Environmental Geography

Principles of Ecology

Ecology is the study of how living things interact with each other and with their environment. It is a major branch of biology, but has areas of overlap with geography, geology, climatology, and other sciences. The Following are the fundamental concepts and principles in ecology, beginning with organisms and the environment.

Organisms and the Environment

Organisms are individual living things. Despite their tremendous diversity, all organisms have the same basic needs: energy and matter. These must be obtained from the environment. Therefore, organisms are not closed systems. They depend on and are influenced by their environment. The environment includes two types of factors: abiotic and biotic.

1. **Abiotic factors** are the nonliving aspects of the environment. They include factors such as sunlight, soil, temperature, and water.
2. **Biotic factors** are the living aspects of the environment. They consist of other organisms, including members of the same and different species.

Niche

One of the most important concepts associated with the ecosystem is the niche. A **niche** refers to the role of a species in its ecosystem. It includes all the ways that the species interacts with the biotic and abiotic factors of the environment. Two important aspects of a species' niche are the food it eats and how the food is obtained. Each species eats a different type of food and obtains the food in a different way.

Habitat

Another aspect of a species' niche is its habitat. The **habitat** is the physical environment in which a species lives and to which it is adapted. A habitat's features are determined mainly by abiotic factors such as temperature and rainfall. These factors also influence the traits of the organisms that live there.

Competitive Exclusion Principle

A given habitat may contain many different species, but each species must have a different niche. Two different species cannot occupy the same niche in the same place for very long. This is known as the **competitive exclusion principle**. If two species were to occupy the same niche, they would compete with one another for the same food and other resources in the environment. Eventually, one species would be likely to outcompete and replace the other.

The Ecosystem

An ecosystem is a unit of nature and the focus of study in ecology. **It consists of all the biotic and abiotic factors in an area and their interactions**. Ecosystems can vary in size. A lake could be considered an ecosystem. So could a dead log on a forest floor. Both the lake and log contain a variety of species that interact with each other and with abiotic factors.

When it comes to energy, ecosystems are not closed. They need constant inputs of energy. Most ecosystems get energy from sunlight. A small minority get energy from chemical compounds. Unlike energy, matter is not constantly added to ecosystems. Instead, it is recycled. Water and elements such as carbon and nitrogen are used over and over again.

The term 'ecosystem' was coined by A.G. Tansley in 1935. Ecosystem is a self-sustaining unit of nature. An ecosystem is a functional unit of nature encompassing complex interaction between its biotic (living) and abiotic (non-living) components. For example- a pond is a good example of ecosystem.

Many ecologists regard the entire biosphere as a global ecosystem, as a composite of all local ecosystems on Earth.

In nature two major categories of ecosystems exist: **terrestrial** and **aquatic**.

- Forests, deserts and grasslands are examples of terrestrial ecosystem.
- Ponds, lakes, wet lands and salt water are some example of aquatic ecosystem.
- Crop lands and aquarium are the example of manmade ecosystems.

The interaction between the living organisms and their environment can be studied in a puddle of water or a hole in a tree, which are very small ecosystems or in large ecosystems such a forest, river or ocean. Irrespective of their sizes all ecosystems share many common characteristics.

Types of ecosystems: Ecosystems are classified as follows: (i) Natural ecosystems (ii) Manmade ecosystems

(i) Natural ecosystems

(a) Totally dependent on solar radiation e.g. forests, grasslands, oceans, lakes, rivers and deserts. They provide food, fuel, fodder and medicines.

(b) Ecosystems dependent on solar radiation and energy subsidies (alternative sources) such as wind rain and tides. e.g. tropical rain forests, tidal estuaries and coral reefs.

(ii) Manmade ecosystems

(a) Dependent on solar energy-e.g. agricultural fields and aquaculture ponds.

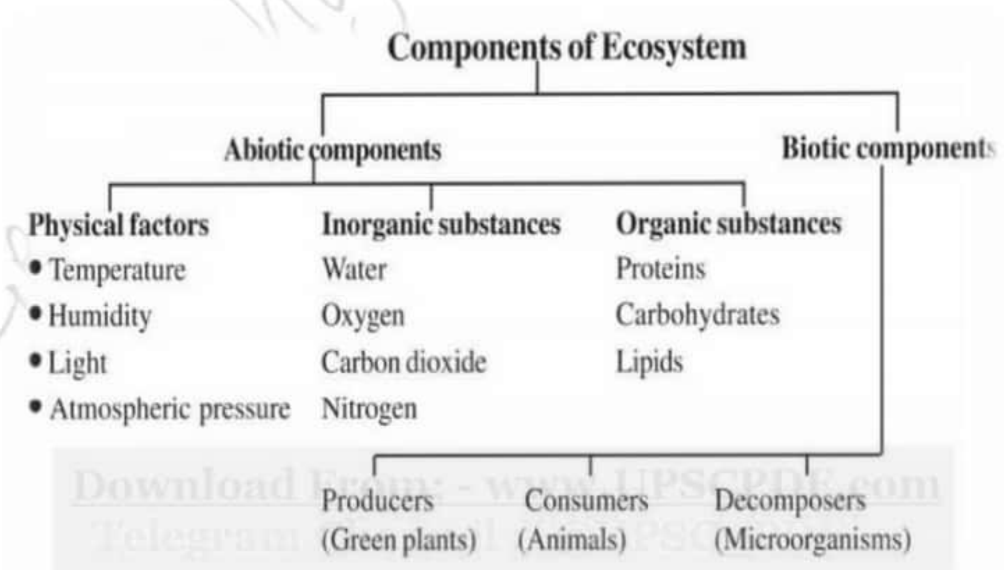
(b) Dependent on fossil fuel e.g. urban and industrial ecosystems.

<u>Components of an Ecosystem</u>

They are broadly grouped into:-

(a)Abiotic and

(b) Biotic components



(a) Abiotic components (Nonliving): The abiotic component can be grouped into following three categories:-

(i) Physical factors: Sun light, temperature, rainfall, humidity and pressure. They sustain and limit the growth of organisms in an ecosystem.

(ii) Inorganic substances: Carbon dioxide, nitrogen, oxygen, phosphorus, Sulphur, water, rock, soil and other minerals.

(iii) Organic compounds: Carbohydrates, proteins, lipids and humic substances. They are the building blocks of living systems and therefore, make a link between the biotic and abiotic components.

(b) Biotic components (Living)

(i) Producers: The green plants manufacture food for the entire ecosystem through the process of photosynthesis. Green plants are called autotrophs, as they absorb water and nutrients from the soil, carbon dioxide from the air, and capture solar energy for this process.

(ii) Consumers: They are called heterotrophs and they consume food synthesized by the autotrophs. Based on food preferences they can be grouped into three broad categories. **Herbivores** (e.g. cow, deer and rabbit etc.) feed directly on plants, **carnivores** are animals which eat other animals (e.g. lion, cat, dog etc.) and **omnivore's** organisms feeding upon plants and animals e.g. human, pigs and sparrow.

(iii) Decomposers: Also called saprotrophs**.** These are mostly bacteria and fungi that feed on dead decomposed and the dead organic matter of plants and animals by secreting enzymes outside their body on the decaying matter. They play a very important role in recycling of nutrients. They are also called **detrivores or detritus feeders**.

Ecosystem – Structure and Function

Interaction of biotic and abiotic components results in a physical structure that is characteristic for each type of ecosystem. Identification and enumeration of plant and animal species of an ecosystem gives its species composition.

The important structural features are **species composition** (types of plants and animals) and **stratification** (vertical and horizontal distribution of various species occupying different levels). Another way of looking at the structural components is through food relationships of producers and consumers. Several **trophic levels** exist in the ecosystem. For example, trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom layers. These structural components function as a unit and produce certain functional aspects of ecosystem.

