INTRODUCTION

(i) The term ecology was coined and described by
– E.Haeckel

(ii) Father of ecology
– Reiter

(iii) Father of Indian Ecology
– Prof. Ram Deo Misra

(iv) First of all term ecology was employed for study of plant by **– Warming**

The study of interaction or inter-relationship of organisms with their environment is called ecology.

Organism ⇌ Environment

Organism and environment are always interdependent, inter related or mutually reactive.

1. BRANCHES OF ECOLOGY

It is based on organism level

(a) **Autecology** – Study of the relation of a species with its environment is known as autecology

(b) **Synecology** – Study of the relation of the group of different species with their environment

ECOLOGICAL HIERARCHY

Organism → Population (species) → community → Ecosystem → Biome → Biosphere

size → Increase

complexity → Increase

2. ORGANISM

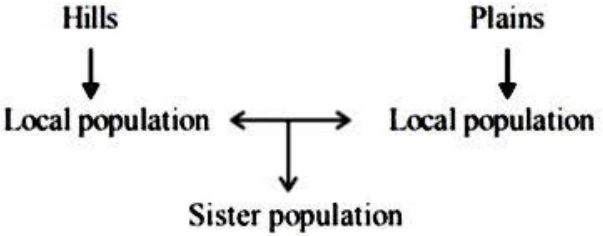
An organism is the smallest unit of ecological hierarchy and basic unit of ecological study.

- It may be small, large, unicellular or multicellular.
- Fixed life span and organized life cycle (birth to death)

3. POPULATION

A group of Individuals (members) of same species living at one place (specific geographical area) constitute a population.

- **Local Population or demes (Sub groups of population)** – Population of organism inhabiting a particular area.
  eg. Homosapiens inhabiting hills, plains
- **Sister population** – Different population of same kind of organisms which are found in different places are known as sister population.



- **Meta population** – A set of local population which are interconnected by dispersing individuals.

4. SPECIES

Definition - Species is a basic unit of classification, defined as the group of living organisms similar in structure, function and behaviour and produced by similar parents, have common gene pool, can inter breed under natural conditions and reproductively isolated from other group of organism.

SOME TERMS RELATED TO SPECIES :

- **Endemic Species or Endemism :**
  A species which is found only in a particular area is known as endemic species.
  e.g. Meta sequoia is found only in valley of China, Kangaroo in Australia

◆ **Key-stone Species :**

The species which have great influence on the community's characteristics relative to their low abundance or biomass are called key-stone species. The activities of key-stone species determine the structure of the community.

e.g. Lion in forest, Kangaroo rat in desert

◆ **Critical Link Species :**

The species which establishes an essential link with other species to help the latter in some vital activity is called link species.

e.g. Mycorrhizal fungi, many insect species which works as pollinators of flowers.

5. COMMUNITY

Groups of organisms of different species that live in common area, which are interrelated and interdependent. It is a natural aggregation of plants and animals in the same environment.

Biotic Community = Animal community + Plant community + Microbial community

Characteristics of a community –

A. Species Diversity

There are different types of population (species) found in community, this is called species diversity. It depends on size of the area, type of area, type of soil , altitude, climate.

B. Dominance

The highest number of organism of a species present in community, is called as the dominant species. Whole community is known by the name of that particular dominant species.

e.g. Prosopis community at Aravali hills, Pinus community at Himalaya

C. Stratification

The different growth form (trees, shrubs, under shrubs, herbs) determines the structure of a plant community. Stratification is based on mode of arrangement of various growth forms.

