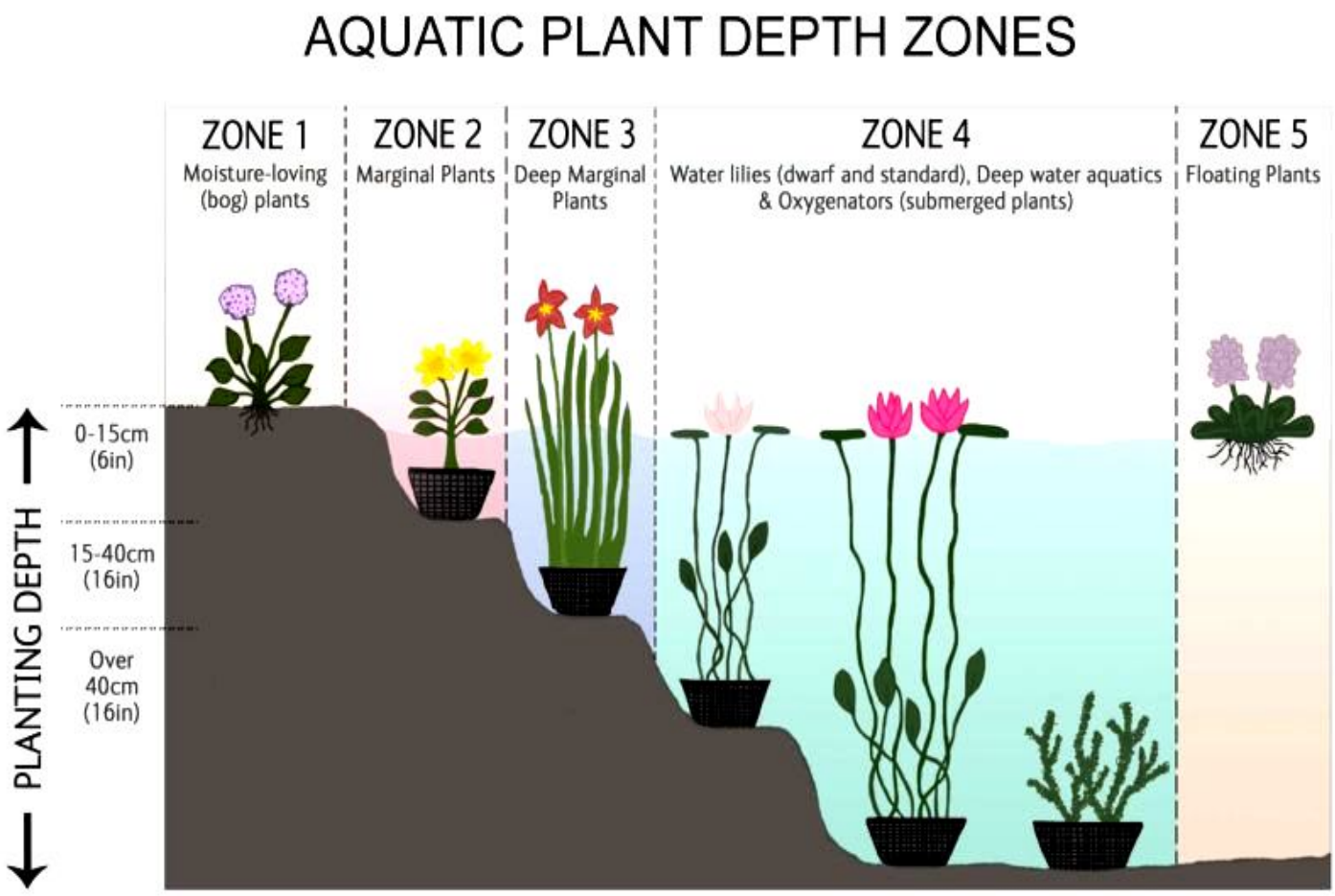
BIOLOGY

for NEET & BOARD



ORGANISM POPULATION

Key Features

1. All-In One Study Material (For Boards/Medical/Olympiads).
2. Concise, Conceptual & Trick – Based Theory.
3. NTA Based Solved Multiple Choice Questions With Answers.

Organism Population

Chapter – 13

India's First Trick Based Study Material

1 INTRODUCTION: ECOLOGY BRANCHES

(a) **Autecology :** Ecology of individuals or species, essentially physiological ecology.
(b) **Synecology :** Study of relationships between communities and environment.
(c) **Genecology :** Study of ecological adaptations in relation to genetic variability.
(d) **Paleoecology :** Study of relationship between organisms and environment in the past.
(e) **Applied ecology :** Application of ecological concepts for human welfare.
(f) **Systems ecology :** Interpretation of ecological concepts in terms of mathematical principles.
(g) **Phytogeography :** Distribution of plants on earth.
(h) **Zoogeography :** Distribution of animals on earth.

SOME IMPORTANT TERMS

- **Habitat** is a specific place (or locality) where an organism usually lives. It is a **physical entity comprising the sum total of the abiotic factors to which a species or a group of species is exposed**
- **Ecological Niche (Concept given by J. Grinnel).** It represents functional role and status of a species in the environment. It represents habitat and trophic position of a species. No two species can have the same niche if they are found in same environment.
- **Population :** Group of individuals of same species in a well defined geographical area which share or compete for similar resources and can potentially interbreed. Their study links ecology to genetics and evolution of a population.
- **Community** : A number of different interrelated populations of different species sharing a common environment.
- **Ecosystem:** A functional unit of nature, where living organisms interact among themselves and with surrounding physical environment.
- **Biosphere** : Any part of atmosphere inhabited by biological organisms.
- **Organisms and its Environment :** Environment is the sum total of all external factors (surroundings), substances and conditions which influence organisms without becoming their constituent part. Environment is usually divided into two parts, **physical environment** and **biotic environment.**

- **Environmental Factors:** Components, conditions and forces of environment which have a direct or indirect effect on the form, functioning, behaviour, survival and reproduction of organisms are called **environmental factors.** They are of two types- abiotic and biotic. **Abiotic factors** are divisible into three categories atmospheric, edaphic and topographic. **Atmospheric factors** are light, temperature, water and wind. **Edaphic factors** are factors related to soil. **Topographic factors** are abiotic or physical factors related to slope, altitude and others concerned with surface of earth. **Biotic factors** include all interactions between living organisms.

2 BIOME (MAJOR ECOSYSTEMS)

- The large natural ecosystem which is distinct in its climatic conditions and has its specific group of climax plants and associated animals constitutes a **biome.**
- Regional and local variations within each biome lead to the formation of a wide variety of habitats.
- Rainfall, temperature range, nature of soil, barriers, latitude and altitude determine the nature and extent of biomes.

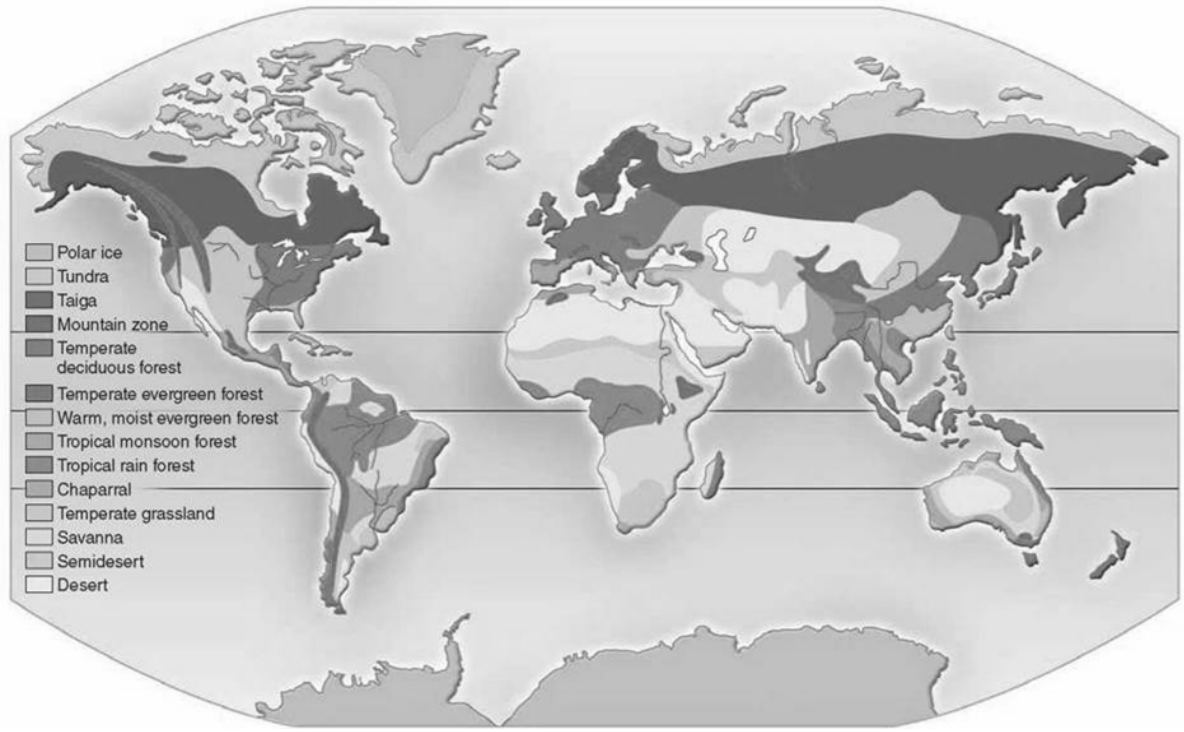


Fig: Distribution of the earth's biomes.

The seven primary types of biomes are tropical rain forest, savanna, desert, temperate grassland, temperate deciduous forest, taiga, and tundra. In addition, seven less widespread biomes are shown.

Major Biomes of India :

1. Tropical Rain forests:

- In India, tropical rain forests are found mainly along western ghats and in North-

Eastern Himalayas.

- ✍ *Dipterocarpus* and *Hopea* are the most common tree species in Indian rain forests.
- ✍ They show 30-40 m tall canopy with 4 -5 strata.
- ✍ These possess highest standing crop among all biomes.

Fig: Tropical rain forest

- ✍ Buttress and leaf drip tip are common
- ✍ Woody climbers and epiphytes grow profusely in these forests.
- ✍ The soil of such forests is highly leached and has low base content, so nutrient storage in soil is low.
- ✍ They require mean annual temperature of **23 -27°C** and **2000 -3500 mm** rainfall.

2. Tropical Deciduous forests:

- ✍ They occur in the northern and southern parts of our country in plains and low hilly areas.
- ✍ Sal, teak, tendu, khair and chiraunji are common trees of these forests.
- ✍ These forests show a short structure of 10-20 mts.
- ✍ During rainy season, the forest is lush green with dense foliage, whereas, in summer forest is largely leafless.
- ✍ The soil of these forest is rich in nutrients due to less leaching.
- ✍ They require a mean annual temperature of 22-32°C and mean annual rainfall of 900-1600mm.

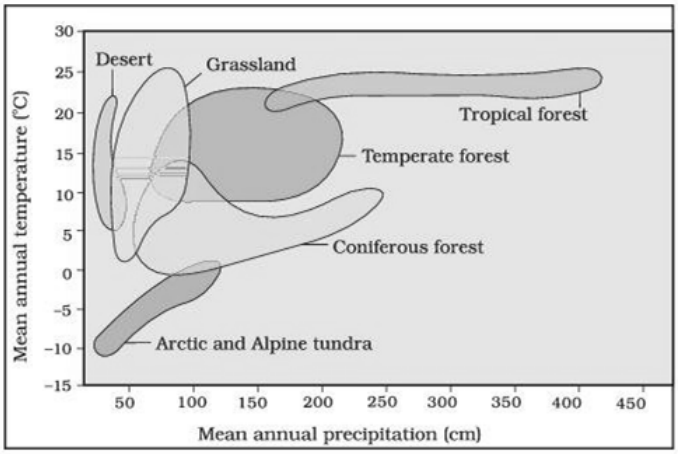


Fig. : Biome distribution with respect to annual temperature and precipitation

3. Desert:

- ✍ In these biomes the vegetation is very sparse due to extremes of temperature and very little rainfall (below 10 cm).
- ✍ Hot deserts are characterised by high rate of evapotranspiration and albedo.
- ✍ In cold deserts, the conditions are physiologically xeric and they exhibit permafrost while in hot deserts the conditions are physically xeric.
- ✍ Important trees of Indian desert are *Prosopis cineraria, Acacia* sp., *Salvadora* sp. and *Tamarix* sp. common succulents are species of *Euphorbia* and many members of family Cactaceae. *Cenchrus* is an abundant grass of these biomes.

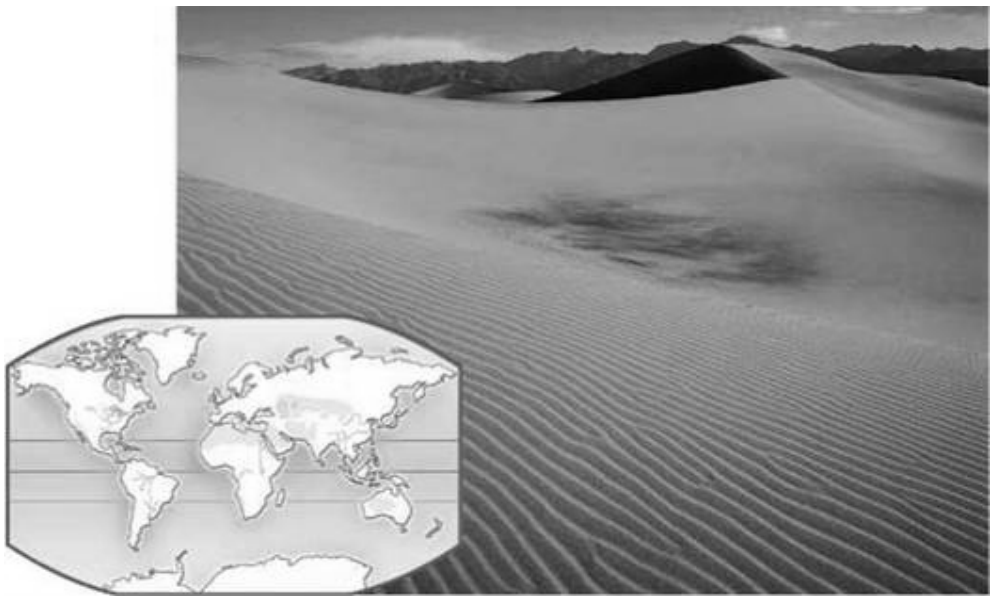


Fig: Desert

4. Coastal Biome :

- ✍ Coastal areas are zones of transition between oceanic and terrestrial habitats, so are very sensitive.
- ✍ These are detritus based biomes, where plants have to adapt for salinity and water logged conditions.
- ✍ [illegible]

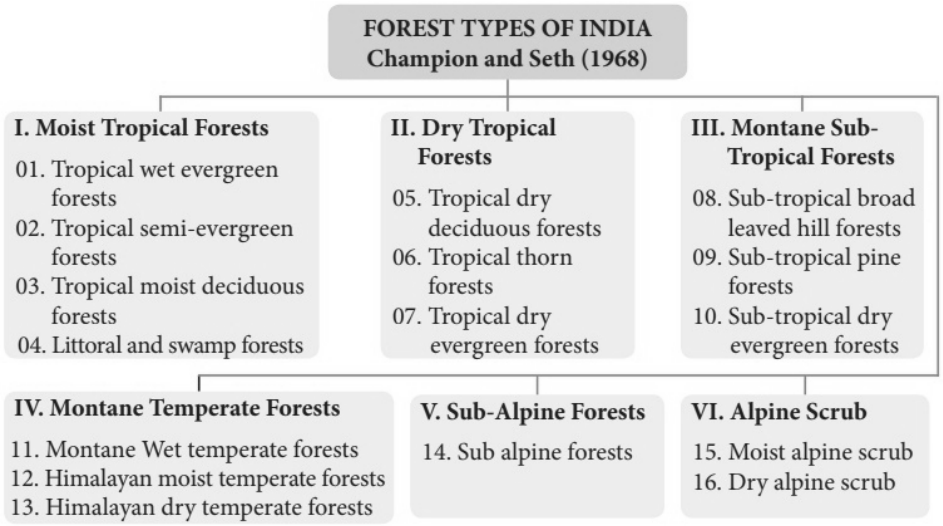
- ✍ Mangrooves are characterized by presence of pneumatophores and viviparous seed germination.
- ✍ Common examples are *Rhizophora, Sonneratia, Avicennia* and *Laguncularia*. Besides this *Phoenix, Pandanus* and *Casuarina* are also found commonly in coastal areas.