Some of these aspects are: Productivity, energy flow, nutrient cycle

Species Composition:

A community is an assemblage of many populations that are living together at the same place and time. For example a tropical forest community consists of trees, vines, herbs and shrubs along with large number of different species of animals. This is known as species composition of tropical forest ecosystem.

Each ecosystem has its own species composition depending upon the suitability of its habitat and climate. A forest ecosystem supports much larger number of species of plants and animals than grassland. The total number and types of species in a community determine its stability and **ecosystem balance** (ecosystem equilibrium).

Stratification:

The vertical and horizontal distribution of plants in the ecosystem is called ecosystem stratification. Tallest trees make the top canopy. This is followed by short trees and shrubs and then the forest floor is covered with herbs and grasses. Some burrowing animals live underground in their tunnels or on the roots of the plants. Each layer from the tree top to the forest floor has its characteristic fauna and flora. This is termed as vertical stratification of forest ecosystem. On the other hand desert ecosystem shows low discontinuous layers of scant vegetation and animals with some bare patches of soil showing a type of horizontal stratification.

Functions of ecosystem

Ecosystems are complex dynamic system. They perform certain functions. These are:-

- Energy flow through food chain
- Nutrient cycling (biogeochemical cycles)
- Ecological succession or ecosystem development
- Homeostasis (or cybernetic) or feedback control mechanisms.

Ponds, lakes, meadows, marshlands, grasslands, deserts and forests are examples of natural ecosystem. We have seen an aquarium; a garden or a lawn etc. in our neighborhood. These are manmade ecosystem.

Energy Flow through Ecosystem:

Food chains and energy flow are the functional properties of ecosystems which make them dynamic. The biotic and abiotic components of an ecosystem are linked through them.

Food Chain:

Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten is called a food chain. Each step in the food chain is called **trophic level**.

E.g. Grasses → Grasshopper → Frog → Snake → Hawk/Eagle

During this process of transfer of energy some energy is lost into the system as heat energy and is not available to the next trophic level. Therefore, the number of steps are limited in a chain to 4 or 5. Following trophic levels can be identified in a food chain.

(i) Autotrophs:

They are the producers of food for all other organisms of the ecosystem. They are largely green plants and convert inorganic material in the presence of solar energy by the process of photosynthesis into the chemical energy (food).

The total rate at which the radiant energy is stored by the process of photosynthesis in the green plants is called **Gross Primary Production** (GPP). This is also known as total photosynthesis or total assimilation. From the gross primary productivity a part is utilized by the plants for its own metabolism. The remaining amount is stored by the plant as **Net Primary Production** (NPP) which is available to consumers.

(ii) Herbivores: The animals which eat the plants directly are called primary consumers or herbivores e.g. insects, birds, rodents and ruminants.

(iii) Carnivores: They are secondary consumers if they feed on herbivores and tertiary consumers if they use carnivores as their food. E.g. frog, dog, cat and tiger.

(iv) Omnivores: Animals that eat both plant and animals e.g. pig, bear and man.

(v) Decomposers: They take care of the dead remains of organisms at each trophic level and help in recycling of the nutrients e.g. bacteria and fungi.

There are two types of food chains:

1. Grazing food chains: This starts from the green plants that make food for herbivores and herbivores in turn for the carnivores.

2. **Detritus food chains:** start from the dead organic matter to the detrivores organisms which in turn make food for protozoan to carnivores etc.

Food web:

Trophic levels in an ecosystem are not linear rather they are interconnected and make a food web. Thus food web is a network interconnected food chains existing in an ecosystem. One animal may be a member of several different food chains. Food webs are more realistic models of energy flow through an ecosystem.

The flow of energy in an ecosystem is always linear or one way. The quantity of energy flowing through the successive trophic levels decreases. At every step in a food chain or web the energy received by the organism is used to sustain itself and the left over is passed on to the next trophic level.

Ecological pyramid:

Ecological pyramids are the graphic representations of trophic levels in an ecosystem. They are pyramidal in shape and they are of three types: The producers make the base of the pyramid and the subsequent tiers of the pyramid represent herbivore, carnivore and top carnivore levels.

- **Pyramid of number:** This represents the number of organisms at each trophic level. For example in grassland the number of grasses is more than the number of herbivores that feed on them and the number of herbivores is more than the number of carnivores. In some instances the pyramid of number may be inverted, i.e. herbivores are more than primary producers as you may observe that many caterpillars and insects feed on a single tree.
- **Pyramid of biomass:** This represents the total standing crop biomass at each trophic level. *Standing crop biomass* is the amount of the living matter at any given time. It is expressed as gm/unit area or kilo Cal/unit area. In most of the terrestrial ecosystems the pyramid of biomass is upright. However, in case of aquatic ecosystems the pyramid of biomass may be inverted.
- **Pyramid of energy:** This pyramid represents the total amount of energy at each trophic level. Energy pyramids are never inverted.

Biogeochemical Cycles

The movement of nutrient elements through the various components of an ecosystem is called nutrient cycling. Another name of nutrient cycling is biogeochemical cycles (bio: living organism, geo: rocks, air, and water). In ecosystems flow of energy is linear but that of nutrients is cyclical. *The entire earth or biosphere is a closed system i.e. nutrients are neither imported nor exported from the biosphere.*

Nutrient cycles are of two types: (a) gaseous and (b) sedimentary.

The reservoir for gaseous type of nutrient cycle (e.g., nitrogen, carbon cycle) exists in the atmosphere and for the sedimentary cycle (e.g., Sulphur and phosphorus cycle); the reservoir is located in Earth's crust.

The Carbon Cycle

Of all the biogeochemical cycles, the **carbon cycle** is the most important. All life is composed of carbon compounds of one form or another. That is why it is of such grave concern today that human activities since the Industrial Revolution have modified the carbon cycle in significant ways.

The carbon cycle is a biogeochemical cycle in which carbon flows among storage pools in the atmosphere, ocean, and on the land. Human activity has affected the carbon cycle, causing carbon dioxide concentrations in the atmospheric storage pool to increase.

The source of all carbon is carbon dioxide present in the atmosphere. It is highly soluble in water; therefore, oceans also contain large quantities of dissolved carbon dioxide.

The global carbon cycle consists of following steps-

- **Photosynthesis:**

  Green plants in the presence of sunlight utilize CO2 in the process of photosynthesis and convert the inorganic carbon into organic matter (food) and release oxygen. Annually 4-9 x 10^{13} kg of CO_2 is fixed by green plants of the entire biosphere. Forests acts as reservoirs of CO_2 as carbon fixed by the trees remain stored in them for long due to their long life cycles. Avery large amount of CO_2 is released through forest fires.

- **Respiration**

  Respiration is carried out by all living organisms. It is a metabolic process where food is oxidized to liberate energy, CO_2 and water. The energy released from respiration is used for carrying out life processes by living organism (plants, animals, decomposers etc.). Thus CO_2 is released into of the atmosphere through this process.

- **Decomposition**

All the food assimilated by animals or synthesized by plant is not metabolized by them completely. A major part is retained by them as their own biomass which becomes available to decomposers on their death. The dead organic matter is decomposed by microorganisms and $CO_2$is released into the atmosphere by decomposers.

- **Combustion**

Burning of biomass releases carbon dioxide into the atmosphere.

Impact of human activities

The global carbon cycle has been increasingly disturbed by human activities particularly since the beginning of industrial era. Large scale deforestation and ever growing consumption of fossil fuels by growing numbers of industries, power plants and automobiles are primarily responsible for increasing emission of carbon dioxide.

Carbon dioxide has been continuously increasing in the atmosphere due to human activities such as industrialization, urbanization and increasing use and number of automobiles. This is leading to increase concentration of CO2 in the atmosphere, which is a major cause of global warming.

