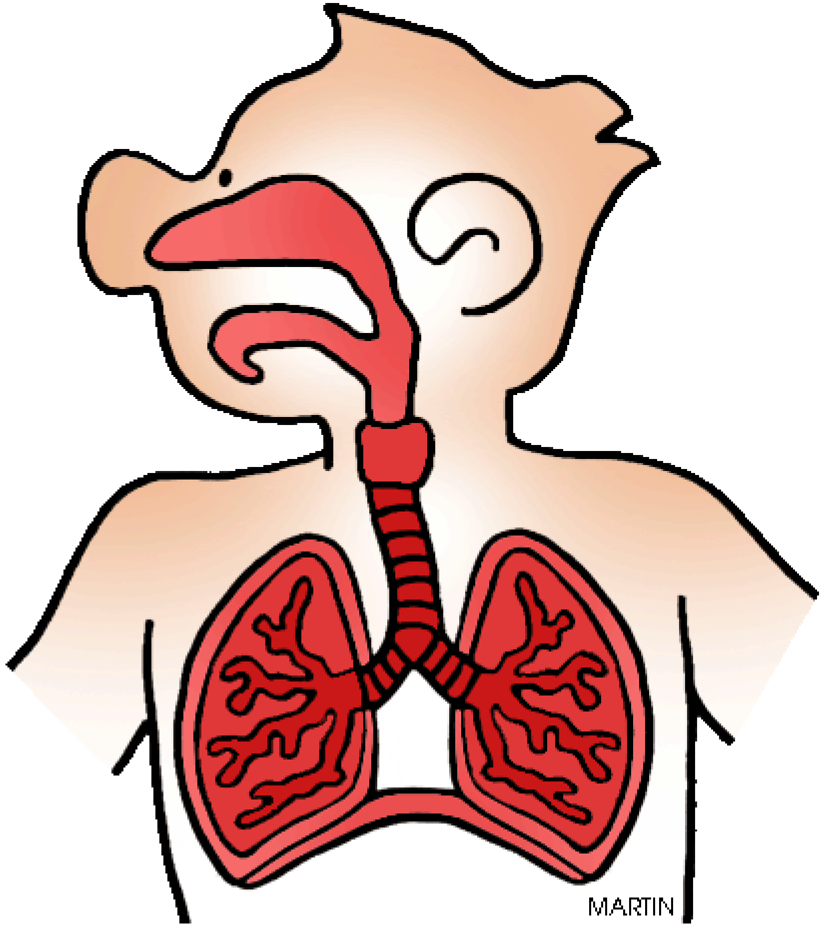
Although some greenhouse gases are necessary, when excess greenhouse gases accumulate in the atmosphere, they contribute to global warming and climate change.


The Greenhouse Effect
Some energy is reflected back out to space
Earth's surface is heated by the sun and radiates the heat back out towards space
Greenhouse gases in the atmosphere trap some of the heat
Solar energy from the sun passes through the atmosphere

Particulates

<u>Particulates</u> are microscopic particles of ash and dust released by certain industrial processes and certain kinds of diesel engines.

Very small particulates can pass through the nose and mouth and enter the lungs, where they can cause serious health problems.



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Biodiversity

Types of Biodiversity

Biological diversity, or biodiversity, is the total of all the genetically based variation in all organisms in the biosphere.

Biodiversity exists on three levels: ecosystem diversity, species diversity, and genetic diversity.

Ecosystem diversity refers to the variety of habitats, communities, and ecological processes in the biosphere.

The number of different species in the biosphere, or in a particular area, is called **species diversity**. To date, biologists have identified and named more than 1.8 million species, and they estimate that at least 30 million more are yet be discovered.

Genetic diversity can refer to the sum total of all different forms of genetic information carried by a particular species, or by all organisms on Earth.

Within each species, genetic diversity refers to the total of all different forms of genes present in that species.

Biodiversity and Medicine

Wild species are the original source of many medicines. For example, a foxglove plant contains compounds called digitalins that are used to treat heart disease.

These plant compounds are assembled according to instructions coded in genes. The genetic information carried by diverse species is like a “natural library” from which we have a great deal to learn.

Biodiversity and Agriculture

Most crop plants have wild relatives. For example, wild potatoes in South America come in many colorful varieties.

These wild plants may carry genes we can use—through plant breeding or genetic engineering—to transfer disease or pest resistance, or other useful traits, to crop plants.

Biodiversity and Ecosystem Services

The number and variety of species in an ecosystem can influence that ecosystem's stability, productivity, and value to humans.

Sometimes the presence or absence of a single **keystone species,** like the sea otter, can completely change the nature of life in an ecosystem. When the otter population falls, the population of its favorite prey, sea urchins, goes up. Population increases in sea urchins cause a dramatic decrease in the population of sea kelp, the sea urchin's favorite food.

Also, healthy and diverse ecosystems play a vital role in maintaining soil, water, and air quality

Threats to Biodiversity

Species diversity is related to genetic diversity. The more genetically diverse a species is, the greater its chances of surviving disturbances. So as human activity reduces genetic diversity, species are put at a greater risk for extinction.

Species diversity is also linked to ecosystem diversity. As ecosystems are damaged, the organisms that inhabit them become more vulnerable to extinction.

Humans reduce biodiversity by altering habitats, hunting, introducing invasive species, releasing pollution into food webs, and contributing to climate change.

Altered Habitats

When natural habitats are eliminated for agriculture or for urban development, the number of species in those habitats drops, and some species may become extinct.

Development often splits ecosystems into pieces, a process called **habitat fragmentation**, leaving habitat “islands.” A biological island can be any patch of habitat surrounded by a different habitat.

For example, deforestation for housing developments in Florida has led to forest “islands.”

The smaller a habitat island, the fewer the species that can live there and the smaller their populations. Both changes make habitats and species more vulnerable to other disturbances.

Hunting and the Demand for Wildlife Products

Humans can push species to extinction by hunting.

Some animals are hunted for meat or for their valuable hides or skins. Others, like green parrots, are hunted to be sold as pets.

Hunted species are affected even more than other species by habitat fragmentation because fragmentation increases access for hunters and limits available hiding spaces for prey.

The Convention on International Trade in Endangered Species (CITES) bans international trade in products from a list of endangered species.

Introduced Species

Organisms introduced to new habitats can become **invasive** and threaten biodiversity.

One European weed, leafy spurge, infests millions of hectares across the Northern Great Plains. Leafy spurge displaces grasses and other food plants, and it can sicken or kill cattle and horses.

Pollution

Many pollutants threaten biodiversity.

DDT, for example, prevents birds from laying healthy eggs.

Acid rain places stress on land and water organisms.

Increased carbon dioxide in the atmosphere is dissolving in oceans, making them more acidic, which threatens biodiversity in marine ecosystems.

Climate Change

Organisms are adapted to their environments and have specific tolerance ranges to temperature and other abiotic conditions.

If conditions change beyond an organism’s tolerance, the organism must move to a more suitable location or face extinction.

Species in fragmented habitats, such as these forest “islands” in Florida, are particularly vulnerable to climate change because if conditions change they may not be able to move easily to a suitable habitat.

Preserving Habitats and Ecosystems: Ecological Hot spots (shown in Red)

To make sure that conservation efforts are concentrated in the most important places, conservation biologists have identified **ecological "hot spots".** An ecological hot spot is a place where significant numbers of species and habitats are in immediate danger of extinction.

By identifying these areas, ecologists hope that scientists and governments can better target their efforts to save as many species as possible.