5. Temperate Broad Leaf Forests:

- ✍ Between 1500 m -2400 m altitude in western Himalayas predominated by oaks. *e.g., Quercus floribunda* , Q. *lanuginose* etc.
- ✍ They require mean annual temperature of 6 -20°C and mean annual rainfall of 1000-2500 mm.
- ✍ Show peak leaf fall during summer but never become leafless.
- ✍ These have four strata with 25-30 m height and are rich in epiphytic flora.
- ✍ Herbaceous layer is least developed and grasses are generally lacking.

6. Temperate Needle Leaf or Coniferous Forest:

- ✍ Between 1700-3000 m altitude.
- ✍ They require mean annual temperature of 6-15° C and mean annual rainfall of 500-1700 mm.
- ✍ Taller trees (30-35 m) with evergreen canopy.
- ✍ Predominated by economically valuable gymnospermous trees, like -Pine *(Pinus wallichiana),* Deodar *(Cedrus deodara)* , Silver fur *(Abies pindrow),* Spruce *(Picea smithiana)* and Cypress *(Cupressus torulosa).*



Some Important Biomes of the World -A Brief Account

A. Tundra :

- ✍ It is located in the north of timber line or 60º N latitude below the polar ice.
- ✍ It is absent in southern hemisphere.
- ✍ It extends across North America, Europe and Asia.
- ✍ Also called as **arctic tundra**.
- ✍ Subsoil remains frozen except upper few inches in the summers.
- ✍ The condition is called **permafrost**.

- ✍ **Vegetation** is scanty, low growing and devoid of trees and thus, the region is termed arctic desert.
- ✍ Common plants found here are grasses, sedges, mosses and lichens with occasional occurence of dwarf birches *(Betula)* and willows *(Salix).*

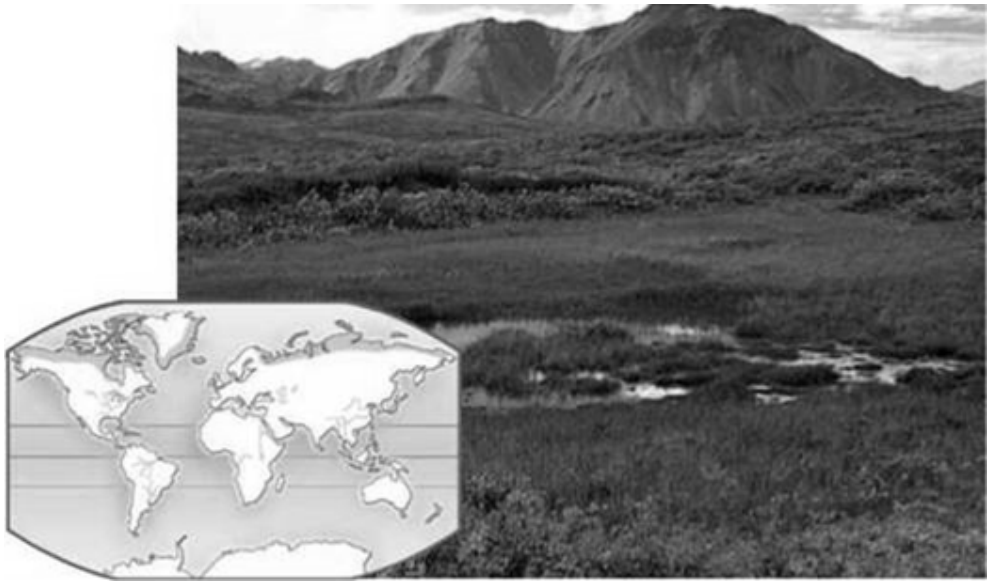


Fig: Tundra

B. Taiga (North coniferous/temperate needle leaf forest) :

- ✍ It stretches as an east west band just south of tundra across North America, Europe and Asia. It is also found in southern hemisphere.
- ✍ Mean annual rainfall is 50-170 cm. In winter, average maximum temperature is 6°C and nights are long and chilly
- ✍ Summers are pleasant with average maximum temperature of 20°C and with long hours of day light.
- ✍ The characteristic feature of this biome is the presence of numerous lakes.
- ✍ Dominant climax vegetation of this biome comprises of tall evergreen conifers with needle-like leaves, capable of tolerating fluctuations in temperature and light intensity.

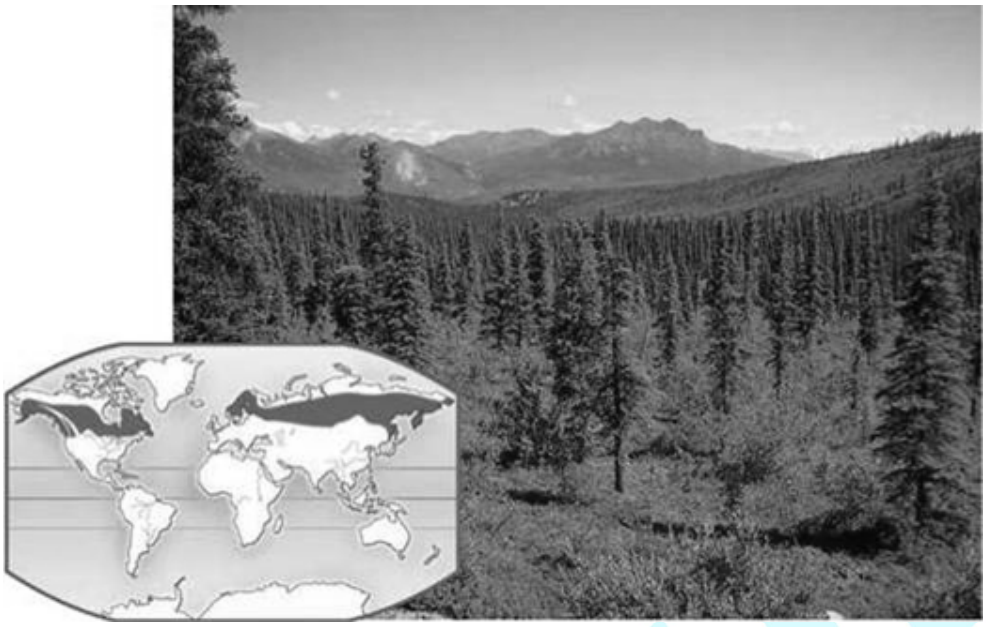


Fig: Taiga

C. Chapparal (Mediterranean scrub forest) :

- ✍ The biome extends along the Mediterranean, Pacific coast of North America, Chile, South Africa and South Australia.
- ✍ Natural fires are characteristic of this biome.
- ✍ Rainfall is very limited, occurs only in winter.
- ✍ The climate remains dry in the rest of the year.

Fig: Chaparral

D. Grasslands:

(a) Savanna: Tropical grassland with well developed grass cover interspersed with scattered shrubs and small trees.

(i) Distributed in warmer parts of India, Africa and Australia.

(ii) Appear in areas with highly seasonal climate having distinct wet and dry periods.

(iii) Abundance of C_4 photosynthetic grasses.

(iv) Common grasses of Indian savannas are -*Dichanthium, Sehima, Phragmites, Saccharum, Cenchrus, Imperata* and *Lasiurus*. Common trees and shrubs are

Zizyphus, Prosopis, Capparis, Acacia and *Butea*.

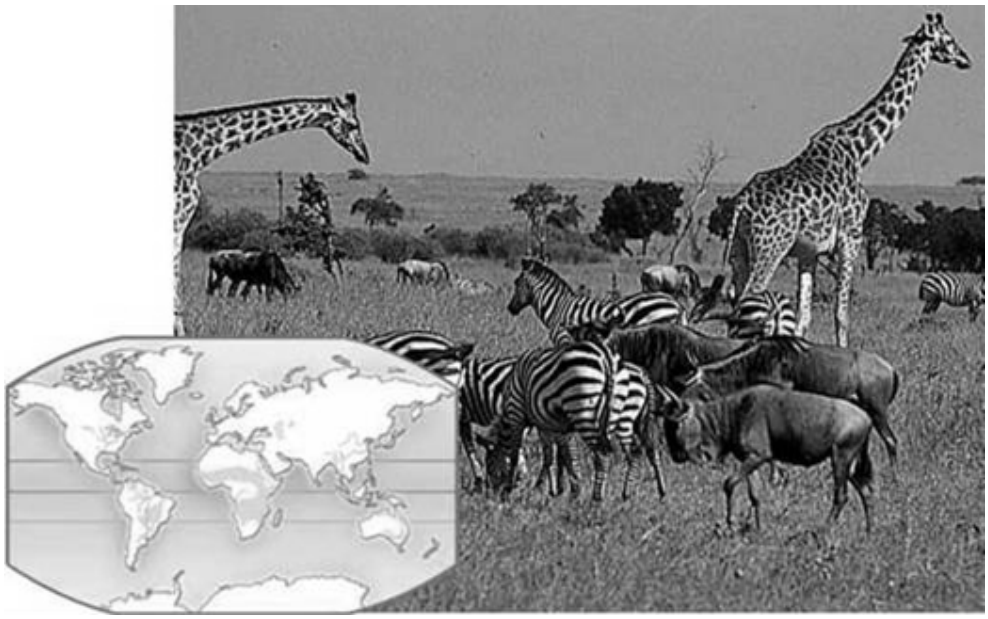


Fig: Savanna

(b) Temperate grasslands : The temperate grasslands are present in North America (Canada and U.S.A.), South America, Eastern Europe, Central Asia, South Africa and Australia. These are of different types depending upon the constituent flora in different countries, such as Prairies (Canada and the WSA), Pampas (South America), Steppes (Europe and Asia), Veldts (South Africa), Tussocks (New Zealand) and Dawns (Australia).

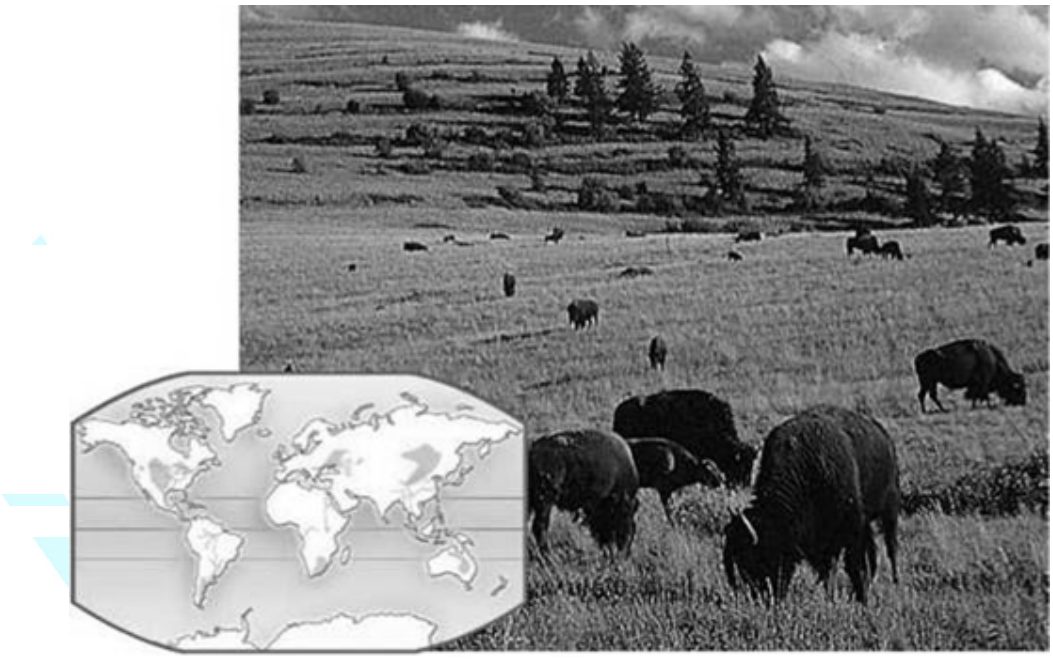


Fig: Temperate grassland

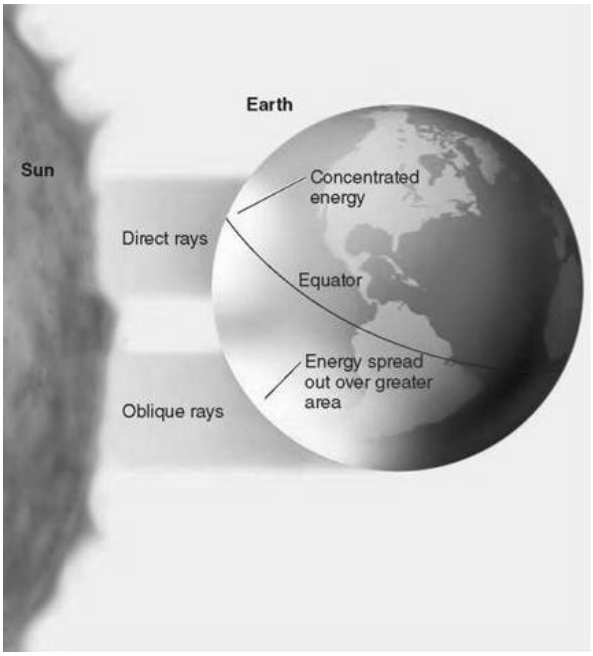
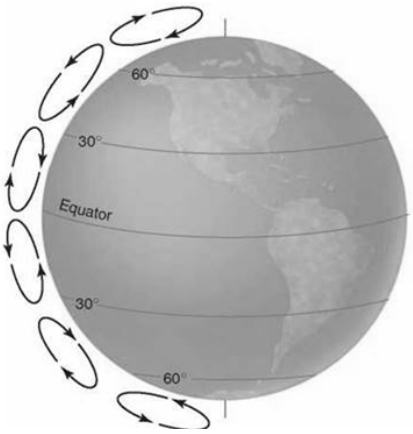


Fig. Latitude affects climate.
The relationship between the earth and sun is critical in determining the nature and distribution of life on earth. The tropics are warmer than the temperate regions because the sun's rays strike at a direct angle, providing more energy per unit of area.



Near the equator, warm air rises and flows toward the poles (indicated by arrows at the equator that rise and circle toward the poles). As it rises and cools, this air loses most of its moisture because cool air holds less water vapor than warm air. (This explains why it rains so much in the tropics where the air is warm.) When this air has traveled to about 30 degrees north and south latitudes, the cool, dry air sinks and becomes reheated, soaking up water like a sponge as it warms, producing a broad zone of low rainfall. It is no accident that all of the great deserts of the world lie near 30 degrees north or 30 degrees south latitude. Air at these latitudes is still warmer than it is in the polar regions, and thus it continues to flow toward the poles. At about 60 degrees north and south latitudes, air rises and cools and sheds its moisture, and such

are the locations of the great temperate forests of the world. Finally, this rising air descends near the poles, producing zones of very low precipitation.

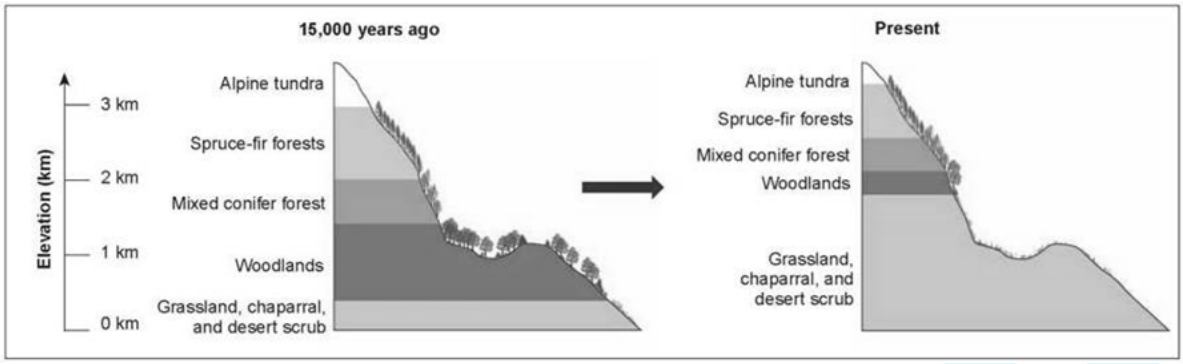


Fig. Altitudinal shifts in population ranges in the mountains of southwestern North America.

During the glacial period 15,000 years ago, conditions were cooler than they are now. As the climate has warmed, tree species that require colder temperatures have shifted their range upward in altitude so that they live in the climatic conditions to which they are adapted.

In addition, populations can expand their ranges when they are able to move from inhospitable habitats to suitable, previously unoccupied areas. For example, cattle egrets native to Africa appeared in northern South America some time in the late 1800s. These birds made the nearly 2,000-mile transatlantic crossing, perhaps aided by strong winds. Since then, they have steadily expanded their range and now can be found throughout most of the United States (figure 35.6).