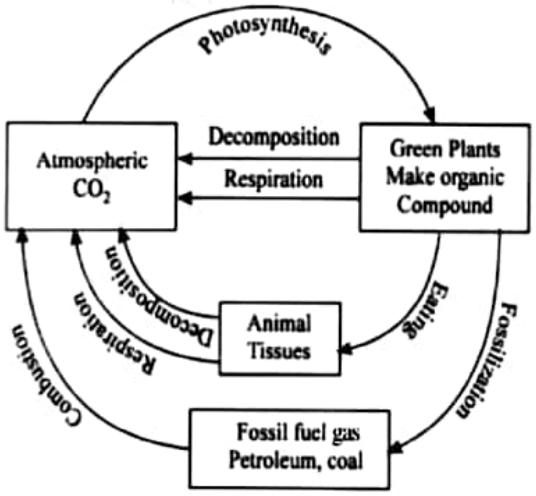


Fig. 5.6: Carbon cycle

<u>***Nitrogen cycle***</u>

Nitrogen is an essential component of protein and required by all living organisms including human beings.

Our atmosphere contains nearly 79% of nitrogen but it cannot be used directly by the majority of living organisms. Broadly like carbon dioxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms. Cycling of nitrogen is vitally important for all living organisms. There are five main processes which essential for nitrogen cycle are elaborated below.

(a) **Nitrogen fixation:** This process involves conversion of gaseous nitrogen into Ammonia, a form in which it can be used by plants. Atmospheric nitrogen can be fixed by the following three methods:-

- **Atmospheric fixation**: Lightening, combustion and volcanic activity help in the fixation of nitrogen.
- **Industrial fixation**: At high temperature (400oC) and high pressure (200 atm.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.
- **Bacterial fixation**: There are two types of bacteria-
  - ✓ **Symbiotic bacteria** e.g. Rhizobium in the root nodules of leguminous plants.
  - ✓ **Free living or symbiotic** e.g. 1. *Nostoc* 2. *Azobacter* 3. Cyanobacteria can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.

(b) **Nitrification:** It is a process by which ammonia is converted into nitrates or nitrites by *Nitrosomonas* and *Nitrococcus* bacteria respectively. Another soil bacterium *Nitrobacter* can covert nitrate into nitrite.

(c) **Assimilation:** In this process nitrogen fixed by plants is converted into organic molecules such as proteins, DNA, RNA etc. These molecules make the plant and animal tissue.

(d) **Ammonification:** Living organisms produce nitrogenous waste products such as urea and uric acid. These waste products as well as dead remains of organisms are converted back into inorganic ammonia by the bacteria. This process is called ammonification. Ammonifying bacteria help in this process.

(e) **Denitrification:** Conversion of nitrates back into gaseous nitrogen is called denitrification. Denitrifying bacteria live deep in soil near the water table as they like to live in oxygen free medium. Denitrification is reverse of nitrogen fixation.

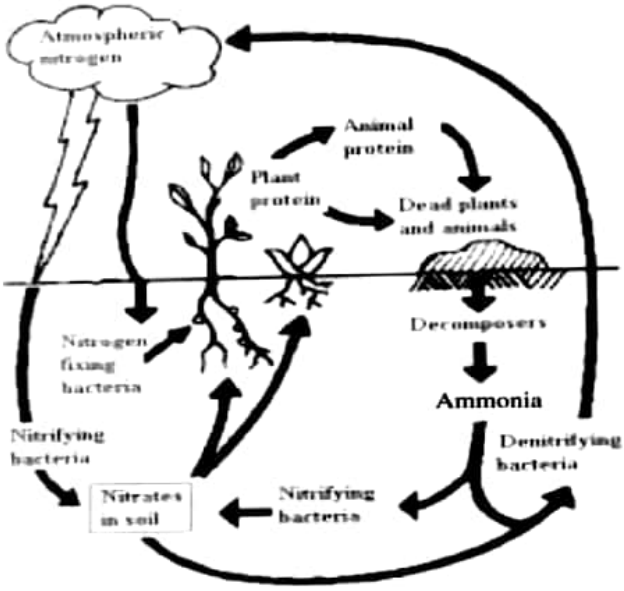


Fig. 5.7: Nitrogen Cycle

Water Cycle

Water is essential for life. No organism can survive without water. Precipitation (rain, snow, slush dew etc.) is the only source of water on the earth. Water received from the atmosphere on the earth returns back to the atmosphere as water vapour resulting from direct evaporation and through evapotranspiration the continuous movement of water in the biosphere is called water cycle (hydrological cycle).

Water is not evenly distributed throughout the surface of the earth. Almost 95 % of the total water on the earth is chemically bound to rocks and does not cycle. Out of the remaining 5%, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only 0.6% is present as fresh water in the form of atmospheric water vapours, ground and soil water.

The driving forces for water cycle are 1) solar radiation 2) gravity.

Evaporation and precipitation are two main processes involved in water cycle. These two processes alternate with each other Water from oceans, lakes, ponds, rivers and streams evaporates by sun's heat energy. Plants also transpire huge amounts of water. Water remains in the vapour state in air and forms clouds which drift with wind. Clouds meet with the cold air in the mountainous regions above the forests and condense to form rain precipitate which comes down due to gravity.

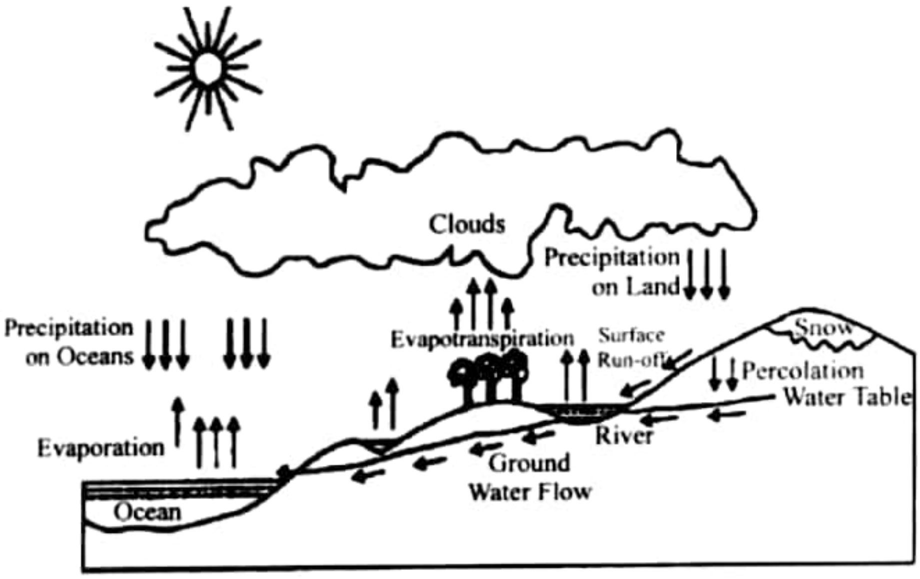


Fig. 5.8: Water Cycle

On an average 84% of the water is lost from the surface of the through oceans by evaporation. While 77% is gained by it from precipitation. Water runoff from lands through rivers to oceans makes up 7% which balances the evaporation deficit of the ocean. On land, evaporation is 16% and precipitation is 23%.

Phosphorus Cycle

Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems. Many animals also need large quantities of this element to make shells, bones and teeth. The natural reservoir of phosphorus is rock, which contains phosphorus in the form of phosphates.

When rocks are weathered, minute amounts of these phosphates dissolve in soil solution and are absorbed by the roots of the plants. Herbivores and other animals obtain this element from plants. The waste products and the dead organisms are decomposed by phosphate-solubilizing bacteria releasing phosphorus. Unlike carbon cycle, there is no respiratory release of phosphorus into atmosphere.

Atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs, and gaseous exchanges of phosphorus between organism and environment are negligible.

