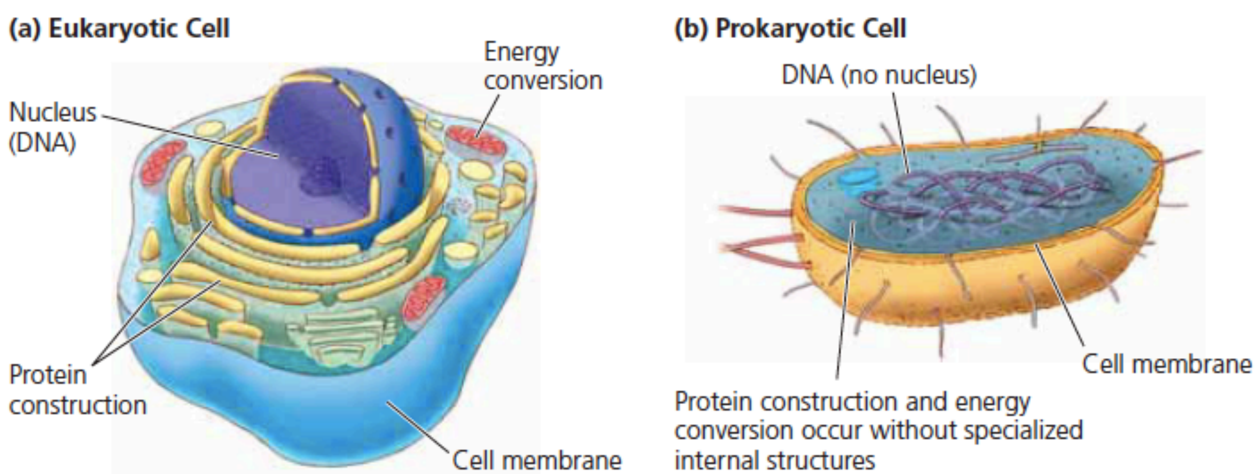
1. FUNDAMENTALS OF ECOLOGY:

Cells:

- Smallest and the most fundamental units of life.
- Cells are minute compartments covered with thin membrane and within which the processes of life occur.
- Idea that all the living beings are composed of cells is called Cell theory
- Organisms may consist of a single cell: example Bacteria or huge number of cells as in case of plants and animals.
- On the basis of their cell structure, animals are classified as either eukaryotic or prokaryotic.
- **Eukaryotic:** Surrounded by a memberane and has a distinct nucleus (nucleus contains genetic material in form of the DNA) and several other internal parts called the organelles (also surrounded by membranes). Most organisms consist of eukaryotic cells.
- **Prokaryotic:** Surrounded by a membrane but no distinct nucleus and no other internal parts surrounded by membranes. All bacteria consist of a single prokaryotic cell.



- *Insects make up most of the world's known species.*

Biosphere — Parts of the earth's air, water, and soil where life is found

Ecosystem — A community of different species interacting with one another and with their nonliving environment of matter and energy

Community — Populations of different species living in a particular place, and potentially interacting with each other

Population — A group of individuals of the same species living in a particular place

Organism — An individual living being

Cell — The fundemental structural and functional unit of life

Molecule — Chemical combination of two or more atoms of the same or different elements

Atom — Smallest unit of a chemical element that exhibits its chemical properties

Genetic Diversity: In most natural populations, individuals vary slightly in their genetic makeup, which is why they do not all look or act alike. This variation in a population is called Genetic Diversity

Ecosystem: An ecosystem is a community of different species interacting with one another and with the nonliving environment of soil, water, other forms of matter, and energy, mostly from the sun. Ecosystems can be natural or artificial. Examples of artificial ecosystems are crop fields, tree farms, and reservoirs.

Biosphere: Parts of the earth's air, water, and soil where life is found.

Figure 3-5 *Genetic diversity* among individuals in a population of a species of Caribbean snail is reflected in the variations in shell color and banding patterns. Genetic diversity can also include other variations such as slight differences in chemical makeup, sensitivity to various chemicals, and behavior.

Four systems that interact with each other and form the backbone of earth's life support are:
1) The atmosphere 2) The hydrosphere 3) The geosphere 4) The biosphere

Biomes:
Terrestrial regions on earth's surface where life is found in interaction the biosphere. These are regions such as grasslands, deserts, forests etc.

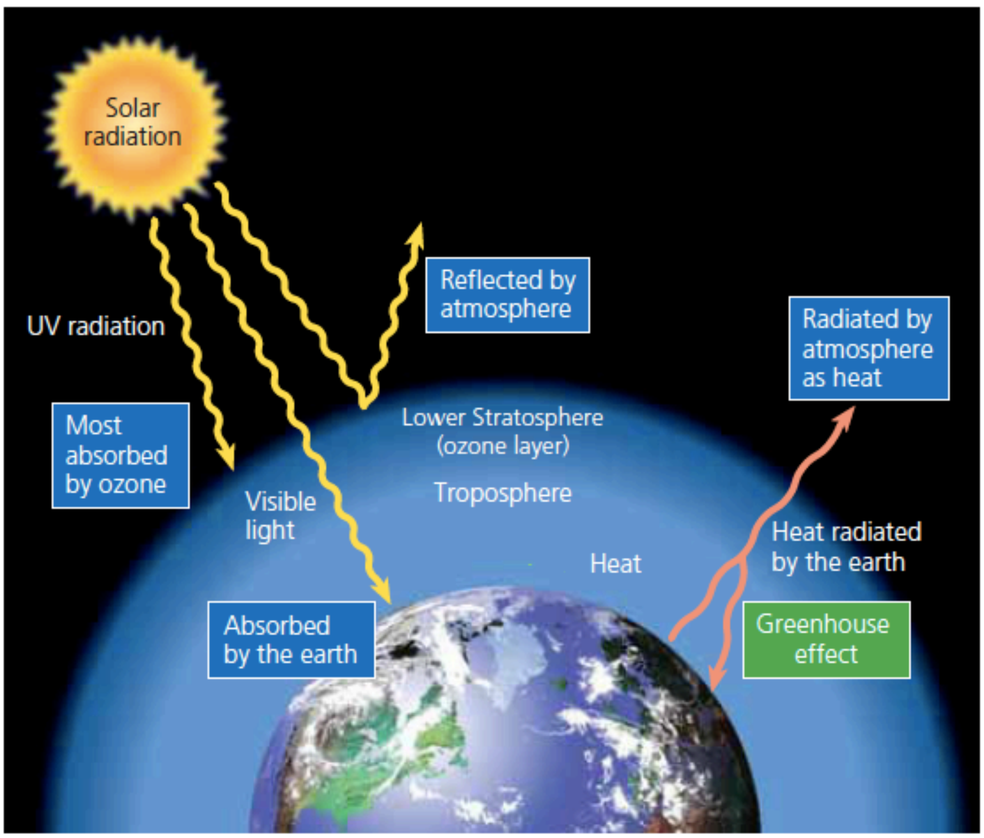
Factor Sustaining Life on Earth (3 Factors):

1. *Flow of energy from the sun through the biosphere*

- One way flow of high quality energy from the sun, through the living things in their feeding interactions, into the environment as low-quality energy (mostly heat dispersed into air, water at low temperature), and then eventually back into the space as heat.
- The first and the second laws of Thermodynamics govern this flow of energy.

2. *Cycling of the Nutrients*
    - Nutrients are atoms, ions and compounds needed for survival by living organisms. These nutrients and their supply must be receded through the earth's atmosphere for sustaining life.
3. *Gravity*
    - Gravity allows the planet to hold onto its atmosphere and helps to enable the movement and cycling of chemicals through the air, water, soil and organisms.

Flow of energy from the sun through the biosphere



Sun's Energy:

- It's in form of electromagnetic waves and reaches earth as UV rays, visible light and heat (infrared radiation)
- Only 1% of the total solar radiation directed towards the earth reaches its surface and is reflected back in the form of longer-wavelength infrared radiation.
- When this reflected longer-wavelength encounters greenhouse gases such as carbon dioxide, ozone, methane or nitrous oxide, it causes these

gaseous molecules to vibrate and release infrared radiation which has even longer wavelengths. The vibrating gaseous molecules then have higher kinetic energy, which helps to warm the lower atmosphere and the earth's surface.

- Ozone absorbs around 95% of the UV rays
- Earth;s atmosphere, clouds and surface reflect back or absorb most of the energy.
- Approx. 1% of this incoming energy generates winds.
- Green plants, bacteria, algae use less than 0.1% of this incoming radiation to produce nutrients they need through photosynthesis and in turn to feed animals that eat plants and flesh.
- Burning carbon fuels releases CO_2 and growing crops and raising livestock releases Methane and Nitrous Oxide.

Components of Ecosystem:

Two components:

1. **Biotic (Living)**
    - Plants, animals, microbes
    - Also include dead organisms and their parts and the waste products of the organisms
2. **Abiotic (Non-living)**
    - Water, Air, Nutrients, Rocks, heat and solar energy

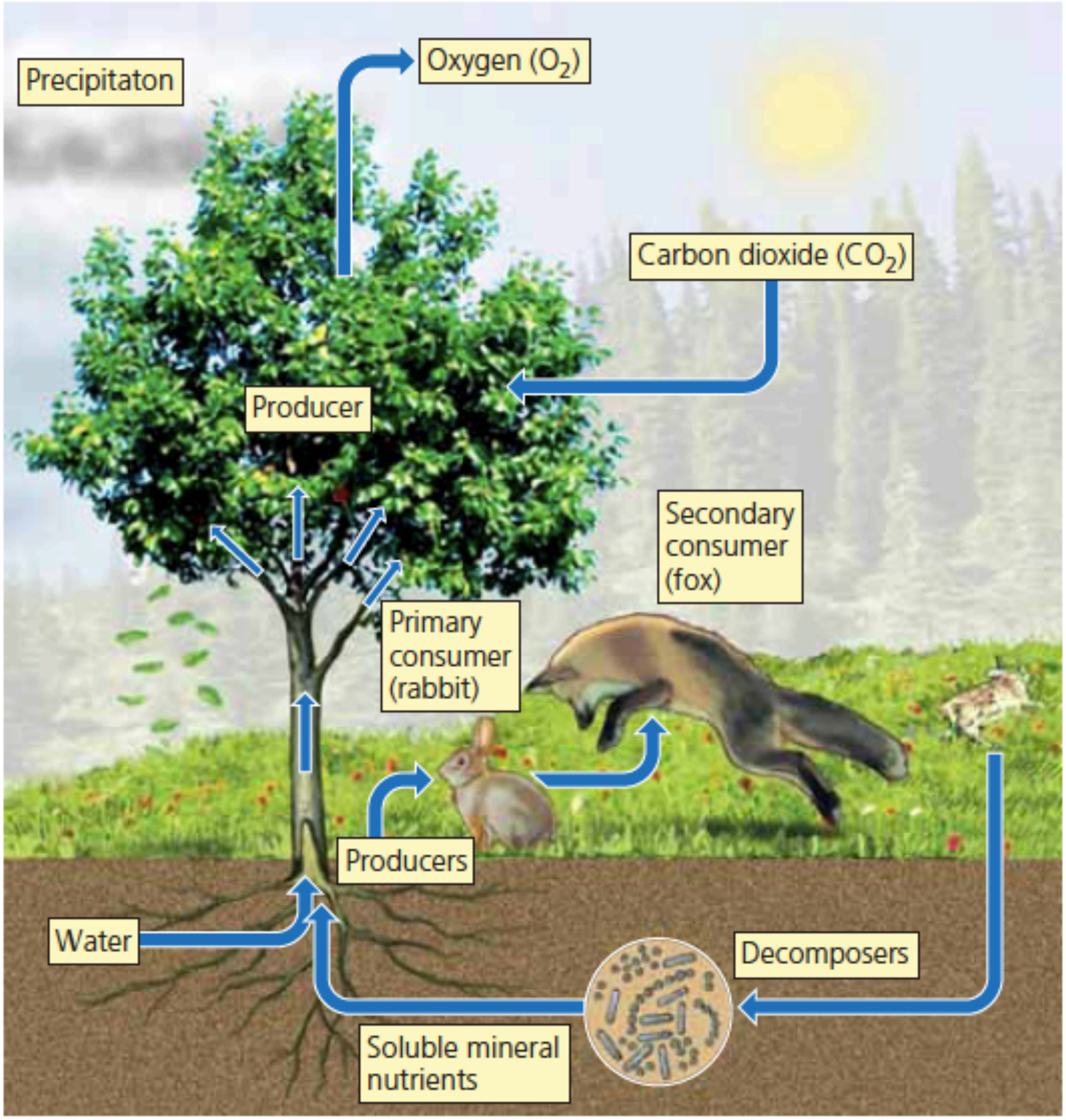
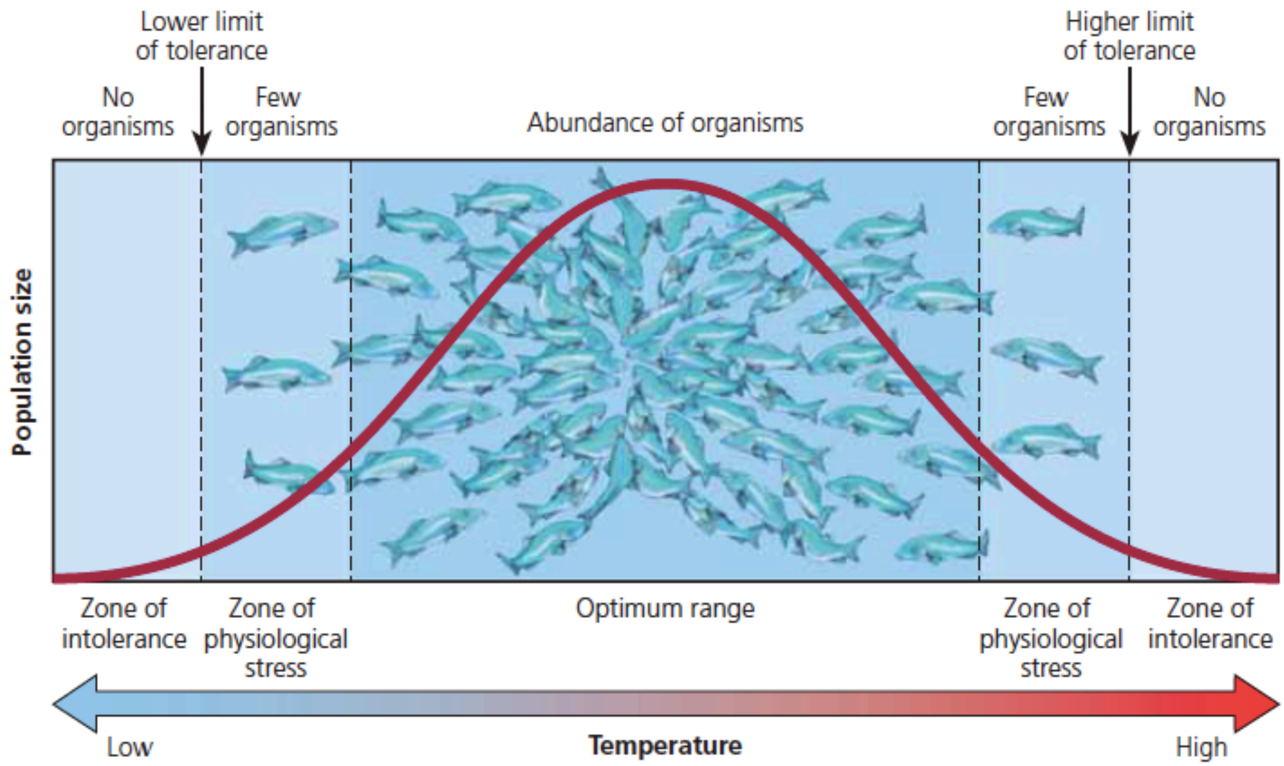


Diagram - Range of Tolerance for survival of living organisms:
This optimal range also depends on many factors such as (for aquatic life zones) nutrient availability, salinity levels, temperature of water, soluble oxygen in water, sunlight etc.



Trophic Level:
Every organism in the ecosystem is assigned a trophic level based on their feeding level and their source of food or nutrients. Organisms that transfer energy from one trophic level to another are broadly classified as *producers and consumers*.

Producers or Autotrophs:
Make their own food from compounds and energy received from the environment. On land, most producers are green plants. In fresh water and marine systems, algae and aquatic plants are major producers near shorelines. In open waters, major producers are phytoplankton - microscopic organisms that float on water. Most producers capture sunlight to produce glucose (C6H12O6) by photosynthesis.

Basic Photosynthesis:

carbon dioxide + water + solar energy → glucose + oxygen

$$6\,CO_2 + 6\,H_2O + \text{solar energy} \rightarrow C_6H_{12}O_6 + 6\,O_2$$

The plants prepare their own food by the process of photosynthesis.

- The process has two phases, the *light reaction and the dark reaction*. Th e light reaction takes place in the presence of sunlight, while the dark re action does not require light and continues both during day and night. Th e byproduct of photosynthesis is Oxygen gas.

- The plants burn their food to produce energy for their survival. This proc ess is respiration. The plants take in O2 and release CO2. Since light reac tion does not take place during night, the respiration dominates. That's why it is not wise to sleep under a tree at night as it releases a lot of Car bon dioxide.

Homeostasis

The organism should try to maintain the constancy of its internal environment (a process called homeostasis) despite varying external environmental conditio ns that tend to upset its homeostasis.

Some organisms are able to maintain homeostasis by physiological (sometimes behavioral also) means which ensures constant body temperature, constant os motic concentration, etc. All birds and mammals, and a very few lower verteb rate and invertebrate species are indeed capable of such regulation (thermore gulation and osmoregulation). Evolutionary biologists believe that the 'success ' of mammals is largely due to their ability to maintain a constant body temperature and thrive whether they live in Antarctica or in the Sahara desert .

The mechanisms used by most mammals to regulate their body temperature ar e similar to the ones that we humans use. We maintain a constant body tempe rature of – 370C. In summer, when outside temperature is more than our body temperatu re, we sweat profusely. The resulting evaporative cooling, similar to what hap pens with a desert cooler in operation, brings down the body temperature. In winter when the temperature is much lower than 370C, we start to shiver, a ki nd of exercise which produces heat and raises the body temperature.

Plants, on the other hand, do not have such mechanisms to maintain internal t emperatures.

Chemosynthesis:

Some bacteria can convert simple inorganic compounds from the environment into complex nutrient compounds without using sunlight. This process is known as Chemosynthesis. These organisms are an exception to the scientific principle of sustainability because they do not depend on the energy of sun to produce carbohydrates. In fact, scientists have found bacteria deep inside the ocean of the earth, living near the geothermal vents, where they use the energy from hydrogen sulfide (H2S) gas escaping through the fissures of the ocean floor.