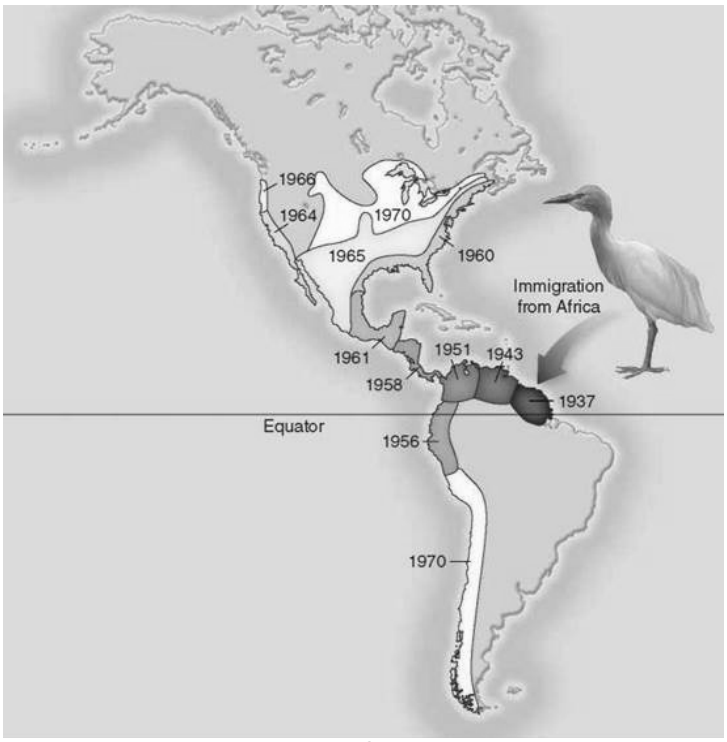


Fig. Range expansion of the cattle egret.

The cattle egret—so-named because it follows cattle and other hoofed animals, catching any insects or small vertebrates that they disturb—first arrived in South America in the late 1800s.

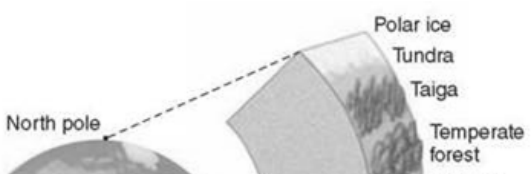


Fig. How elevation affects ecosystems.
The same land ecosystems that normally occur as latitude increases north and south of the equator at sea level (a) can occur in the tropics as elevation increases (b).

RAIN SHADOWS

When a moving body of air encounters a mountain, it is forced upward, and as it is cooled at higher elevations, the air's moisture-holding capacity decreases, producing the rain you see on the windward side of the mountains shown below—the side from which the wind is blowing. Thus, moisture-laden winds from the Pacific Ocean rise and are cooled when they encounter the Sierra Nevada mountains. As the winds cool, their moisture-holding capacity decreases and precipitation occurs.

3 AQUATIC BIOMES

- The aquatic ecosystems range from ocean to small ponds or lakes showing wide range of variations regarding salinity, depth and temperature.
- Consequently the organisms show lot of diversity in their adaptations to the surroundings.
- Aquatic biomes are of four main types:

1. Oceanic or marine biomes:

- ✍ Oceanic biomes occupy more than two third of the earth's surface.
- ✍ The marine environment is characterized by high concentration of salts (about 3.5% in open sea) and mineral ions (mostly Na^+ and Cl^- ions followed by sulphur, magnesium and calcium).

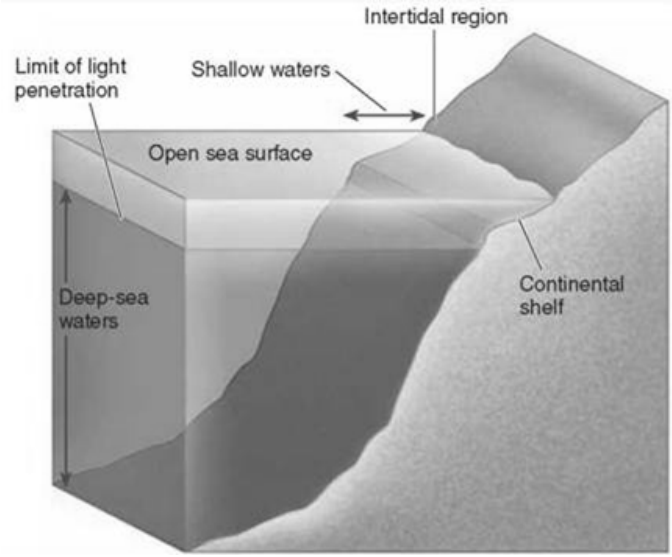


Fig. Ocean ecosystems.

There are three primary ecosystems found in the earth's oceans. Shallow water ecosystems occur along the shoreline and at areas of coral reefs. Open sea surface ecosystems occur in the upper 100-200 meters where light can penetrate. Finally, deep-sea water ecosystems are areas below 300 meters.

- ✍ The productivity of oceanic biome is less than that of most the terrestrial biomes.
- ✍ The ocean basin is always like a wash basin or inverted hat and is differentiated into *continental shelf, continental slope and ocean floor*.

(i) **Continental shelf:** It extends from coastline to about 160 km in the sea, including a gradual sloping area with depth varying from 8-200m. It has high productivity.

(ii) **Continental slope:** It extends beyond continental shelf formed by abrupt steepening of angle of slope. It is characterized by presence of ridges, trenches and basins of mud and sand.

(iii) **Ocean floor:** It is nearly horizontal with deep trenches at places. It is bottom area of open sea.

- ✍ **Oceanic biome is divided into three major ecosystems-open** sea, coastal region and estuary.

(i) **Open sea:** It includes the area of sea beyond continental shelf and is divided into 3 zoneseuphotic, disphotic and abyssal zone depending upon the degree of light penetration. On the basis of environment, it has two **parts-pelagic** (open water zone) and **benthic** (bottom zone).

Both producers and consumers occur in photic zone in abundance, whereas only few producers along with consumers occur in disphotic zone. The abyssal zone is

characterized by the presence of consumers, scavengers and decomposers, while producers are absent.

(ii) **Coastal region** : It is the area of continental shelf and is usually divided into 3 zones: intertidal, littoral and neritic zones.

Intertidal zone is alternately exposed and covered with water. Beaches belong to this zone. Very few plants grow in sandy beaches. Crabs and few burrowing animals occur.

Littoral zone : It represents the floor area of continental shelf. This zone is characterized by strong wave action. Main producers of this area are brown and red algae like *Laminaria, Macrocystis, Nereocystis* and *Gelidium.*

Neritic zone : It comprises the coastal part (near shore area). It contains phytoplankton.

(iii) **Estuary** : Ecotone areas where river mouth meets the oceanic water. This area shows wide fluctuations in salinity due to mixing of fresh and sea-water. Estuary constitutes one of the most productive ecosystems. It includes both fresh water and marine organisms.

2. Ponds and lakes:

- ✍ These are stationary fresh water bodies **(Lentic ecosystems)** on land occur in almost all biomes.
- ✍ **Ponds** vary in size and may be natural or man-made depressions which get filled with rain or run off water.
- ✍ These may be seasonal or permanent.
- ✍ The **lakes** are much larger than ponds and have size of several hundred hectares with depth upto 100 meters.
- ✍ Lakes develop in nature due to three reasons-(i) result of glaciation, (ii) natural or man-made depressions getting filled with water (iii) formed by cut off water from main stream of river and may be termed **ox-bow** or **cut-off lakes.**

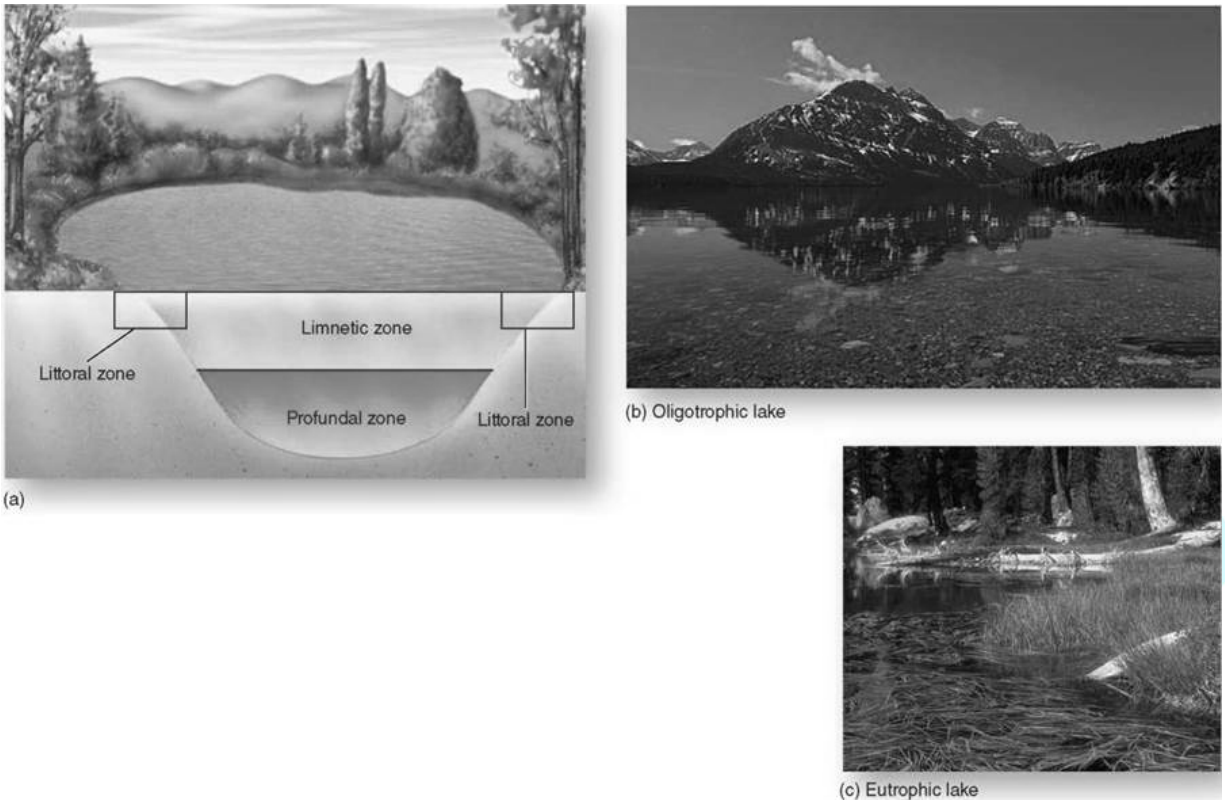


Fig. Characteristics of ponds and lakes.
(a) Ponds and lakes can be divided into three zones based on the types of organisms that live in each. A shallow "edge" (littoral) zone lines the periphery of the lake where attached algae and their insect herbivores live. An open-water surface (limnetic) zone lies across the entire lake and is inhabited by floating algae, zooplankton, and fish. A dark, deep-water (profundal) zone overlies the sediments at the bottom of the lake. The profundal zone contains numerous bacteria and wormlike organisms that consume dead debris settling at the bottom of the lake. Lakes can be oligotrophic (b), containing scarce amounts of organic material, or eutrophic (c), containing abundant amounts of organic material.

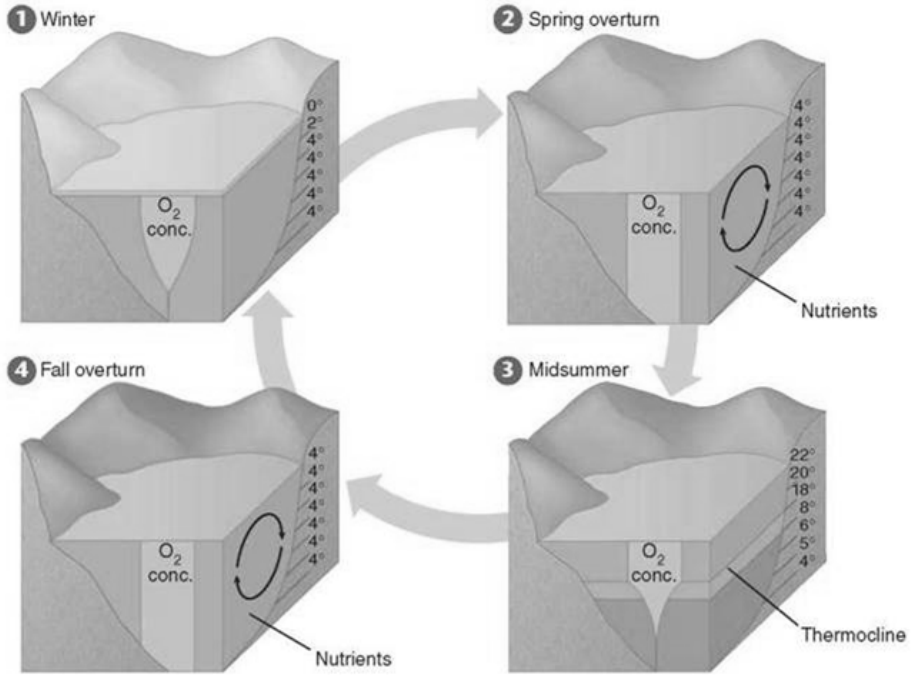


Fig. Spring and fall overturns in freshwater ponds or lakes.

The pattern of stratification in a large pond or lake in temperate regions is upset in the spring and fall overturns. Of the three layers of water shown in midsummer (lower right), the densest water occurs at 4°C. The warmer water at the surface is less dense. The thermocline is the zone of abrupt change in temperature that lies between them. In summer and winter, oxygen concentrations are lower at greater depths, whereas in the spring and fall, they are more similar at all depths.

3. Streams and Rivers:

- These are flowing fresh water bodies (Lotic ecosystems) which differ in physical and chemical conditions, oxygen content, temperature, speed and volume of water.
- River beds having sand are less in productivity than the ones having mud and stones.
- Planktons are very rare in higher reaches due to fast moving water, while these appear in lower reaches when water flow slows down.

4. Marshes:

- These are temporarily produced low lying areas, few cms in depth, containing turbid water.
- These are common on the side of road, railway track, rivers, streams and inside forests.
- Planktons are little due to turbidity of water and temporary nature.
- Amphibious plants are common.

4 MAJOR ABIOTIC FACTORS

- The most important key elements that lead to so much variation in the physical and chemical conditions of different habitats are temperature, light, water and soil.

(A) *Temperature*

- Ecologically it is the most relevant factor, as temperature variation affects the enzyme kinetics, basal metabolic activities and the physiological functions of the organisms.
- So thermal tolerance decides the geographical distribution of different species to a large extent as for example ; mango trees do not and cannot grow in temperate countries like Canada and Germany, snow leopards are not found in kerala forests and tuna fish are rarely caught beyond tropical latitudes in the ocean.
- Based upon thermal tolerance, organisms are of two types:

(i) **Stenothermal :** Such organisms live in areas where the temperature is uniform throughout the year. The organisms cannot tolerate large temperature variation.

(ii) **Eurythermal :** Such organisms can tolerate large changes in temperature.

- The organisms are classified into four temperature groups on the basis of their occurrence in different climatic zones:

(i) **Megatherms :** Organisms are adapted to high temperature throughout the year as found in tropical zone.

(ii) **Mesotherms :** They are adapted to mild winters and high summer temperature. The organisms live in subtropical zone.

(iii) **Microtherms:** They live in temperate areas where the winter temperature is low but the summer temperature is moderate.

(iv) **Hekistotherms:** The organisms are adapted to brief summer period of below 10°C and long snowy winter period. This condition occurs in arctic or alpine zone.

Some Rules Based Upon Effects of Temperature

(i) **Bergman's Rule:** Warm blooded animals (birds and mammals) have larger body size in cold climate than in hotter areas.

(ii) **Allen's Rule:** Extremities (legs, ears, tail and mouth) of warm blooded animals become smaller in colder areas as compared to animals of warmer areas.

(iii) **Rensch's Rule:** In colder climate, birds possess narrow and acuminate wings as compared to broader wings of birds found in warmer areas.

(iv) **Jordan's Rule:** As the temperature is lowered, some fishes possess larger size with larger number of vertebrae.

THERMOPERIODICITY

✍ Thermoperiodicity or thermoperiodism is the response of living organisms to regular changes of temperature.

✍ It is of two types, diurnal and seasonal.

(i) **Diurnal Thermoperiodicity :** It is response of organisms to daily changes of temperature. Generally, day time temperature is higher, while night time temperature is lower.

(ii) **Seasonal Thermoperiodicity :** It is response of organisms to seasonal changes in temperature. Alongwith photoperiodicity, it controls phenology of plants. Phenology is the occurrence of seasonal activities in relation to change in environmental conditions.

Thermal Stratification in Lakes

✍ The occurrence of temperature variations in different horizontal layers as in a deep water body is called **thermal stratification**.