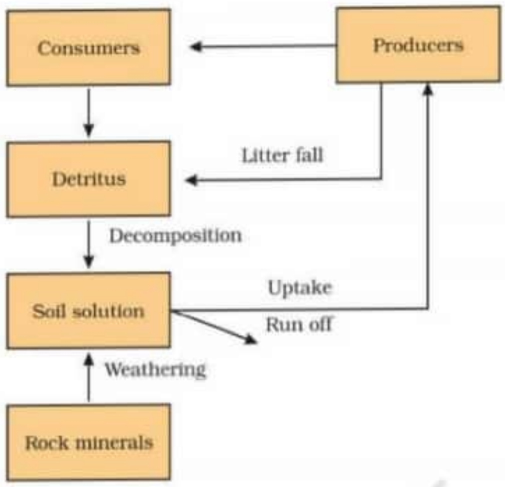


Figure 14.7 A simplified model of phosphorus cycling in a terrestrial ecosystem

Ecological Succession

Biotic communities are dynamic in nature and change over a period of time. The process by which communities of plant and animal species in an area are replaced or changed into another over a period of time is known as **ecological succession**.

Both the biotic and abiotic components are involved in this change. This change is brought about both by the activities of the communities as well as by the physical environment in that particular area. The physical environment often influences the nature, direction, rate and optimal limit of changes.

During succession both the plant and animal communities undergo change. During succession some species colonize an area and their populations become more numerous, whereas populations of other species decline and even disappear.

The entire sequence of communities that successively change in a given area are called sere(s). The individual transitional communities are termed seral stages or seral communities. In the successive seral stages there is a change in the diversity of species of organisms, increase in the number of species and organisms as well as an increase in the total biomass. There are two types of successions (i) Primary succession and (ii) Secondary succession.

Primary succession

Primary succession takes place over bare or unoccupied areas such as rocks outcrop, newly formed deltas and sand dunes, emerging Volcano Islands and lava flows as well as glacial moraines (muddy area exposed by a retreating glacier) where no community has existed previously. The plants that invade first bare land, where soil is initially absent are called pioneer species. The assemblage of pioneer plants is collectively called pioneer community. A pioneer species generally show high growth rate but short life span.

The community that initially inhabits a bare area is called **pioneer community**. The pioneer community after some time gets replaced by another community with different species combination. This second community gets replaced by a third community. This process continues sequence-wise in which a community replaced previous by another community.

The terminal (final) stage of succession forms the community which is called as *climax community* .A climax community is stable, mature, more complex and long lasting. The animals of such a community also exhibit succession which to a great extent is determined by plant succession. A climax community as long as it is undisturbed, remains relatively stable in dynamic equilibrium with the prevailing climate and habitat factors.

Succession that occurs on land where moisture content is low for e.g. on bare rock is known as *xerarch*. Succession that takes place in a water body, like ponds or lake is called *hydrarch*.

Secondary succession

Secondary succession is the development of a community which forms after the existing natural vegetation that constitutes a community is removed, disturbed or destroyed by a natural event like hurricane or forest fire or by human related events like tilling or harvesting land.

A secondary succession is relatively fast as, the soil has the necessary nutrients as well as a large pool of seeds and other dormant stages of organisms.

Homeostasis of Ecosystem

Ecosystems are capable of maintaining their state of equilibrium. They can regulate their own species structure and functional processes. This capacity of ecosystem of self-regulation is known as **homeostasis**. In ecology the term applies to the tendency for a biological system to resist changes.

For example, in a pond ecosystem if the population of zooplankton increased, they would consume large number of the phytoplankton and as a result soon zooplankton would be short supply of food for them. As the number zooplankton is reduced because of starvation, phytoplankton population starts increasing. After some time the population size of zooplankton also increases and this process continues at all the trophic levels of the food chain.

Note that in a homeostatic system, negative feedback mechanism is responsible for maintaining stability in an ecosystem. However, homeostatic capacity of ecosystems is not unlimited as well as not everything in an ecosystem is always well regulated. Humans are the greatest source of disturbance to ecosystems.

Fundamental Concepts and Principles of Ecology

There are certain basic fundamental ecological principles which describe various aspects of living organisms e.g. evolution and distribution of plants and animals, extinction of species consumption and transfer of energy in different components of biological communities, cycling and recycling of organic and inorganic substances, interactions and inter relationships among the organisms and between organisms and physical environment etc.

Some important fundamental concepts and principles of ecology in terms of eco-system may be outlined as follows:

1. Eco-system is a fundamental well-structured and organised unit that brings physical environment and living organisms together in a single framework which facilitates the study of interactions between biotic and abiotic components. Ecosystems are also functional units where in two biotic components, namely autotrophic and heterotrophic components are of major significance.

2. The biotic and abiotic components of biosphere ecosystem are intimately related through a series of large scale cyclic mechanisms which help in the transfer of energy, water, chemicals and sediments in various components of the biosphere.

3. Sustained life on the earth is a characteristic of eco-system, not of individual organisms or population.

4. In 1974, M. J. Holliman suggested four environmental principles to describe holistic nature of natural environment which largely influence the biological communities in a biosphere eco-system.

The different principles are as follows:

(i) Nothing actually disappears when we throw it away because all the materials are rearranged and cycled and recycled through a series of cyclic pathways in the natural environment.

(ii) All systems and problems are ultimately if not intimately, inter-related. It does not make squabble over which crisis is most urgent. We cannot afford the luxury of solving problems one by one that is both obsolete and ecologically unsound anyway.

(iii) We live on a planet earth whose resources are finite.

(iv) Nature has spent literally millions of years refining a stable eco-system.

5. According to D. B. Botkin and E.A. Keller (1982) the physical and biological processes follow the principle of uniformitarianism. This principle states that same physical (right from the origin of the planet, earth and its atmosphere) and biological (since the origin of first organism) processes which operate today, operated in the past not necessarily with constant magnitude and frequency with time and will operate in future but at rates that will vary as the environment influenced by human activity.

6. Natural hazards affect adversely the biological communities in general and man in particular when biological processes are associated with natural hazards, yet severe hazards are created.

7. All living organisms and physical environment are mutually reactive. The varying degrees of interactions among organisms, at both inter and intraspecific levels are positive, negative and sometimes neutral.

8. Solar radiation is the main driving force of the eco-system and it is trapped by green plants through the process of photo-synthesis. Energy flow in eco-system is unidirectional and non-cyclic. Eco-system energy flow (energetics) helps eco-system. The energy pattern and energy flow are governed by the laws of thermodynamics.

9. The energy is transferred from one trophic level to the next higher trophic level but organisms at higher trophic levels receive energy from more than one trophic level.

10. R. L. Linderuan (1942) suggested some principles about the relationships between the trophic levels within a natural ecosystem.

(i) **Principle-1:** With an increase in distance between the organisms of a given trophic level and the initial source of energy, the probability of the organisms to depend exclusively on the preceding trophic level for energy decreases.

(ii) **Principle-2:** The relative loss of energy due to respiration is progressively greater to higher trophic levels because the species at higher trophic levels being relatively larger in size have to move and work for getting food and therefore more energy is lost due to respiration.

(iii) **Principle-3:** Species at progressively higher trophic levels appear to be progressively more efficient in using their available food supply, because increased activity by predators increases their chances of encountering suitable prey species, and in general predators are less specific than their prey in food preference.

(iv) **Principle-4:** Higher trophic levels tend to be less discrete than the lower ones because the organisms at progressively higher trophic levels receive energy from more than one source and are generalists in their feeding habit and they are more efficient in using their available food.

(v) **Principle-5:** Food-chains tend to be reasonably short. Four vertical links is a common maximum because loss of energy is progressively higher for higher trophic levels and species at higher levels tend to be less discrete.

11. The inorganic and organic substances are circulated among the various components of biosphere through a series of closed system of cycles collectively known as bio- geochemical cycles.

12. The eco-system productivity depends on two factors:

(i) The availability of the amount of solar radiation to the primary producers at trophic level-I.

(ii) The efficiency of the plants to convert solar energy into chemical energy.

There is marked positive correlation between primary productivity and solar radiation.