Consumers or Heterotrophs:

All other organisms in the ecosystem are consumers. Types of consumers:

- Primary consumers or herbivores
- Secondary consumers or carnivores
- Third or high level consumers

- Omnivores
- Decomposers - primarily bacteria and fungi that release nutrients from the dead bodies of plants and animals and return it to the soil, water, and air for reuse by the producers.
- Detritus feeders (Saprophytes) or Detritivores or Scavengers - mites, earth worms, some insects, catfish, vultures

Producers, consumers, and decomposers use the chemical energy stored in glucose and other organic compounds to fuel their life processes. In most cells this energy is released by **aerobic respiration,** which uses oxygen to convert glucose (or other organic nutrient molecules) back into carbon dioxide and water. The net effect of the hundreds of steps in this complex process is represented by the following reaction:

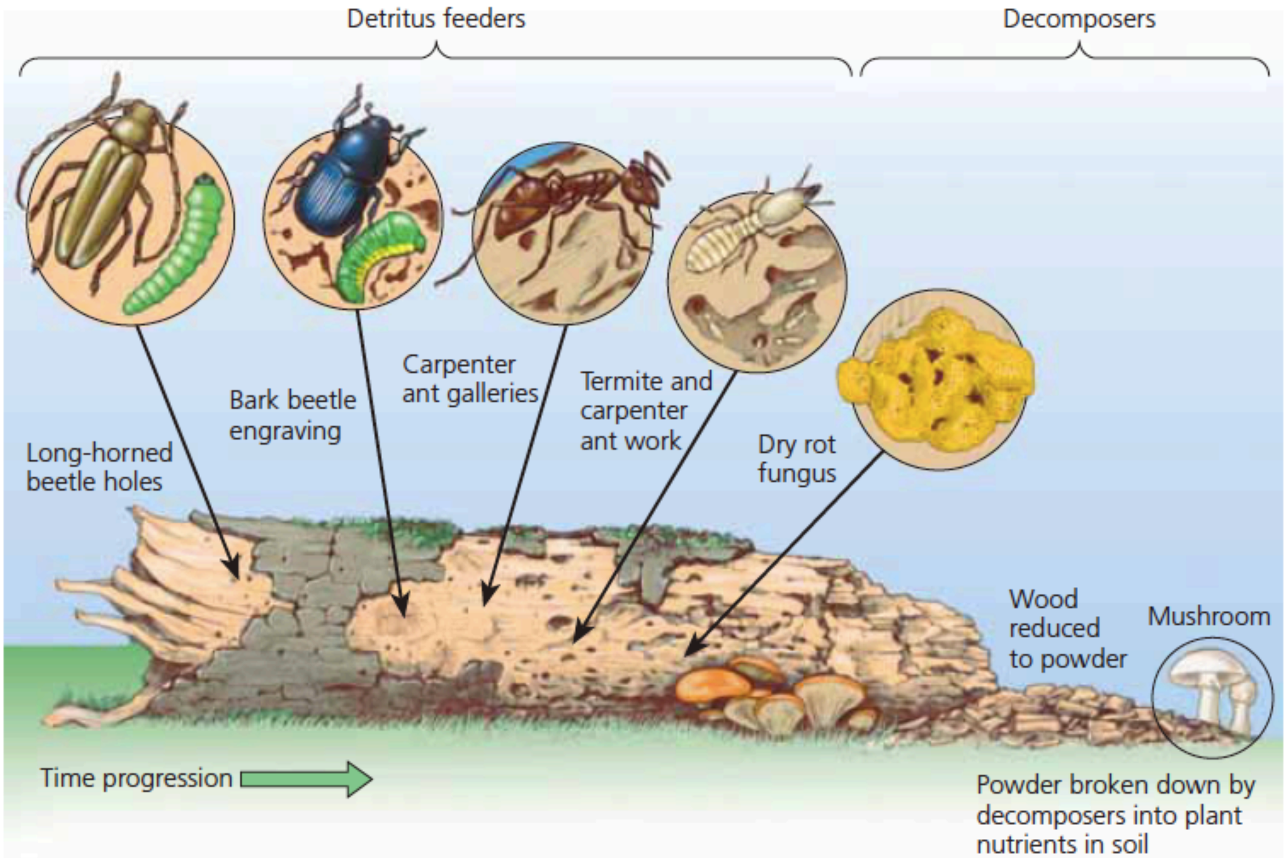
glucose + oxygen → carbon dioxide + water + energy

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + \text{energy}$$

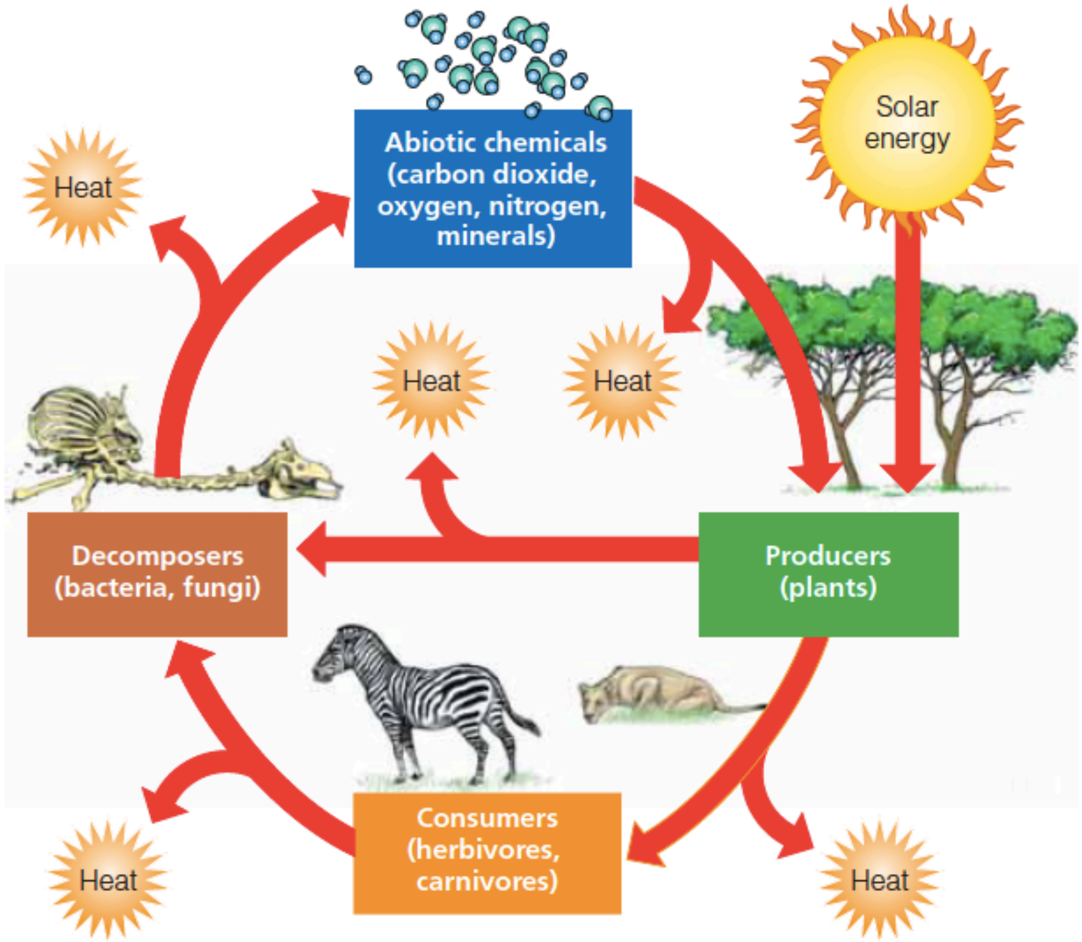
Anaerobic Respiration or Fermentation (without oxygen)

Some decomposers get energy by breaking down glucose in the absence of oxygen. This form of cellular respiration is known as anaerobic respiration or fermentation.

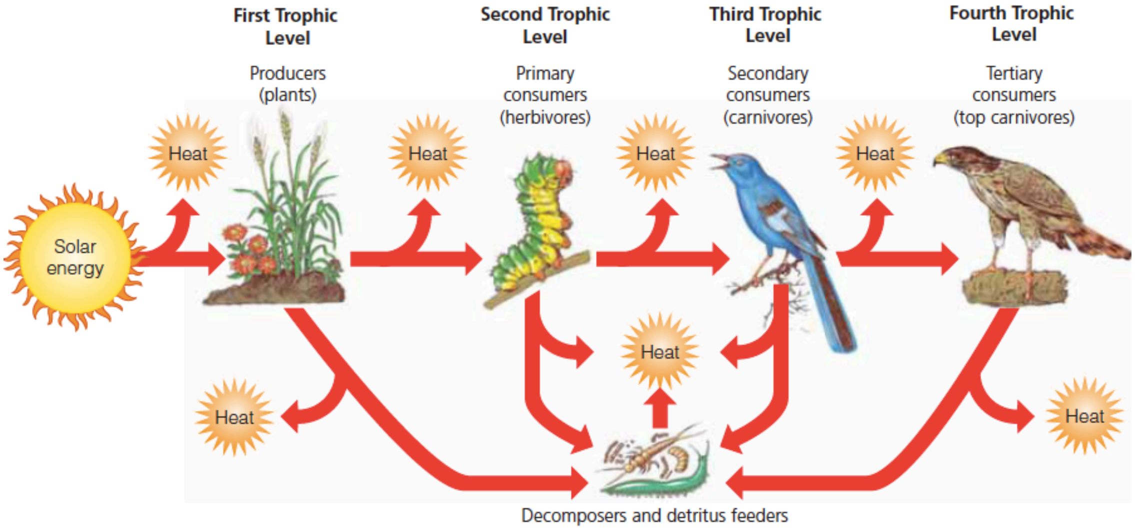
Instead of CO2 and water, the end products of this process are compounds like Methane (main component of natural gas), Ethyl alcohol, Acetic Acid (key compound of vinegar) and Hydrogen Sulfide (when sulfur compounds are broken down).



Energy Flow (one way from sun to earth's environment) and Nutrient cycle process



Food chain:
A sequence of organisms, each of which serves as a source of food or energy for the next, is called a **food chain.** It determines how chemical energy and nutrients move from one organism to another through trophic levels in an ecosystem - *primarily through photosynthesis, feeding and decomposition.*



Biomass: Each trophic level in a food chain or web contains a certain amount of *biomass*, the dry weight of all organic matter contained in its organisms. Chemical energy in a biomass transfers from one trophic level to another.

Gross Primary Productivity (GPP) - Rate at which an ecosystem's producers (usually plants) convert solar energy into chemical energy as biomass found in their tissues. Measured in terms of energy production per unit area over a period of time or kilocalories/m2/year.

NPP = GPP - R
R = respiration (energy used in respiration)

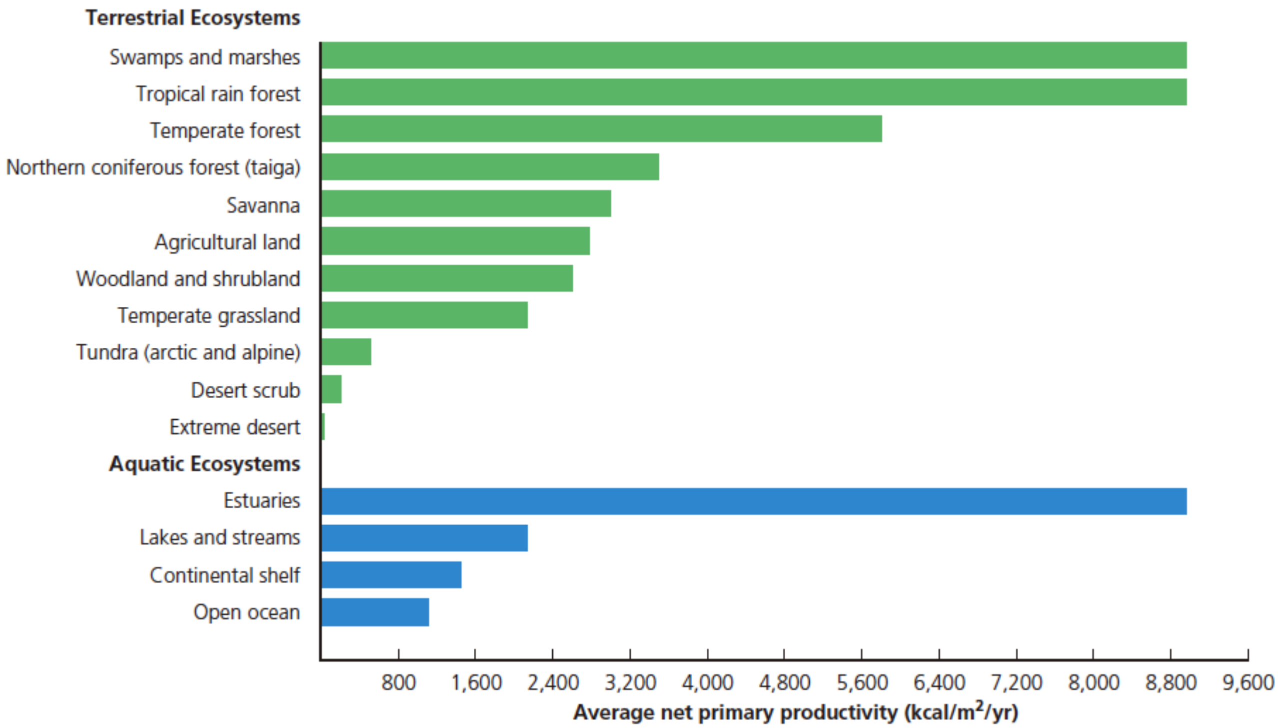


Figure 3-16 Estimated annual average *net primary productivity* in major life zones and ecosystems, expressed as kilocalories of energy produced per square meter per year (kcal/m^2/yr). **Question:** What are nature's three most productive and three least productive systems? (Data from R. H. Whittaker, *Communities and Ecosystems,* 2nd ed., New York: Macmillan, 1975)

- Oceans produce more biomass than any other producers even though their productivity is lower. This is because there is so much ocean out there.
- The planet's NPP limits the number of consumers (including humans) that can survive on the earth.
- Humans today consume, waste or destroy around 20-30% of earth's biomass even though they form less than 1% of the total population of earth's consumers that depend on producers for their nutrients.
- Ecosystems and life zones differ in their NPP as illustrated above.
- On land, NPP generally decreases from the equator toward the poles because the amount of solar radiation available to terrestrial plant producers is highest at the equator and lowest at the poles.
- In the ocean, the highest NPP is found in estuaries where high inputs of plant nutrients flow from nutrient-laden rivers, which also stir up nutrients in bottom sediments. Because of the lack of nutrients, the open ocean has a low NPP, except at occasional areas where an upwelling (water moving up from the depths toward the surface) brings nutrients in bottom sediments to the surface. Despite its low NPP, the open ocean produces more of the earth's biomass per year than any other ecosystem or life zone, simply because there is so much open ocean.

- The increase of species richness from poles to the equator is referred to as **Latitudinal Diversity Gradient. Terrestrial biodiversity is 25 times more diverse than that in the oceans.**

Holocene Extinction

Holocene is a geological epoch which began around 12,000 to 11,500 years ago and continues to the present. The scientists propose that a **Sixth Extinction** of biodiversity is going on currently in this Holocene epoch, which started around 10,000 BC. The large number of extinctions span numerous families of plants and animals including mammals, birds, amphibians, reptiles and arthropods. The Holocene extinction includes the disappearance of large mammals known as megafauna, starting between 9,000 and 13,000 years ago, the end of the last Ice Age. Such disappearances are considered to be results of both climate change and the proliferation of modern humans. These extinctions are sometimes referred to as the ***Quaternary extinction event***. All of us are witnessing this Holocene extinction.

Bioprospecting

Bioprospecting is the process of discovery and commercialization of new products based in biological resources. Bioprospecting often draws on indigenous knowledge about uses and characteristics of plants and animals. Thus, ***Bioprospecting includes Biopiracy***, the exploitative appropriation of indigenous forms of knowledge by commercial actors, as well as the search for previously unknown compounds in organisms that have never been used in traditional medicine.

Biopiracy

In Biopiracy, indigenous knowledge of nature, originating with indigenous peoples, is used by others for profit, without permission from and with little or no compensation or recognition to the indigenous people themselves.

Representing one of the most agriculturally bio-diverse nations in the world, India has become a primary target for biopiracy. In a first, in 1995, a firm in United States had successfully applied for a patent on a technique to extract an antifungal agent from the **neem tree** (*Azadirachta indica*), which grows throughout India and Nepal. This was a case of biopiracy as the Indian people have long understood the tree's medicinal value. The efforts on part of Government of India led to cancellation of the patent. Similarly, in 2000, US Corporation RiceTec attempted to patent certain hybrids of basmati rice and semi dwarf long-grain rice. The Indian government intervened and several claims of the patent were invalidated.

The most recent case of biopiracy is the **first ever bio-piracy case by National Biodiversity Authority against the developers of Bt brinjal**, which has been discussed later in these modules.

Cycles of Matter in the Ecosystem or Cycling of Nutrients:

Unlike energy, elements move within an ecosystem in cycles.These cycles move nutrients between organisms and the environment continuously.

1. **Water Cycle**
    - Water moves between the oceans, the atmosphere, and the land. Water enters the atmosphere through the process of evaporation, precipitation and transpiration (from the leaves of the plants). Over 90% of the water that reaches the atmosphere evaporates from the surfaces of plants through *transpiration*.

SCIENCE FOCUS

Water's Unique Properties

Water is a remarkable substance with a unique combination of properties:

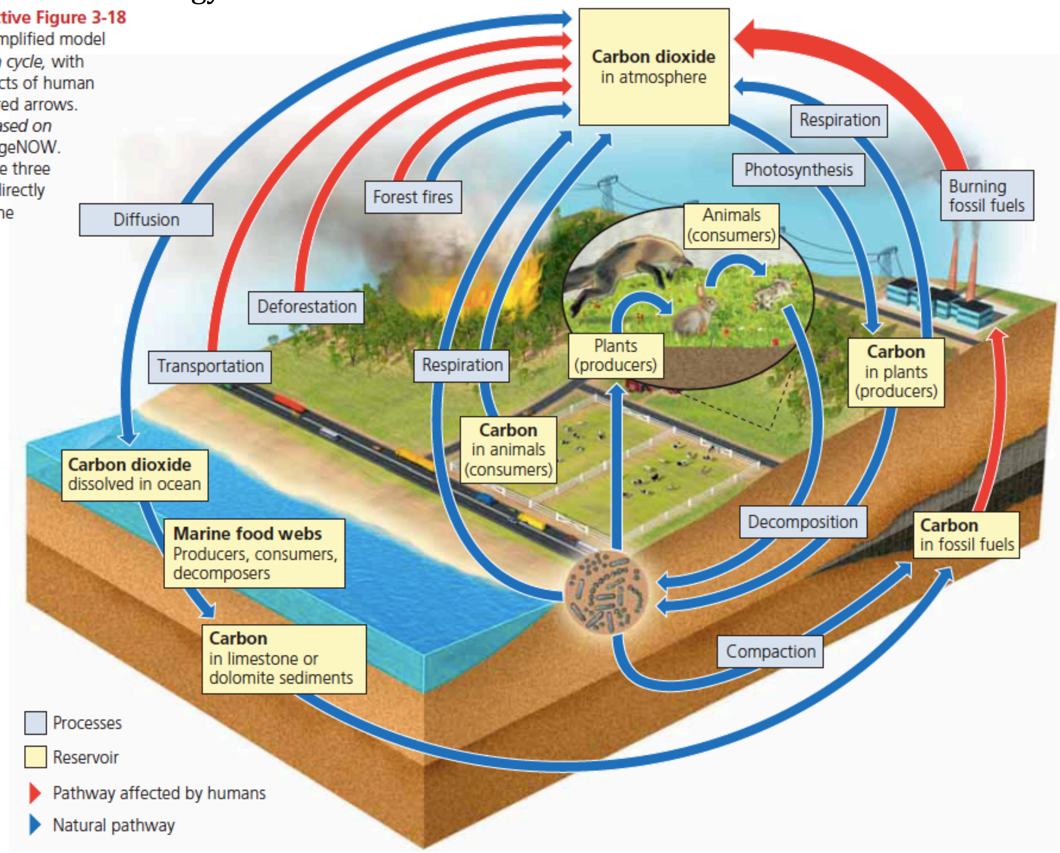
- *Forces of attraction,* called *hydrogen bonds* (see Figure 7 on p. S42 in Supplement 6), *hold water molecules together*—the major factor determining water's distinctive properties.
- *Water exists as a liquid over a wide temperature range because of the hydrogen bonds.* Without water's high boiling point the oceans would have evaporated long ago.
- *Liquid water changes temperature slowly because it can store a large amount of heat without a large change in temperature.* This high heat storage capacity helps protect living organisms from temperature changes, moderates the earth's climate, and makes water an excellent coolant for car engines and power plants.
- *It takes a large amount of energy to evaporate water because of the hydrogen bonds.* Water absorbs large amounts of heat as it changes into water vapor and releases this heat as the vapor condenses back to liquid water. This helps to distribute heat throughout the world and to determine regional and local climates. It also makes evaporation a cooling process—explaining why you feel cooler when perspiration evaporates from your skin.
- *Liquid water can dissolve a variety of compounds* (see Figure 3, p. S40, in Supplement 6). It carries dissolved nutrients into the tissues of living organisms, flushes waste products out of those tissues, serves as an all-purpose cleanser, and helps remove and dilute the water-soluble wastes of civilization. This property also means that water-soluble wastes can easily pollute water.
- *Water filters out some of the sun's ultraviolet radiation* (Figure 2-8, p. 42) *that would harm some aquatic organisms.* However, up to a certain depth it is transparent to visible light needed for photosynthesis.
- *Hydrogen bonds allow water to adhere to a solid surface.* This enables narrow columns of water to rise through a plant from its roots to its leaves (a process calle capillary action).
- *Unlike most liquids, water expands when it freezes.* This means that ice floats on water because it has a lower density (mas per unit of volume) than liquid water. Oth erwise, lakes and streams in cold climates would freeze solid, losing most of their aquatic life. Because water expands upon freezing, it can break pipes, crack a car's engine block (if it doesn't contain antifreeze), break up street pavements, and fracture rocks.

Critical Thinking

Water is a bent molecule (see Figure 4 on p. S40 in Supplement 6) and this allows it to form hydrogen bonds (Figure 7, p. S42, in Supplement 6) between its molecules. What are three ways in which your life would be different if water were a linear or straight molecule?