✍ A deep water body like lake has three temperature strata -epilimnion, metalimnion and hypolimnion.

(a) **Epilimnion:** Upper stratum, with highest dissolyed oxygen concentration. This area is warmer during summers.

(b) **Hypolimnion:** Lower stratum of water characterised by a temperature gradient of less than 1°C per meter. It contains more dense, cooler and relatively quite water.

(c) **Metalimnion:** It is transitional stratum of marked thermal fluctuations between hypolimnion and epilimnion. Its middle layer is characterised by temperature gradient of more than 1°C per meter of depth called as thermocline. The term thermocline refers to plane or surface of maximum rate of fluctuations in temperature of metalimnion

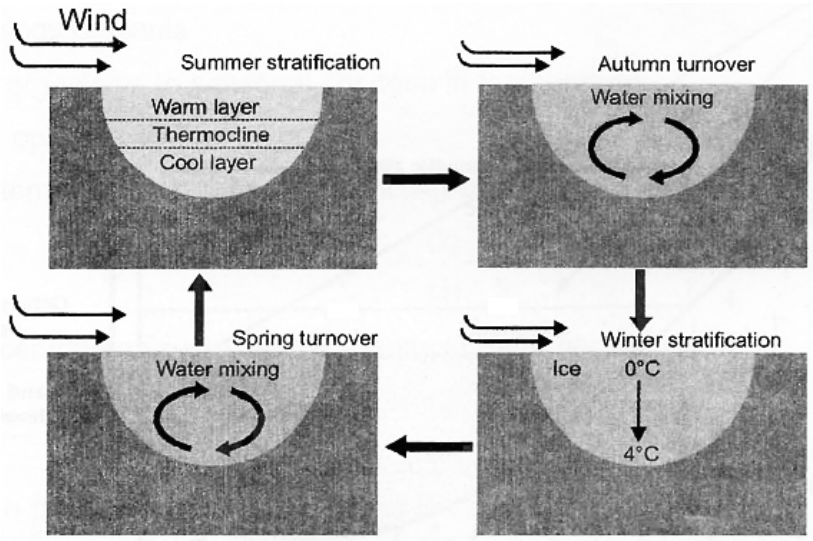


Fig. : Thermal stratification in a temperate lake

(B) Water

- Next to temperature, water is another important factor influencing the life of organisms.
- It is an important component of protoplasm which is a general solvent.
- Water is also present over more than 71% surface of earth as oceans, lakes, rivers, ice caps and glaciers.
- Sea water has high percentage of salt content (3.5%).
- Water present on land is called **fresh water**. Its salt content is low *i.e.*, less than 0.5%.
- The salt concentration (measured as salinity in parts per thousand) is less than 5 percent in inland water, 30 -35 percent for sea and more than 100 percent in some hypersaline lagoons.
- Some organisms are tolerant to a wide range of salinities (euryhaline), but others are restricted to a narrow range (stenohaline).
- Regular movement of water amongst various regions and components of biosphere viz. aquatic systems, air and land constitutes water cycle.
- Water comes over land or water body as precipitation or rainfall.
- The total global rainfall is equal to 4.46 G.
- Precipitation comes from water vapours present in air.
- At any time atmosphere contains only 0.13 G of water vapours (1 G or geogram = 10^{20} gram).

(C) Light

- Light has a wide range of spectrum.
- Electromagnetic spectrum is a complete range of oscillating waves that travel together through space at a speed of 3×10^5 km/sec.
- At 83 km above Earth's surface, solar radiation carries energy equivalent to 2 cal/cm^2/min. This value is called as **solar constant**.
- Short wave radiations are Cosmic Rays (with wavelength less than 10^{-5} nm), gamma rays (10^{-3} to 10^{-5} nm), X-rays (10^{-1} to 10^{-2} nm) and UV rays (100 to 400 nm).

- ✍ All the short wave radiations are extremely harmful. Most of them are trapped in ionosphere and mesosphere.
- ✍ UV rays are also harmful. They are of three types :

Category	Wave length	Effect
UV-C	100-280 nm (0.1 – 0.28 µm)	Lethal
UV-B	280-320 nm (0.28 – 0.32 µm)	Quite harmful
UV-A	320-400 nm (0.32 – 0.4 µm)	Moderately harmful

- ✍ UV-C and about half of UV-B radiations are absorbed by ozone layer of stratosphere.
- ✍ A large amount of the rest is dissipated by particles of troposphere, only a small amount reaches on the Earth.
- ✍ Light affects photosynthesis, growth, reproduction, movements, stratification, photoperiodism and phenology in plants, whereas, it affects migration, reproduction, development, pigmentation, locomotion and periodic activity in animals.

Light Zonation of Lakes :

Littoral zone : Exposed to wave action and is highly productive

Limnetic zone : Open water body, rich in planktons.

Euphotic zone : Receives maximum light above light compensation point.

Disphotic zone : Receive diffuse light at or below light compensation point. Also known as twilight zone.

Profundal (Dark) zone : No light

Benthic zone : It is the bottom zone of perpetual darkness.

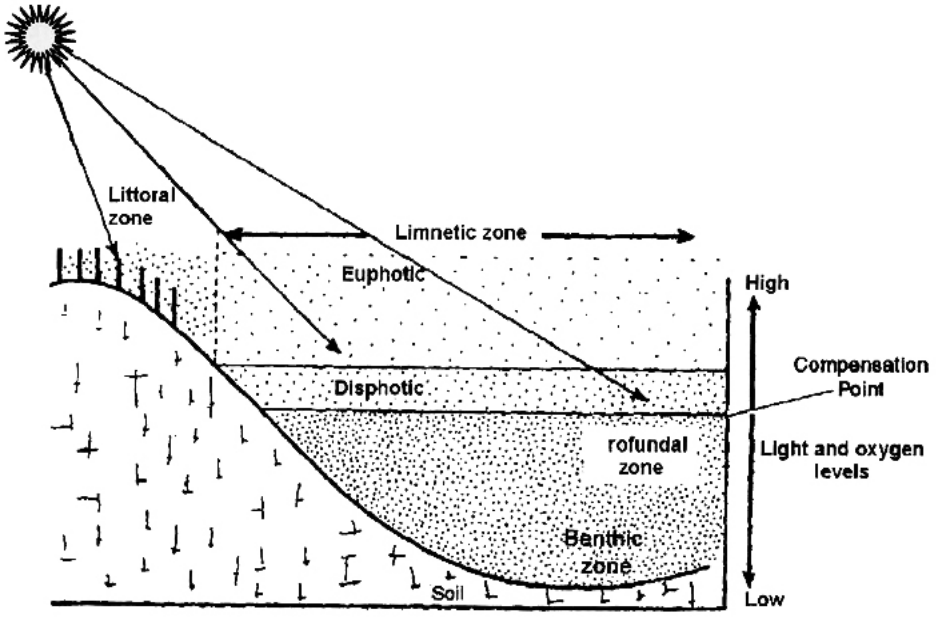


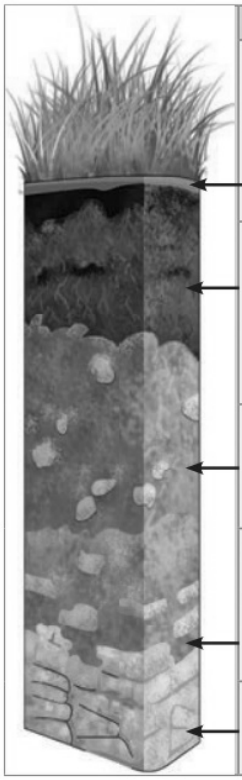
Fig. : Zonation in deep lake showing gradient of light and oxygen

(D) Soil

- Earth's uppermost crust is having a mixture of organic matter and minerals. Study of soil is called **Pedology.**

Soil Composition

- Soil consists of four components, two solid and two non-solid.
- The solid components are mineral particles and organic matter.
- The two non-solid components are air and water.
- A fifth component of variable nature is soil organisms
- The proportion of different components is
  - ✓ Mineral Particles 40%
  - ✓ Organic Matter 10%
  - ✓ Air 25%
  - ✓ Water 25%
- Chief characteristics of the soil are studied with the help of soil profile.
- Type of soil profile depends upon climate and vegetation of the area.
- The smallest three dimensional volume of soil required to study its profile is called **pedon**.
- Most soils possess 3-4 horizons and a number of sub horizons.
- A soil horizon is a horizontal layer approximately parallel to soil surface that possesses distinctive properties which are unlike the ones present in adjoining regions. In general, a profile consists of O, A, B, C & R horizons.



Horizon	Description
O–Horizon (Organic horizon) Humus	It consists of fresh or partially decomposed organic matter. O1 – Freshly fallen leaves, twigs, flowers and fruits O2 – Dead plants, animals and their excreta decomposed by micro-organisms. Usually absent in agricultural and deserts.
A–Horizon (Leached horizon) Topsoil - Often rich in humus and minerals.	It consists of top soil with humus, living creatures and in-organic minerals. A1 – Dark and rich in organic matter because of mixture of organic and mineral matters. A2 – Light coloured layer with large sized mineral particles.
B-Horizon (Accumulation horizon) (Subsoil-Poor in humus, rich in minerals)	It consists of iron, aluminium and silica rich clay organic compounds.
C - Horizon (Partially weathered horizon) Weathered rock Fragments - Little or no plant or animal life.	It consists of parent materials of soil, composed of little amount of organic matters without life forms.
R – Horizon (Parent material) Bedrock	It is a parent bed rock upon which underground water is found .

Fig: Soil profile

- It is the breaking of rocks into fine particles as present on the soil.
- Weathering occurs due to the following methods:

(i) **Physical Weathering:** It is caused by alternate heating and cooling, alternate wetting and drying, action of frost, snow, rain and wind.

(ii) **Chemical Weathering:** Oxidation, reduction, carbonation and solubilization reactions to break the rock.

(iii) **Biological Weathering :** By Lichens, Mosses.

HUMIFICATION

- It is addition of organic matter or humus into weathered rock.
- Humification is essential for starting biological activity and nutritional cycling.
- Humus is dark coloured amorphous substance, is slightly acidic, colloidal and acts as reservoir of nutrients.
- Main functions of humus are biogeochemical cycling, preventing soil from compaction, helping in formation of soil crumbs, improving aeration and water holding capacity of soil.
- It also makes soil spongy, therefore, easy for penetration by the roots.

Eluviation and Illuviation

- These two processes bring about transport and deposition of materials in the soil.
- Eluviation is washing down of materials from upper strata.
- Eluviation helps in enriching the different layers of soil with minerals.
- Illuviation is deposition of washed down minerals in lower strata.

Mineral Matter

- It consists of inorganic substances present as particles of different sizes and composition.

(i) **Gravel:** It is made of fine pebbles with a size of 2-10 mm.

(ii) **Sand:** It consists of grains of quartz or silicon dioxide ($Si0_2$). Size varies from 0.02-2.0 mm. Sand is chemically inert. It allows quick percolation of rain or irrigation water. Aeration is good.

(iii) **Silt:** It is formed of fine grains of quartz. The size is 0.002-0.02 mm. It is chemically inert.

(iv) **Clay:** It is made of Al, Fe and Si. The size is below 0.002 mm. Clay particles are chemically active and have fine interspaces that can hold abundant water but **aeration is poor.**

Soil Porosity

- It is percentage of interspaces present per unit dry weight of soil.
- The value of soil porosity is 30% in sandy soils, 45% in loam soil and 50% in clay soil.
- There are two types of soil pores, micropores and macropores.
- **Micropores** are small sized interspaces having a diameter of 20 µm or below.
- They hold water by capillarity. **Macropores** are interspaces with a size of more than 20 µm.
- **Types of soil particles**
- Based on the relative proportion of soil particles, four types of soil are recognized.

	Soil type	Size	Relative proportion
1	Clayey soil	Less than 0.002 mm	50% clay and 50% silt (cold / heavy soil)
2	Silt soil	0.002 to 0.02mm	90% silt and 10% sand
3	Loamy soil	0.002 to 2mm	70% sand and 30 % clay / silt or both (Garden soil)
4	Sandy soil	0.2 to 2 mm	85% sand and 15% clay (light soil)

Fig: Types of soil particles

Soil Air

- It is air present in macropores with a size between 20-50 µm.
- A good soil should have 25% air by volume.
- Soil air is required for respiration of roots and several microorganisms.
- Soil air is richer in CO_2 and poorer in O_2.

Soil Types

(a) **Red Soils:** These are acidic laterite soils which are deficient in lime, magnesium, phosphorus and potassium, but rich in organic matter, iron and aluminium. Such soils support tea, coffee, rubber, cardamom, areca nut and p'addy cultivation.

(b) **Black soils** : Also called black cotton soils/regurs with dark brown or black colour from organic matter, clay/hydrated iron and aluminium silicate and have undifferentiated B-horizon (A-C soil).

(c) **Terai/Babar soils:** Mostly colluvial and highly productive

Residual soils develop *in situ*. **Transported** soils are brought from other places through gravity **(colluvial),** running water (deposited at flood plains and called **alluvial),** wind **(eolian** = aeolian) and glacier **(glacial soil).**

Soil Texture

- Three main types.

(a) **Sandy soils:** The soils contain about 80% or more of sand, the remaining being silt and clay. Sandy soils are porous and loose. Water holding capacity is poor. Chemical nutrition is little.

(b) **Clay soils:** They are soils having 40-50% of clay, the rest being silt. Sand is little. Clay soils have abundant capillary pores. Therefore, water holding capacity is high. Inorganic nutrients are available in good quantity. However, aeration is poor.

(c) **Loam soils:** The soils contain 20% clay, 40% sand and 40% silt. These have good mineral nutrition, aeration and hydration. Therefore, loam soils are the **best for plant growth.**

Soil pH

- It determines the type of soil microorganisms, solubility of different minerals and type of plants which can grow.
- In alkaline soils (pH above 7), there is reduced availability of Zn, Mn, Cu and Fe.
- In acidic soils there is abundance of iron, Mn and Al, but deficiency of Ca, Mg and K.
- Certain soils possess excess of salts especially those of Na and Mg.

- They are called **Saline soils.** Salinity increases with excessive irrigation.

Soil Organism

- A number of organisms live inside soil.
- It includes bacteria, actinomycetes, fungi, algae, parts of higher plants, protozoa, rotifers, nematodes, insects, earthworms, molluscs and burrowing vertebrates. They form the **living components** of soil.

***(E)** Topography*

- **Topography** *i.e.,* surface configuration of an area (physical features like hills, plains or slopes) also influences the distribution of organisms. For example,

(i) The centre and edge of a pond or a stream

(ii) Exposed side and underside of a rock

(iii) North and South face of a ridge or a mountain

are usually inhabited by different species of organisms.

STEEPNESS OF THE MOUNTAIN

The steepness of the mountain or hill allows the rain to run off. As a result the loss of water causes water deficit and quick erosion of the top soil resulting in **poor vegetation**. On the other hand, the plains and valley are **rich in vegetation** due to the slow drain of surface water and better retention of water in the soil.

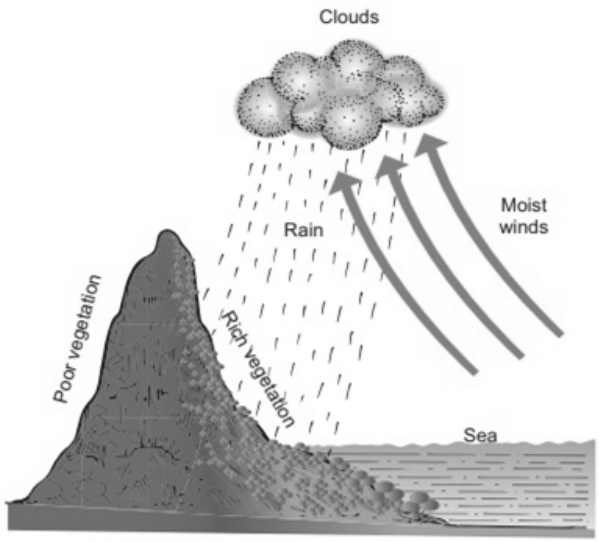


Fig: Steepness Of The Mountain

5 RESPONSE TO ABIOTIC FACTORS

- Change in one environmental factor leads to change in others also i.e., all factors are integrated.
- An organism would have evolved various mechanisms to maintain its internal environment at homeostasis to perform its physiological and biochemical functions in response to changing external factors of environment.
- This constancy is necessary for its overall fitness or maximum performance. This may be maintained naturally or artificially.