13. There is inbuilt self-regulating mechanism in natural ecosystem, known as homeostatic mechanisms, through which any change caused by external factors in the eco-system is counter balanced by the responses of the system to the change in such a way that ultimately eco-system or ecological stability is restored. The ecological diversity and complexity enhance ecological or eco-system stability.

The ecological stability can be attained by the following manners:

(i) According to C. S. Elton (1958), increase in the diversity of food webs promotes ecosystem stability.

(ii) According to P.H. MacArthur (1955), the ecosystem stability increases with increase of number of links in the food web.

(iii) According to E.P. Odum (1971), high species diversity of a mature ecosystem representing a climax community is related to more stability of natural eco-system.

14. Eco-system instability results when an eco-system becomes unable to adjust with environmental changes.

15. According to Charles Darwin (1859), evolution of species epitomises the inherently dynamic nature of ecosystem.

16. Darwin's concept of progressive evolution of species was subsequently challenged by Devries and a new concept of mutation was proposed. Mutation is a process of spontaneous evolutionary change which introduces inheritable variations in species.

T. Dobzhansky (1950) suggested the following ideas regarding mutation:

(i) The mutation process furnishes the raw materials for evolution.
(ii) During sexual reproduction, numerous gene patterns are produced.
(iii) The possessors of some gene patterns have greater fitness than the possessors of other patterns in available environment.
(iv) The frequency of superior gene patterns is increased by the process of natural selection while the inferior gene patterns are suppressed.
(v) Groups of some combinations of proven adaptive worth become segregated into closed genetic system, called species.

17. The transition stages of sequential changes from one vegetation community to another vegetation community are called 'sere'. The sere is complete when the succession of vegetation community after passing through different phases, culminates into equilibrium condition. The vegetation community developed at the end of succession is called 'Climax vegetation' or 'Climax community'

18. Besides community succession, the eco-system also undergoes the process of successional changes. There are two fundamental ideas regarding the process of successional changes.

(i) According to E.P. Odum (1962), ecological succession is one of the most important processes which results from the community modifying the environment,
(ii) According to R. H. Whittaker (1953), the successional development of ecosystem is characterised by four major changes in the ecosystem viz.

(a) Progressive increase in the complexity and diversity of community;
(b) Progressive increase in the structure and productivity of the eco-system;
(c) Increase in soil maturity;
(d) Increase in relative stability and regularity of populations within the eco-system and stability of the eco-system itself.

19. The eco-system is mainly modified by man through the exploitation of natural resources. Man reduces ecological diversity and complexity by removing a host of biotic communications.

20. Preserving diversity in a world of rapidly shrinking resources will require a prompt and universal response on an appropriate application of ecological knowledge.

Biotic Regions (or) Biomes of the World

Biome is defined by a broad-scale collection of flora and fauna that although different in detail from ecosystem to ecosystem share some commonalities. Ecosystems within a biome are often similar in nutrients and energy available to plants and animals. This leads to similar types of flora and fauna across the biome, even though individual ecosystems within the biome differ in scale, structure, and function.

The contraction or expansion of biome pattern and distribution is not solely a function of changing temperatures; it also displays changes in atmospheric pressure, humidity, and amount of precipitation, wind directions, and other atmospheric factors. Biomes are also strongly controlled by the type of soil and other aspects related to the lithosphere, hydrosphere, and cryosphere.

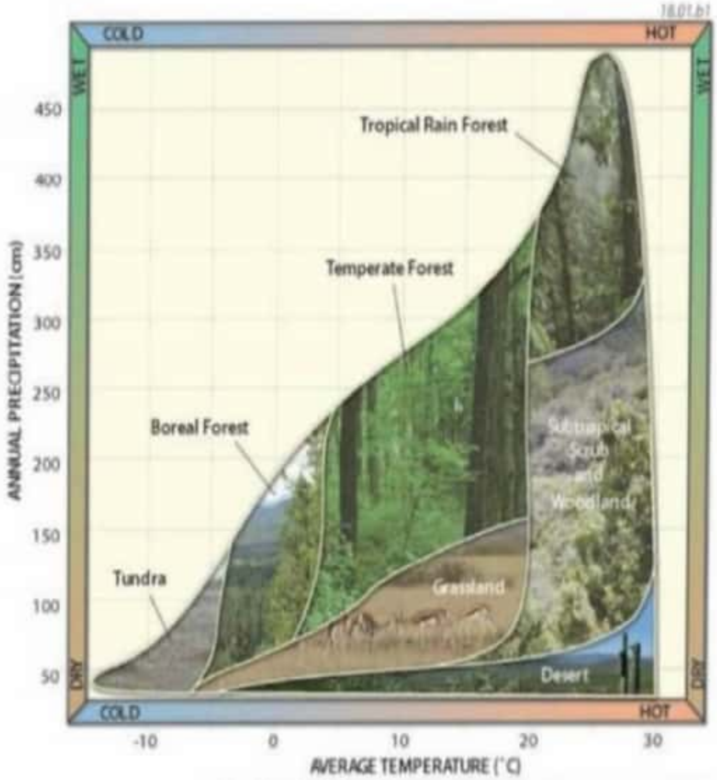
Ecosystems fall into two major groups, aquatic and terrestrial. Aquatic ecosystems include marine environments and the freshwater environments of the lands. Marine ecosystems include the Open Ocean, coastal estuaries, and coral reefs. Freshwater ecosystems include lakes, ponds, streams, marshes, and bogs. *Terrestrial ecosystems*, which are dominated by land plants spread widely over the upland surfaces of the continents.

We divide terrestrial ecosystems into **biomes**. There are four principal biomes: ***(a) forests (b) grasslands, (c) deserts and (d) tundra***

Mean annual temperature and precipitation set broad limits on what biomes exist, and so can be used to predict what biome is likely in a specific regime of temperature and precipitation. Local features and other environmental conditions, however, are also important and make the actual life-environment relationship much more complex.

This diagram plots average annual temperature versus the annual average amount of precipitation for terrestrial biomes. Cold and dry conditions plot in the lower left part of the diagram, hot and dry plot in the lower right, and hot and wet plot in the upper right. Note that there are no biomes—or regions on Earth—that are very cold and also have high precipitation. Very cold air simply has a water-vapor capacity too low for such a regime to occur.

The cold and dry extremes are represented by the *tundra biome*. Somewhat warmer and overall wetter conditions are in the *boreal forest biome*.



Hot and wet conditions (high average amounts of precipitation) result in the *rain forest biome*, with its dense vegetation and high biodiversity.

If conditions are equally warm, but there is less overall—and commonly more seasonal—rainfall, then it results in the *subtropical scrub and woodland biome*.

Moderate temperatures and moderate amounts of precipitation favor the temperate forest biome. Under even drier conditions are the *desert biome* (hot and dry) and *grassland biome* (not quite as hot and not quite as dry as a desert).

1. Forest Biome

Forests are large areas supporting rich growth of trees. Depending on the climate and type of trees they are generally grouped into:

1. Tropical rain forests
2. Temperate deciduous forests
3. Boreal or north coniferous forests

Tropical rain forest

The tropical rain-forest occupies low-altitude areas near the equator in South America, Central and West Africa, and in the Indo-Malay peninsula and New Guinea regions. Although these areas are physically isolated, the forest growing in them shows great similarity of structure and function. These are found in the high rain fall areas on either side of the equator, having high temperature and high humidity and receive above 200 cm of rainfall per year. Soil is rich in humus.

It is a broad-leaved evergreen forest of dense, prolific growth and an extremely diverse fauna and flora. The hot, wet tropical climate is highly conducive to plant growth and there is very little seasonality which means that the growing period extends throughout the year.

All green plants strive to reach the light so that they either become very tall, or adopt a climbing habit or live as *epiphytes* (plants living on other plants but not deriving food from them). The dominant trees are extremely varied in species but have similar appearances, typically characterised by buttress roots, dark leaves and a thin bark. The leaves possess thick cuticles for protection against the strong sunlight, and drip tips whose probable function is to shed water rapidly, thereby aiding transpiration.