2. **Carbon Cycle**
    - Carbon is a basic building block of carbohydrates, fats, proteins and DNA and other organic compounds.
    - Its circulation depends on photosynthesis and aerobic respiration by the earth's living organisms.
    - Terrestrial producers remove the CO2 from the atmosphere and aquatic producers remove its from water.
    - While decomposers release the carbon stored in bodies of dead organisms on land back into the atmosphere as CO2, the decomposers in water can release carbon that is stored as insoluble carbonates in bottom sediment. Therefore, *marine sediments are the largest store of earth's carbon.*
    - These marine deposits are converted into fossil fuels by high pressure and high heat in layers of sediment rocks they are stored in

3.



CENGAGENOW™ **Active Figure 3-18**
Natural capital: simplified model of the global *carbon cycle*, with major harmful impacts of human activities shown by red arrows. *See an animation based on this figure at* CengageNOW. **Question:** What are three ways in which you directly or indirectly affect the carbon cycle?

4. **Nitrogen Cycle**
    - Chemically unreactive Nitrogen gas forms 78% of the atmosphere.
    - It is a crucial element of proteins, many vitamins, and nucleic acid such as DNA.
    - However, plants cannot use Nitrogen directly from the atmosphere.
    - Two processes that fix nitrogen into compounds that are useful to plants are:
        1. *Electrical Discharges or lightening*
        2. *Nitrogen Fixing Bacteria:*
            - In aquatic system, soils, and roots of some plants. Specialized bacteria in soil and blue green algae (cyanobacteria) in aquatic environments combine gaseous N2 with hydrogen to make ammonia (NH3).
            - The bacteria use some of this ammonia as nutrient and release rest of it into the soil or water. Some of the ammonia is converted to ammonium ions (NH4+) that can be used by plants as nutrients.
            - Ammonia not taken up by plants may undergo nitrification. It is a two step process in which specialized soil bacteria converts the ammonia and NH4+ (ammonia ions) into nitrate ions (NO3-). These are easily taken up by plant roots and this form of nitrogen is used by plants to form amino acids,

nucleic acids, proteins and vitamins. Animals eat these plants and hence consume these nitrogen containing compounds.

- Human interference in nitrogen cycle:
    1. Human interfere in the nitrogen cycle by sending large amounts of Nitric Oxide into the atmosphere by burning fuels. In the atmosphere this gas can be converted into nitrogen dioxide gas (NO_2) and nitric acid vapor (HNO_3), which can return to the earth's surface as damaging acid deposition, commonly known as acid rain.
    2. We also add Nitrous Oxide (N_2O) to the atmosphere through the action of anaerobic bacteria on livestock wastes and commercial inorganic fertilizers applied to the soil. This greenhouse gas can warm the atmosphere and deplete stratospheric ozone, which keeps most of the sun's harmful ultraviolet radiation from reaching the earth's surface.
    3. We upset nitrogen cycle in the water by adding fertilizers to crops that runoff to these water bodies and through municipal
    sewage.

    According to the 2005 Millennium Ecosystem Assessment, since 1950, human activities have more than doubled the annual release of nitrogen from the land into the rest of the environment. Most of this is from the greatly increased use of inorganic fertilizer to grow crops, and the amount released is projected to double again by 2050 (Figure 3-20). This excessive input of nitrogen into the air and water contributes to pollution, acid deposition, and other problems to be discussed in later chapters.

5. **Phosphorus Cycles**
    - Phosphorus circulates through water, the earth's crust and living organisms in the phosphorus cycle. It does not include in the atmosphere like carbon water and nitrogen cycles. Only through the surface of earth
    - Major reservoirs of phosphorus are in rock formations and ocean bottom sediments.
    - Huge runoffs of phosphates (which are used as fertilizers) into water bodies may cause abnormal growth of algae producers, which can upset the chemical cycle and other processes in lakes.
6. **Sulfur Cycles**
    - Much of the earth's sulphur is stored in the earth's interior underground rocks and minerals, including sulfate (SO_4^{2-}) salts buried deep under ocean sediments.

- Sulfur also enters the atmosphere from several natural sources. Example is Hydrogen sulfide (poisonous) which enters the atmosphere through volcanic eruptions and from organic matter break down by anaerobic decomposers in flooded swamps, bogs and tidal flats.
- Plant roots absorb sulfate ions and incorporate sulfur as an essential component of many
  proteins.

  Certain marine algae produce large amounts of volatile dimethyl sulfide, or DMS (CH_3SCH_3). Tiny droplets of DMS serve as nuclei for the condensation of water into droplets found in clouds. In this way, changes in DMS emissions can affect cloud cover and climate.

  In the atmosphere, DMS is converted to sulfur dioxide, some of which in turn is converted to sulfur trioxide gas (SO_3) and to tiny droplets of sulfuric acid (H_2SO_4). DMS also reacts with other atmospheric chemicals such as ammonia to produce tiny particles of sulfate salts. These droplets and particles fall to the earth as components of *acid deposition,* which along with other air pollutants can harm trees and aquatic life.

- *Human Activities impacting sulfur cycle:*

  Human activities have affected the sulfur cycle primarily by releasing large amounts of sulfur dioxide (SO_2) into the atmosphere (as shown by red arrows in Figure 3-22). We add sulfur dioxide to the atmosphere in three ways. *First,* we burn sulfur-containing coal and oil to produce electric power. *Second,* we refine sulfur-containing petroleum to make gasoline, heating oil, and other useful products. *Third,* we convert sulfur-containing metallic mineral ores into free metals such as copper, lead, and zinc. Once in the atmosphere, SO_2 is converted to droplets of sulfuric acid (H_2SO_4) and particles of sulfate (SO_4^{2-}) salts, which return to the earth as acid deposition.
-

2. BIODIVERSITY AND EVOLUTION

Biological Evolution:

- Biological Evolution is the process whereby earth's life changes over time through changes in the genes of populations.

Six Kingdoms of Species (Eubacteria, Archaebacteria, Protists, Plants, Fungi, Animals) and Their Evolution:

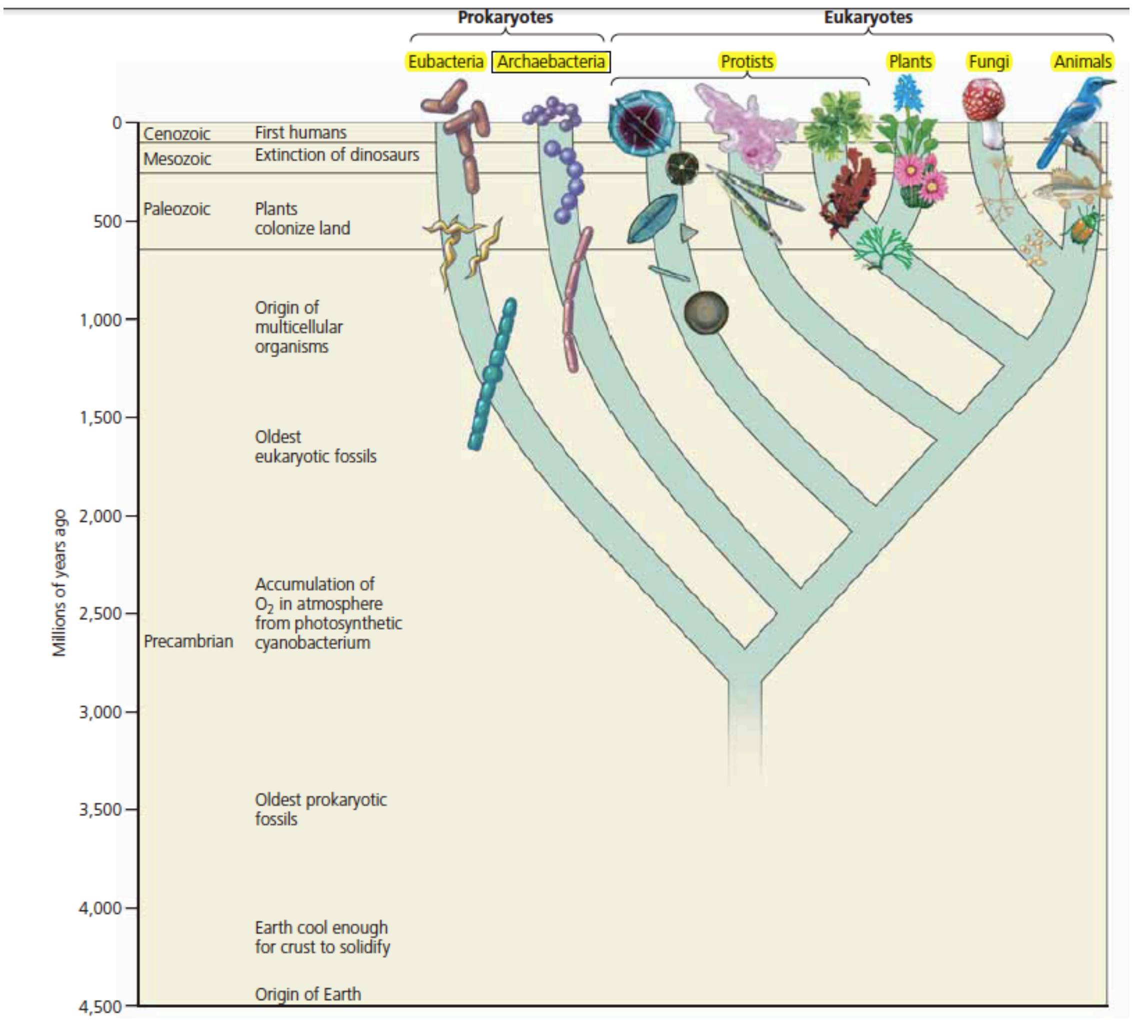


Figure 4-3 Overview of the evolution of life on the earth into six major kingdoms of species as a result of natural selection.

Evolution:

- Evolution is a change in the characteristics of a *population* of organisms over time. Happens when some organisms (individuals) have genetic variations that allow them to produce more offspring that other members of the population. Over time, these changes, or adaptations will be passed from generation to generation. More individuals in the population will have these traits with each generation.
- This natural selection for advantageous traits eventually changes the whole population.
- An example of this a a group of bacteria where some are resistant to antibiotics. While most bacteria not resistant to antibiotics die, the

resistant ones survive and produce offspring that are also resistant to the antibiotics. Overtime, the larger populations of bacteria become resistant to antibiotics.

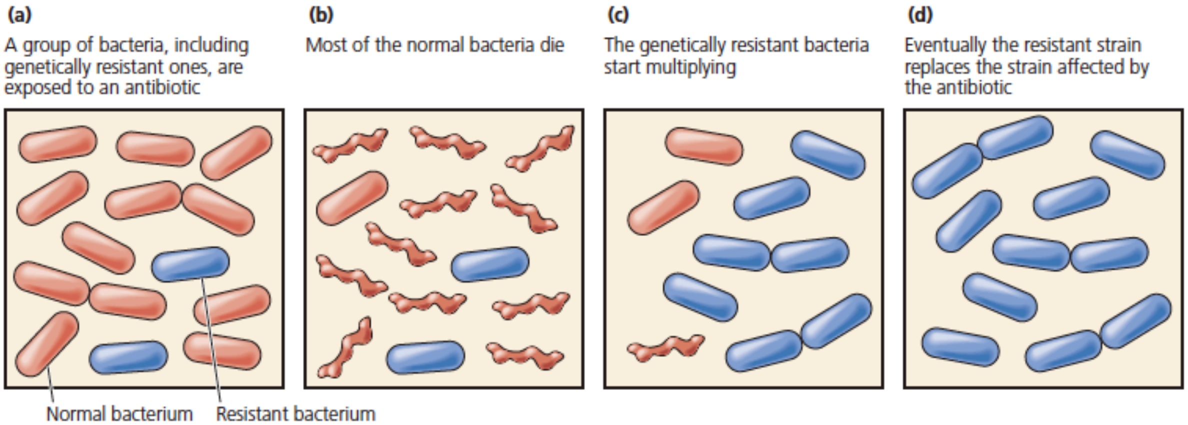


Figure 4-5 *Evolution by natural selection.* **(a)** A population of bacteria is exposed to an antibiotic, which **(b)** kills all but those possessing a trait that makes them resistant to the drug. **(c)** The resistant bacteria multiply and eventually **(d)** replace the nonresistant bacteria.

Antibiotic Resistance:
http://www.cdc.gov/getsmart/antibiotic-use/antibiotic-resistance-faqs.html#e

Note: Natural selection acts on individuals while evolution occurs in populations.

- Another way to summarize biological evolution by natural selection is: Genes mutate, individuals are selected, and populations evolve that are better adapted to survive and reproduce under existing environmental conditions.
- The Case of Humans:
    - Evolutionary biologists attribute three main adaptations for the success of Human as a species:
        1. Strong Opposable Thumbs
            - Allows to better grip tools than other animals
        2. Walking Upright
        3. Complex Brain
- Three misconceptions about Evolution:
    - Survival of the fittest: To biologists, fittest does not mean strongest, but it means ability to leave most descendants
    - Misconception that organisms develop certain traits because they need or want them. However, this is untrue as organisms simply have genes that give them certain adaptations that could become an advantage over other organisms. But these are not developed because of their need or want.
    - Evolution by natural selection is not a grand plan of nature. It's a random process.

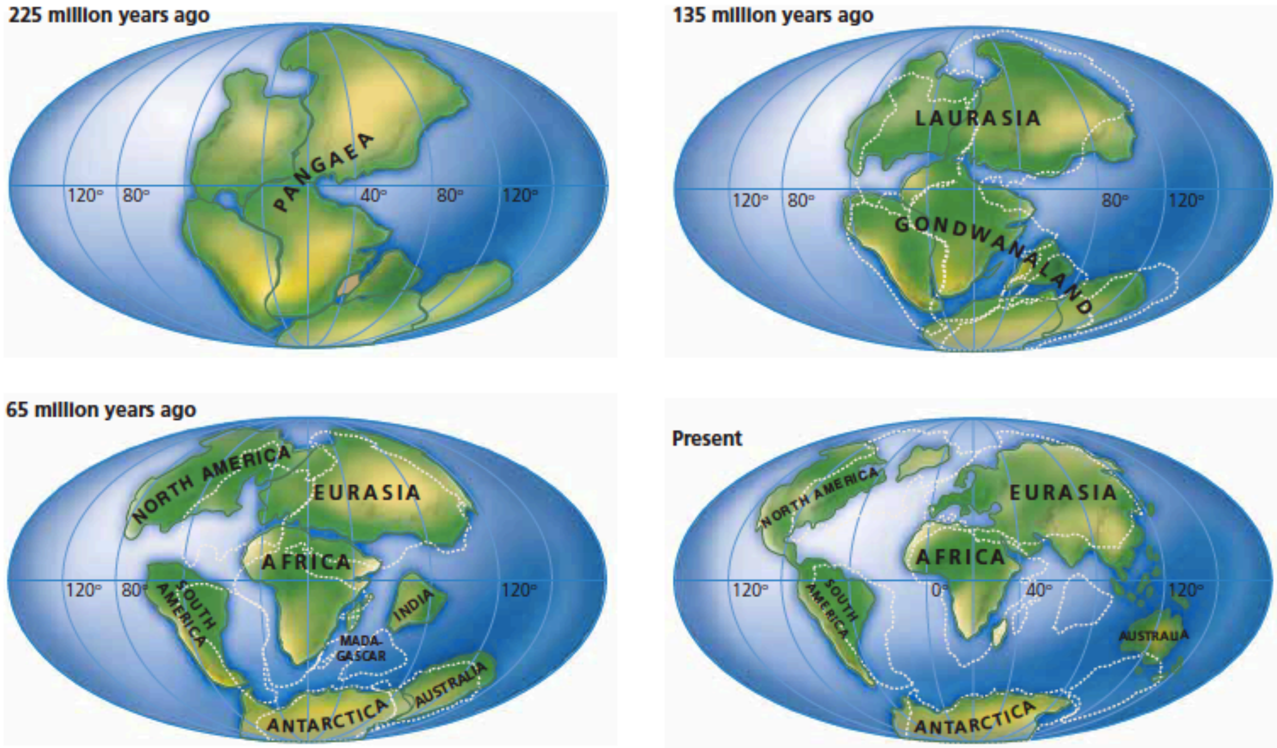


Figure 4-6 Over millions of years, the earth's continents have moved very slowly on several gigantic tectonic plates. This process plays a role in the extinction of species, as land areas split apart, and also in the rise of new species when isolated land areas combine. Rock and fossil evidence indicates that 200–250 million years ago, all of the earth's present-day continents were locked together in a supercontinent called Pangaea (top left). About 180 million years ago, Pangaea began splitting apart as the earth's tectonic plates separated, eventually resulting in today's locations of the continents (bottom right). **Question:** How might an area of land splitting apart cause the extinction of a species?

Speciation:

- Under certain circumstances, natural selection can lead to an entirely new species. In this process, called speciation, two species arise from one. For sexually reproducing species, a new species is formed when some members of a population have evolved to the point where they no longer can breed with other members to produce fertile offsprings.
- The most common mechanism of speciation (especially among sexually reproducing animals) takes place in two phases: geographic isolation and reproductive isolation:
    1. **Geographic Isolation and Reproductive Isolation**
        - Causes different groups of the same species to become physically isolated from one another for long periods. Due to this geographical isolation, mutation and changes by natural selection operate independently in the gene pools of these isolated populations. Example is given below in Arctic Fox and Grey Fox.

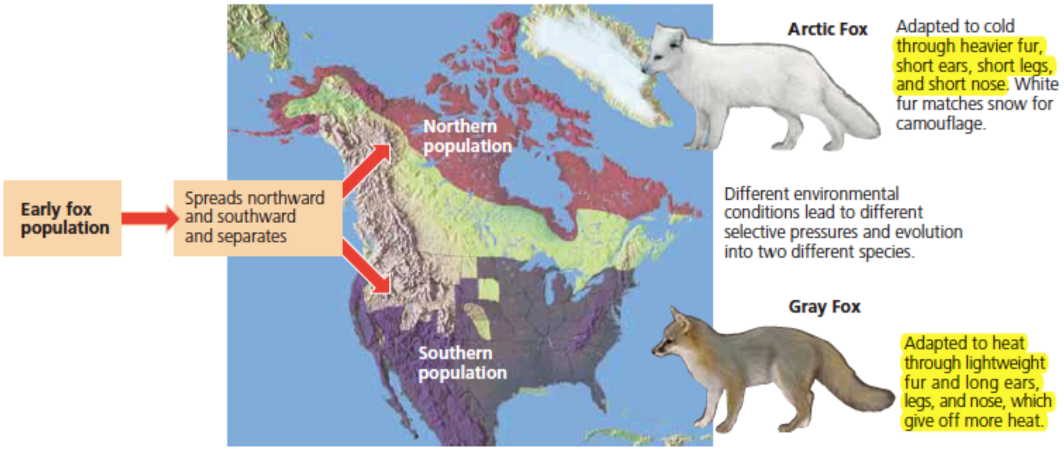


Figure 4-8 *Geographic isolation* can lead to reproductive isolation, divergence of gene pools, and speciation.

<u>**Endemic Species:**</u> Species found in only one area. These are more vulnerable to extinction.

Background Extinction: Through most history species have disappeared at a slow rate through background extinction. Avg. annual rate of background extinction is 1-5 species for each million species on the earth.
Mass Extinction: 25-70% of species are wiped out in a geological period lasting up to 5 million years.

<u>**Artificial Selection and Genetic Engineering:**</u>

We have used **artificial selection** to change the genetic characteristics of populations with similar genes. In this process, we select one or more desirable genetic traits in the population of a plant or animal, such as a type of wheat, fruit, or dog. Then we use *selective breeding* to generate populations of the species containing large numbers of individuals with the desired traits. Note that artificial selection involves crossbreeding between genetic varieties of the same species and thus is not a form of speciation. Most, of the grains, fruits, and vegetables we eat are produced by artificial selection.

Artificial selection has given us food crops with higher yields, cows that give more milk, trees that grow faster, and many different types of dogs and cats. But traditional crossbreeding is a slow process. Also, it can combine traits only from species that are close to one another genetically.

Now scientists are using genetic engineering to speed up our ability to manipulate genes. **Genetic engineering,** or **gene splicing,** is the alteration of an organism's genetic material, through adding, deleting, or changing segments of its DNA (Figure 11, p. S43, in Supplement 6), to produce desirable traits or eliminate undesirable ones. It enables scientists to transfer genes between different species that would not interbreed in nature. For example, genes from a fish species can be put into a tomato plant to give it certain properties.