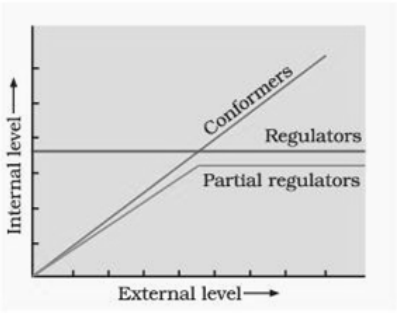


Fig: Diagrammatic representation of organismic response

- There appears various possibilities of responses, such as :

(i) **Regulate:** It is maintenance of homeostasis by physiological or behavioural means like thermoregulation and osmoregulation. *e.g.,* all birds and mammals and a few lower vertebrate and invertebrates; but plants do not have such mechanisms. Evolutionary success of mammals is believed largely due to their regulation ability.

(ii) **Conform:** These organisms cannot maintain thermal and osmotic balance with environment. *e.g.,* approximately 99% of animals and nearly all plants. Thermoregulation is energetically expensive especially for small animals having large surface area relative to their volume, due to this, very small animals are rare in polar regions. Some species have ability to regulate upto a limited range, beyond which they simply conform (partial regulators). For localised or short outburst of stressful conditions the organisms have two alternatives, like migration or suspended growth.

(iii) **Migrate:** Temporary movement of organisms from stressful area to more favourable area in terms of food, shelter, spawning or climate. *e.g.,* Siberian crane migration from Siberia to Keoladeo National Park (Bharatpur, Rajasthan). Locust migrates for food and salmon fish migrates for egg spawning. Ungulate migration in Africa is for food .

(iv) **Suspend:** It is the stage in life cycle where an organism changes its developmental, physiological, structural, biochemical behaviour to pass through unfavourable conditions. e.g., Thick walled spores in bacteria, fungi and lower plants.

- ✓ **Dormancy** in seeds and other vegetative parts in higher plants.
- ✓ **Hibernation** (winter sleep) is shown by organisms which are unable to migrate, like Bears. **Aestivation:** It is metabolic inactivity of organism during hot dessicating summers. *e.g.,* snails and fishes.
- ✓ **Diapause :** Stage of temporary suspension of development under unfavourable conditions. *e.g.,* Zooplanktons in lakes and ponds.

6 ADAPTATION

- It is an attribute of the organism that enables it to survive and reproduce in its habitat. Adaptations may be morphological, physiological or behavioural and are either fixed genetically or remain epigenetic

- Some adaptations are given below :

(i) Seals have a thick layer of fat (blubber) below the skin to reduce loss of body heat.

(ii) Altitude sickness can be expressed at high altitude where body does not get enough oxygen due to low atmospheric pressure and causes nausea, fatigue and heart palpitations. Under these conditions, body increases RBC production, decreases binding capacity of Hb and increases breathing rate. These physiological adaptations allow organisms to respond quickly to stressful conditions.

(iii) Archaebacteria can flourish at temperature exceeding 100°C while humans can perform the metabolism in a narrow range (37ºC).

(iv) Antarctic fishes can survive below 0°C and a variety of invertebrates and fishes are adapted biochemically to survive great depths with crushing pressure. In Antarctic fishes, body fluid contain antifreeze solutes.

(v) Desert lizards lack the physiological ability to cope with extreme temperature but manage the body temperature by behavioural means.

(vi) Kangaroo rat of North American desert fulfil water demands by internal oxidation of fats and it also has the ability to concentrate its urine.

Water Based Adaptations (Plant Specific)

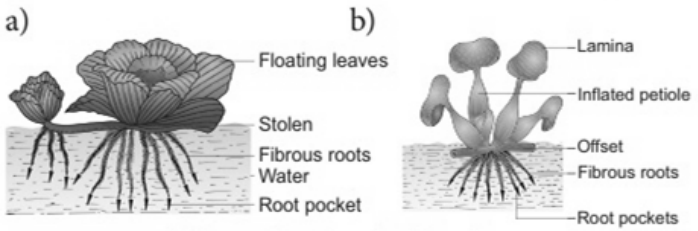
- On the basis of dependence of plants on water and relations of plants to water, Warming (1909) recognised three kinds of plant communities:
  (1) Hydrophytes, (2) Mesophytes and (3) Xerophytes

1. Hydrophytes

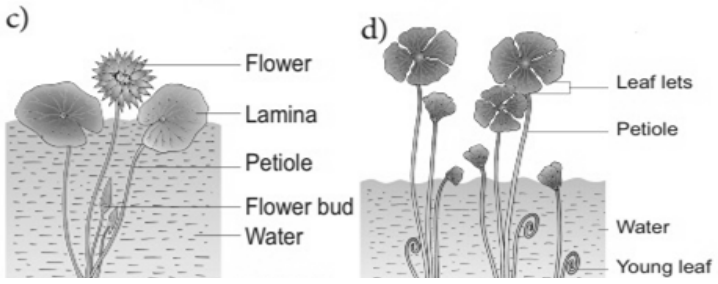
- Plants growing in water or in water saturated soil are called hydrophytes. They require abundance of water to complete their life cycle. These are of basic three types:

A. Submerged: Submerged plants are those in which the leaves are entirely beneath the water.

e.g., Hydrilla, Vallisneria, Potamogeton and *Ceratopyllum.*



i) Free floating hydrophyte
a) *Eichhornia* b) *Pistia*



B. **Floating:** In floating plants leaves float on the water surface, but roots and stem may remain in water, or float on water like the leaves. On the basis of root fixation, these are classified into two groups.

(i) **Free floating:** They change their position due to water current, because their roots are not embedded in soil. Leaves float on the water surface and stem and roots are also free from substratum.
e.g., Wolffia, Lemna, Eichhornia, Pistia.

(ii) **Rooted floating:** In these plants leaves float but the roots adhere to bottom soil

particles *e.g., Nelumbium speciosum, Nymphaea stelata, Jussiaea, Trapa* etc.

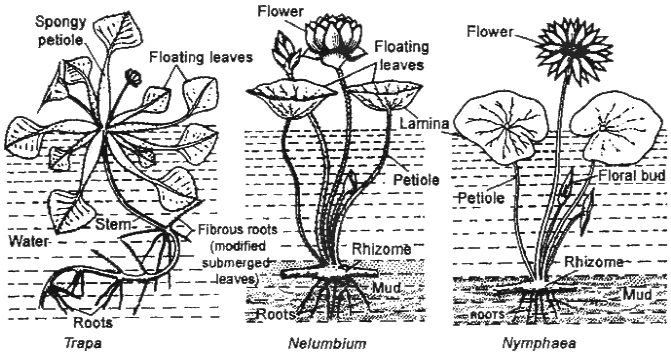


Fig. : Fixed floating plants

C. Amphibious plants: The basal part of the body (roots and lower portion of stem) is embedded in water saturated soil. The remaining body (upper part of stem and leaves) lie straight up, emerging in the air. Occasionally due to rain, leaves also may be immersed into water.

e.g., Typha, Ranunculus, Polygonum, Cyperus etc.

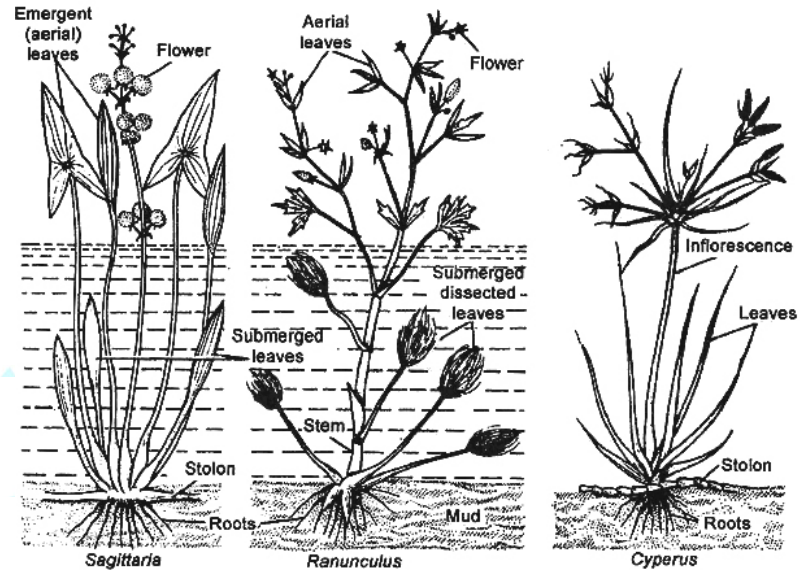


Fig. : Amphibious Plants

MORPHOLOGICAL ADAPTATIONS:

Root:

1. Roots are either completely absent *(e.g., Salvinia, Wolffia, Ceratophyllum)* or poorly developed.
   (e.g., Hydrilla).
2. Root pockets are present as balancing organs in *Azolla, Eichhornia, Lemna, Pistia* etc. instead of root cap.
3. Some hydrophytes have floating roots in addition to normal adventitious roots which

provide buoyancy *e.g., Jussiaea repens.*

Stem:

1. Long, slender, spongy and flexible *e.g., Potamogeton* and *Hydrilla.*
2. It may float horizontally on the surface of water *e.g., Azolla* or may form offset as in *Eichhornia* or may be a rhizome *e.g., Nymphaea.*

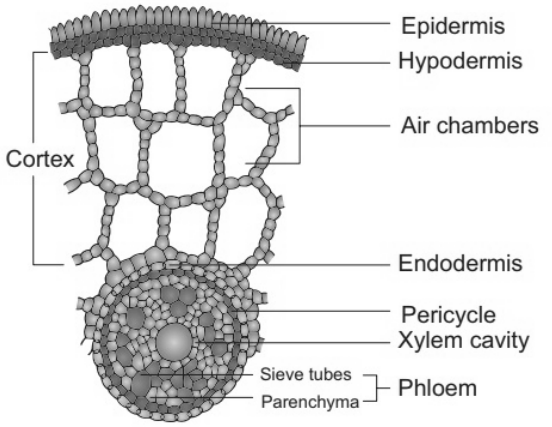


Fig: T.S. of Hydrilla stem

Leaves:

1. Long, slender, delicate petioles with floating leaves *e.g., Nymphaea.*
2. Petiole may be swollen and spongy *e.g., Eichhornia.*
3. Submered hydrophytes have thin, long ribbon shaped leaves *(e.g., Vallisneria)* or finely dissected leaves *e.g., Ceratophylum.*
4. Leaves of floating hydrophytes are large, entire and flat. These are often coated with wax *e.g., Nymphaea* or covered with hairs *e.g., Salvinia.*
5. Emergent hydrophytes show heterophylly *i.e.* leaves below the water are long, narrow, and dissected and those outside the water are entire and broad *e.g., Ranunculus aquatilis, Umnophilla heterophylla, Sagittaria sagitifolia*.

ANATOMICAL ADAPTATIONS

a) Presence of large air spaces and aerenchyma.
b) Mechanical tissue *i.e.* sclerenchyma is either poorly developed or absent. In *Typha,* pith is sclerenchymatous.
c) Vascular tissue specially xylem is poorly developed.
d) Cuticle is absent.
e) Stomata are absent or vestigeal in submerged hydrophytes. Floating leaves are epistomatic and emergent leaves are isostomatic.
f) Epidermis is always single layered.
g) Mesophyll is uniform.

2. Mesophytes

Plants growing in places of moderate water supply. These plants cannot live for a long time either in water saturated or in moisture deficient soil. *e.g.,* garden plants and crops.

3. Xerophytes

Plants growing in places of deficient water supply. These plants grow in deserts or on rocks, *e.g., Opuntia, Aloe, Agave, Casuarina, Calotropis, Muehlenbeckia,* etc.

Types of xerophytes :

(A) On the basis of nature of soil and cause of unavailability of water:

(a) Physical xerophytes grow in soils which are physically dry (due to shortage of water) *e.g. Opuntia, Casuarina, Ruscus, Muehlenbeckia* (Cocoloba) etc.

(b) Physiological xerophytes grow in soils having sufficient water which is not available due to high salt concentration (salinity) or very low temperature.

(B) On the basis of life cycle and water storage:

(a) **Ephemerals:** Short living, brief life span (6-8 weeks), escape dry season by disappearing leaving their seeds; hence, not true xerophytes, so are called **drought evaders** and **drought escapers** *e.g. Cassiatora, Tribulus.*

(b) **Succulents** (fleshy xerophytes) : Absorb large quantities of water during rainy season and store it in different body parts; suffer only externally; hence **drought avoiding or drought resistant** xerophytes.

(i) **Stem succulents (chylocauly)** : *e.g., Opuntia, Euphorbia antiquorum, E. splendens, E. tirucalli, Cereus.*

(ii) **Leaf succulents (chylophyllous)** : *e.g., Aloe, Agave, Begonia, Bryophyllum.*

(iii) **Root succulents (chylorhizous)** : *e.g., Asparagus, Ceiba parviflora.*

(c) **Non-succulents : Drought endurers,** true xerophytes; can withstand long drought periods (perennial non succulents) *e.g., Casuarina, Zizyphus, Nerium, Acacia, Capparis.*

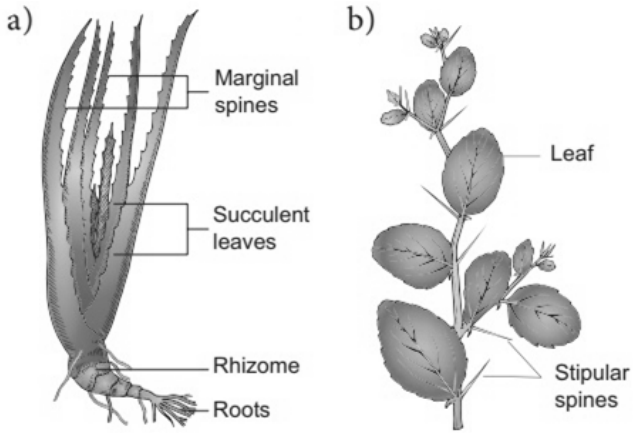


Fig: (a) Succulent xerophytes – Aloe (b) Non-succulent perennial - Zizipus

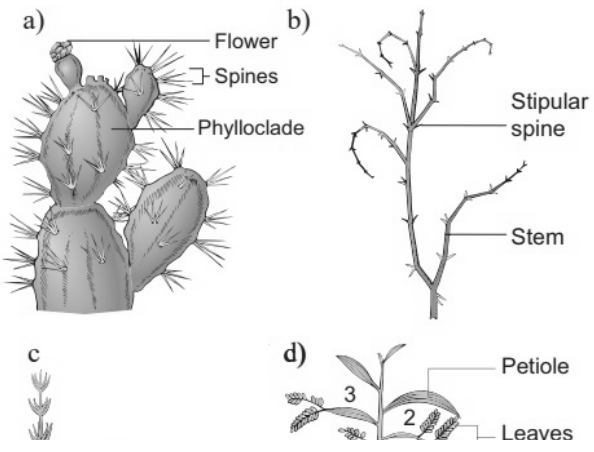


Fig. : Xerophytic plants : A. Phylloclade of *Opuntia,* B. Phylloclade of *Muehlenbeckia* , C. *Casuarina*

MORPHOLOGICAL ADAPTATIONS

Root:

1. Roots are well developed, profusely branched and extensively spread.
2. Roots are deep **(phreatophytes).**

Stem:

1. It is generally hard and woody with thick bark
2. Mostly covered with hairs, wax, silica.
3. Some plants may show modification of stem into leaf like structure called **phylloclade** *e.g. Opuntia;* while in *Ruscus* and *Asparagus* the stem is modified into cladode.

Leaves: are modified in the following ways.

(a) **Sclerophyllous:** Stiff and hard leaves *e.g., Banksia, Dasilirion.*

(b) **Trichophyllous:** Leaves covered with hair *e.g., Nerium, Calotropis.*

(c) **Microphyllous :** Small, fleshy leaves *e.g., Capparis.*

Leaves of xerophytes are generally caducous *e.g., Euphorbia* or may be completely absent *e.g., Capparis aphylla.* Leaves of grasses get rolled to reduce transpiration *e.g., Agropyron, Ammophi/a*.