These forests have a very rich biodiversity e.g. Brazilian tropical rain forests have more than 300 species of trees in an area of 200 square kilometer. Trees are tall growing up to 50 to 60 m. These forests also support epiphytes, like vines, creepers, woody creepers and orchid etc. These forests are rich in tree dwelling animals such as monkeys, flying squirrels, snails, centipedes, millipedes, and many insect species are common on the forest floor. Many snakes and mammals are adapted to live in the trees because this is where the bulk of the foliage exists.

Providing the tropical rain-forest is undisturbed it is the most diverse and productive type of forest ecosystem, but if the canopy is depleted the soils soon become infertile. Nutrient cycling is rapid, as the vegetation is demanding, and decomposition is accomplished quickly by bacterial action.

(c)

Temperate deciduous forests

This type of forest, dominated by broad-leaved deciduous trees, had a great extent in the past when it covered most of the temperate areas of Europe, eastern North America, eastern Asia and small parts of

South America and Australia. The temperate deciduous forest has probably been more modified by human activity than any other type of ecosystem.

Temperate deciduous forest consists largely of trees that drop their leaves during the cold season. It is characteristic of the marine west-coast and moist continental climates.

There is a longer growing season, higher light intensity and a moderate amount of precipitation of between 50 and 150 cm per annum. The temperature regime is also characterised by lack of extremes but there is still a marked cold season which plants and animals must endure. The climatic zone it occupies is less extreme than that of the boreal forest.

Trees common to the deciduous forest of eastern North America, southeastern Europe, and eastern Asia are oak, beech, birch, hickory, walnut, maple, elm, and ash. Where the deciduous forests have been cleared by lumbering, pines readily develop as second-growth forest.

In Western Europe, the mid-latitude deciduous forest is associated with the marine west-coast climate. Here, the dominant trees are mostly oak and ash, with beech found in cooler and moister areas. In Asia, the mid-latitude deciduous forest occurs as a belt between the boreal forest to the north and steppe lands to the south. A small area of deciduous forest is found in Patagonia, near the southern tip of South America.

Larger amounts of nutrients are used and their movement is more rapid. There is a bulk return of nutrients from the trees with the leaf fall of autumn. Characteristically the leaf litter is nutrient-rich and decays by the action of bacteria to form mull humus. The soils associated with the temperate deciduous forest are varied but on the whole they are brown earths.

Boreal Forest or north coniferous forests:

Boreal forest is the cold-climate needle leaf forest of high latitudes .It occurs in two great continental belts, one in North America and one in Eurasia. These belts span their land masses from west to east in latitudes 45° N to 75° N and they closely correspond to the region of boreal forest climate.

The area occupied by this formation has been subjected to severe glacial or periglacial activity and has much subdued relief and surface water. The conditions for life are harsh because of the adverse climate. The growing season is only of three or four months' duration and even during this time; the energy input from solar radiation is small because of the high latitude. Temperatures are low throughout the year, although the average temperature of the warmest month of the year is higher than 10° C. In the winter the temperatures fall too many degrees below freezing and permafrost frequently extends into the northern edge of the forest. Precipitation ranges from 40 to 70 cm per annum, mostly falling as snow, the weight of which may cause mechanical damage to the trees.

Despite the climate, coniferous trees forms dense canopies which intercept a great amount of light and precipitation so that conditions beneath are dark and dry. Consequently there is little opportunity for undergrowth to develop and very few other plants are associated with the coniferous trees.

The boreal forest of North America, Europe, and western Siberia is composed of such evergreen conifers as spruce and fir, while the boreal forest of north-central and eastern Siberia is dominated by larch. The larch tree sheds its needles in winter and is thus a deciduous needle leaf tree.

The combination of coniferous dominants which are low in nutrient demand, the lack of diversity, and the climatic conditions, results in slow, impoverished nutrient cycles. Most decomposition is fungal since bacterial activity will be slow in these conditions, and the resulting humus is the mor type. Characteristically the boreal forest is found growing on podzols which tend to become highly acidic.

(a)

Monsoon forest:

Monsoon forest, also called **dry forest** or **tropical deciduous forest**. It is typically open, but grades into woodland, with open areas occupied by shrubs and grasses .Monsoon forest of the tropical latitude zone differs from tropical rainforest in that it is *deciduous*; that is, most of the trees of the monsoon forest shed their leaves due to stress during the long dry season, which occurs at the time of low Sun and cool temperatures.

This forest develops in the wet-dry tropical climate, where a long rainy season alternates with a dry, rather cool season. They are located in the monsoon climate beyond the equatorial region between 10° and 25 ° and North and South of the equator. The countries are along the coastal regions of southwest India, Sri Lanka, Bangladesh, Myanmar, Thailand, and Cambodia, South western Africa, French Guiana, and northeast and south-eastern Brazil.

In the monsoon forest of southern Asia, the teakwood tree was once abundant, but it was cut down and the wood widely exported to the Western world to make furniture, paneling, and decking.

2. Grassland Biome

Grasslands are areas dominated by grasses. They occupy about 20% of the land on the earth surface. Grasslands occur in both in tropical and temperate regions where rainfall is not enough to support the growth of trees. Grasslands are known by various names in different parts of the world. Grasslands are found in areas having well defined hot and dry, warm and rainy seasons

Place	Name Of The Grass Land
1. North America	Prairies
2. Eurasia	Steppes
3. Africa	Savanna
4. South America	Pampas
5. India	Grass Land, Savanna

Grassland ecosystems contrast with forest ecosystems in several ways. They have a much smaller biomass, of which a large percentage is made up of roots. Grasses are probably not as effective at precipitation interception as trees, except for the period of maximum growth. The grass form facilitates stem flow, and surface run-off is greater from grass-covered than from forested slopes. The annual primary productivity of a grassland ecosystem is only about an eighth or ninth of an adjacent forest area. The smaller standing crop also means that there are more limited nutrient reservoirs in grassland.

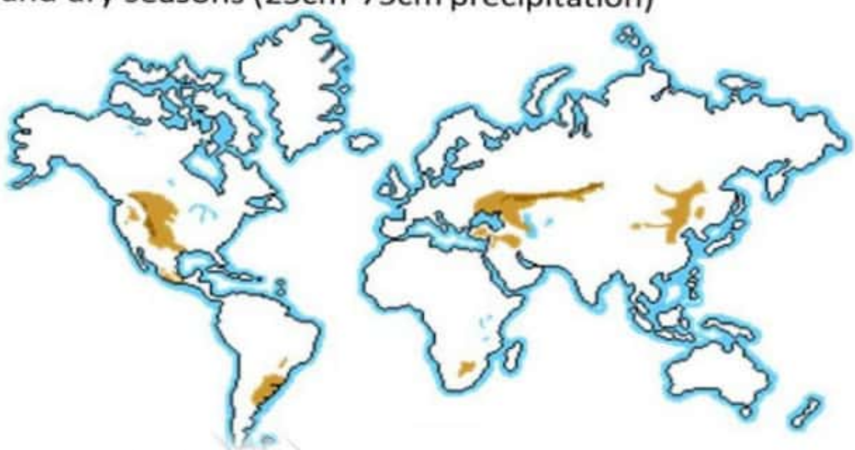
Two main types of grassland are normally distinguished: *temperate grasslands*, in which woody growth is absent or negligible, and *tropical grassland (savanna)* in which scattered trees are much more common.

Temperate Grasslands

These include the prairies of North America, the steppes of Eurasia, the pampas of South America, and the veldt of South Africa. Smaller tracts occur in Australia and New Zealand. Precipitation in these areas ranges from 25 to 100 Cm per annum, and the grasslands extend over a wide range of soil conditions. Trees only occur on steep slopes or near water. The geographical isolation of these areas from each other has led to some species differentiation, but most other features are similar.