Scientists have used gene splicing to develop modified crop plants, new drugs, pest-resistant plants, and animals that grow rapidly (Figure 4-A). They have also created genetically engineered bacteria to extract minerals such as copper from their underground ores and to clean up spills of oil and other toxic

<u>Species Diversity:</u>

Figure 4-10 *Variations in species richness and species evenness.* A coral reef (left), with a large number of different species (high species richness), generally has only a few members of each species (low species evenness). In contrast, a grove of aspen trees in Alberta, Canada, in the fall (right) has a small number of different species (low species richness), but large numbers of individuals of each species (high species evenness).

<u>Species Richness on Islands proposed by The Species Equilibrium Model or the Theory of Island Biogeography:</u>

- This theory was based on the observation that large islands tend to have more species of certain category such as insects, birds, or ferns than do small islands.
- It proposes two reasons that command the number of species that exists on an island:
    1. Size of the Island
        - Smaller the island, lesser number of species
    2. Distance of the Island from Mainland
        - Farther the island from mainland, lesser number of species
- Species diversity is most at the tropics and decreases as we move towards the poles.
    1. The most species rich environments are *tropical rain forests, coral reefs, the ocean bottom zone, and large tropical lakes.*
- Species richness increases the productivity and stability or sustainability of an ecosystem.

<u>Role of Species in Ecosystems:</u>

- Role played by a species in its ecosystem is known as its **<u>Ecological Niche.</u>** The role of each species encapsulates actions like gathering food, reproducing, and avoiding predators. Collectively these define role of a species, which forms the ecological niche.
- Niche is a pattern of living, while Habitat is the place where the species lives.

1. <u>Generalist Species:</u> Those that have a broad or general niche. They can live at different places, eat a variety of foods, and often tolerate a wide variety of environmental conditions. Eg: Flies, Cockroaches, mice, rats, humans etc.
2. <u>Specialized Species:</u> Those that have a limited niche. They can live at only one habitat, eat a few types of foods, and tolerate a narrow variety of environmental conditions. Eg: Tiger Salamanders breed only in fish less ponds. China's giant panda feeds only on
bamboo.

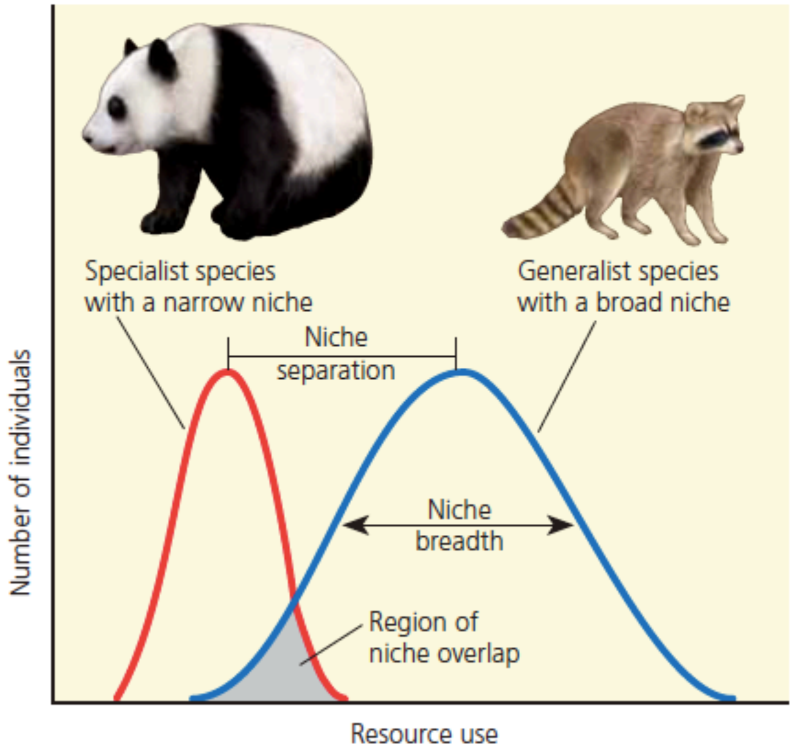


Figure 4-11 Specialist species such as the giant panda have a narrow niche (left) and generalist species such as a raccoon have a broad niche (right).

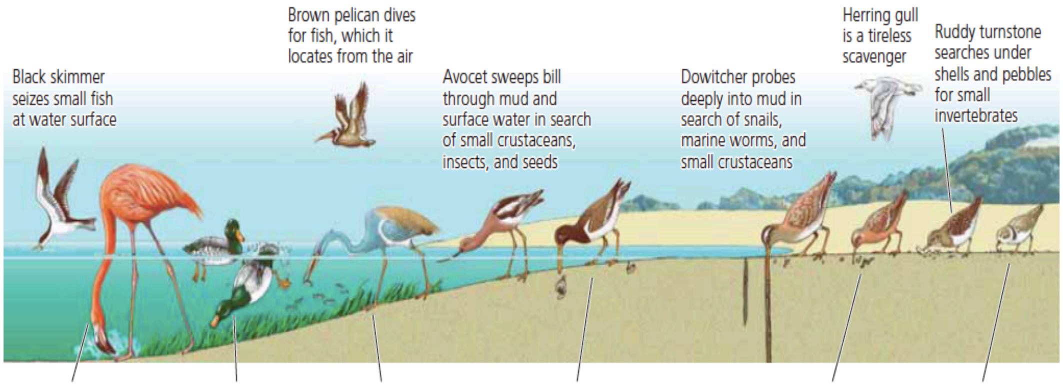


Figure 4-13 Specialized feeding niches of various bird species in a coastal wetland. This specialization reduces competition and allows sharing of limited resources.

- **<u>Roles of Species in Niches:</u>**
  1. **Native Species -** species that live and thrive in a particular ecosystem.
  2. **Nonnative** Species - Species that are accidentally or deliberately introduced into an ecosystem are known as nonnative species, also referred to as alien, invasive or exotic species
  3. **Indicator** Species - Species that provide early warnings of damage to a community or an ecosystem are called indicator species.For example, the presence or absence of trout species in water at temperatures within their range of tolerance is an indicator of the quality of water because trout need clean water with high levels of dissolved oxygen. Birds are excellent indicator species.
  4. **Keystone Species and Foundation Species** - Help determine the structure and functions of their ecosystems.
     - They form the key to an ecosystem and have a large effect on the types and abundances of other species in an ecosystem.
     - Roles of Keystone species:
       - Pollination: This function by birds, bats, bees make them keystone species because without their existence, pollination would cease to exist causing limitations to reproductive system of plants and flowers
       - Top Predator Keystone Species: Feed on other populations and regulate their populations. Example: alligators, wolf, leopard, lion etc.
  5. **Foundation Species:**These species create and enhance other species' habitats and hence shape communities in a major way.
     - Example: Elephants push over, break, or uproot trees, creating forest openings in grasslands and woodlands of Africa.

- Beavers are another example. They build dams in streams to create ponds and wetlands used by other species. Hence they are known as "ecological engineers."

- **Ecotone:**
  1. An **ecotone** is a transition area between two biomes. It is where two communities meet and integrate. It may be narrow or wide, and it may be local (the zone between a field and forest) or regional (the transition between forest and grassland ecosystems).
  2. Ecotone describes a **variation in species prevalence** and is often not strictly dependent on a major physical factor separating an ecosystem from another, with resulting habitat variability. Here are 2 examples to help you understand better. Alternatively, it can be described ais a **"zone of junction"** between two or more diverse ecosystems. It can be local or regional, narrow or wide. Here, the conditions are intermediate two the adjacent systems and hence a zone of tension. Two concrete examples :
     - ESTUARIES - It represents an ecotone b/w fresh water and marine ecosystem and shows a variation of salinity due to mixing of sea water with fresh water.
     - MANGROVES - Since mangroves are located between the land and sea they represent the best example of ecotone.
  3. Sometimes the number of species and the population density of some of the species is much greater in this zone than either community. This is called **<u>edge effect</u>**. The organisms which occur primarily or most abundantly in this zone are known as edge species. In the terrestrial ecosystems edge effect is especially applicable to birds. For example the density of song birds is greater in the mixed habitat of the ecotone between the forest and the desert.
- Ecocline
  1. In biology and ecology, an **ecocline** or simply cline (from Greek: κλίνω "to possess or exhibit gradient, to lean") describes an ecotone in which a series of biocommunities display a continuous gradient.
  2. Ecocline describes a type of an ecotone which is a tranistion area btwn 2 biomes where they integrate.egs-thermocline (btwn 2 bodies of water with varying temp), halocline(salinity)etc ecocline thus describes a gradient and is more like a subset of ecotone.
  3. It can be understood as **"physical transition zone"**.

Roles of Ecosystem

1. Provision of clean water and air
2. Pollination of crops
3. Mitigations of environmental hazards
4. Pest and disease control
5. Carbon sequestration

Eutrophication

- Eutrophication escalates rapidly when high nutrients from fertilizers, domestic and industrial wastes, urban drainage, detergents and animal, sediments enter water streams.
- Eutrophication is mainly divided into natural and cultural Eutrophication.
    - In natural Eutrophication, a lake is characterized by nutrient enrichment. During this process an oligotrophic lake is converted into an eutrophic lake. It permits the production of phytoplankton, algal blooms and aquatic vegetation that in turn provide ample food for herbivorous zooplankton and fish.
    - *When the process of Eutrophication is increased by the human activities, it is called cultural **Eutrophication***. This is because the human activities (mainly development in nature) increase the surface run off and the nutrients such as Phosphates, Nitrates are supplied to the Ocean water. They may be supplied by Constriction works, treatment plants, golf courses, fertilizers, and farms. Human activities are responsible for addition of 80% nitrogen and 75% phosphorus to lake and streams.
- Eutrophication causes several physical, chemical and biological changes, which considerably deteriorate the water quality.
- It creates algal bloom, releases toxic chemicals that kill fish, birds and other aquatic animals.
- Decomposition of algal bloom leads to the depletion of oxygen in water. Thus with a high CO_2 level and poor oxygen through reduction of nitrates.

- On complete exhaustion of nitrate, oxygen may as last resort be obtained by reduction of sulphate yielding hydrogen sulphide causing foul smell and putrefied taste of water. Many pathogenic microbes, viruses, protozoa and bacteria and grow on sewage products under anaerobic conditions. It results into the spread of fatal water-borne disease such as polio, dysentery, diarrhoea, typhoid and viral hepatitis.

Control of Eutrophication

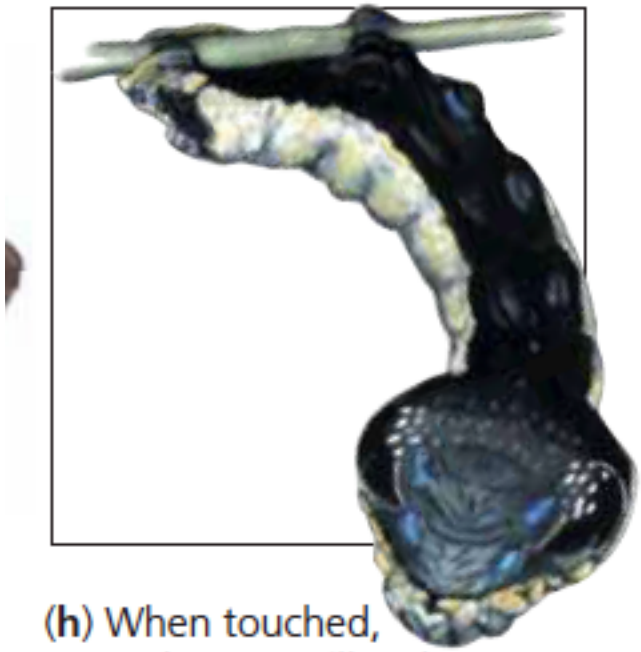
- Several prevention and technical devices have been used to control Eutrophication. The wastewater must be treated before its discharge into water streams.
- Recycling of nutrients can be checked through harvest. Removing nitrogen and phosphorous at the source, division of nutrient-rich waters from the receiving bodies and dilution of these elements can minimize Eutrophication.
- Algal blood should be removed upon their death and decomposition. Limiting the dissolve nutrients can control algal growth. The most suitable, feasible and effective method involves the use of chemicals to precipitate additional phosphorus.
- Precipitants like alum, lime, iron and sodium aluminate may be used. Physicochemical methods can be adopted to remove nutrients. for example phosphorous can be removed by precipitation and nitrogen by nitrification or denitrification.
- Electrodialysis, reverse osmosis and ion exchange methods. Cooper-sulphate and sodium arsenite are employed for killing algae and rooted planet respectively.

3. BIODIVERSITY, SPECIES, INTERACTIONS AND POPULATION CONTROL

Species Interactions:

5 types of species interactions affects the resource use and population sizes of species in an ecosystem.

1. **Interspecific Competition**
   - Occurs when members of two or more species interact to gain access to the same limited resources such as food, light, or space.
   - ***Competitive Exclusion***
     - While different species may share some aspects of their niches, no two species can occupy exactly the same niche for a very long time. Hence, competitive exclusion is extinction of a species at a particular place (niche) due to competition while it may exists in another.
2. **Predation**
   - When member of one species (the predator) feeds on some or all members of another species (the prey)
   - Herbivores, carnivores and omnivores are considered predators.
   - However, detritus feeders are not considered predators since they do not feed on other live organisms and only decompose dead bodies.
   - Ways of preys to avoid predators:
   - (1) Camouflage — Example: praying mantises sit in flowers of a similar color and ambush visiting insects.
   - (2) Chemical Warfare — e.g: snakes and spiders use venom to stun their prey, or bad tasting, or bad smelling odors.
   - (3) Warning Coloration
   - (4) Mimicry



(h) When touched, snake caterpillar changes shape to look like head of snake.

- (5) Deceptive Looks (lo moth)
- (6) Deceptive Behavior (snake caterpillar)
- *Coevolution:* When populations of two different species interact in a way to adopt with one another, coevolution takes places. Coevolution can help both sides to become more competitive or can help to avoid or reduce competition.
    - Eg: Bats (predator) and Moths (prey). Bats eat moths and use echolocations to locate the moths. As a countermeasure to this effective prey-detection, some moth species have developed evolved ears that can hear these sound frequencies of bats, hence helping them to escape when they hear such frequencies. In turn, some bat species developed a different sound frequency, and in turn again, some moth species evolved their own high frequency clicks to jam the bats' echolocation systems. Some bats species then adapted by turning off their echolocation systems and using the moths' clicks to locate their prey.

3. **Parasitism**
    - When one organism (the parasite) feeds on the body of, or the energy used by, another organism (the host), usually by living on or inside the host.
4. **Mutualism**
    - Interaction which benefits both species by providing food, shelter or some other resource.
    - Mutualistic relationships that combine nutrition and protection. One involves birds that ride on the backs of large animals like

African buffalo, elephants, and rhinoceroses. The birds remove and eat parasites and pests (such as ticks and flies) from the animal's body and often make noises warning the larger animals when predators approach.

In *gut inhabitant mutualism,* vast armies of bacteria in the digestive systems of animals help to break down (digest) their hosts' food. In turn, the bacteria receive a sheltered habitat and food from their host. Hundreds of millions of bacteria in your gut secrete enzymes that help digest the food you eat. Cows and termites are able to digest the cellulose in plant tissues they eat because of the large number of microorganisms, mostly bacteria, that live in their guts.

5. **Commensalism**
    - Is an interaction that helps one species but has little or no effect on the other.
    - Eg: Epiphytes such as certain kinds of orchids or bromeliads

Figure 5-6 In an example of *commensalism,* this bromeliad—an epiphyte, or air plant, in Brazil's Atlantic tropical rain forest—roots on the trunk of a tree, rather than in soil, without penetrating or harming the tree. In this interaction, the epiphyte gains access to water, other nutrient debris, and sunlight; the tree apparently remains unharmed.

<u>Some Species Evolve Ways to Share Resources:</u>

- *Resource Partitioning:*
    - Some species evolve to reduce niche overlap. They do this by developing adaptations through natural selection that allow them to reduce or avoid competition for the same resources.

Figure 5-8 *Sharing the wealth: resource partitioning* of five species of insect-eating warblers in the spruce forests of the U.S. state of Maine. Each species minimizes competition for food with the others by spending at least half its feeding time in a distinct portion (shaded areas) of the spruce trees, and by consuming different insect species.

- *Evolutionary Divergence:*

Another example of resource partitioning through natural selection involves birds called honeycreepers that live in the U. S. state of Hawaii. Long ago these birds started from a single ancestor species. But because of evolution by natural selection, there are now numerous honeycreeper species. Each has a different type of beak specialized to feed on certain food sources, such as specific types of insects, nectar from particular types of flowers, and certain types of seeds and fruit (Figure 5-9). This is an example of a process called *evolutionary divergence.*

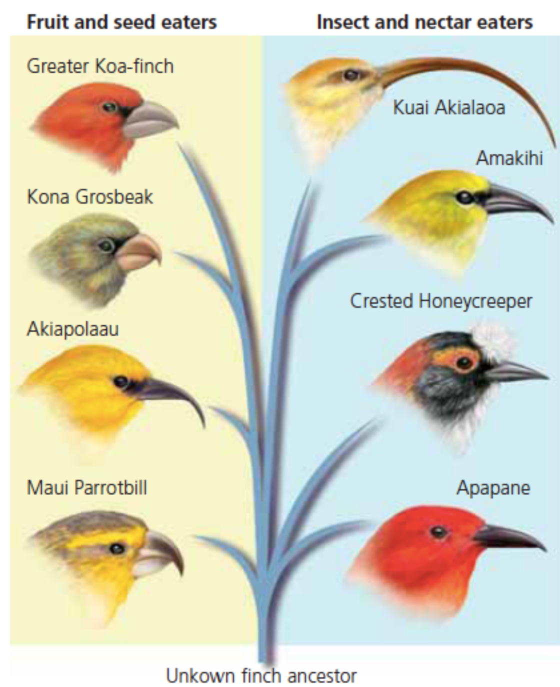
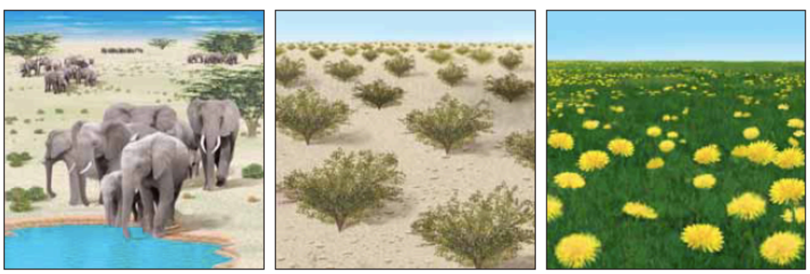


Figure 5-9 *Specialist species of honeycreepers.* Evolutionary divergence of honeycreepers into species with specialized ecological niches has reduced competition between these species. Each species has evolved a beak specialized to take advantage of certain types of food resources.