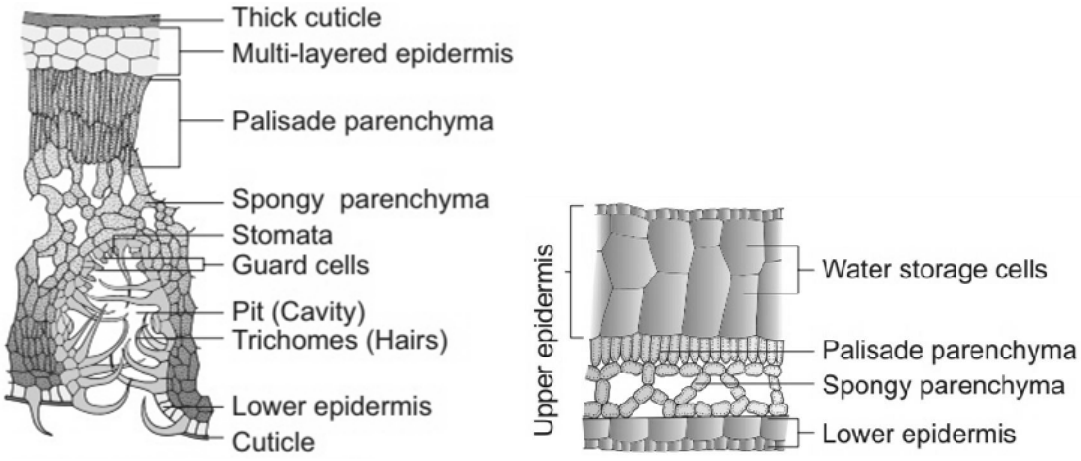


Fig: T.S. of Nerium leaf & A succulent leaf of Pepromia (T.S.) (lateral wing portion only)

Anatomical adaptations

1. Presence of thick cuticle on leaf and stem epidermis.
2. Presence of waxy layer on the epidermis of leaves.
3. Stomatal frequency is reduced.
4. Sunken stomata are present.

5. Hairs are present on the leaf epidermis and substomatal chamber.
6. Intercellular spaces are only few and small.
7. Mechanical tissue *i.e.*, collenchyma and sclerenchyma are well developed.
8. Epidermis may be multiple.
9. Water storage tissue is present.
10. Vascular tissues are present in large amount.

4. Halophytes

Plants growing in saline soil.

Morphological characters

Root: Mangrooves have specialized roots called **pneumatophores** which are negatively geotropic. These are modified tap roots which have pneumathodes for gaseous exchange.

Stem : Mostly succulent or fleshy.

Leaves: Evergreen, thin, leathery.

Anatomical characters

1. Presence of thick cuticle on stem.
2. Stem hypodermis is multilayered, thick walled.
3. H-shaped specules are present in the stem cortex to provide mechanical support.
4. Pericycle is sclerenchymatous, 3-4 layered.
5. Vascular tissue is well developed
6. Upper and lower leaf epidermis is thickly cuticularized.
7. Sunken stomata are present only in the lower leaf epidermis

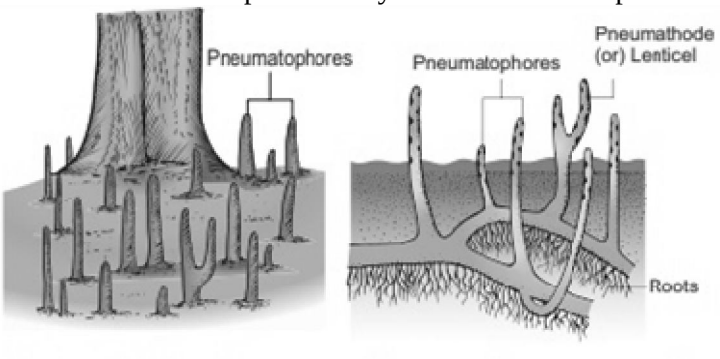


Fig: Pneumatophores of mangrove plant

Fig: Succulent halophytes – *Salicornia*

8. Leaves are thick, entire, succulent and glossy. Some species are **aphyllous** (without leaves).
9. Vivipary mode of seed germination is found in halophytes

Epiphytes

- Epiphytes are plants which grow perched on other plants (Supporting plants). They use the supporting plants only as shelter and not for water or food supply. These epiphytes are commonly seen in tropical rain forests. Examples: Orchids, Lianas, Hanging Mosses and Money plant.

Morphological adaptations

- *Root system is extensively developed. These roots may be of two types. They are Clinging roots and Aerial roots.*

✍ **Clinging roots** fix the epiphytes firmly on the surface of the supporting objects.
✍ **Aerial roots** are green coloured roots which may hang downwardly and absorb moisture from the atmosphere with the help of a spongy tissue called **velamen**.
✍ Stem of some epiphytes are succulent and develop pseudo bulb or tuber.
✍ Generally the leaves are lesser in number and may be fleshy and leathery
✍ **Myrmecophily** is a common occurrence in the epiphytic vegetation to prevent the predators.

- The fruits and seeds are very small and usually dispersed by wind, insects and birds.

Anatomical adaptations

- Multilayered epidermis is present. Inner to the velamen tissue, the peculiar exodermis layer is present.
- Presence of thick cuticle and sunken stomata greatly reduces transpiration.
- Succulent epiphytes contain well developed parenchymatous cells to store water.

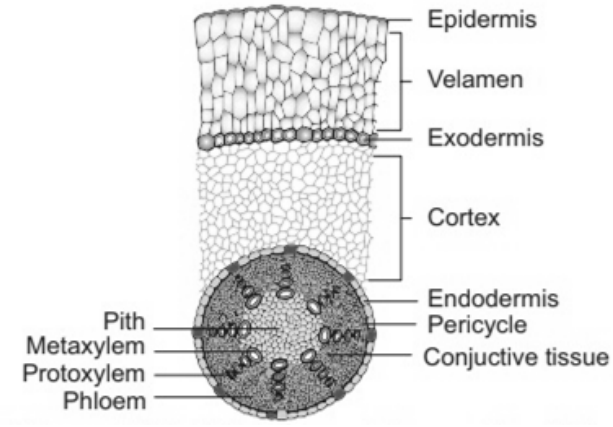


Fig: T.S. of an aerial root of orchid showing *velamen* tissue

Physiological adaptations

✍ Special absorption processes of water by velamen tissue .

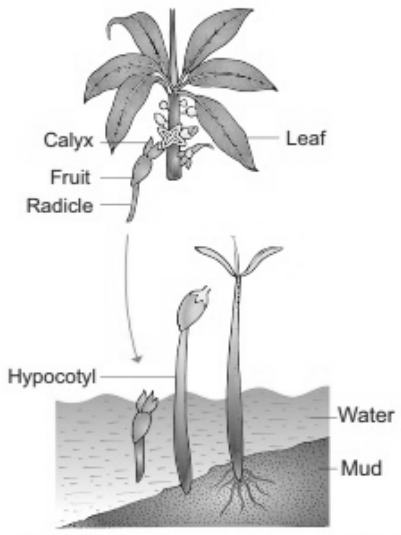


Fig: Vivipary germination

7 POPULATIONS

(i) **Deme:** Local population (population living in a specific area).

(ii) **Metapopulation :** Whole set of local populations connected by dispersing individuals.

(iii) For the purpose of ecological studies, a group of individuals resulting from asexual reproduction is also considered as population.

Population attributes / group attributes

- Some characters are unique to the group and are not characteristic of the individuals forming it, like an organism born and dies, and has age, but it does not have a birth rate, death rate and age ratio.
- These population characters can be best expressed by statistical methods, some important characters are:

1. Population Density

- The number of individuals per unit area, like millions of *Spirogyra* filaments in a pond, or 200 plants of *Parthenium* in an area.
- This can also be expressed as "The population biomass per unit area or volume" when we have to count a large number of organisms (like grasses) or to find out the role of a single huge banyan tree in an area.
- Relative density is a good measure of finding out the total density of fishes in a lake by counting the number of fishes caught per trap.
- Tiger census in India is based upon pug marks and fecal pellets which indirectly estimates population size.

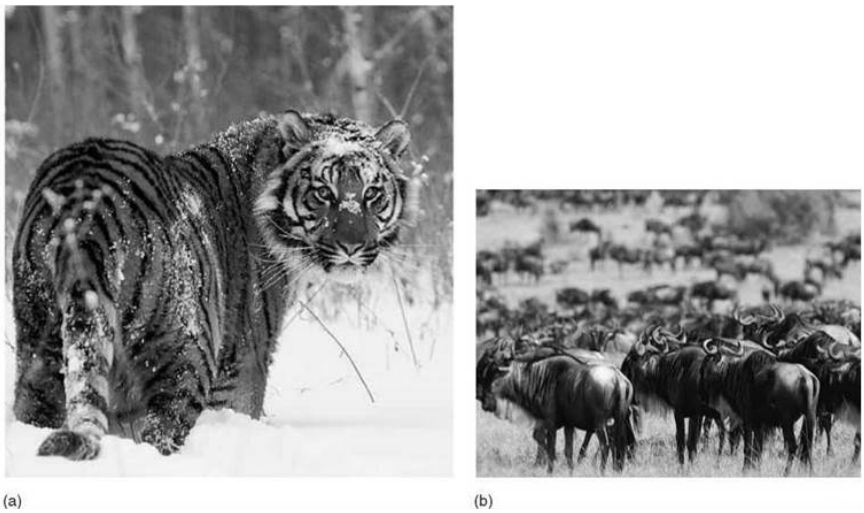


Fig. Population density.

(a) Siberian tigers occupy enormous territories (typically 60-100 km2 for an adult male) because of the relative lack of prey in the dense Siberian forests, especially in winter. (b) This Serengeti wildebeest herd numbers over 1 million animals.

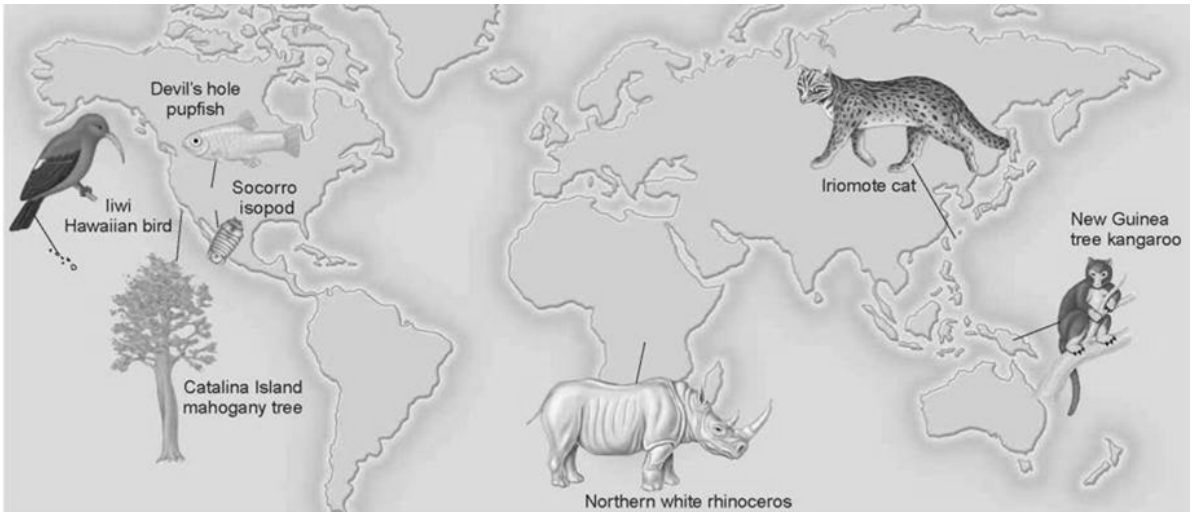


Fig. Species that occur in only one place.

These species, and many others, are only found in a single population. All are endangered species, and should anything happen to their single habitat, the population, and the species, would go extinct.

2. Age Ratio Pyramids

- **Age Pyramlds :** An age pyramid is a graphic representation of proportion of various age groups of a population. There are three types of age pyramids -triangular, bell-shaped and urn-shaped.

(a) **Triangular :** It is graphic representation of a **young** or **growing population** and has a very high proportion of pre-reproductive individuals.

(b) **Bell-Shaped:** The pyramid is bell-like with pre-reproductive individuals being only marginally more than the reproductive individuals. Population is said to be **mature** or **stable**.

(c) **Urn-Shaped :** It has small number of pre-reproductive individuals followed by a large number of reproductive individuals. Such a population shows **negative growth**

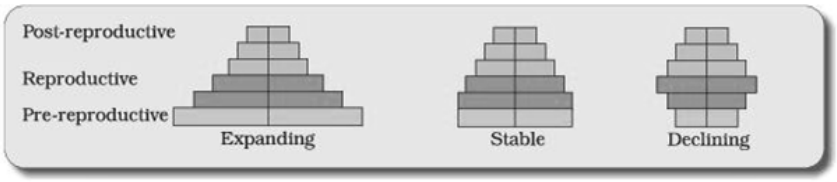


Fig. : Representation of age pyramids for human population

Age distribution : The relative abundance of the organisms of various age groups in the population is called age distribution of population. With regard to age distribution, there are three kinds of population.

(a) **Rapidly growing or Expanding population :** It has high birth rate and low death rate, so there are more number of young individuals in the population.

(b) **Stationary or stable population :** It has equal birth and death rates, so population shows zero population growth.

(c) **Declining population :** It has higher death rate than birth rate, so the population of young members is lower than that of old members e.g. Japan (Ageing population) .

Human population has three age groups : Pre reproductive, Reproductive, and post reproductive.

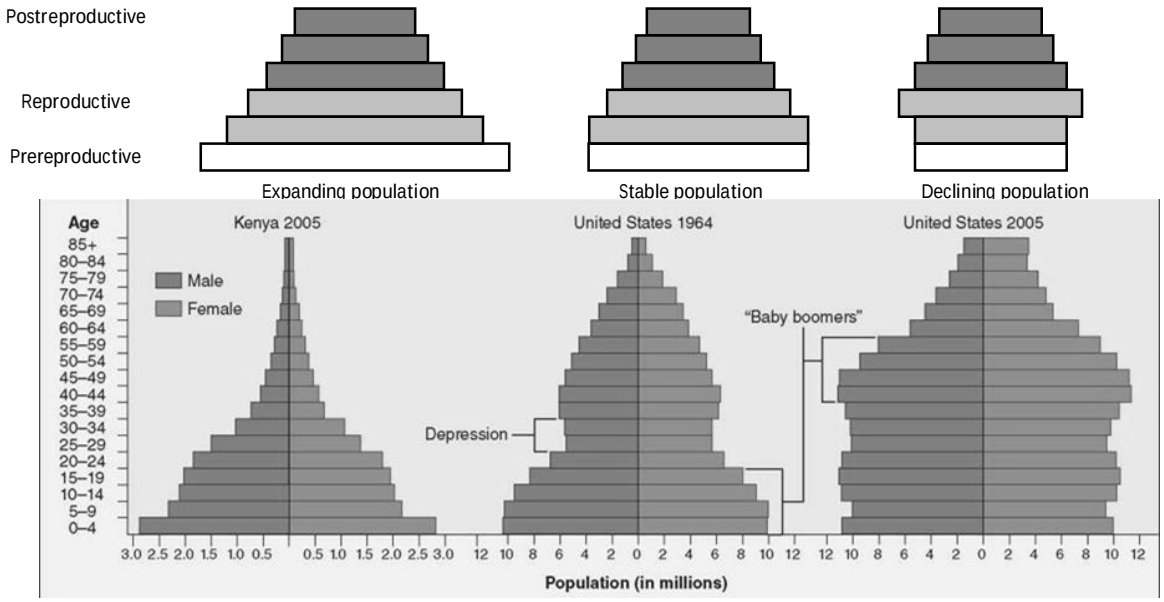


Fig. Population pyramids.

Population pyramids are graphed according to a population's age distribution. Kenya's pyramid has a broad base because of the great number of individuals below child-bearing age. When all of the young people begin to bear children, the population will experience rapid growth. The 2005 U.S. pyramid demonstrates a larger number of individuals in the "baby boom" cohort—the pyramid bulges because of an increase in births between 1945 and 1964, as shown at the base of the 1964 pyramid. The 25 to 34 cohort in the 1964 pyramid represents people born during the Depression and is smaller in size than the cohorts in the preceding and following years.

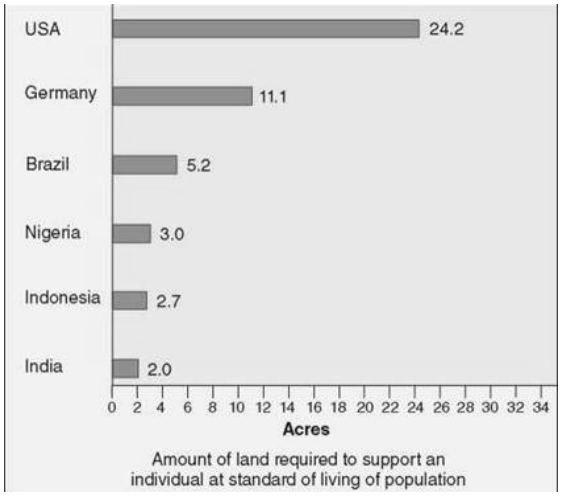


Fig. Ecological footprint of individuals in different countries in 2003.

The Influence of Population Density

Many factors act to regulate the growth of populations in nature. Some of these factors act independently of the size of the population; others do not.