Temperate Grassland

- Average Temperature: 0°C - 25°C.
- Nutrient rich top soil (good for farming)
- Warm to hot summers and cool to cold winters
- Wet and dry seasons (25cm-75cm precipitation)



The animals of the grassland are distinctive, and feature many grazing mammals. The grassland ecosystem supports some rather unique adaptations to life .Animals such as jackrabbits and jumping mice have learned to jump or leap, to gain an unimpeded view of their surroundings.

Tall grass prairie is a ground cover of tall grasses along with some broad-leafed herbs, named *forbs*. **Steppe**, or short-grass prairie, consists of sparse clumps of short grasses. Steppe grades into semi desert in dry environments and into prairie where rainfall is higher. Steppe grassland is concentrated largely in the mid-latitude areas of North America and Eurasia.

Prairie grasslands are associated with the drier areas of moist continental climate, and steppe grasslands correspond well with the semiarid subtype of the dry continental climate. The Pampa region falls into the moist subtropical climate with mild winters and abundant precipitation.

This grassland biome includes tall-grass and short-grass prairie (steppe). Tall-grass prairie provides rich agricultural land suited to cultivation and cropping. Short-grass prairie occupies vast regions of semi desert and is suited to grazing.

Tropical grasslands (Savannas):

Tropical grasslands are commonly called Savannas. They occur in eastern Africa, South America, Australia and India. Savannas form a complex ecosystem with scattered medium size trees in grass lands.

The **savanna biome** is usually associated with the tropical wet-dry climate of Africa and South America. Its vegetation ranges from woodland to grassland. In *savanna woodland*, the trees are spaced rather widely apart because there is not enough soil moisture during the dry season to support a full tree cover. The woodland has an open, park like appearance. Savanna woodland usually lies in a broad belt adjacent to equatorial rainforest.

Savanna biome vegetation is described as rain-green. Fires occur frequently in the savanna woodland during the dry season, but the tree species are particularly resistant to fire. The much greater diversity of tropical as opposed to temperate grasslands is often a function of the added variety afforded by wooded plants. In some cases the tree cover may be as much as 50 per cent; in others it may be nil. Marked contrasts exist in the appearance of the savanna during the year: the brown and withered short grasses of the dry season give way rapidly to tall lush growth with the arrival of the summer rains. The Ferralsolic soils of savanna areas frequently include near-surface lateritic crusts, creating an impermeable surface soil layer in which nutrients, especially phosphates and nitrates, are markedly lacking.

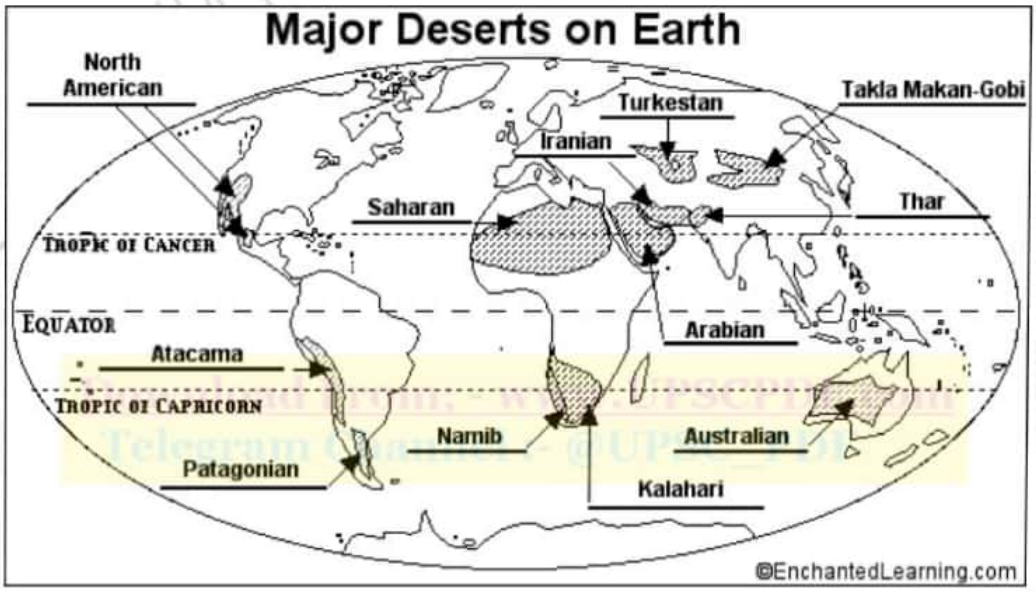
As in the case of prairies, tropical grasslands tend to show little ecotone development, especially on margins adjacent to tropical rain-forest. Overall, savanna boundaries on all continents reveal only poor correlation with precipitation amounts or the duration of the rainy season.

The African savanna is widely known for the diversity of its large grazing mammals. With these grazers come a large variety of predators—lions, leopards, cheetahs, hyenas, and jackals. Elephants are the largest animals of the savanna and adjacent woodland regions.

Savannas found in Africa, Australia, South America and India

3. Desert biome

The desert is a highly evolved ecosystem that supports a multitude of plants and animals. The desert biome includes semi desert and dry desert and occupies the tropical, subtropical, and mid-latitude dry climates. Desert plants vary widely in appearance and in adaptation to the dry environment. Deserts are hot and low rain areas suffering from water shortage and high wind velocity. Annual rain fall is very little. It may be less than 25 cm per annum. At some places if it is high it is unevenly distributed. They show extremes of temperature. Globally deserts occupy about 1/7thof the earth's surface.



The **desert biome** includes several formation classes that are transitional from grassland and savanna biomes into vegetation of the arid desert.

Semi desert is a transitional formation class found in a wide latitude range, from the tropical zone to the mid-latitude zone. Semi desert consists primarily of sparse xerophytic shrubs. One example is the sagebrush vegetation of the middle and southern Rocky Mountain region and Colorado Plateau.

Dry desert is a formation class of plants that are widely dispersed over the ground. It consists of small, hard-leafed, or spiny shrubs, succulent plants (such as cactus), and/or hard grasses. Many species of small annual plants appear only after rare and heavy downpours.

Desert plants around the world look very different from each other. In the Mojave and Sonoran deserts of the southwestern United States, for example, plants are often large, giving the appearance of woodland.

Desert animals are insects, reptiles, and burrowing rodents. Desert shrew, fox, kangaroo, wood rat, rabbit; armadillo are common mammals in desert. Camel is known as the ship of the desert as it can travel long distances without drinking water for several days.

Adaptations: Desert plants are hot and dry conditions.

(i) These plants conserve water by following methods:
- They are mostly shrubs.
- Leaves absent or reduced in size.
- Leaves and stem are succulent and water storing.
- In some plants even the stem contains chlorophyll for photosynthesis.
- Root system well developed spread over large area.

(ii) The animals are physiologically and behaviorally adapted to desert conditions.
- They are fast runners.
- They are nocturnal in habit to avoid the sun's heat during day time.
- They conserve water by excreting concentrated urine.
- Animals and birds usually have long legs to keep the body away from the hot ground.
- Lizards are mostly insectivorous and can live without drinking water for several days.
- Herbivorous animals get sufficient water from the seeds which they eat.

4. Tundra biome

The word tundra means a "barren land" since they are found in those regions of the world where environmental conditions are very severe. There are two types of tundra- **arctic** and **alpine.**

- ✓ **Arctic tundra** extends as a continuous belt below the polar ice cap and above the tree line on the northern hemisphere. It occupies the northern fringe of Canada Alaska, European Russia, and Siberia and island group of Arctic Ocean.
- ✓ **Alpine tundra** occurs at high mountain peaks above the tree line. Since mountains are found at all latitudes therefore alpine tundra show day and night temperature variations

Permanently frozen subsoil called permafrost is found in the arctic and Antarctic tundra. The summer temperature may be around 15°C and in winter it may be as low as –57°C in arctic tundra .A very low precipitation of less than 400 mm per year .A short vegetation period of generally less than 50 days between spring and autumn frost. Productivity is low.