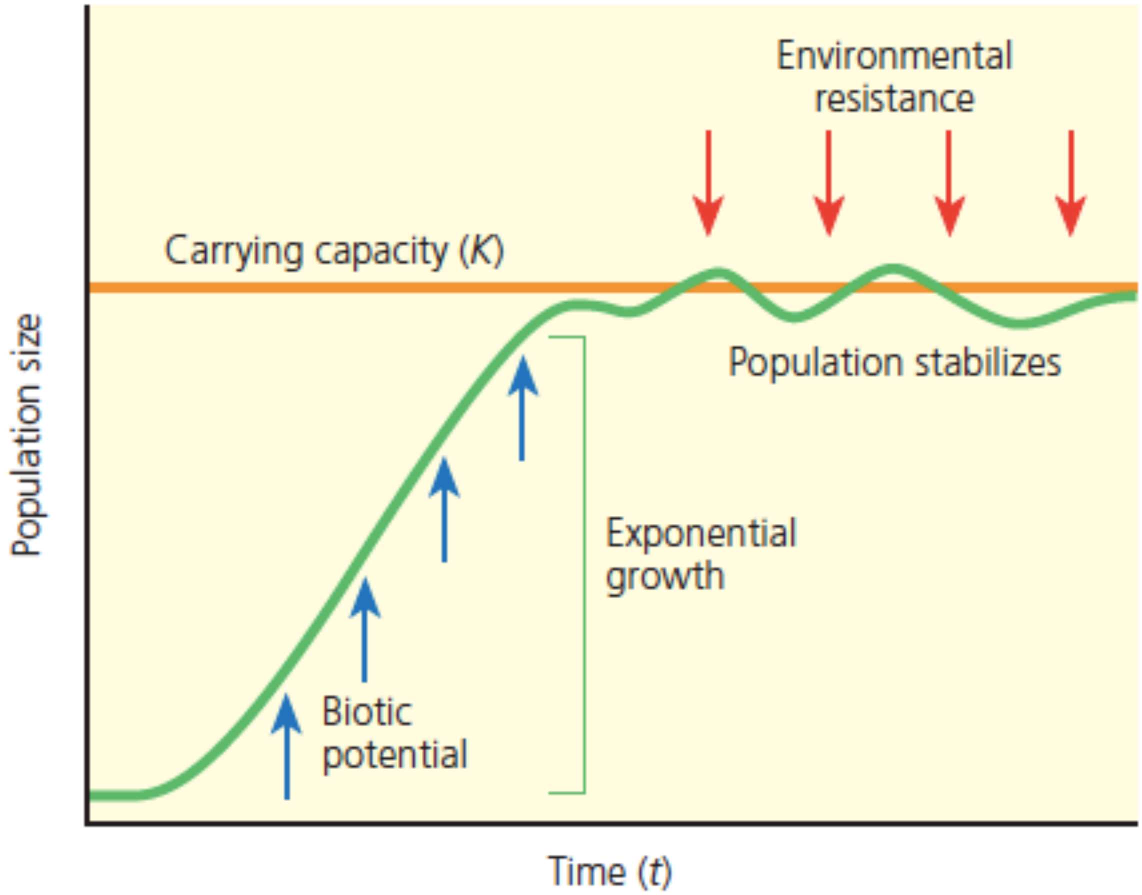
- *Evolutionary Convergence:*

    - Independent development of similar adaptation in two species with similar niches is called convergent evolution.
    - Example: Birds and bats both have wings.This was due to the niche where these both exist, which requires the evolution of wings.
- Population Dispersion of Species:
    - Clumping (patches)
        - Why:
            - First, the resources a species needs vary greatly in availability from place to place, so the species tends to cluster where the resources are available.
            - Second, individuals moving in groups have a better chance of encountering patches or clumps of resources, such as water and vegetation, than they would searching for the resources on their own.
            - Third, living in groups protects some animals from predators.
            - Fourth, hunting in packs gives some predators a better chance of finding and catching prey.
            - Fifth, some species form temporary groups for mating and caring for young.
    - Uniform Dispersion
    - Random Dispersion
- 

  (a) Clumped (elephants) (b) Uniform (creosote bush) (c) Random (dandelions)

  Figure 5-10 Generalized *dispersion pattern*s for individuals in a population throughout their habitat. The most common pattern is *clumps* of members of a population scattered throughout their habitat, mostly because resources are usually found in patches. **Question:** Why do you think the creosote bushes are uniformly spaced while the dandelions are not?

- *Environmental Resistance to population and Exponential Growth of Population*
    - There are always limits to population growth in nature. This is one of nature's four scientific principles of sustainability.



CENGAGENOW™ **Active Figure 5-11** No population can continue to increase in size indefinitely. *Exponential growth* (left half of the curve) occurs when resources are not limiting and a population can grow at its *intrinsic rate of increase* (*r*) or *biotic potential*. Such exponential growth is converted to *logistic growth*, in which the growth rate decreases as the population becomes larger and faces environmental resistance. Over time, the population size stabilizes at or near the *carrying capacity* (*K*) of its environment, which results in a sigmoid (S-shaped) population growth curve. Depending on resource availability, the size of a population often fluctuates around its carrying capacity, although a population may temporarily exceed its carrying capacity and then suffer a sharp decline or crash in its number.

R-Selected Species and K-Selected Species:

- *R-selected Species:* Species have different reproductive patterns that can help enhance their survival. Species with a capacity of high rate of population increase are known as r-selected species.
    - These species have many and smaller offsprings, with shorter lifespans. Example, algae, bacteria, rodents, frogs, turtles, annual plants, and most insects.
    - These species may go through boom and bust cycle in their populations.
- *K-selected Species:*
    - These types of species tend to reproduce late in life, have fewer offsprings with fairly longer life spans.
    - They are born fairly larger, are more mature at birth and are cared for an protected by their parents unlike the R-selected ones.
    - They tend to do well when their population is near the carrying capacity (K) of the ecosystem.

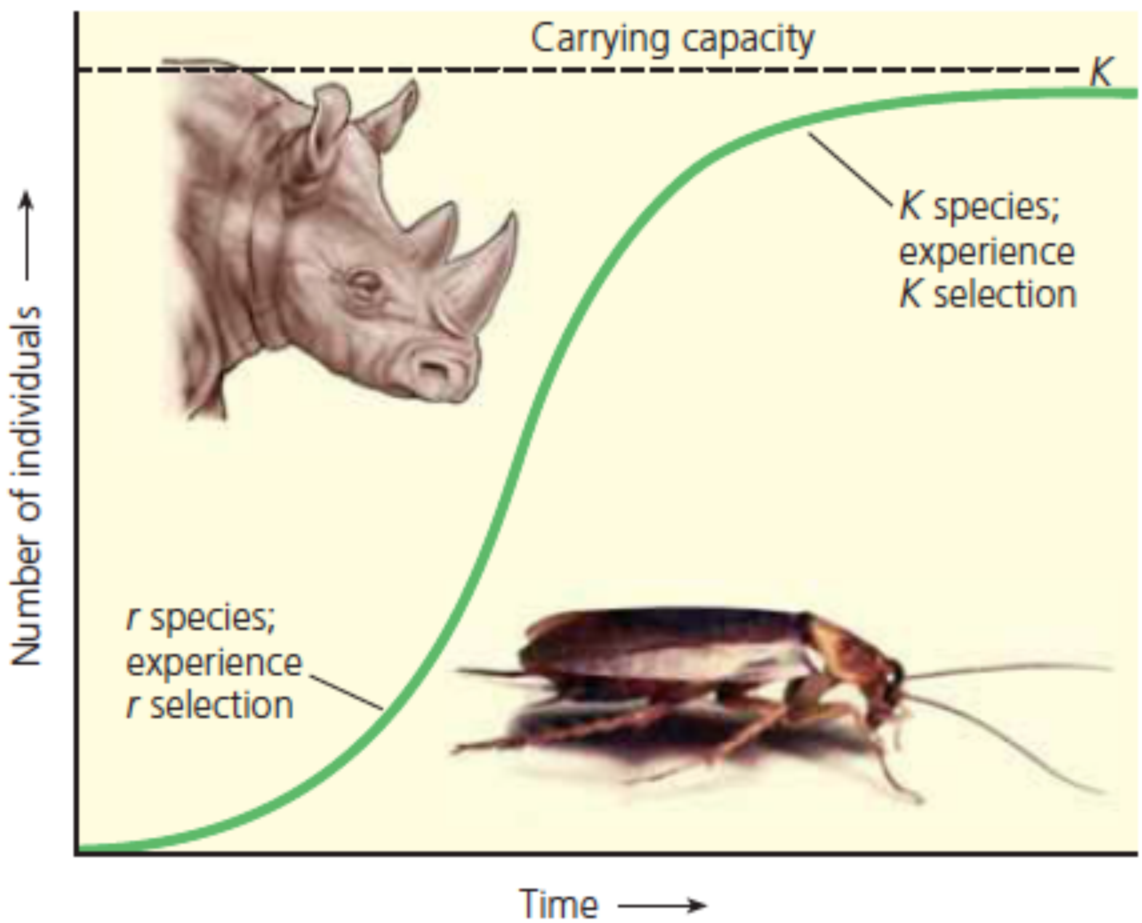


Figure 5-14 Positions of *r-selected* and *K-selected* species on the sigmoid (S-shaped) population growth curve.

Factors Affecting Population Sizes:

- Several genetic factors can lead to loss of genetic diversity and the survival of small, isolated populations. These factor are:
    1. *Founder Effect*
        - Can occur when a few individuals in a population colonize a new habitat that is geographically isolated from other members of the population. In this case, lack of genetic diversity may hamper the ability of these individuals against the colonizers.
    2. *Demographic Bottleneck*
        - Occurs when a few individuals in a population survive a catastrophe such as a fire or a hurricane, as if they passed through a narrow neck of a bottle. Lack of genetic diversity may hamper the ability of these individuals to rebuild the population.
    3. *Genetic Drift*
        - It involves random changes in the gene frequencies in a population that can lead to unequal reproductive success. Example, some species may breed more than the others, leading to domination of the gene pool in the population.
    4. *Inbreeding*
        - When individuals in small population mate with each other. May occur when a population passes through a demographic bottleneck. This can increase the frequency of defective genes and affect its long term survival.

-

One such factor, called the *founder effect,* can occur when a few individuals in a population colonize a new habitat that is geographically isolated from other members of the population (Figure 4-8, p. 87). In such cases, limited genetic diversity or variability may threaten the survival of the colonizing population.

Another factor is a *demographic bottleneck*. It occurs when only a few individuals in a population survive a catastrophe such as a fire or hurricane, as if they had passed through the narrow neck of a bottle. Lack of genetic diversity may limit the ability of these individuals to rebuild the population. Even if the population is able to increase in size, its decreased genetic diversity may lead to an increase in the frequency of harmful genetic diseases.

A third factor is *genetic drift*. It involves random changes in the gene frequencies in a population that can lead to unequal reproductive success. For example, some individuals may breed more than others do and their genes may eventually dominate the gene pool of the population. This change in gene frequency could help or hinder the survival of the population. The founder effect is one cause of genetic drift.

A fourth factor is *inbreeding*. It occurs when individuals in a small population mate with one another. This can occur when a population passes through a demographic bottleneck. This can increase the frequency of defective genes within a population and affect its long-term survival.

Conservation biologists use the concepts of founder effects, demographic bottleneck, genetic drift, inbreeding, and island biogeography (Science Focus, p. 90) to estimate the *minimum viable population size* of rare and endangered species: the number of individuals such populations need for long-term survival.

Minimum Viable Population Size

- The minimum number of individuals a population needs for long term survival

Population Changes in Nature

- In nature, we find four general patterns of variation in population size: stable, irruptive, cyclic, and irregular.
- Stable: A species whose population size fluctuates slightly above and below its carrying capacity is said to have a fairly stable population size
- Irrupt: For some species, population growth may occasionally explode, or irrupt, to a high peak and then crash to a more stable lower level or in some cases to a very low level. Many short-lived, rapidly reproducing species such as algae and many insects have irruptive population cycles that are linked to seasonal changes in weather or nutrient availability. For example, in temperate climates, insect populations grow rapidly during the spring and summer and then crash during the hard frosts of winter.
- Cyclic: A third type of fluctuation consists of regular cyclic fluctuations, or boom-and-bust cycles, of population size over a time period
- Irregular: no recurring pattern

Ecological Succession

- The gradual change in species composition in a given area is called **ecological succession**, during which, some species colonize an area and their populations become more numerous, while populations of other species decline and may even disappear. In this process, **colonizing or pioneer species arrive first**. As environmental conditions change, they are replaced by other species, and later these species may be replaced by another set of species.
- Two main types of ecological successions:
    - **Primary Succession:**
        - Primary succession involves the gradual establishment of biotic communities in lifeless areas where there is no soil in a terrestrial ecosystem or no bottom sediment in an aquatic ecosystem.
        - Examples include bare rock exposed by a retreating glacier or severe soil erosion, newly cooled lava from a volcanic eruption, an abandoned highway or parking lot, and a newly created shallow pond or reservoir.
        - Takes along time.
        - **Pioneer or early successional species** arrives and attaches itself to hostile habitat. Examples are lichens and mosses whose seeds or spores are distributed by the wind and carried by animals.
        - A lichen consists of an algae and fungi acting in a mutualistic relationship. The fungi in the lichens provide protection and support for the algae, which, through

photosynthesis, provide sugar nutrients for both of the interacting species.
- Process of soil formation started by these species.
- **Mid-Secessional Plant Species** then come up such as herbs, grasses, low shrubs etc.
- **Late-Secessional plant species**

nutrients. Physical weathering occurs when a rock is fragmented, as water in its cracks freezes and expands. Rocks also undergo chemical weathering, reacting with substances in the atmosphere or with precipitation, which can break down the rock's surface material.

The slow process of soil formation begins when *pioneer* or *early successional species* arrive and attach themselves to inhospitable patches of the weathered rock. Examples are lichens and mosses whose seeds or spores

that need lots of sunlight and are adapted to the area's climate and soil usually replace the grasses and shrubs.

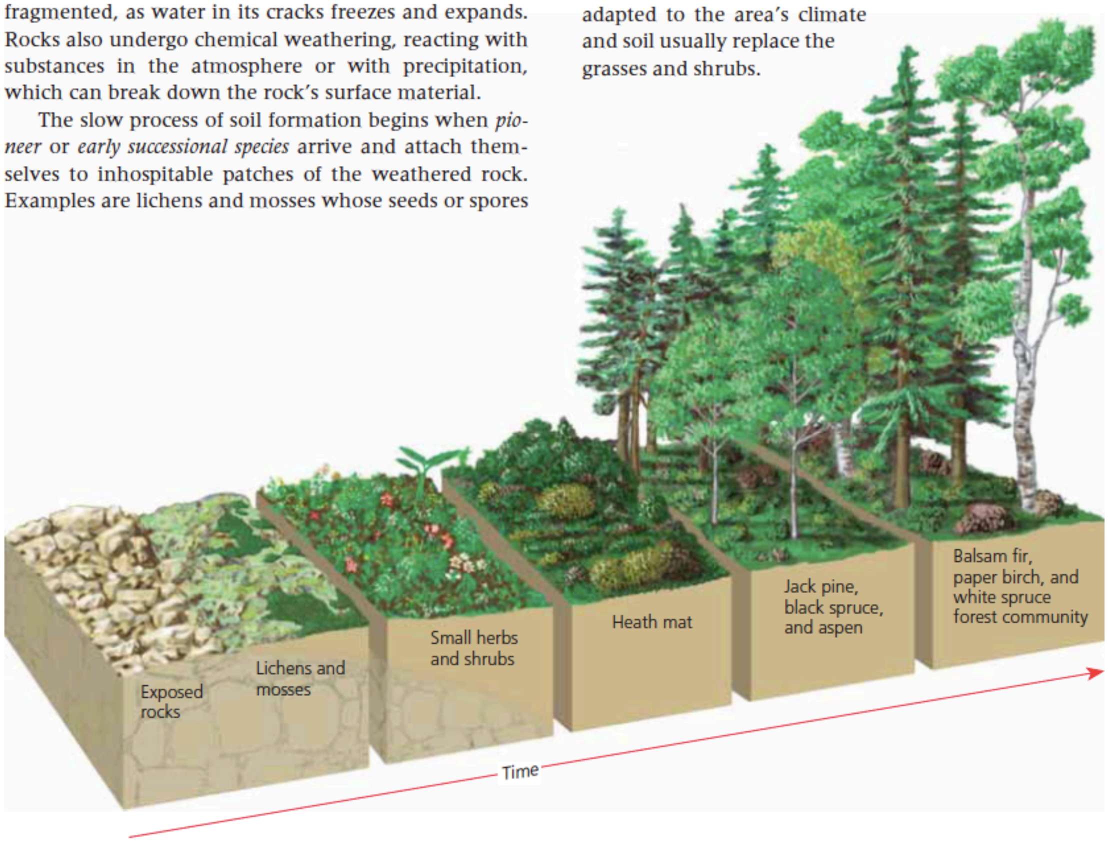


Figure 5-16 *Primary ecological succession.* Over almost a thousand years, plant communities developed, starting on bare rock exposed by a retreating glacier on Isle Royal, Michigan (USA) in northern Lake Superior. The details of this process vary from one site to another. **Question:** What are two ways in which lichens, mosses, and plants might get started growing on bare rock?

- **Secondary Succession:**
  - Secondary succession begins in an area where an ecosystem has been disturbed, removed, or destroyed, but some soil or bottom sediment remains. Candidates for secondary succession include abandoned farmland, cut forests, heavily polluted streams, and flooded land.
  - A series of communities or ecosystems with different species develop in places containing soil or bottom sediment. As part of the earth's natural capital, both types of succession are examples of natural ecological restoration, in which various forms life adapt to changes in environmental conditions, resulting in changes to the species composition, population size, and biodiversity in a given area.

- It is useful to distinguish among two aspects of stability in living systems. One is **inertia, or persistence:** the ability of a living system, such as a grassland or a forest, to survive moderate disturbances.
    - A second factor is resilience: the ability of a living system to be restored through secondary succession after a moderate disturbance. (restoration)
- Evidence suggests that some ecosystems have one ofthese properties but not the other.
- For example, tropicalrain forests have high species diversity and high inertiaand thus are resistant to significant alteration ordestruction.
- But once a large tract of tropical rain forestis severely damaged, the resilience of the resultingdegraded ecosystem may be so low that the forest maynot be restored by secondary ecological succession.
- Onereason for this is that most of the nutrients in a tropicalrain forest are stored in its vegetation, not in the soil asin most other terrestrial ecosystems. Once the nutrientrichvegetation is gone, daily rains can remove most ofthe other nutrients left in the soil and thus prevent atropical rain forest from regrowing on a large clearedarea.
- Another reason for why the rain forest cannot recoveris that large-scale deforestation can change anarea's climate by decreasing the input of water vaporfrom its trees into the atmosphere. Without such watervapor, rain decreases and the local climate gets warmer.Over many decades, this can allow for the developmentof a tropical grassland in the cleared area but not forthe reestablishment of a tropical rain forest.
- By contrast, **grasslands** are much less diverse than most forests, and consequently they have low inertia and can burn easily. However, because most of their plant matter is stored in underground roots, these ecosystems have high resilience and can recover quickly after a fire as their root systems produce new grasses. Grassland can be destroyed only if its roots are plowed up and something else is planted in its place, or if it is severely overgrazed by livestock or other herbivores.
- Variations among species in resilience and inertia are yet another example of biodiversity—one aspect of natural capital that has allowed life on earth to sustain itself for billions of years.
- **Tipping Point:**
    - However, there are limits to the stresses that ecosystems and global systems such as climate can take. As a result, such systems can reach a tipping point, where any additional stress can cause the system to change in an abrupt and usually irreversible way that often involves collapse. For example, once a certain number of trees have been eliminated from a stable tropical rain forest, it can crash and become a grassland. And continuing to warm the atmosphere by burning fossil fuels that emit CO_2 and cutting down tropical forests that help remove CO_2 could eventually change the global climate system in ways that could last for thousands of years.

Bio-Accumulation, Bio-concentration and Bio-magnification

- Bio-Accumulation and bio-concentration occur when an organism absorbs toxic substance at a rate greater than at which the substance is lost from the body.
- Bio-concentration refers, more specifically, to case when toxic substance accumulates in the organism's tissues due to exposure to such in the surrounding medium, such as their habitat. Ex: Fish in the water
- Bio-accumulation refers, more specifically, to case when toxic substance accumulates in the organism's tissues due to intake through food. Ex: Humans eating contaminated fish
- Bio-maginification: occurs across the various trophic levels in a food chain.
    - This refers to the increase in POPs such as DDT that occurs in the food chain. The substance becomes more and more concentrated as we move higher up on the trophic level.

Human Population

Three major factors that have led to the bursting of human population:

1. Adaptation to living in different climatic zones
2. Modern medicine
3. Agriculture to feed people

Factors affecting average birth rate in a country:

1. Importance of children as part of the labor force.
2. Cost of raising and educating a child.
3. Availability of private and public pension systems.
4. Urbanization.
5. Educational and employment opportunities available for women.
    - TFRs tend to be low when women have access to education and paid employment outside the home. In developing countries, a woman with no education typically has two more children than does a woman with a high school education.
6. Average age at marriage.
7. Religious beliefs, cultural norms etc.

Aquatic Life

Plankton — Three types:

1. **Phytoplankton** — "drifting plants". These are primary producer algae that provides food to higher level planktons and fish.
2. **Zooplankton** — "drifting animals". These are herbivore planktons (primary consumers) that feed on phytoplankton and also secondary consumers that feed on other zooplankton. They range from single celled protozoa to large invertebrates such as the jelly fish.
3. **Ultraplankton** — huge populations of photosynthetic bacteria that are responsible for 70% of the primary productivity of the oceans.

Nekton

- These are strongly swimming consumers such as fish, turtles and whales.

Benthos

- These are bottom dwellers such as oysters, which anchor themselves to one spot; and clams and worms, lobsters and crabs.

Decomposers

- A fourth major type is decomposers (mostly bacteria), which break down organic compounds in the dead bodies and wastes of aquatic organisms into nutrients that can be used by aquatic primary producers.

Importance of Marine Ecosystems:

Zones of the Ocean:

- **Euphotic Zone:** The euphotic zone is the brightly lit upper zone where drifting phytoplankton carry out about 40% of the world's photosynthetic activity
- **Bathyal Zone:** The bathyal zone is the dimly lit middle zone, which, because it gets little sunlight, does not contain photosynthesizing producers. Zooplankton and smaller fishes, many of which migrate to feed on the surface at night, populate this zone.
- **Abyssal Zone:** The deepest zone, called the abyssal zone, is dark and very cold; it has little dissolved oxygen. Nevertheless, the deep ocean floor is teeming with life—enough to be considered a major life zone—because it contains enough nutrients to support a large number of species, even though there is no sunlight to support photosynthesis.