Density-Independent Effects

Effects that are independent of the size of a population and act to regulate its growth are called density-independent effects. A variety of factors may affect populations in a density- independent manner. Most of these are aspects of the external environment, such as weather (extremely cold winters, droughts, storms, floods) and physical disruptions (volcanic eruptions and fire). Individuals often will be affected by these activities regardless of the size of the population. Populations that occur in areas in which such events occur relatively frequently will display erratic population growth patterns, increasing rapidly when conditions are relatively good, but suffering extreme reductions whenever the environment turns hostile.

Density-Dependent Effects

Effects that are dependent on the size of the population and act to regulate its growth are called density-dependent effects. Among animals, these effects may be accompanied by hormonal changes that can alter behavior that will directly affect the ultimate size of the population. One striking example occurs in migratory locusts (which you encountered at the beginning of this chapter). When they become crowded, the locusts produce hormones that cause them to enter a migratory phase; the locusts take off as a swarm and fly long distances to new habitats. Density-dependent effects, in general, have an increasing effect as population size increases. As the population of song sparrows in figure 35.12 grows, the individuals in the population compete with increasing intensity for limited resources. Darwin proposed that these effects result in natural selection and improved adaptation as individuals compete for the limiting factors.

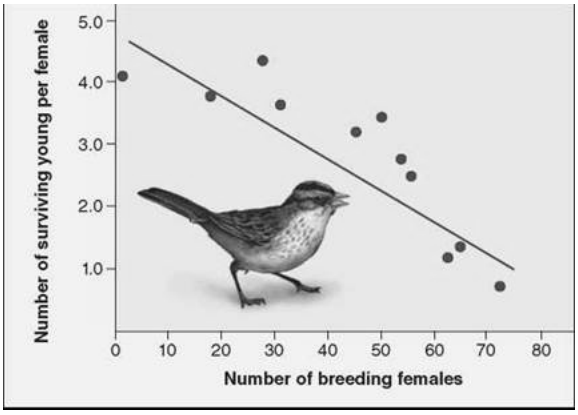


Fig. Density-dependent effects.
Reproductive success of the song sparrow (Melospiza melodia) decreases as population size increases.

Maximizing Population Productivity

In natural systems that are exploited by humans, such as fisheries, the aim is to maximize productivity by exploiting the population early in the rising portion of its sigmoid growth curve. At such times, populations and individuals are growing rapidly, and net productivity—in terms of the amount of material incorporated into the bodies of these organisms—is highest. Commercial fisheries attempt to operate so that they are always harvesting populations in the steep, rapidly growing parts of the curve. The point of maximal sustainable yield (the red line in figure 35.13) lies partway up the sigmoid curve. Harvesting the population of an economically desirable species near this point will result in the best sustained yields. Overharvesting a population that is smaller than this critical size can destroy its productivity for many years or even drive it to extinction. This evidently happened in the Peruvian anchovy fishery after the populations had been depressed by the 1972 El Nino. It is often difficult to determine population levels of commercially valuable species, and without this information it is equally difficult to determine the yield most suitable for long-term, productive harvesting.

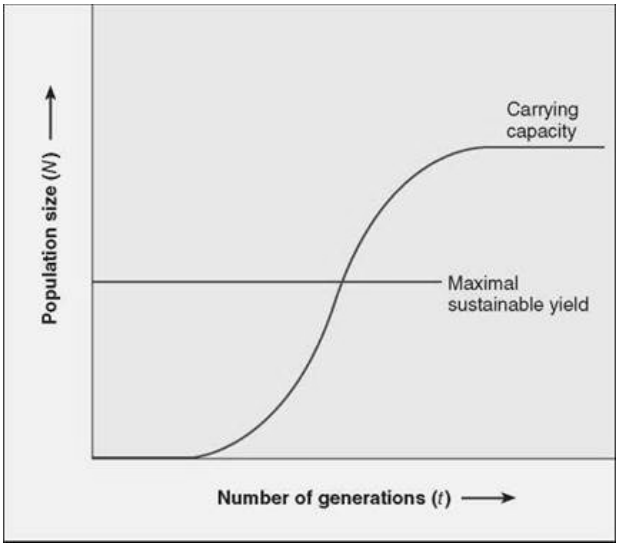


Fig. Maximal sustainable yield.

The goal of harvesting organisms for commercial purposes is to harvest just enough organisms to maximize current yields but also to sustain the population for future yields. Harvesting the organisms when the population is in the rapid growth phase of the sigmoidal curve, but not overharvesting, will result in sustained yields.

Factors affecting the age composition

(1) Number of infants below one year of age and the older people as these have higher mortality rate than individuals of other age groups.

(2) Proportion of reproductive active males and females in a population.

(3) Number of females in active reproductive age (i.e. between 15 to 44 years

3. Population Growth

- Some attributes of population are used to estimate its growth, as population size may fluctuate in a given habitat during a given period due to change in four basic processes, namely

(i) Natality: Birth rate,

(ii) Mortality: Death rate.

(i) **Birth rate or Natality :** The birth rate of a population refers to the average number of young ones produced by birth, hatching or germination per unit time (usually per year). In the case of humans, it is commonly expressed as the number of births per 1000 individuals in the population per year.

The maximum birth rate of a species can achieve under ideal environmental conditions is called potential natality. However, the actual birth rate under the existing conditions is much less. It is termed realised natality. Crude birth rate is the number of births per 1000 persons in the middle of a given year i.e. on July. Natality increases the population size (total number of individuals of a population) and population density.

(ii) **Death rate or mortality :** The death rate of a population is the average number of individuals that die per unit time (usually per year). In humans it is commonly expressed as the number of death per 1000 persons in a population per year. Lowest death rate for a given species in most favourable conditions is called potential mortality, while the actual death rate being observed in existing conditions is called realized mortality. Crude death rate is the number of deaths per 1000 persons in the middle of a given year i.e. on July. Mortality decreases the population size and population density both.

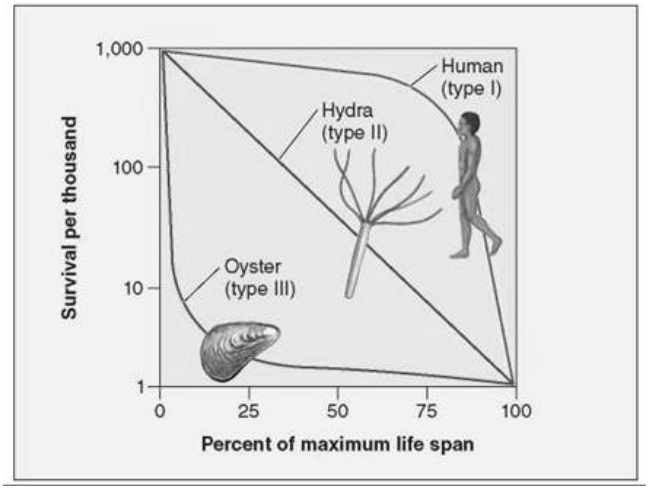


Fig. Survivorship curves.

By convention, survival (the vertical axis) is plotted on a log scale. Humans have a type I life cycle, the hydra (an animal related to jellyfish) type II, and oysters type III.

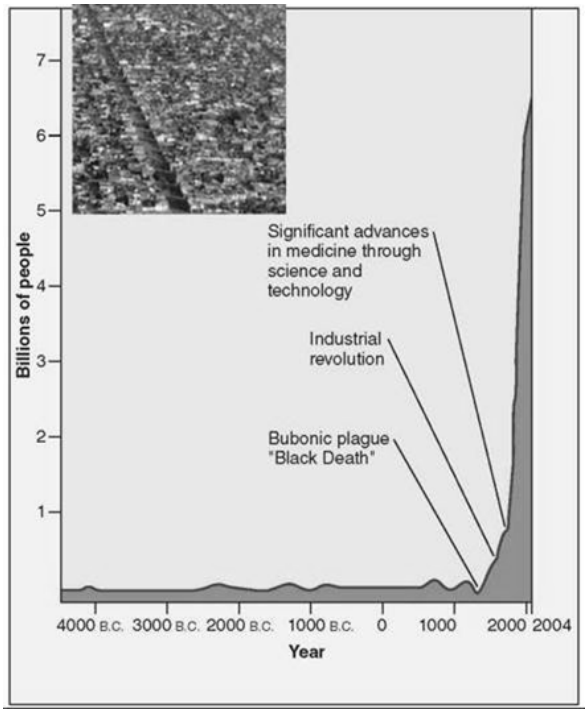


Fig. Growth of the human population.

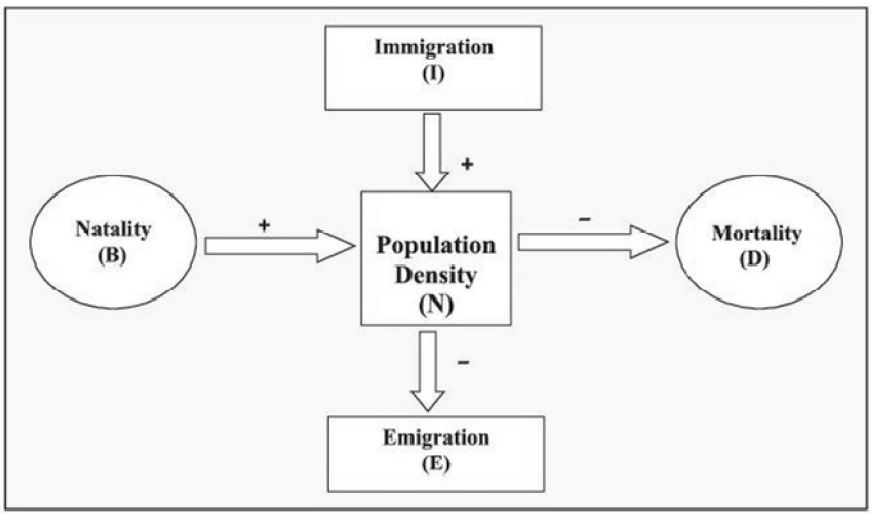
Difference between Natality rate and Mortality rate

Character	Natality rate	Mortality rate
(1) Definition	Number of births per 1,000 individuals of a population per year.	Number of deaths per 1,000 individuals of a population per year.
(2) Population density	Increases population size and population density.	Decreases population size and population density.

(iii) Immigration : One way permanent inward movement of the individuals of same species into a habitat with existing population. This may help to speed up the growth or prevents extinction of a smaller population. In plants, it is equivalent to settlement of disseminules.

(iv) Emigration : One way permanent outward movement of number of individuals from a population to other habitat area, hence reducing the size of local population. Plants are fixed, so do not show emigration. By these population characters the density of a population (N) at time *t* can be expressed after a period of time *t* + 1 as $N_{(t+1)} = N_t + [(B + I) - (D + E)]$. Where; *B* = Number of birth, *I* = Number of immigrants, *D* = Number of deaths and

E = Number of emigrants



- So, it can be concluded that births and deaths are most important factors influencing population density and other two are specialised cases

4. Growth Models

- Biotic Potential and Environmental Resistance: Biotic potential is the maximum or potential natality.
- The sum of environmental factors that limits the population size is called **environmental resistance**.
- Environmental resistance rises with the rise in population size.
- The influence of environmental resistance over the biotic potential is denoted by (K-N/K). **Carrying Capacity (K) :** The maximum number of individuals of a population which can be supported with optimum resources for their survival is called carrying capacity of the environment.
- Growth of a population depends upon its biotic potential, death rate and birth rate. Depending upon the amplitude of these three, a population may show :
  (a) Exponential growth, and (b) Logistic growth

(a) Exponential growth :

- Darwin believed the geometric growth of a population when the resources are unlimited, as each species realises its inherent power to grow.
- This intrinsic rate of natural increase is called ***r***.
- The value of *r* is an important parameter to assess impact of environmental factors on population growth.

(i) Any increase or decrease in a population *N* during time *t* will be **dN/dt = (b - d) × N**, where (b = per capita birth rate) and d = per capita death rate. If (b - d) = r, then dN/dt = Rn.

(ii) The integral form of exponential growth equation will be $N_t = N_0e^{rt}$ where; N_t = Population density after time t, N_0 = population density at time zero, e = the base of natural logarithms (2.71828).

(iii) The magnitude of *r* was 0.0205 in 1981 for human population in India while it reached 0.0176 in 2001. For Norway rat it is 0.015 and for flour beetles it is 0.12.

(iv) Equation *dN/dt = rN* describes geometric growth resulting in a J-shape curve. Such population stops abruptly due to environmental resistance, which becomes effective

suddenly, or a resource may become depleted. Decline in J-shape population is density triggered *e.g.*, Algal blooms, insect population.

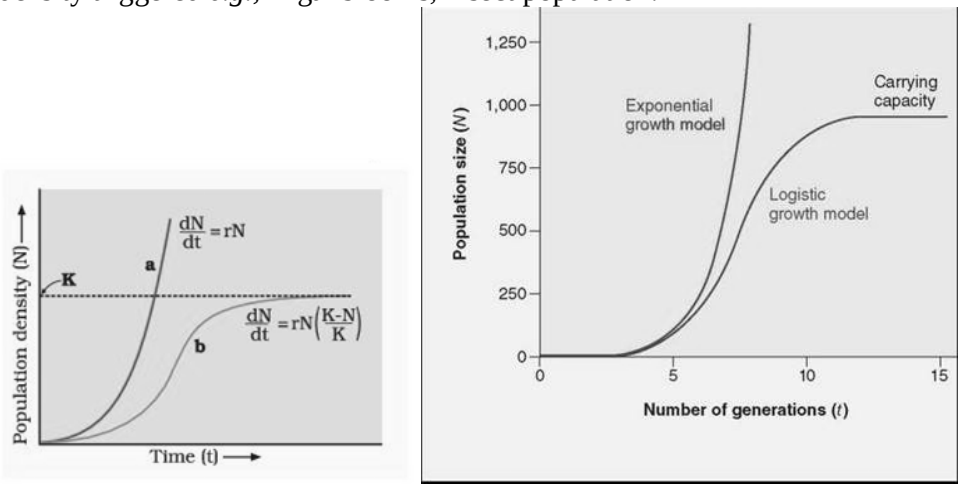


Fig. : Population Growth Curve & Two models of population growth.

The red line illustrates the exponential growth model for a population with an r of 1.0. The blue line illustrates the logistic growth model in a population with r = 1.0 and K = 1,000 individuals. At first, logistic growth accelerates exponentially, and then, as resources become limiting, the birthrate decreases or the death rate increases, and growth slows. Growth ceases when the death rate equals the birthrate. The carrying capacity (K) ultimately depends on the resources available in the environment.

(b) Logistic Growth

- This growth form is characterised by function of carrying capacity (K) for a given population giving it a more realistic form.
- Such forms are represented under limited resource conditions where a population finally reaches an asymptote.
- Since resources for growth for most animal populations are finite and become limiting sooner or later, this plot is more realistic.

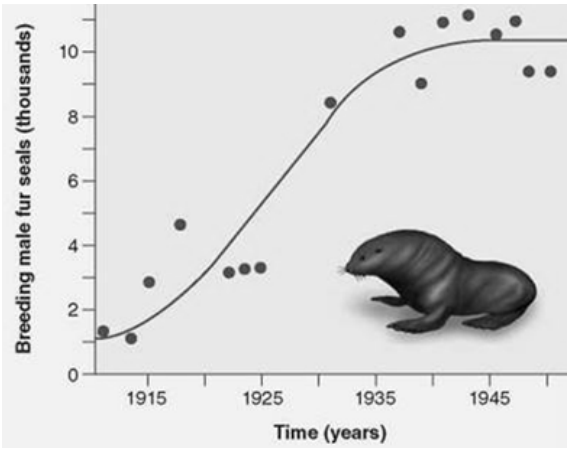


Fig. Most natural populations exhibit logistic growth.

These data present the history of a fur seal (Callorhinus ursinus) population on St. Paul Island, Alaska. Driven almost to extinction by hunting in the late 1800s, the fur seal made a comeback after hunting was banned in 1911. Today the number of breeding males with "harems" oscillates around 10,000 individuals, presumably the carrying capacity of the island.

- **Life History Variation :** Populations evolve to maximise their reproductive fitness in a given habitat. It includes variation in life history, evolved in relation to the selection pressure imposed by environmental factors in order to achieve the most efficient reproductive strategy. Some of the strategies are listed below:

(i) Small number of large sized individuals are produced (mammals and birds).

(ii) Larger number of small sized individuals are produced (Oysters and pelagic fishes).

(iii) Some organisms breed once in life time *(8ambusa* and Pacific salmon fish).

(iv) Some organisms breed many times during their life (mammals and many birds).

5. Population Interactions

- The interactions between members of different populations are based upon 3 factors:

(i) Requirement and mode of obtaining food.

(ii) Nature of shelter or space required.

(iii) Habits of the species like aggregation, breeding etc.