Typical vegetation of arctic tundra is cotton grass, sedges, dwarf heath, willows birches, and lichens. Animals of tundra are hurepian reindeer, musk ox, arctic hare, caribous, lemmings and squirrel. Their body is covered with fur for insulation; Insects have short life cycles which are completed during favourable period of the year.

Most of them have long life e.g. *Salix arctica* that is arctic willow has a life span of 150 to 300 years. They are protected from chill by the presence of thick cuticle and epidermal hair. Mammals of the tundra region have large body size and small tail and ear to avoid the loss of heat from the surface.

AQUATIC BIOMES

An aquatic ecosystem refers to plant and animal communities' occurring in water bodies. Aquatic ecosystems are classified on the basis of salinity into following two types:

- ✓ Freshwater
- ✓ Marine

Fresh water ecosystem

Water on land which is continuously cycling and has low salt content is known as fresh water and its study is called limnology.

i. Static or still water (Lentic) e.g. pond, lake, bogs and swamps.
ii. Running water (Lotic) e.g. springs, mountain brooks, streams and rivers.

Physical characteristics:

Fresh waters have a low concentration of dissolved salts. The temperature shows diurnal and seasonal variations. In tropical lakes, surface temperature never goes below 40^0C, in temperate fresh waters, never goes above or below 4^0C and in polar lakes never above 4^0C.

- In temperate regions, the surface layer of water freezes but the organisms survive below the frozen surface.
- Light has a great influence on fresh water ecosystems. A large number of suspended materials obstruct penetration of light in water.
- Certain animals float upto water surface to take up oxygen for respiration. Aquatic plants use carbon dioxide dissolved in water for photosynthesis.
- Lakes and ponds are inland depressions containing standing water. The largest lake in the world is Lake Superior in North America. Lake Baikal in Siberia is the deepest. Chilka lake of Orissa is largest lake in India.

Three main zones can be differentiated in a lake:-

a. Peripheral zone (littoral zone) with shallow water.
b. Open water beyond the littoral zone where water is quite deep.
c. Benthic zone (bottom) or the floor of the lake.

Aquatic organisms can be floating in water or free swimming or sedentary (fixed), depending on their size and habit. Microscopic floating organisms such as algae, diatoms, protozoans and larval forms are called **plankton.** Rooted aquatic plants, fish, mollusk and echinoderms are bottom dwellers.

Wetlands are areas that periodically get inundated with water and support a flourishing community of aquatic organisms including frog and other amphibians. **Wetlands** are between aquatic and terrestrial ecosystem. *They show an **edge effect** and form a **ecotone**. Ecotone is a transitional zone between two ecosystems.* Swamps, marshes and mangroves are examples of wetlands.

Marine Ecosystem

Oceans cover 70 per cent of the surface area of the world, they are habitable throughout and support a total biomass probably as much as ten times that on land. In many ways, the marine environment is much more favourable to life than land areas; it is more equable, and the two most essential gases for life, oxygen and carbon dioxide, are readily available in water, provided it is not polluted. In addition, many of the nutrient minerals found in the Earth's crust are dissolved in the sea in varying amounts. The main environmental gradients in the sea are related to temperature, salinity, and light intensity.

The most saline conditions occur where temperatures, and hence evaporation, are highest. Many marine organisms have very narrow tolerance ranges to particular salinity concentrations, which may therefore localise them considerably in terms of depth or area. In the open water of the major oceans, the range is much less, from 37‰ in the tropics to 33‰ in polar seas.

Temperature variations in the sea are much less than those on land. The difference between the surface temperature of the warmest seas (32°C) and the coldest (-2°C) gives a range far less than that of land (about 90°C). Both vertical and horizontal ocean currents play a major role in equalizing variations of temperature, salinity and dissolved gases in the oceans, as well as being important factors in the global energy budget.

The availability of light exercises as much fundamental control on the basic process of photosynthesis in the sea as it does on the land. The amount of light reaching the surface varies with latitude and with season; much is lost by reflection from the water surface in high latitudes and when the sea is rough.

Marine plants are confined to the euphotic zone by the light factor. They are far less diverse than land plants, being dominated by algae, with only a few angiosperms present, most of which are found in the near-shore zone. The most obvious and visible types of marine algae are seaweeds, but about 99 per cent of marine vegetation is made up of microscopic floating algae (phytoplankton). These are one-celled organisms containing chlorophyll, and include diatoms and dinoflagellates.

Near-shore areas additionally receive nutrients from rivers. Coastal and estuarine areas therefore have a high productivity and great diversity of plant life, making them among the most fertile parts of the marine ecosystem.

Biodiversity of the marine ecosystems is very high as compared to terrestrial ecosystems. Almost every major group of animals occurs in the sea. Insects and vascular plant are completely absent in marine ecosystem. Maximum diversity of marine organisms is found in the tidal zone that is near the shore. Diatoms, algae, dinoflagellates and jelly fishes are some of the free floating life forms in oceans. Large crustaceans, molluscs, turtles and mammals like seals, porpoises, dolphins and whales are free swimming animals that can navigate. Bottom dwellers are generally sessile (fixed) organisms like sponges, corals, crabs and starfish.

Adaptations:

- Light weight animals and plants float in water and move with the water currents.
- Animals and plants in ocean are tolerant to high concentration of salts (Osmoregulation).Osmoregulation is the process by which a constant osmotic pressure is maintained in blood.
- Swimming animals have streamlined body. Their body is laterally compressed.
- Deep sea forms show bioluminescence (they emit light).
- They are dependent for their food on the upper sea zones.

Human Ecological Adaptations:

Human Ecology is an interdisciplinary and transdisciplinary study of the relationship between humans and their natural, social, and built environments. In order to survive, all societies have to adapt to the opportunities and constraints that their environment presents for them, given their current culture. Successful adaptation can be said to have occurred when all of a society's important values are able to be achieved over the long term.

Because of the fact that humans live in a greater variety of habitats than any other species, it's natural to ask how humans adapt to these varied environments. Human adaption involves both biological and behavioural mechanisms. Human behavioural ability to modify the environment is the major factor that has allowed us to occupy the diverse ecosystems that we do. In fact many of the biological adaptations that we see in humans are adaptations to environmental conditions we ourselves have produced.

Adaptations can occur at a variety of levels.

Genetic adaptations are the changes in the genetic makeup of populations that come about over generations as a result of natural selection. Genetic adaptations are fairly permanent adaptations.

There are also less permanent types of adaptations.

Acclimatization's are changes that come about during the life time of the individual in response to particular environmental stresses. Although the ability to undergo acclimatization has a genetic basis, the actual response does not occur unless the individual experiences the environmental stress. Tanning in response to ultraviolet radiation is a good example of acclimatization.

Developmental adaptations (or Developmental acclimatization) are changes that occur in response to an environmental stress during the period of growth. Because the developmental adaptations usually change the way that some part of the body grows or develops, they are generally more permanent than acclimatization. Adaptation to high latitude involves the developmental adaptation.

Humans exhibit a number of biological adaptations to the great variety of environments they occupy. The best example of human genetic adaptation to climate is skin color, which likely evolved as an adaptation to ultraviolet radiation. Variation among populations in body size and shape also may at least partially relate to adaptation to climate.

One of the most important influences on human adaptation is our ability to modify the environment. This modification both reduces our exposure to physical environment and creates a new environmental condition to which we must adapt. Human modification of the environment has altered our diet and the diseases we get. We see genetic adaptation to the changes, but also failure to adapt. Several of the chronic diseases that are so frequent in industrialized countries may result from the fact that we are consuming diets to which we are not biologically adapted. Our behavioural flexibility and our ability to modify the environment lessen our need for biological adaptations.

Many of the biological characteristics of living organisms evolved during time periods when our technology was much less sophisticated than it is today. Biological characteristics that were limitations under past condition are frequently not limitations today. Conversely, traits that were advantageous in past environments may be detrimental today.