Marine Snow

- Showers of dead animals and decaying organisms from top layers of ocean life that sinks towards the bottom is known as Marine Snow.

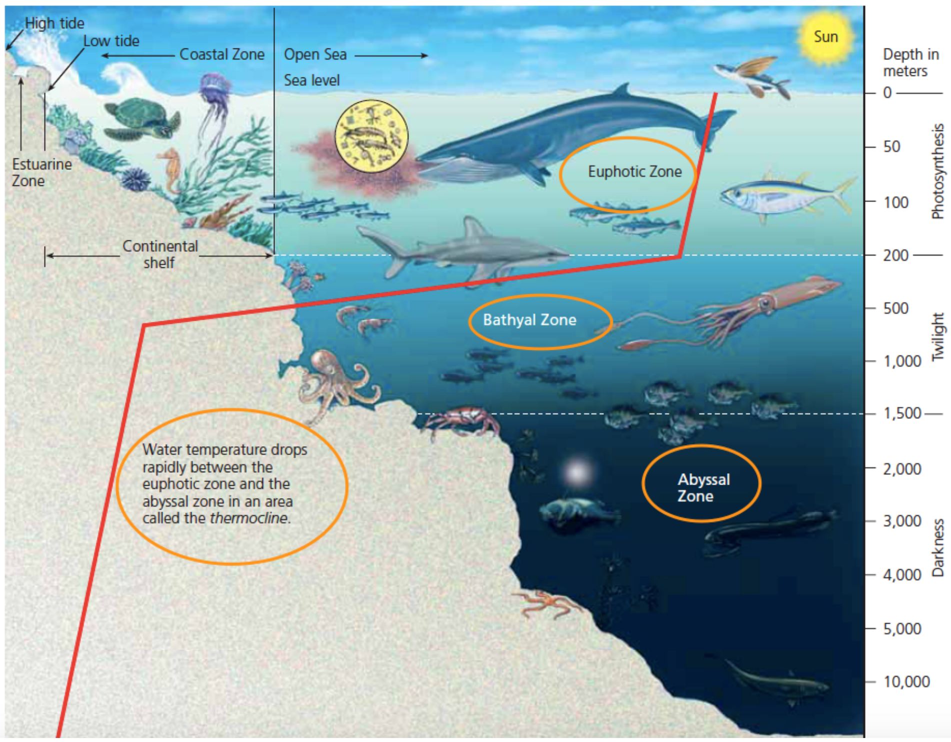
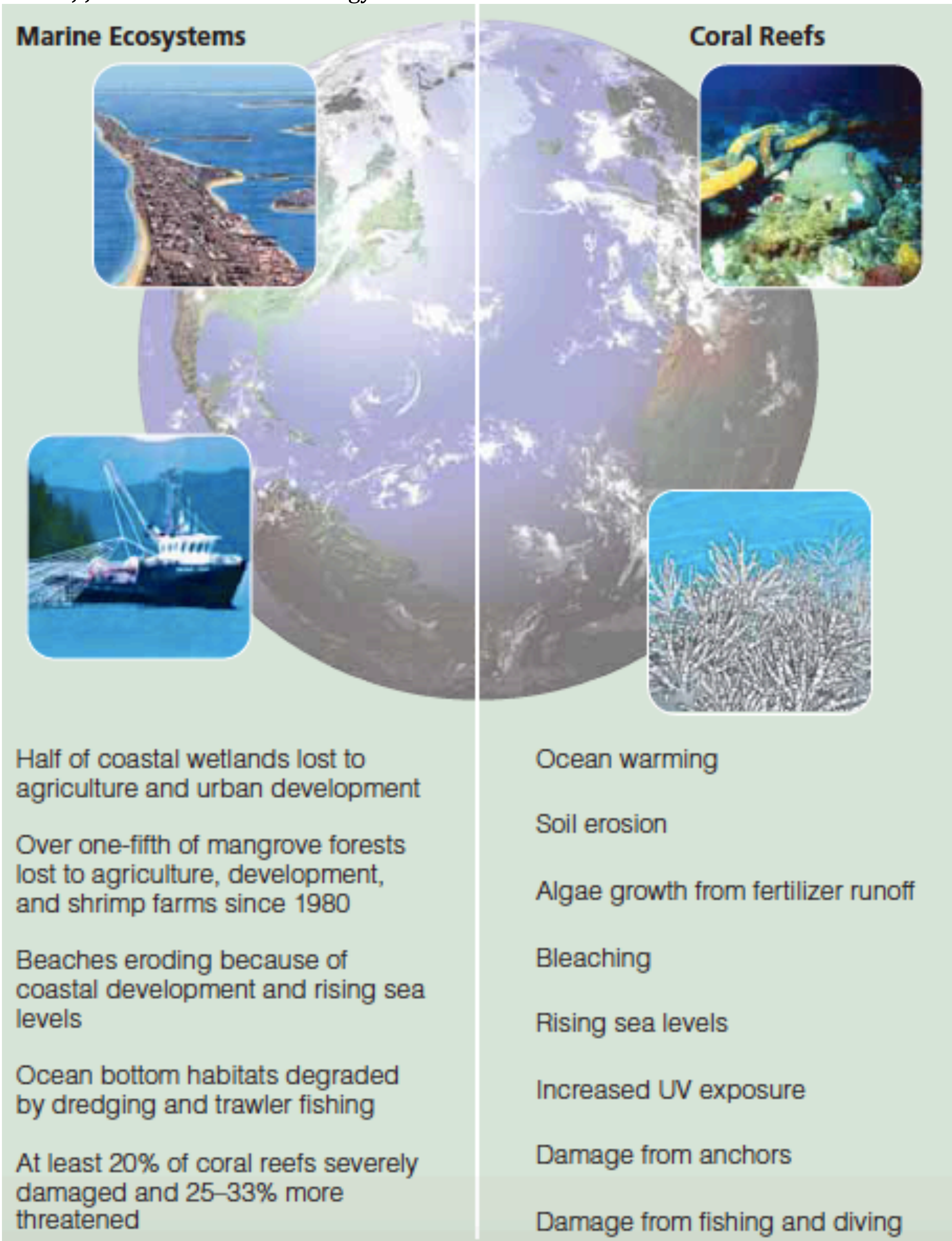


Figure 8-5 **Natural capital:** major life zones and vertical zones (not drawn to scale) in an ocean. Actual depths of zones may vary. Available light determines the euphotic, bathyal and abyssal zones. Temperature zones also vary with depth, shown here by the red curve. **Question:** How is an ocean like a rain forest? (*Hint:* see Figure 7-17, p. 156.)

Human Impact on Marine Systems:



Mangroves

- Mangrove forests are the tropical equivalent of salt marshes.

- They are found along some 70% of gently sloping sandy and silty coastlines in tropical and subtropical regions, especially Southeast Asia.
- The dominant organisms in these nutrient-rich coastal forests are mangroves—69 different tree species that can grow in salt water. They have extensive root systems that often extend above the water, where they can obtain oxygen and support the trees during periods of changing water levels (aerial roots).
- *These coastal aquatic systems provide important ecological and economic services.*
- **Functions of Mangroves:**
    - They help to maintain water quality in tropical coastal zones by filtering toxic pollutants, excess plant nutrients, and sediments, and by absorbing other pollutants.
    - They provide food, habitats, and nursery sites for a variety of aquatic and terrestrial species.
    - They also reduce storm damage and coastal erosion by absorbing waves and storing excess water produced by storms and tsunamis. Historically, they have sustainably supplied timber and fuelwood to coastal communities.
- Continental shelf contains 10% of the world's ocean area but constitutes 90% of marine life.

Freshwater Systems (Lakes etc.)

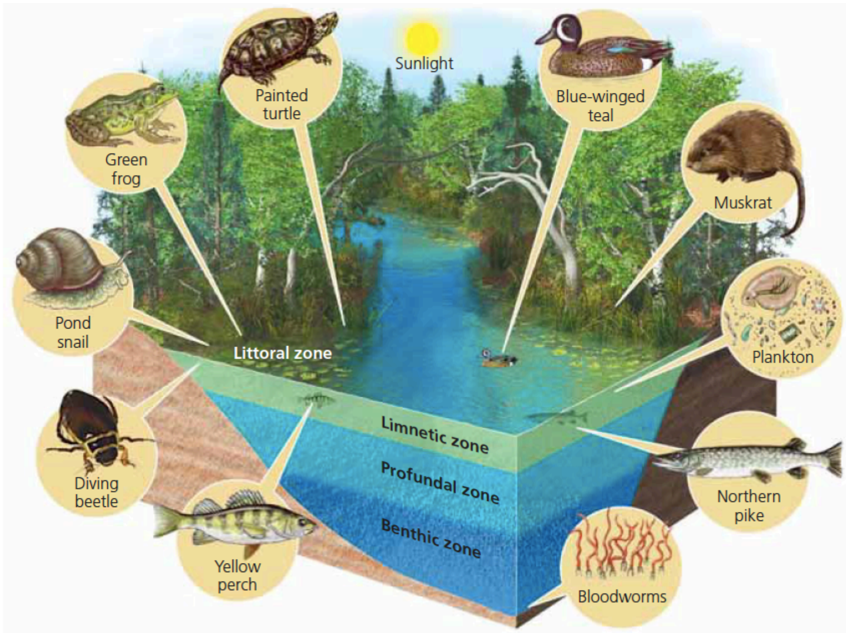
Why Important?

- Groundwater recharge
- Climate moderation
- Drinking water
- Food
- Hydroelectricity
- Nutrient Cycling
- Waste treatment
- Flood Control
- Habitat
- Recreation
- Transportation corridors

Deep Lake Zones:

1. Littoral (Top Zone)
2. Limnetic (open sunlight layer away from the shore)
3. Profundal (deep, open water, too dark for photosynthesis)
4. Benthic

- Lakes with more nutrients than others are known as Oligotrophic lakes.
- A lake with a large supply of nutrients needed by producers is called a eutrophic (well-nourished) lake. Such lakes typically are shallow and have murky brown or green water with high turbidity. Because of their high levels of nutrients, these lakes have a high net primary productivity.



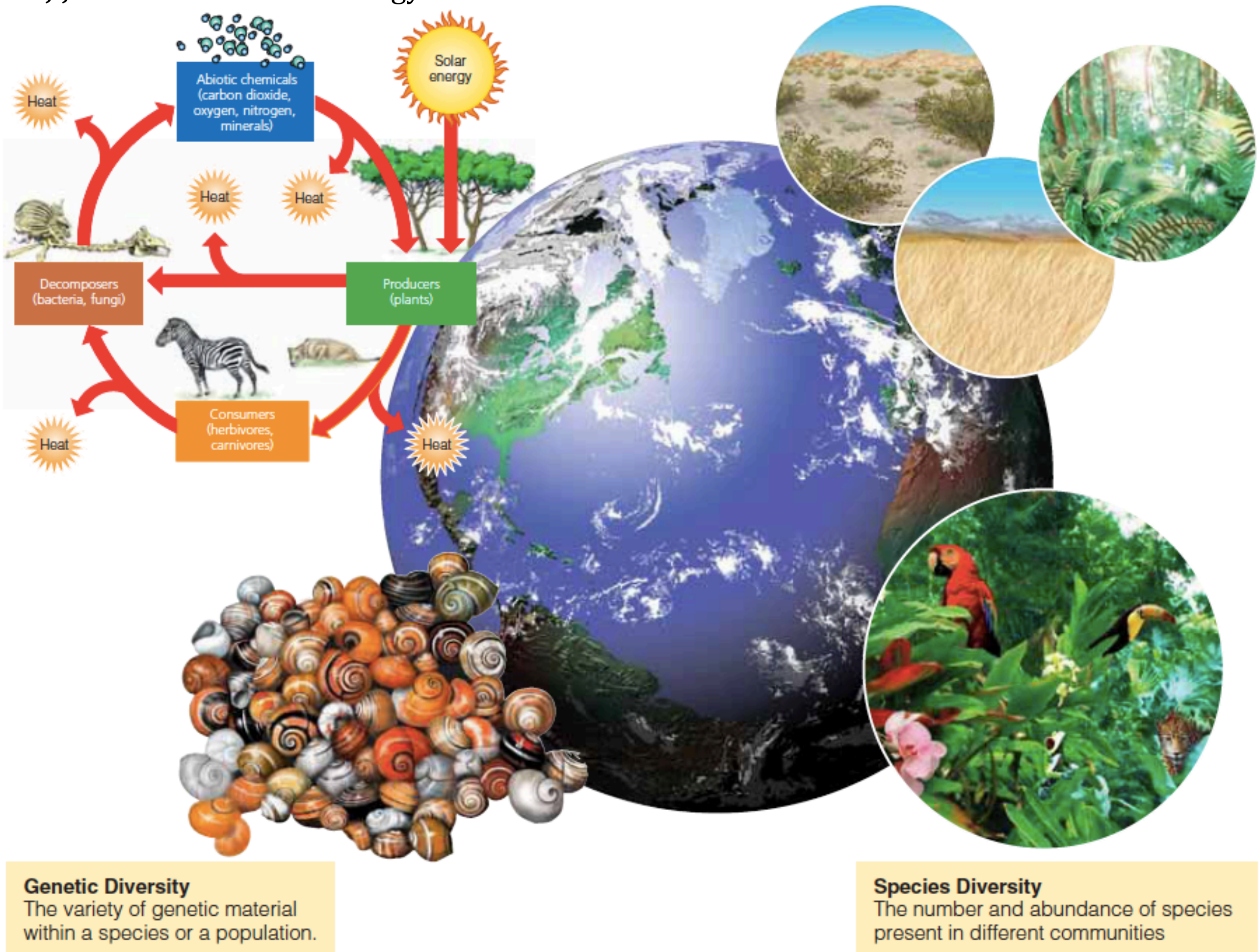
CENGAGENOW™ **Active Figure 8-15**
Distinct zones of life in a fairly deep temperate zone lake. *See an animation based on this figure at* CengageNOW. **Question:** How are deep lakes like tropical rain forests? (*Hint:* See Figure 7-17, p. 156)

Inland Wetlands or Marshes:

Inland wetlands provide a number of other free ecological and economic services, which include:

1. Filtering and degrading toxic wastes and pollutants
2. Reducing flooding and erosion by absorbing storm water and releasing it slowly and by absorbing overflows from streams and lakes
3. Helping to replenish stream flows during dry periods
4. Helping to recharge groundwater aquifers
5. Helping to maintain biodiversity by providing habitats for a variety of species

Major Components of Earth's Biodiversity:

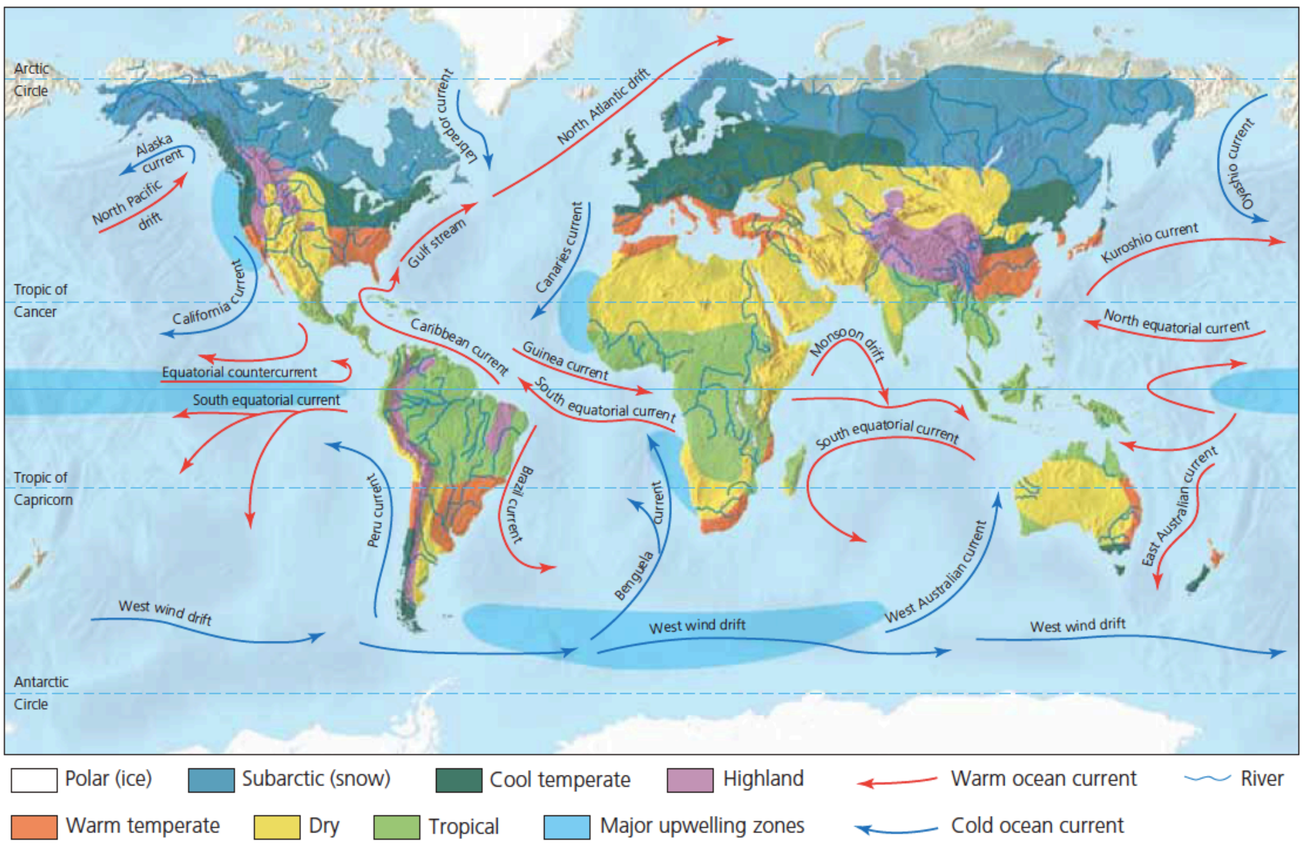


CENGAGENOW™ **Active Figure 4-2** **Natural capital:** the major components of the earth's *biodiversity*—one of the earth's most important renewable resources. *See an animation based on this figure at* CengageNOW™.

3. CLIMATE AND TERRESTRIAL BIODIVERSITY

- Approximately 1% of the solar energy results in the formation of winds. Wind, therefore, is an indirect form of solar energy and it is an important factor in the earth's climate.
- It is part of earth's circulatory system of heat, moisture, plant nutrients, soil particles, and long lived air pollutants.
- ***Red Tides:*** Outbreaks of toxic algal blooms in Florida's coastal waters due to the iron-rich particles that get blown from western coast of Africa to Florida.
- Factors influencing climate:
  - Solar radiation
  - Earth's rotation
  - Global patterns of air and water movement
  - Gases in the atmosphere
  - Earth's landforms
- Climate affects nature and location of biomes through differing rates of precipitation and temperature.