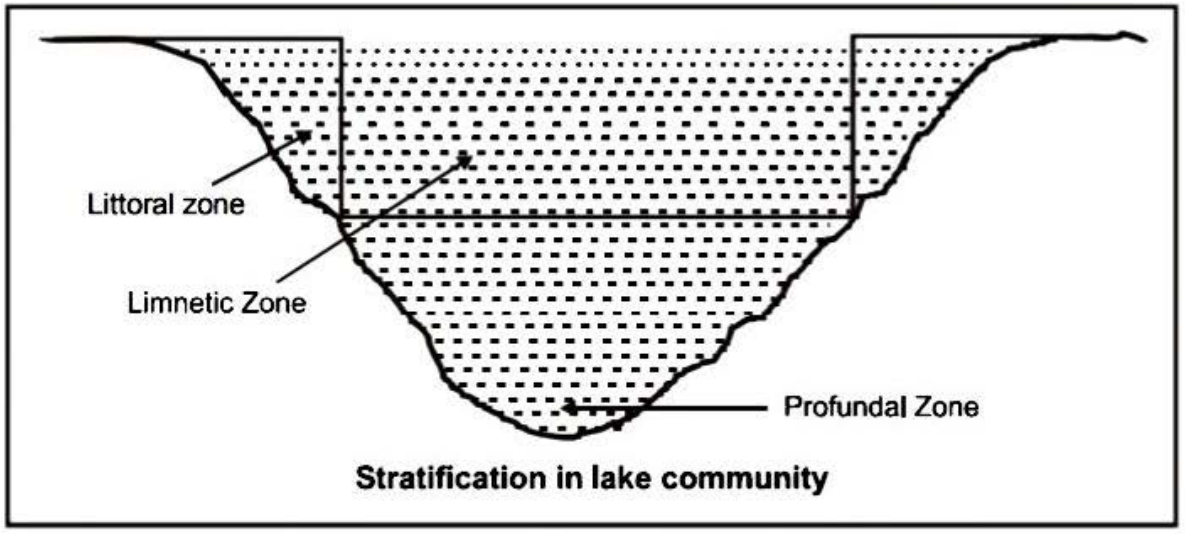
◆ **Stratification in lake–**

In deep lake, zonation or stratification may be according to the need of **light**. There are three types of zones differentiated in a deep lake.

(i) **Littoral Zone** – This zone is found at bank of lake where very shallow water or marshy land is present. Rooted vegetation is found in this zone.

(ii) **Limnetic zone** – This is the zone of lake water, where light reaches in sufficient amount to entire surface area. It means this is not too deep. In this region different types of floating plants (phytoplanktons), suspended and submerged plants are present.

(iii) **Profundal zone** – It is very deep area of the lake where light does not reach up to the bottom. Only heterotrophs are present in this zone.



Stratification in lake community

Fig. 1.1

◆ **Stratification in forest –**

The clear stratification (vertical arrangement) in various growth forms of plants according to the need of light in any dense forest.

Surface dewellers → Herbs → Under shrubs → Shrubs → Trees

Knowledge Cloud

1. Term ecology was first used by Reiter in 1868.
2. Ernst Haeckel (1886) first correctly defined ecology as the science dealing with reciprocal relationship of organisms and the external world.
3. Prof. R. Mishra is known as father of ecology in India. Warming is known as father of plant ecology.
4. E.P. Odum – defined it as the "study of structure and function of nature".

Terrestrial Biomes

1. Tundra
2. Taiga (coniferous forest)
3. Temperate forest
4. Grasslands
   (i) Temperate grassland
   (ii) Tropical savanna grassland (grass cover with scattered trees)
5. Desert
6. Chaparral
7. Tropical rain forest.

Sr. No.	Biome	Location	Features
1	Tropical Rain forest	Equatorial & sub – equatorial region of central America, South America, parts of Africa, Southeast Asia.	• Rich in biodiversity • 30-40 m tall trees • 4-5 strata • Buttress roots • Drip tips, maximum leaching • Woody climbers and Epiphytes
2	Coniferous forest/Temperate needle leaf/Taiga	Cold temperate region of Asia, North America, Europe, South of tundra.	• 30-35 m tall trees • Coniferous trees • Evergreen trees • Leaves long needle like • E.g., Pine, (*Pinus*), Deodar (*Cedrus*,) Cypress (*Cupressus*), Silver fir (*Abies*)
3	Temperate broad leaf forest	Temperate areas of America, Europe, Asia, New Zealand, Australia	• 25-30 m tall trees • Deciduous trees • Broad leaf • Several species of oak, Predominate.
4	Grassland	Steppes - Russia Prairies - N. America Pampas - S. America Veldts - S. Africa Tussocks - New Zealand Dawns - Australia	• Tree less biome • Grasses (Poaceae) • Non graminaceous herbs mostly legumes.
5.	Tundra	North - Arctic tundra South - Absent	• Permafrost (sub soil remains frozen) • Scantly vegetation • Trees absent • Grasses, sedges, mosses & lichens present • Birches (*Betula*) & Willows (*Salix*)
6	Desert	Cold desert – Tibet, Gobi Hot desert – Thar, Sahara	• Vegetation sparse. Three types of plants. • Ephemerals or short lived annuals herbs • Succulent xerophytes • Deep rooted shrubs & small trees *e.g.*, *Prosophis*, *Salvadora*, *Tamarix*, *Cenchrus* is a desert grass.