Type of Interaction	Species		General Nature of Interaction
	A	B	
1. Competition	–	–	Direct or indirect inhibition of one species by the other
2. Amensalism	–	0	A is inhibited, B is unaffected
3. Parasitism	+	–	A is parasite and B is host
4. Predation	+	–	A is predator and B is prey
5. Commensalism	+	0	A is commensal-getting benefits, B is host -unaffected.
6. Protocooperation	+	+	Interaction is favourable to both A & B, but not obligatory
7. Mutualism	+	+	Interaction is favourable to both but obligatory

Different population interactions (+, -, 0 for beneficial, detrimental and neutral respectively).

- The various important types of interactions between members of biotic community are described below:

A. Competition

- It is a process in which the fitness of one species (measured in terms of its 'r' the intrinsic rate of increase) is significantly lower in the presence of another species.
- It is the struggle between two or more organisms for obtaining various requirements for their survival.
- It is both intraspecific, *i.e.,* between organisms of the same species and interspecific, *i.e.,* between organisms of different species.
- Intraspecific competition is more acute because all organisms of the same species have similar requirements for food, space, light, water, shelter, mate etc.
- The interspecific competition occurs when organisms of different species belong to same trophic level or have similar feeding habit *e.g.,* in grassland, severe competition occurs between herbivores like rabbits, deer, bisons etc., as all feed upon grass.
- Competition for zoopalnktons between visiting flamingoes and resident fishes in South American lakes.
- It may be emphasized that competition is noticed only when required commodity is in short supply.

- If grass is in plenty and fulfill the needs of all herbivores of that area, there will be no competition or only little, if at all it occurs.
- Carnivorous animals like tigers and leopards compete for the common prey.
- In forest, shrubs, herbs and trees compete with one another for water, inorganic nutrients, sunlight and for insects that bring about pollination and for animals that bring about dispersal.
- In competition superiority of individual (intraspecific) or superiority of species (interspecific) plays an important role.
- No two species can occupy the same ecological niche and live together in a biotic community, this can be further understood by Gause's competitive exclusion principle (1934).
- Gause found that if two species of *Paramecium* namely *P caudatum* and *P aurelia*, were grown together in same culture medium, initially both increase in number, but eventually *P caudatum* population declines and is eliminated by superior species *P aurelia*.
- This shows that if two species are occupying same ecological niche and competing for common resources, then superior type will **exclude or eliminate** the inferior type of species.
- There are some circumstancial evidences which supports exclusion of species due to competition *e.g.*,

(i) Introduction of goats resulted in exclusion of Abingdon tortoise from Galapagos islands.

(ii) Same interaction occurs between *Balanus* and *Chathamalus* on rocky coasts of Scotland (Connell, 1961).

COEXISTENCE :

- Species facing competition might evolve mechanism to live in the same niche by changing the feeding time or foraging patterns, *i.e.*, resource partitioning.
- If different species **coexist** inspite of being competitors, it is because they are specialised or adapted differently (different feeding habits) to obtain same resources.
- That is why Darwin found that fourteen species of finches coexist in Galapagos islands due to development of different feeding habits.

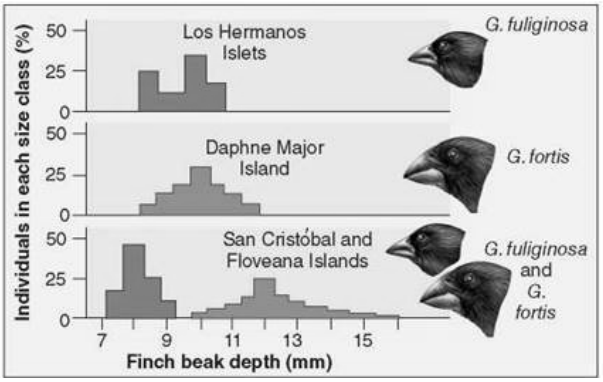


Fig. Character displacement.

These two species of Galapagos finches (genus Geospiza) have beaks of similar sizes when living apart, but different sizes when living together.

- Several plants grow together by sending roots to various depths.
- More examples are cited below to explain coexistence aspect of competition

(i) Five closely related species of warblers avoid competition by changing foraging pattern (MacArthur).

(ii) *"Tribolium-Trifolium"* model is best to explain both exclusion and coexistence.

(iii) Habitat diversification can also reduce competition *e.g., Tribolium* and *Oryzaephilum* (Crombic, 1947).

- **Competitive release:** There occurs a dramatical increase in population of a less distributed species in a geographical area when its superior competitor is removed experimentally from that area.
- Plant and herbivores are more affected than carnivores.
- Resource need not to be limiting for competition to occur as feeding efficiency of one species might be reduced due to inhibitory presence of other species. This is called "interference competition".

B. Predation

- It is a type of interaction in which the members of one species capture, kill and eat up members of other species.
- The species that captures is called **predator** and the other that is captured is called **prey.**
- Most of the animals except the scavengers (animals eating the dead animals only) are predators.
- Even certain plants *(e.g., Nepenthes, Utricularia, Oionaea, Orosera)* are predators, catching and digesting insects in addition to their autotrophic mode of nutrition.
- They are called **insectivorous** or **carnivorous** plants.
- Prey-predator relationship, like competition, is an interaction of ecological importance.
- Prey-predator relationship is utilized by man in **biological control of pests.**
- *Opuntia* was weeded out in Australia with the help of its natural herbivore called ***Cactoblastis*** (Cochineal insect).
- Red locust menace was brought under control in Mauritius by Mynah.
- Mosquito larvae are eaten by larvicidal fish such as *Gambusia* (top minnow).
- In the rocky intertidal communities of the American pacific coast the starfish *Pisaster* is an important predator.

Role of predation :

(a) Transfer of energy (in ecological sense herbivores are not very different from predators).

(b) Keeping prey population under control.

(c) Rabbit population in Australia increased tremendously because the land does not have its natural predators. Red faxes in Newzealand became top carnivores due to absence of a natural top carnivore.

(d) Predators **help to maintain species diversity** in a community as they can reduce the intensity of competition among prey species *e.g.,* Experimental removal of *Pisaster* (star fish) resulted in extinction of more than 10 species of invertebrates in American Pacific coast.

(e) Term **prudent predator** (Slobodkin, 1962) explains that predator does not exterminate its prey by overexploitation. For their defence, prey species have evolved various adaptations, viz

(i) Camouflage *e.g.,* Insects, frogs

Type	Example	Activities
Camouflage (Cryptic Appearance)	*(i)* Grasshopper *(Arantia rectifolia)*	Resembles a green leaf.
	(ii) Praying Mantis *(Mantis religiosa)*	Resembles green leaf and twig.
	(iii) Dead Leaf Butterfly *(Phyllocrania paradoxa)*	Resembles dead leaf.
	(iv) Stick insect *(Carausius)*	Resembles dead leaf.

(ii) Monarch butterfly is well known for its general unpalatability to its predator birds. This insect is able to sequester the highly toxic glycosides present in milkweeds on which its caterpillar stages feed (Brower *et.a/.,* 1968). There larvae develop on milkweed, providing the protection to plant against herbivory.

(iii) Highly poisonous cardiac glycosides are produced by *Ca/otropis* and nicotine, caffeine, quinine, strychnine, opium are other means of chemical defence in plants.

(iv) Association of bull horn *Acacia cornigera* with *Pseudomyrmex ferrugenea* (ant) is also against herbivory.

Association of *Acacia -Pseudomyrmex* and Monarch butterfly -milkweed are examples of **coevolution** also.

C. Parasitism

- It is a relationship between two organisms of different species usually differing in size in which one organism spends a part or whole of its life, on or in the body of other organisms and gets nourishment and shelter from that.
- The former organism is termed **parasite** and the latter as **host.**
- This also **depresses the growth rate of host population** or may reduce the total size of host population.
- Parasites are smaller generally, majority of them are host specific.
- High reproductive potential, loss of digestive system and unnecessary sense organs, presence of specific sucking or adhesive organs are some of their characters, but they have poor means of dispersal

D. Mutualism

- It is an obligate association of two organisms in which each derives benefit from the other.
- In mutualism, two organisms often live together and can't live separately, the two organisms may be plants, animals or one plant and other animal.

(i) Mutualism between plant and plant *e.g.,* **lichen** (Alga and Fungus), **mycorrhiza** (Fungus and roots of higher plants), *Rhizobium* (N_2-fixing bacteria in root nodules of legumes).

(ii) **Mutualism between plant and animal** *e.g.* , Green algae *Chlorella vulgaris* (endosymbiont) in gastrodermal cells of *Hydra.* Plant pollinator relation sometimes is a one-to-one coevolutionary relation like fig and wasp relation, *Ophrys* and *Colpa* relation, *Yucca* and *Pronuba* relation.

(iii) **Mutualism between animal and animal** *e.g.*, Protozoan *Trichonympha* in gut of termites. Protozoan helps in cellulose digestion and in return gets shelter.

E. Protocooperation

- It is a non-obligatory interaction between two organisms of different species, in which both are mutually beneficial to each other, but can easily live separately.
- Two birds, namely **red-billed ox pecker** and **yellow-billed ox pecker** feed on ticks and other parasites sticking to the skin of black rhinoceros and relieve him of the parasites.
- The birds sitting on *Rhinoceros* for feeding on ticks, etc., also warn the animal of approaching danger.
- The birds are not only benefitting the animal, but themselves are benefitted too as the animal is providing food (ticks, etc.) to the birds.
- This is an example of protocooperation as the birds have no close association with animal, it just visits him occasionally for feeding.

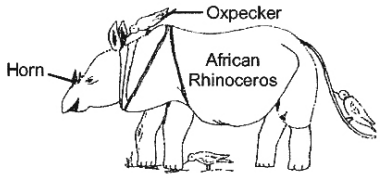


Fig. : Protocooperation between tick bird Ox Pecker and Rhinoceros.

- Another example of protocooperation is the relationship between **plover bird and the crocodile.**
- The bird enters the open mouth of the crocodile, feeding on the leeches which are attached to the lining of buccal cavity.
- The bird not only is getting benefit from the animal (getting food) but helps the animal in getting rid of leeches which are sucking its blood.
- The association between **sea-anemone and hermit crab** may also be taken as an example of protoco-operation in which sea-anemone is attached to snail's shell.
- Sea-anemone is sedentary and can move from one place to another using snail's shell as portable home and is able to procure more food.
- The hermit crab is protected from its enemies by the sea-anemone having nematocysts.

F. Commensalism

- It is an interaction between two organisms of different species, benefitting only one species, the other species is neither benefitted nor harmed.
- The species which is benefitted is termed **commensal** and the other species is called **host.**
- Examples of commensalism are observed in diverse types of animals and even in plants.

(i) The pilot fish *(Remora)* always accompanies shark with a purpose of feeding upon small pieces of food falling off when shark is tearing its prey. The fish is not attached

to shark at anytime.

(ii) Sucker fish is attached to underside of shark, getting a free ride and occasionally detaching itself when the latter is caoturina its orev to feed uoon small nieces of food.

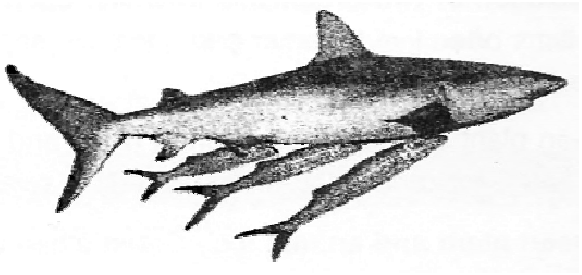


Fig. : Commensalism between Sucker fish and Shark

(iii) Jackals and arctic foxes follow lions and seals, respectively for feeding upon left out food pieces by the predators.

(iv) Barnacles *(Balanus)* live attached to whale's body, not getting any benefit from it except shelter.

(v) Epiphytes are attached to other plants but not getting anything from the host. They are green, thus nutritionally independent and have special hygroscopic roots which can absorb water present in the atmosphere in the form of vapours. They get shelter only from the host. They are able to get proper sunlight too for photosynthesis by growing on higher branches of trees in thick forests.

(vi) Cattle egrets (birds) forage close to where cattles are grazing because the cattles as they move, stir up and flush out from the vegetation insects that otherwise might be difficult for the egrets to find and catch.

(vii) Sea anemone has stinging tentacles that protect clown fish living among them.

G. Amensalism

- It is an interaction between two organisms of different species in which one species inhibits the growth of other species by **secreting certain chemicals.**
- This phenomenon of inhibition of growth of one species by the other species through secretion of certain chemicals is also termed **allelopathy (in plants), or antibiosis or biological antagonism.**
- Examples of amensalism are evident in micro-organisms.
- *Penicillium* secretes penicillin, that inhibits the growth of large number of bacteria. Similarly, different species of *Streptomyces,* an actinomycete, produce wide range of chemicals which inhibit the growth of other bacteria, some of which cause various diseases in human beings.
- Such chemicals isolated from these microorganisms are thus, used as **antibiotics** for curing various diseases caused by bacteria.
- Inhibition of growth of one species by organism of other species is observed in higher plants as well.
- Roots of black walnut *(Juglans nigra),* secrete a chemical **juglone** which is toxic to other plants like apple, alfalfa, etc. *Convolvulus arvensis* inhibits the growth of wheat

	Interaction type	Combination		Effects	Examples
1.Positive interaction					
1	**Mutualism**	(+)	(+)	Both species benefitted	Lichen, *Mycorrhiza* etc.
2	**Commensalism**	(+)	(0)	One species is benefitted and the other species is neither benefitted nor harmed	orchids, Lianas etc.
2.Negative interaction					
4	**Predation**	(+)	(-)	One species benefitted, the other species are harmed	*Drosera, Nepenthes* etc.
5	**Parasitism**	(+)	(-)	One species benefitted, the other species are harmed	*Cuscuta, Duranta, Viscum* etc.
6	**Competition**	(-)	(-)	Harmful for both	Grassland species
7	**Amensalism**	(-)	(0)	Harmful for one, but the other species are unaffected	*Penicillium* and *Staphylo coccus*

(+) Benefitted, (-) Harmed (0)Unaffected

Fig: Different interactions of plants

Population Distribution

A key characteristic affecting a species' range is the way in which individuals of its populations are distributed. They may be randomly spaced, uniformly spaced, or clumped (fig.).

Randomly Spaced

Individuals are randomly spaced within populations when they do not interact strongly with one another or with nonuniform aspects of their environment. Random distributions are not common in nature. Some species of trees, however, appear to exhibit random distributions in Panamanian rainforests (fig.).

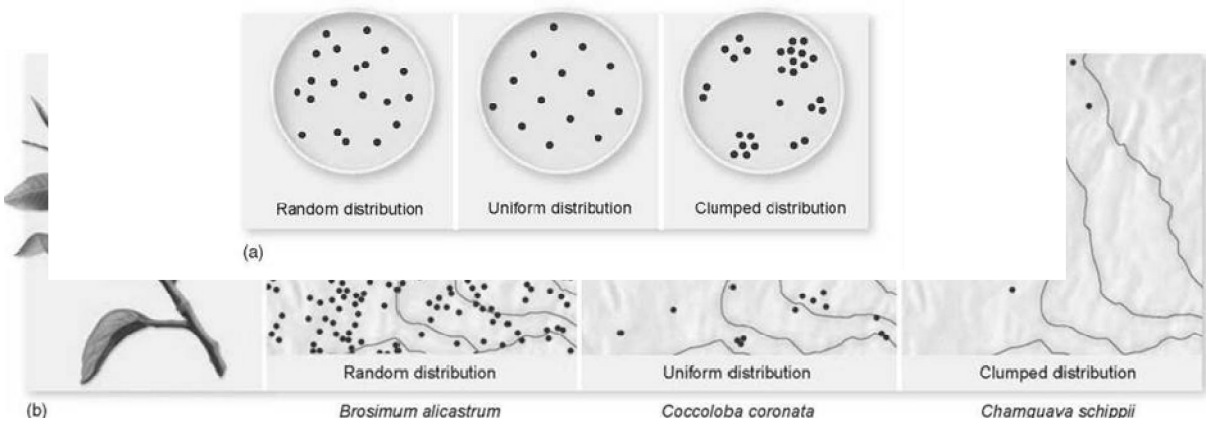


Fig. Population distribution.
The different patterns of spacing are exhibited by (a)different arrangements of bacterial colonies and (b) three different species of trees from the same locality in Panama.

Uniformly Spaced

Uniform spacing within a population may often, but not always, result from competition for resources. The means by which it is accomplished, however, varies.

Clumped Spacing

Individuals clump into groups or clusters in response to uneven distribution of resources in their immediate environments (see fig.). Clumped distributions are common in nature because individual animals, plants, and microorganisms tend to prefer microhabitats defined by soil type, moisture, or other aspects of the environment to which they are best adapted.