- **Prevailing winds** blow over the oceans, forming mass movements of water over the oceans. These movements of water over oceans are known as currents. These ocean currents are driven by the prevailing winds and rotation of the earth, and they travel across the oceans to redistribute the energy of the sun from place to place, thereby influencing climate and vegetation, especially near the coastal areas.
- **The oceans and the atmosphere are strongly linked together by this system of winds in two major ways: (1) Ocean currents are affected by winds in the atmosphere (2) Heat from the oceans affects atmospheric circulation.**
- One example of interactions between the oceans and the atmosphere **is the El Nino - Southern Oscillation or ENSO.**



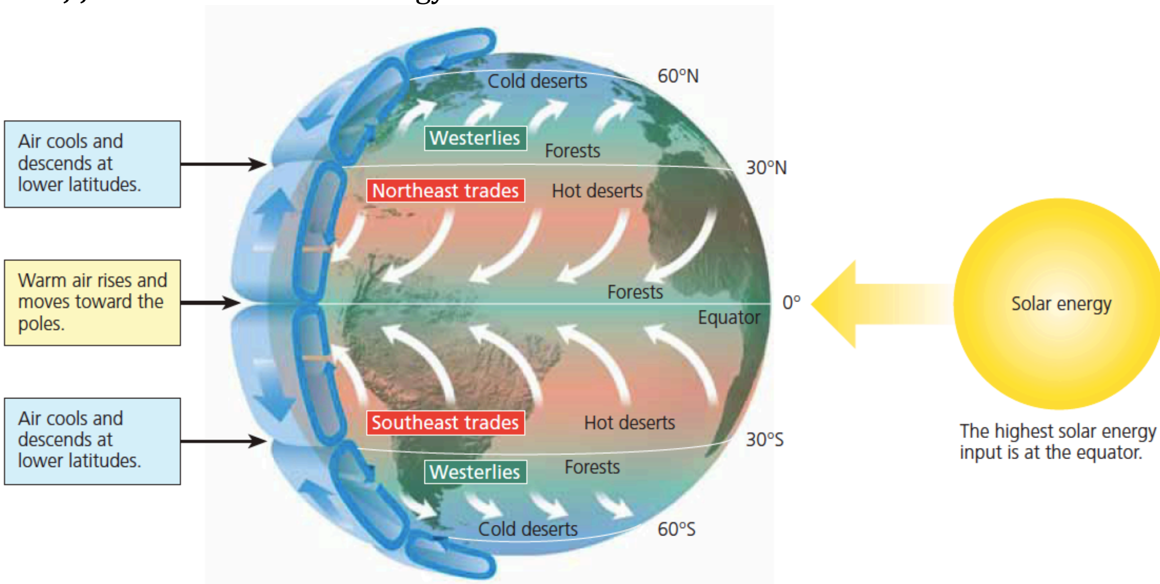


Figure 7-3 *Global air circulation.* The largest input of solar energy occurs at the equator. As this air is heated it rises and moves toward the poles. However, the earth's rotation deflects the movement of the air over different parts of the earth. This creates global patterns of prevailing winds that help distribute heat and moisture in the atmosphere.

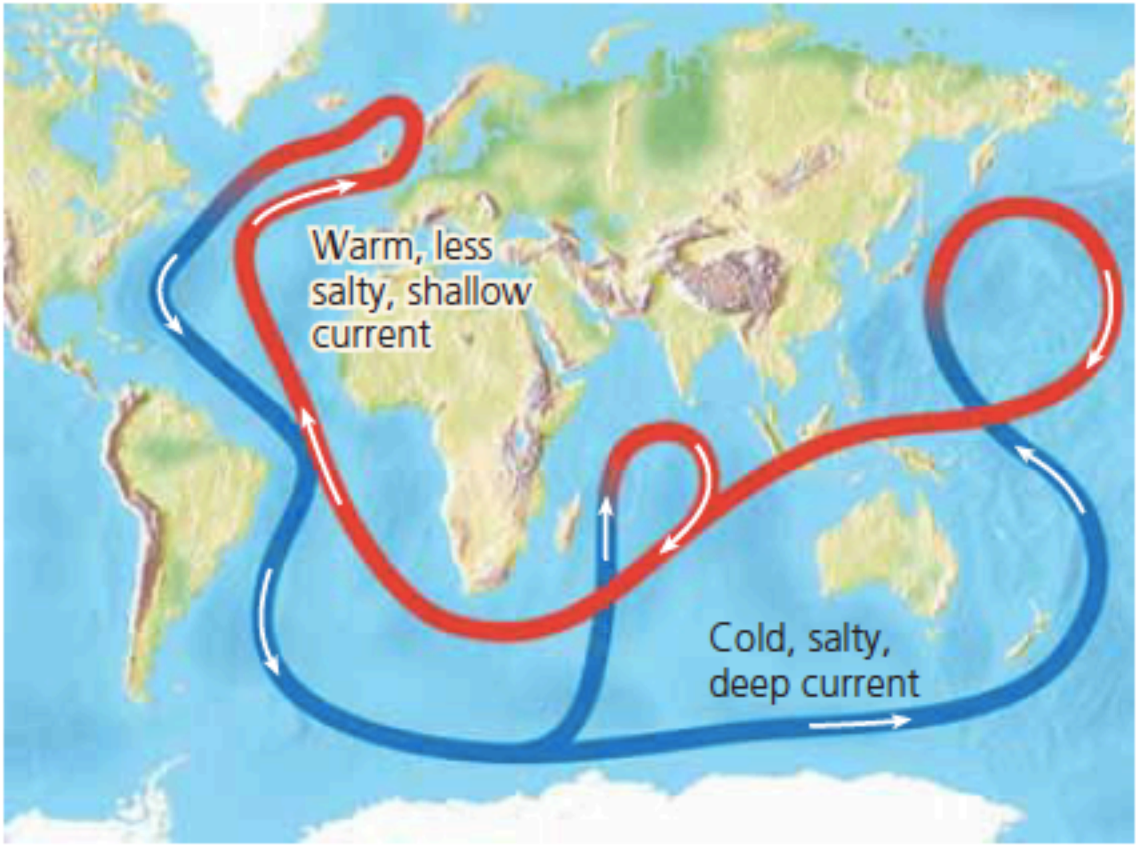


Figure 7-5 *Connected deep and shallow ocean currents.* A connected loop of shallow and deep ocean currents transports warm and cool water to various parts of the earth. This loop, which rises in some areas and falls in others, results when ocean water in the North Atlantic near Iceland is dense enough (because of its salt content and cold temperature) to sink to the ocean bottom, flow southward, and then move eastward to well up in the warmer Pacific. A shallower return current aided by winds then brings warmer, less salty—and thus less dense—water to the Atlantic. This water can cool and sink to begin this extremely slow cycle again. **Question:** How do you think this loop affects the climates of the coastal areas around it?

The earth's air circulation patterns, prevailing winds, and configuration of continents and oceans result in six giant convection cells (like the one shown in Figure 7-4) in which warm, moist air rises and cools, and cool, dry air sinks. Three of these cells are found north of the equator and three are south of the equator. These cells lead to an irregular distribution of climates and deserts, grasslands, and forests, as shown in Figure 7-6 (**Concept 7-1**).

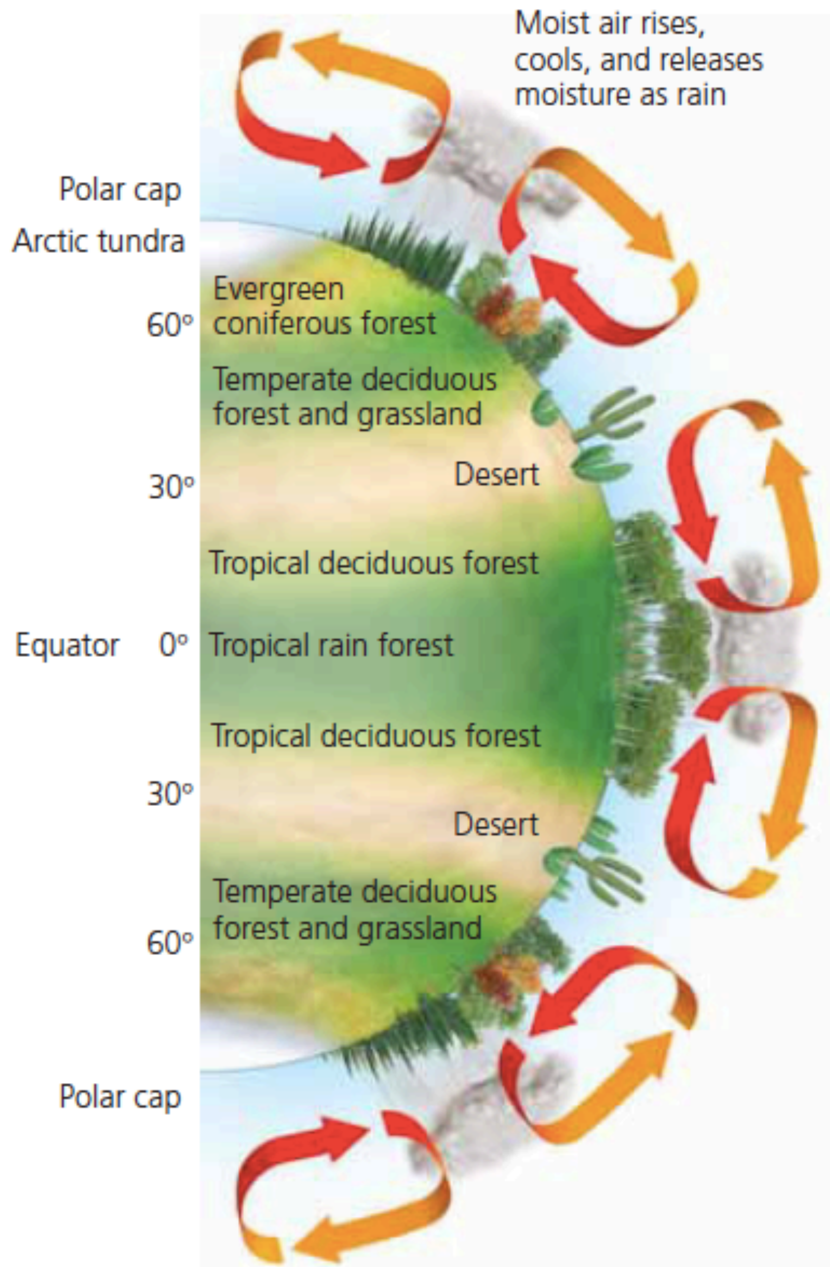
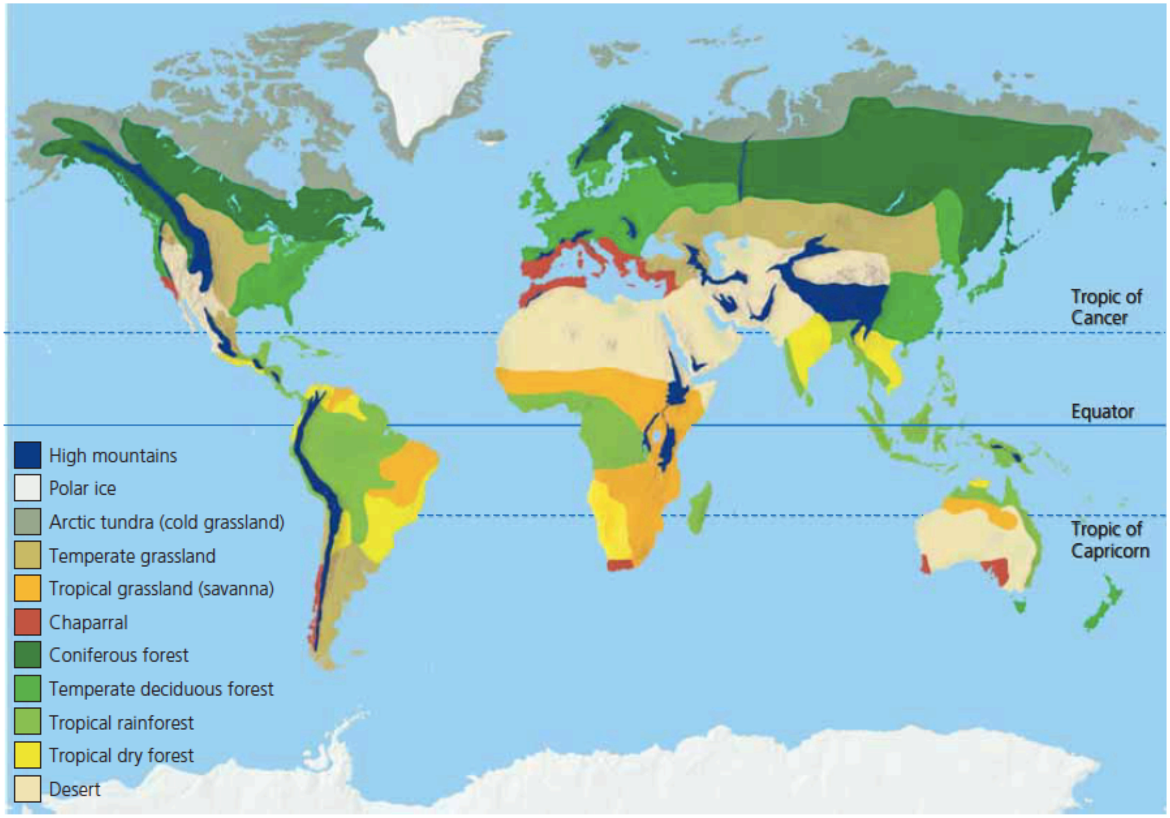


Figure 7-6 *Global air circulation, ocean currents, and biomes.* Heat and moisture are distributed over the earth's surface via six giant convection cells (like the one in Figure 7-4) at different latitudes. The resulting uneven distribution of heat and moisture over the planet's surface leads to the forests, grasslands, and deserts that make up the earth's terrestrial biomes.

MAJOR BIOMES OF THE EARTH:



CENGAGENOW™ **Active Figure 7-8** **Natural capital:** the earth's major *biomes*—the main types of natural vegetation in various undisturbed land areas—result primarily from differences in climate. Each biome contains many ecosystems whose communities have adapted to differences in climate, soil, and other environmental factors. Figure

Effect of Latitude and Elevation on Vegetation:

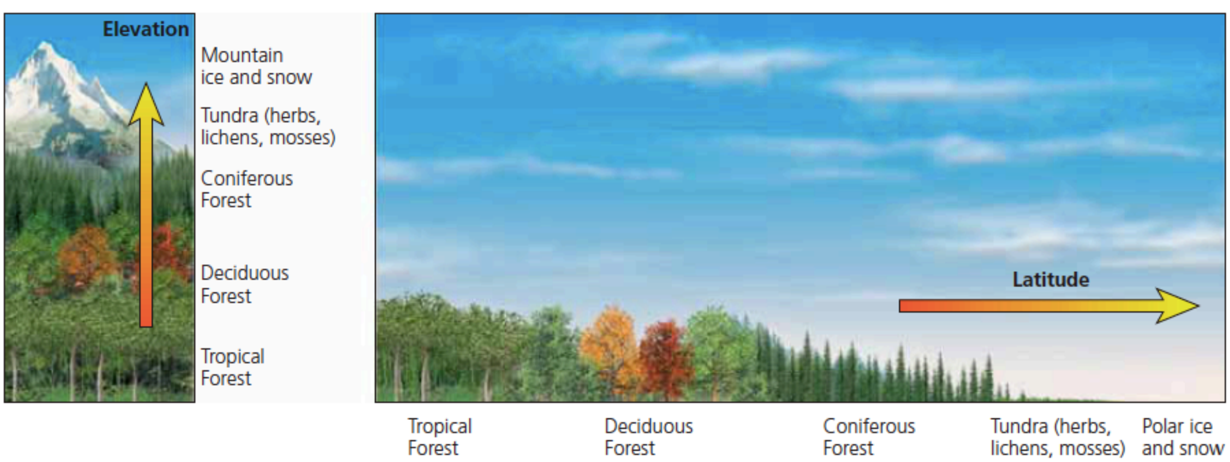


Figure 7-9 Generalized effects of elevation (left) and latitude (right) on climate and biomes. Parallel changes in vegetation type occur when we travel from the equator to the poles or from lowlands to mountain-tops. **Question:** How might the components of the left diagram change as the earth warms during this century? Explain.

BIOMES:

***For Biomes refer to Direction Notes of Neetu Singh*

Deserts

- Deserts are classified by low bio diversity, fragile ecosystems, slow and sparse plant growth, slow nutrient cycle, and extreme lack of water.
- Three types of deserts:
- Tropical Desert
  - Extremely low precipitation, great difference in temperatures during the day and night, constant temperature in daytime in summers and winters.
  - Example: Sahara and Namib Deserts
- Temperate Desert
  - Example: Mohave Desert in Southern US
  - More precipitation than Tropical desert, great difference in temperatures during day and night, however, lower day temperatures during the winter season.
- Cold Desert
  - Example: Gobi Desert of Mongolia
  - Extremely cold winters, warm and hot summers, low precipitation

SCIENCE FOCUS

Staying Alive in the Desert

Adaptations for survival in the desert have two themes: *beat the heat*, and *every drop of water counts*.

Desert plants have evolved a number of strategies for doing this. During long hot and dry spells, plants such as mesquite and creosote drop their leaves to survive in a dormant state. *Succulent* (fleshy) *plants*, such as the saguaro ("sah-WAH-ro") cactus (Figure 7-11, middle photo), have three adaptations: they have no leaves, which can lose water by evapotranspiration; they store water and synthesize food in their expandable, fleshy tissue; and they reduce water loss by opening their pores to take up carbon dioxide (CO_2) only at night. The spines of these and many other desert plants guard them from being eaten by herbivores seeking the precious water they hold.

Some desert plants use deep roots to tap into groundwater. Others such as prickly pear and saguaro cacti use widely spread, shallow roots to collect water after brief showers and store it in their spongy tissue.

Evergreen plants conserve water by having wax-coated leaves that reduce water loss. Others, such as annual wildflowers and grasses, store much of their biomass in seeds that remain inactive, sometimes for years, until they receive enough water to germinate. Shortly after a rain, these seeds germinate, grow, and carpet some deserts with dazzling arrays of colorful flowers that last for a few weeks.

Most desert animals are small. Some beat the heat by hiding in cool burrows or rocky crevices by day and coming out at night or in the early morning. Others become dormant during periods of extreme heat or drought. Some larger animals such as camels can drink massive quantities of water when it is available and store it in their fat for use as needed. The camel is also covered with dense hair and does not sweat, which

evaporation. Kangaroo rats never drink water. They get the water they need by breaking down fats in seeds that they consume.

Insects and reptiles (such as rattlesnakes and Gila monsters) have thick outer coverings to minimize water loss through evaporation, and their wastes are dry feces and a dried concentrate of urine. Many spiders and insects get their water from dew or from the food they eat.

Critical Thinking

What are three things you would do to survive in the open desert?

<u>Aquatic Biomes:</u>

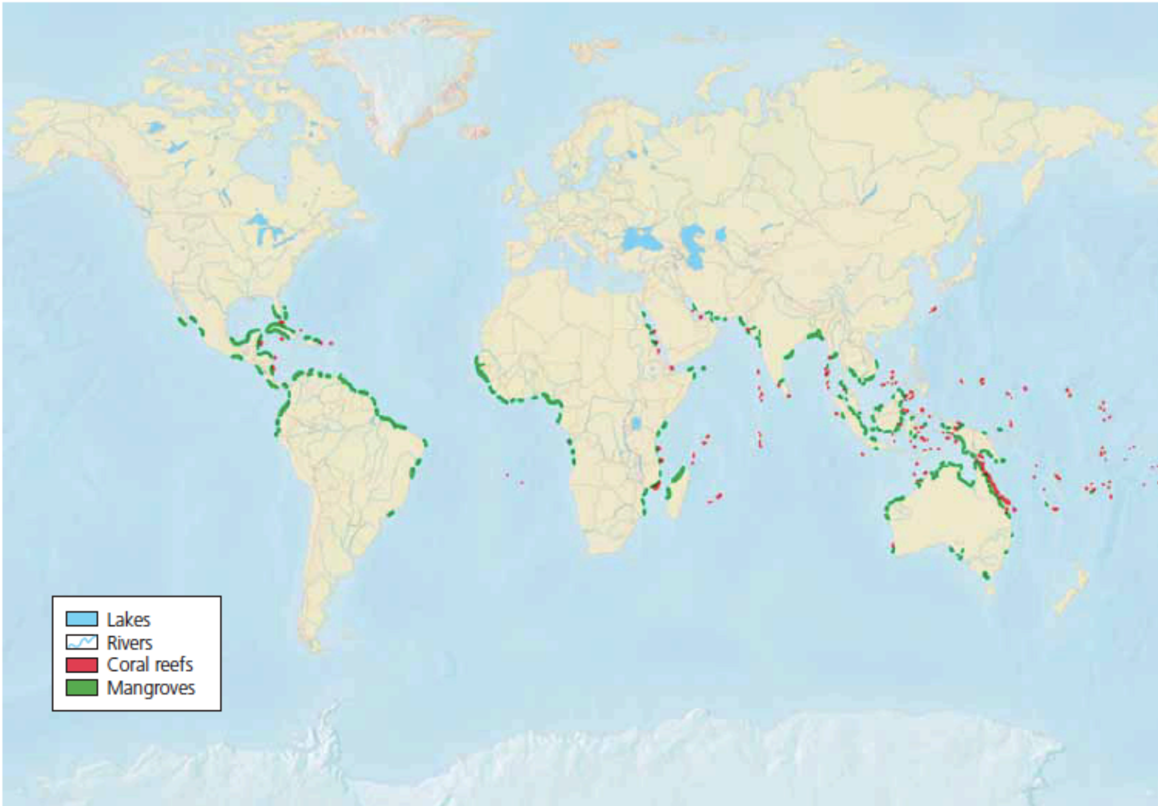


Figure 8-3 Natural capital: distribution of the world's major saltwater oceans, coral reefs, mangroves, and fresh-water lakes and rivers. **Question:** Why do you think most coral reefs lie in the southern hemisphere?