S. No.	Type of Biome	Mean Annual temperature (°C)	Mean annual rainfall (mm)	Important vegetation
1.	Tropical rain forest	23-27	2000-3500	*Dipterocarpus*, *Hopea*
2.	Tropical deciduous forest	22-32	900-1600	Sal, Teak, Tendu, Chiraunji, Khair
3.	Temperate broad-leaf forest	6-20	1000-2500	Oak (*Quercus*)
4.	Temperate needle leaf forest	6-15	500-1700	Pine, Deodar, Cypress, Spruce, Silver fir

i) Based upon thermal tolerance, organisms are classified into two categories:

Stenothermal	Eurythermal
Such organisms live in areas where the temperature is uniform throughout the year. These organisms cannot tolerate large temperature variations and thus, restricted to narrow range of temperatures. Vast majority of organisms belong to this category.	A few organisms can tolerate and thrive in a wide range of temperatures. They are called as eurythermal. Such organisms can tolerate large changes in temperature.

i) **Based upon the thermoregulation and homeostasis, organisms are classified into two groups**

Ectotherms	Endotherms
1. Also known as **Poikilotherms** or **Cold blooded** organisms. 2. These organisms cannot regulate their body temperature, which changes with surrounding *i.e.* homeostasis is absent.	1. Also known as **Homiotherms** or **Warm blooded** organisms. 2. These organisms can regulate their body temperature, which remains constant irrespective of surroundings.

ii) The organisms are **classified into four temperature groups** on the basis of their occurrence in differe climatic zones :

Megatherms	Mesotherms	Microtherms	Hekistotherms
Organisms adapted to high temperature throughout the year are found in **tropical zones.**	Organisms are adapted to mild winters and high summer temperatures. The organisms live in **subtropical zone.**	Organisms live in **temperate** regions where the winter temperature is low but the summer temperature is moderate.	Organisms are adapted to brief summer period of below 10°C and long snowy winter period, as in **arctic** or **alpine zone.**

Water bodies	Salinity (parts per thousand)
Inland water	5
Sea	30-35
Hyper saline lagoons	>100

Based up on salinity tolerance, organisms are classified into two categories :

Euryhaline	Stenohaline
Euryhaline are organisms which tolerate a wide range of salinities (*e.g.*, Salmon)	Stenohaline are those which are restricted to a narrow range of salinities (*e.g.*, Shark) . Due to osmotic problems and lack of adaptations, many fresh water animals cannot live for long in sea water and vice versa.

Category	Wave length
UV-C	100 - 280 nm (0.1 - 0.28 μm)
UV-B	280 - 320 nm (0.28 - 0.32 μm)
UV-A	320 - 400 nm (0.32 - 0.4 μm)

Light Zonation of Lakes :

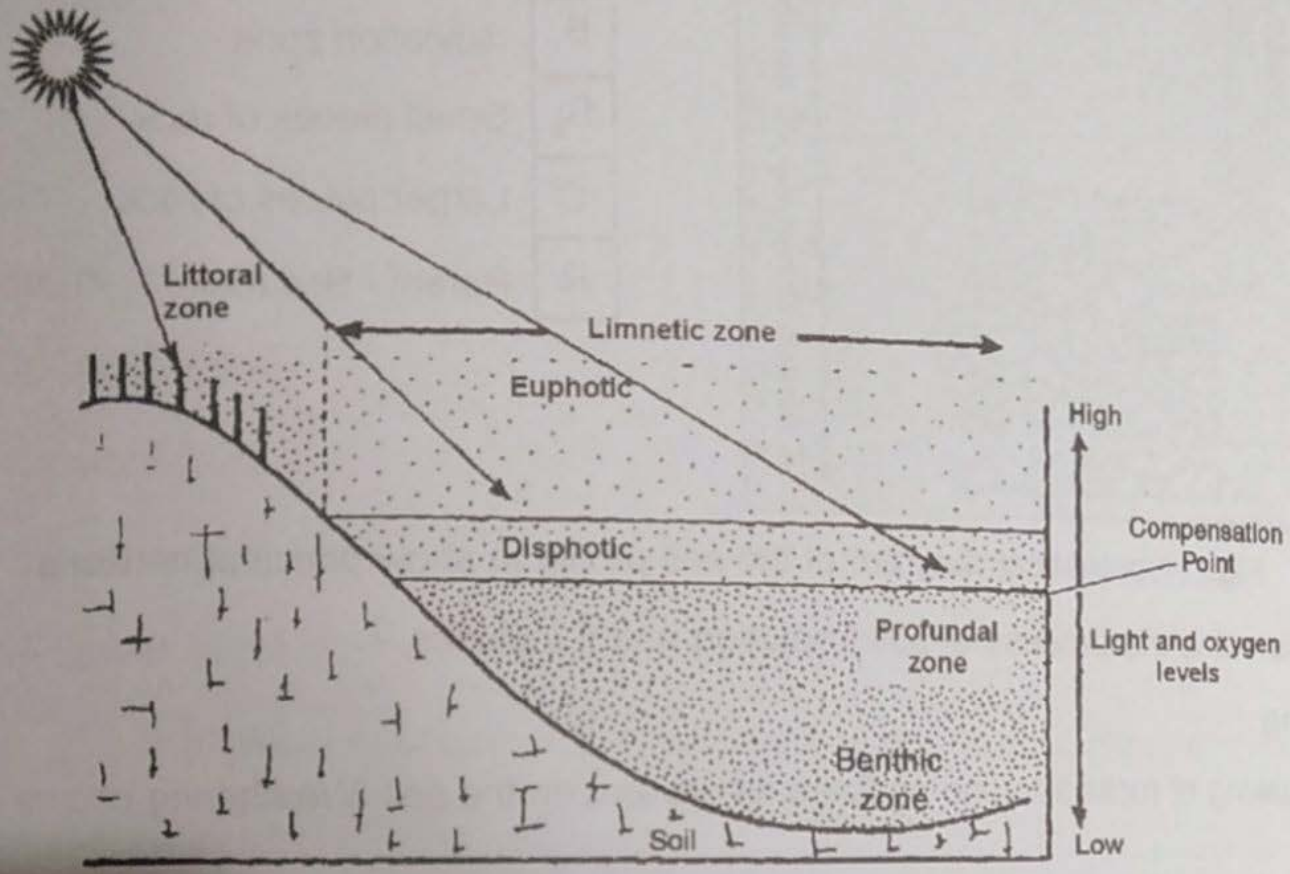


Fig.: Zonation in deep lake showing gradient of light and oxygen

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 → Receives 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.

Knowledge Cloud

1. **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%

2. **Mineral matter/soil particles :** There are four types of mineral particles.

(a) Gravel (Fine pebbles) : > 2mm

(b) Sand (Quartz or SiO_2) : 2 – 0.02 mm

(c) Silt (Very fine quartz grains) : 0.002 – 0.02 mm

(d) Clay (Hydrated silicates of aluminium) : < 0.002 mm

3. **Soil texture :** It is a physical structure of the soil which is due to size, proportion and arrangement o its constituents. There are three main types of soil textures:

Sandy Soil	Clay Soil	Loam Soil
1. 80% or more sand + 20% or less silt or clay	1. 40–50% clay + 50–60% silt + little sand may be present	1. 20% clay + 40% sand + 40% silt
2. Poor water-holding capacity	2. High water-holding capacity	2. Moderate water-holding capacity
3. Porous and loose	3. Abundant capillary pores	3. Moderately porous
4. Little chemical nutrition	4. Good quantity of nutrients available but aeration is poor	4. Good mineral nutrition, aeration and hydration therefore best for plant growth

A. Adaptations for water abundance : Hydrophytes are plants growing in water. *e.g. Hydrilla, Wolffia, Trapa Polygonum.*

Morphological adaptations	Anatomical adaptations
1. Root : a. Roots are either completely absent (*e.g., Salvinia, Wolffia, Ceratophyllum*) or poorly developed (*e.g., Hydrilla*). b. Root pockets are present as balancing organs in *Azolla, Eichhornia, Lemna, Pistia* etc. instead of root cap. **2. Stem :** Long, slender, spongy and flexible (*e.g., Potamogeton* and *Hydrilla.*) **3. Leaves :** a. Petiole may be swollen and spongy *e.g., Eichhornia.* b. Submerged hydrophytes have thin, long ribbon shaped leaves (*e.g., Vallisneria*) c. Leaves of floating hydrophytes are large, entire and flat. These are often coated with wax (*e.g., Nymphaea*) d. 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, Limnophilla heterophylla, Sagittaria sagitifolia*).	1. Presence of large air spaces and aerenchyma. 2. Mechanical tissue *i.e.* sclerenchyma is either poorly developed or absent. 3. Vascular tissue specially xylem is poorly developed. 4. Cuticle is absent. 5. Stomata are absent Floating leaves are epistomatic. 6. Epidermis is always single layered.