Animal Kingdom and Naming of Species:

All organisms on the earth today are descendants of single-cell organisms that lived almost 4 billion years ago. As a result of biological evolution through natural selection, life has evolved into six major groups of species, called *kingdoms: eubacteria, archaebacteria, protists, fungi, plants,* and *animals* (Figure 4-3, p. 81).

Eubacteria are prokaryotes with single cells that lack a nucleus and other internal compartments (Figure 3-2b, p. 52) found in the cells of species from other kingdoms. Examples include various cyanobacteria and bacteria such as *staphylococcus* and *streptococcus*.

Archaebacteria are single-celled bacteria that are closer to eukaryotic cells (Figure 3-2a, p. 52) than to eubacteria. Examples include methanogens, which live in oxygen-free sediments of lakes and swamps and in animal guts; halophiles, which live in extremely salty water; and thermophiles, which live in hot springs, hydrothermal vents, and acidic soil. These organisms live in extreme environments.

The remaining four kingdoms—protists, fungi, plants, and animals (Figure 4-3, p. 81) are eukarotes with one or more cells that have a nucleus and complex internal compartments (Figure 3-2a, p. 52). *Protists* are mostly single-celled eukaryotic organisms, such as diatoms, dinoflagellates, amoebas, golden brown and yellow-green algae, and protozoans. Some protists cause human diseases such as malaria (pp. 444–447) and sleeping sickness.

Fungi are mostly many-celled, sometimes microscopic, eukaryotic organisms such as mushrooms, molds, mildews, and yeasts. Many fungi are decomposers (Figure 3-11, p. 60). Other fungi kill various plants and animals and cause huge losses of crops and valuable trees.

Plants are mostly many-celled eukaryotic organisms such as red, brown, and green algae and mosses, ferns, and flowering plants (whose flowers produce seeds that perpetuate the species). Some plants such as corn and marigolds are *annuals*, meaning that they complete their life cycles in one growing season. Others are *perennials*, which can live for more than 2 years, such as roses, grapes, elms, and magnolias.

Animals are also many-celled, eukaryotic organisms. Most have no backbones and hence are called *invertebrates*. Invertebrates include sponges, jellyfish, worms, arthropods (e.g., insects, shrimp, and spiders), mollusks (e.g., snails, clams, and octopuses), and echinoderms (e.g., sea urchins and sea stars). *Vertebrates* (animals with backbones and a brain protected by skull bones) include fishes (e.g., sharks and tuna), amphibians (e.g., frogs and salamanders), reptiles (e.g., crocodiles and snakes), birds (e.g., eagles and robins), and mammals (e.g., bats, elephants, whales, and humans).

Within each kingdom, biologists have created subcategories based on anatomical, physiological, and behavioral characteristics. Kingdoms are divided into *phyla*, which are divided into subgroups called *classes*. Classes are subdivided into *orders*, which are further divided into *families*. Families consist of *genera* (singular, *genus*), and each genus contains one or more *species*. Note that the word *species* is both singular and plural. Figure 1 shows this detailed taxonomic classification for the current human species.

Most people call a species by its common name, such as robin or grizzly bear. Biologists use scientific names (derived from Latin) consisting of two parts (printed in italics, or underlined) to describe a species. The first word is the capitalized name (or abbreviation) for the genus to which the organism belongs. It is followed by a lowercase name that distinguishes the species from other members of the same genus. For example, the scientific name of the robin is *Turdus migratorius* (Latin for "migratory thrush") and the grizzly bear goes by the scientific name *Ursus horribilis* (Latin for "horrible bear").

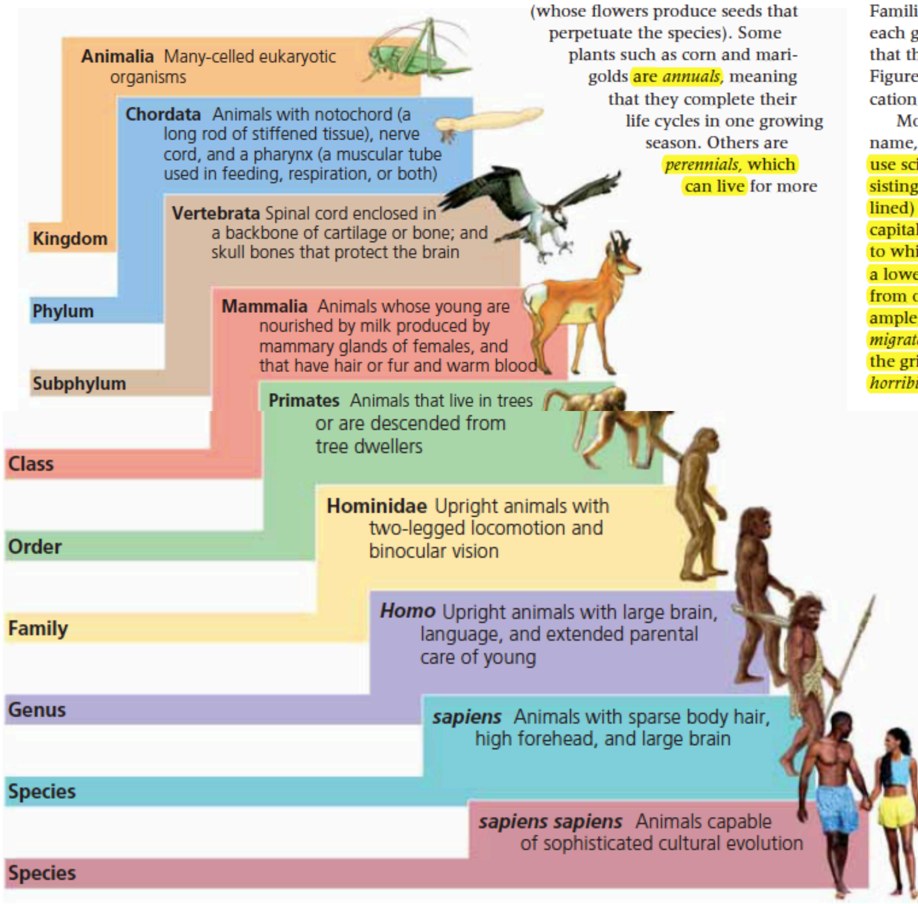


Figure 1 Taxonomic classification of the lat human species, *Homo sapiens sapiens.*

Photosynthesis

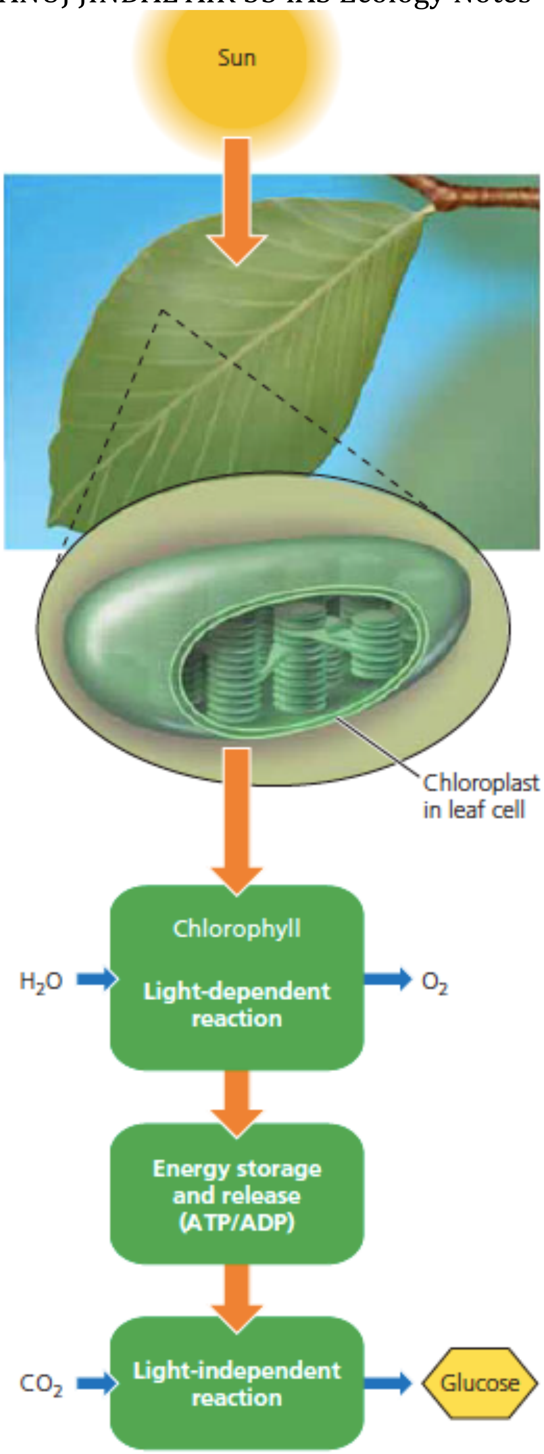
A Closer Look at Photosynthesis

In photosynthesis, sunlight powers a complex series of chemical reactions that combine water taken up by plant roots and carbon dioxide from the air to produce sugars such as glucose. This process converts solar energy into chemical energy in sugars for use by plant cells, with the solar energy captured, stored, and released as chemical energy in ATP and ADP molecules (Figure 13). Figure 14 is a greatly simplified summary of the photosynthesis process.

Photosynthesis takes place within tiny enclosed structures called *chloroplasts* found within plant cells. Chlorophyll, a special compound in chloroplasts, absorbs incoming visible light mostly in the violet and red wavelengths. The green light that is not absorbed is reflected back, which is why photosynthetic plants look green. The absorbed wavelengths of solar energy initiate a sequence of chemical reactions with other molecules in what are called *light-dependent reactions*.

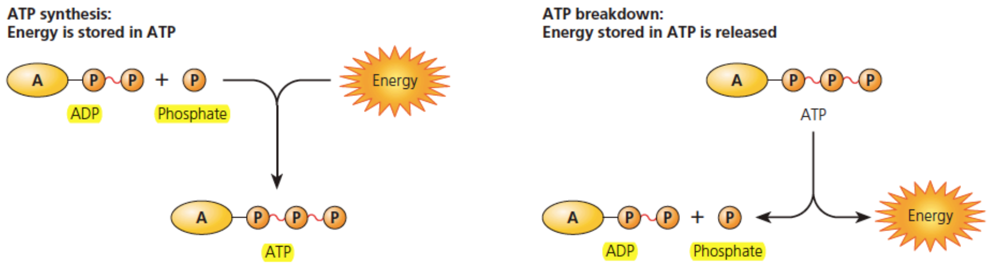
This series of reactions splits water into hydrogen ions (H^+) and oxygen (O_2) which is released into the atmosphere. Small ADP molecules in the cells absorb the energy released and store it as chemical energy in ATP molecules (Figure 13). The chemical energy released by the ATP molecules drives a series of *light-independent* (*dark*) *reactions* in the plant cells. In this second sequence of reactions, carbon atoms stripped from carbon dioxide combine with hydrogen and oxygen to produce sugars such

as glucose ($C_6H_{12}O_6$, Figure 7, p. S42) that plant cells can use as a source of energy and carbon.



$$6CO_2 + 6H_2O \xrightarrow{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$ \

Figure 13 Energy storage and release in cells.



Four Types of Large Organic Compounds Are the Molecular Building Blocks of Life

1. Complex Carbohydrates
2. Proteins
3. Nucleic Acids
4. Lipids

Complex carbohydrates consist of two or more monomers of *simple sugars* (such as glucose, Figure 7) linked together. One example is the starches that plants use to store energy and also to provide energy for animals that feed on plants. Another is cellulose, the earth's most abundant organic compound, which is found in the cell walls of bark, leaves, stems, and roots.

Proteins, are large polymer molecules formed by linking together long chains of monomers called *amino acids* (Figure 8). Living organisms use about 20 different amino acid molecules to build a variety of proteins, which play different roles. Some help to store energy. Some are components of the *immune system* that protects the body against diseases and harmful substances by forming antibodies that make invading agents harmless. Others are *hormones* that are used as chemical messengers in the bloodstreams of animals to turn various bodily functions on or off. In animals, proteins are also components of hair, skin, muscle, and tendons. In addition, some proteins act as *enzymes* that catalyze or speed up certain chemical reactions.

Nucleic acids are large polymer molecules made by linking hundreds to thousands of four types of monomers called *nucleotides*. Two nucleic acids—DNA (deoxyribonucleic acid) and RNA (ribonucleic acid)—participate in the building of proteins and carry hereditary information used to pass traits from parent to offspring. Each nucleotide consists of a *phosphate group, a sugar molecule* containing five carbon atoms (deoxyribose in DNA molecules and ribose in RNA molecules), and one of four different *nucleotide bases* (represented by A, G, C, and T, the first letter in each of their names, or A, G, C, and U in RNA; see Figure 9). In the cells of living organisms, these nucleotide units combine in different numbers and sequences to form *nucleic acids* such as various types of RNA and DNA (Figure 10).

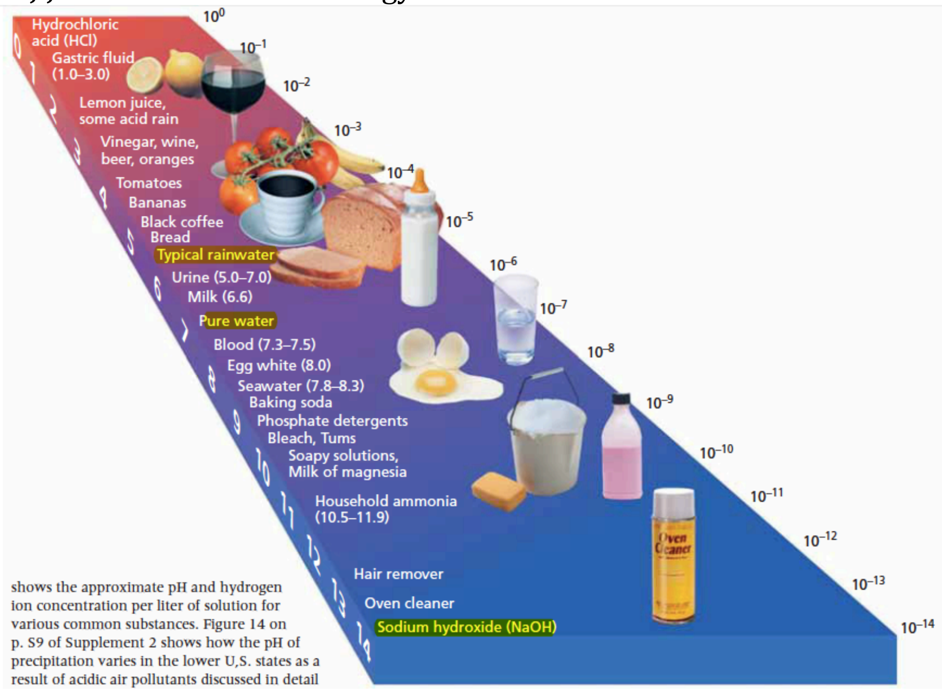
Lipids, a fourth building block of life, are a chemically diverse group of large organic compounds that do not dissolve in water. Examples are *fats and oils* for storing energy (Figure 11), *waxes* for structure, and *steroids* for producing hormones.

What Makes Solutions Acidic? Hydrogen Ions and pH

The *concentration*, or number of hydrogen ions (H^+) in a specified volume of a solution (typically a liter), is a measure of its acidity. Pure water (not tap water or rainwater) has an equal number of hydrogen (H^+) and hydroxide (OH^-) ions. It is called a **neutral solution**. An **acidic solution** has more hydrogen ions than hydroxide ions per liter. A **basic solution** has more hydroxide ions than hydrogen ions per liter.

Scientists use **pH** as a measure of the acidity of a solution based on its concentration of hydrogen ions (H^+). By definition, a neutral solution has a pH of 7, an acidic solution has a pH of less than 7, and a basic solution has a pH greater than 7.

Each single unit change in pH represents a 10-fold increase or decrease in the concentration of hydrogen ions per liter. For example, an acidic solution with a pH of 3 is 10 times more acidic than a solution with a pH of 4. Figure 5



shows the approximate pH and hydrogen ion concentration per liter of solution for various common substances. Figure 14 on p. S9 of Supplement 2 shows how the pH of precipitation varies in the lower U.S. states as a result of acidic air pollutants discussed in detail on pp. 479–480.

Figure 5 The *pH scale,* representing the concentration of hydrogen ions (H^+) in one liter of solution is shown on the righthand side. On the left side are the approximate pH values for solutions of some common substances. A solution with a pH less than 7 is *acidic,* one with a pH of 7 is *neutral,* and one with a pH greater than 7 is *basic.* A change of 1 on the pH scale means a tenfold increase or decrease in H^+ concentration. (Modified from Cecie

THINKING ABOUT
pH

National Park : Protected area; No human activity is allowed; under Wildlife Protection Act 1972 (India)

Wildlife Sanctuary : Protected area; Limited human activity is allowed; under Wildlife Protection Act 1972 (India)

Biosphere Reserve : Limited Economic activity is allowed(sand and stone mining); Conservation of biodiversity, landscape and cultural heritage with its sustainable use; "Living Laboratory" for testing out and demonstrating integrated management of land,water and biodiversity; comes under UNESCO's Man and Biosphere (MAB) programme nominated by National Governments

IUCN Categorization of Critically Endangered, Endangered and Vulnerable Species:

1. **Critically Endangered**
    - Reduction of >=90% of the population over the last 10 years or three generations, whichever is longer, where the causes of reduction are clearly reversible and understood and ceased.
    - Reduction of >=80% of the population over the last 10 years or three generations, whichever is longer, where the causes of reduction may not not be reversible or may not be understood or may not have ceased.
    - Extent of occurrence is less than 100 Km2 area
        - Severly fragmented area or single area only

- Area of occupancy is below 10 Km2
- Population below 250 in number of mature individuals
  - An estimated decline of 25% or higher in the last 3 years

2. **Endangered**
   - Reduction of >=70% of the population over the last 10 years or three generations, whichever is longer, where the causes of reduction are clearly reversible and understood and ceased.
   - Reduction of >=50% of the population over the last 10 years or three generations, whichever is longer, where the causes of reduction may not not be reversible or may not be understood or may not have ceased.
   - Extent of occurrence is less than 5000 Km2 area
     - Severly fragmented area or single area only
   - Area of occupancy is below 500 Km2
   - Population below 2500 in number of mature individuals
     - An estimated decline of 20% or higher in the last 3 years
3. **Vulnerable**
   - Reduction of >=50% of the population over the last 10 years or three generations, whichever is longer, where the causes of reduction are clearly reversible and understood and ceased.
   - Reduction of >=30% of the population over the last 10 years or three generations, whichever is longer, where the causes of reduction may not not be reversible or may not be understood or may not have ceased.
   - Extent of occurrence is less than 20000 Km2 area
     - Severly fragmented area or single area only
   - Area of occupancy is below 2000 Km2
   - Population below 10000 in number of mature individuals
     - An estimated decline of 10% or higher in the last 3 years

Heterosphere

- Gases in this part are not evenly mixed.
- Lightest gases highest (hydrogen and helium) and heavier gases towards the earth (oxygen and nitrogen)
- Begins at 80 KM height from the earth and outwards for more than10,000 KM

Homosphere

- Sea-level to 80 KMs
- Uniform blend of gases here

Soils:

- More organic carbon in soils than the ground vegetation and atmosphere combined
- Can sequester carbon and help in the fight against CC and decrease in release of GHGs

- The higher the organic matter of soil, higher is carbon sequestration
- Soil degradation due to the following factors leads to soil contributing to CC by releasing GHGs:
    - Deforestation
    - Loss of nutrients
    - Compaction
    - Erosion and Water logging
    - Urbanization

Water in lakes and the ocean also varies in the amount of dissolved oxygen and nutrients it contains:

1. Water near the surface of lakes and the ocean usually has more dissolved oxygen than does deeper water. This is because surface water absorbs oxygen from the air above it.
2. Water near shore generally has more dissolved nutrients than water farther from shore. This is because most nutrients enter the water from land. They are carried by runoff, streams, and rivers that empty into a body of water.
3. Water near the bottom of lakes and the ocean may contain more nutrients than water closer to the surface. When aquatic organisms die, they sink to the bottom. Decomposers near the bottom of the water break down the dead organisms and release their nutrients back into the water.

Temperature ranges for organisms:

1. **Eurythermal** organisms can tolerate and thrive in wide range of tempera ture.
2. **Warm blooded** animals can maintain a constant body temperature even when the surrounding temperature is changing.
3. **Stenothermal** organisms are restricted to a small range of temperature.
4. **Cold blooded** animals generally hibernate to protect themselves from ex treme climatic conditions.