B. Adaptations for water scarcity : Xerophytes are plants growing in places of deficient water supply. Th grow in deserts or rocks. *e.g. Opuntia, Aloe, Agave, Casuarina, Calotropis.*

Morphological adaptations	Anatomical adaptations
1. Root : a. Roots are well developed, profusely branched and extensively spread. b. Roots are deep in **phreatophytes**. **2. Stem :** a. It is generally hard and woody with thick bark. b. Some plants may show modification of stem into leaf like structure called **phylloclade** (*e.g. Opuntia*). **3. Leaves:** Leaves of xerophytes are generally caducous (*e.g., Euphorbia*) or may be completely absent (*e.g., Capparis aphylla*).	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. Sunken stomata are present. 4. Mechanical tissue and vascular tissue are well developed. 5. Epidermis may be multiple. 6. Water storage tissue is present.

C. Adaptations for salinity : [Halophytes - grow in saline soil]

Morphological adaptations	Anatomical adaptations
1. **Root :** Mangrooves have specialized roots called **pneumatophores** which are negatively geotropic. These are modified tap roots which have **pneumathodes** for gaseous exchange.	1. Presence of thick cuticle on stem. Upper and lower leaf epidermis is thickly cuticularized.
2. **Stem :** Mostly succulent or fleshy.	2. Stem hypodermis is multilayered, thick walled. Pericycle is **sclerenchymatous,** 3-4 layered.
3. **Leaves :** Evergreen, thin, leathery.	3. Vascular tissue is well developed.
	4. Sunken stomata are present only in the lower leaf epidermis.

Knowledge Cloud

Xerophytes are of two basic types

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.

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; **(drought evaders** or **drought escapers)** *e.g. Cassia tora, 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).**

(i) Stem succulents (chylocauly) : *e.g., Opuntia, Euphorbia.*

(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.

INTRODUCTION

DEMOGRAPHY (POPULATIONS)

Scientific study of human population is called demogrpahy.

Population is defined as the total number of individual of a species present in a particular area at a given time.

The population have specific character different from the character of individual.

1. Character of population :

A. Population density (Population size)

It is measured as total number of individual present in unit area or unit volume.

The size of a population for any species is not a static parameter. It keeps changing in time depending on various factor including food availability, predation pressure and reduced weather.

For human population density is officially counted in first four month of Ist year of each decade is called census.

(i) For human population density is calculated as number of person living in per square km area.

(ii) The tiger census in our national park and tiger reserves is often based on pug marks and fecal pellets.

B. Birth rate / Biotic potential / Fertility / Natality :

Birth rate is defined as total number of birth in a population with respect to total number of individual of the population in a year.

Birth rate is represented as per capita birth rate

$$\text{Per capita birth rate (b)} = \frac{\text{Total birth}}{\text{Initial population}}$$

Eg. If in a pond there are 20 lotus plant last year and through reproduction 8 new plant are added, then the birth rate during the year is calculated as :

$$\text{Solution : } b = \frac{\text{Total birth}}{\text{Initial population}}$$

$$= \frac{8}{20}$$

b = 0.4 offspring per lotus per year.

- Birth rate varies from region to region
- Developed country have lower birth rate.
- Developing or poor country have higher birth rate than developed country
- Higher fertility in developing world is partially explained by large number of hand needed to perform work.
- Population evolve different strategy to maximise their reproductive fitness . Some organism breed only once in their life time like Pacific salmon fish, Bamboo etc. and some produces small sized offspring like Oyester, Pelagic fishes etc. maximise their fitness by producing large number of offspring. Some organism breed many times in their life and produces a small number of large sized offspring (Birds, Mammals).

C. Death rate / Mortality :

- Death rate is defined as total number of death in a population with respect to total number of individual of the population in a year.
- Death rate is represented as per capita death rate

$$d = \frac{\text{Total number of death}}{\text{Initial population}}$$

Eg.: If 4 individuals in a laboratory population of 40 fruit fly died during week. The death rate is calculated

Sol. $$d = \frac{\text{Total number of death}}{\text{Initial population}}$$

$$= \frac{4}{40}$$

d = d = 0 .1 individual per fruitfly per week

D. Growth rate:

Intrinsic growth rate (r) = b - d

$$\text{Growth rate} = \frac{\Delta N}{\Delta t}$$

$$\text{Percent growth rate} = \frac{\left(\frac{\Delta N}{\Delta t}\right)}{N_0} \times 100$$

Note : Natality, Mortality, Immigration and Emigration are the basic process responsible for fluctuation in population size under normal conditions, Natality and Mortality are the

most important factors influencing population

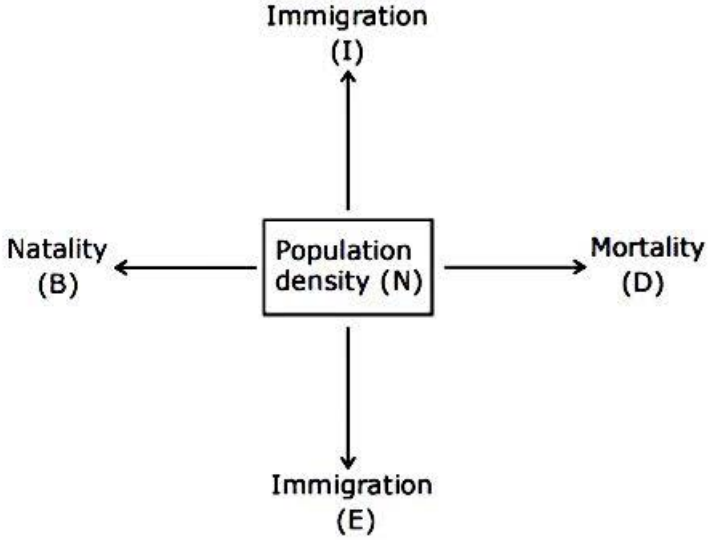


Fig.5.1

size than other two factor i.e., Immigration and Emigration.

$N_{[+]} = N_t + [(B + I) - (0 + E)]$

E. Age and Sex Structures:

The age structure of a given population refers to the proportion of individuals of different age. This is important aspect because many functional aspect of individuals are related to age. (Like Reproduction)

Age structure of a population can be depicted in the form of a pyramid diagram.

Diagram is particularly important in understanding future growth.

Population has 3 age groups.

(i) Pre-Reproductive individuals

(ii) Reproductive individuals

(iii) Post-Reproductive individuals

2. Representation of age pyramids for human population

- A higher number of pre-reproductive individuals, moderate number of reproductive individuals and fewer post reproductive individuals will form young population it shows rapid growth.
- Fewer number of pre reproductive individuals as compared to reproductive ones will make population aged. It shows negative growth.
- An equal number of pre reproductive and post reproductive individuals will constitute a mature population or stable population.
- Developed countries have a steeper pyramid which represent nearly a stable population.

A. Population Growth Models / Curve

There are two type of growth curve

a. Exponential growth (Geometric growth curve or J-Shaped Curve) :

Any species growing exponentially under unlimited resource conditions can reach enormous population densities in a short time. If in a population of size "N", the birth rates are represented as b and death rates as d, then the increase in N during a unit time period t $\left(\frac{dN}{dt}\right)$ will be.

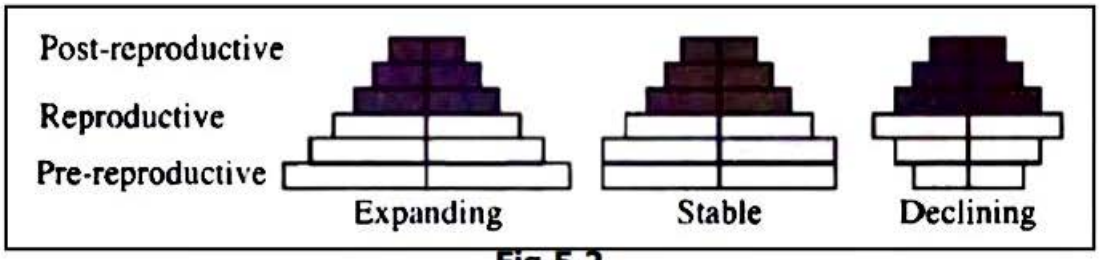


Fig.5.2

Population Interactions

S.No.	Species A	Species B	Name of Interaction
(i)	+	+	Mutualism
(ii)	+	+	Protocooperation
(iii)	+	0	Commensalism
(iv)	–	–	Competition
(v)	+	–	Predation
(vi)	+	–	Parasitism
(vii)	–	0	Amensalism

'+' → Beneficial interaction, '–' → Detrimental interaction, '0' → Neutral interaction