Organisms and Populations

Organisms and Environment

- **Ecology** deals with interactions among different organisms and their environment.
- Organisms get adapted to their environment for their survival and reproduction.
- The rotation of the earth about its axis brings about changes in the environment, leading to different seasons. This leads to the formation of various biomes such as desert, grassland, etc.
- Life not only exists in favourable habitats, but also in harsh and extreme conditions.
- The environment of an organism can be divided into:
- **Abiotic factors**
- **Biotic factors**

Abiotic Factors

- Some of the major abiotic factors that interact with the organisms are:
- **Temperature** – It is the most relevant abiotic factor since all organisms require an optimum temperature for their metabolism and other body functions. Depending upon their ability to tolerate temperature range, organisms are of two types- stenothermal (restricted to a narrow range of temperature) and eurythermal (can tolerate a wide range of temperature).
    - **Water** – Water also is a major influencing factor. Life on earth is impossible without water as it forms the major constituent of all living cells. In oceans where quantity of water is not a limitation, the quality of water becomes one. Depending upon the ability to tolerate salinity, organisms can be stenohaline (restricted to narrow range of salinity) and euryhaline (tolerant to wider range of salinity).
    - **Soil** – The nature and composition of soil differs from one place to another depending upon the climate, weathering process, and soil development method. The characteristic features such as soil composition, grain size, percolation, water holding capacity, etc. determine the native of the organisms it can support.
    - **Light** – The major source of light on earth is the Sun. Light is essential for plants to perform photosynthesis. Certain plants become adapted to perform photosynthesis under very low light since they are constantly overshadowed by tall trees. Many plants also depend on light for their flowering (photoperiodism). The availability of light on land is comparatively higher than that in water.

Responses to Abiotic Factors

- All organisms in order to sustain maximum functionality maintain a constant internal environment (homeostasis). An organism may adopt one of the following strategies for homeostasis:

- **Regulate** – Certain animals have the ability to maintain a constant temperature and a constant osmolarity to keep up their homeostasis. Mammals have a constant body temperature (37°C) irrespective of the outside temperature. In summers, to maintain the temperature, we sweat and in winters we shiver, which produces heat.

- **Conform** – Animals and plants except mammals do not have a constant body temperature and their body temperature changes in accordance with the outside temperature. Such organisms are called conformers. Conformers have not evolved. They have not become regulators since regulation is energetically more expensive.

- **Migrate** – The organism can move temporarily from stressful habitats to more hospitable areas and return once the period changes. Birds can migrate from cold regions to relatively warmer regions during winter and vice-versa during summers.

- **Suspend** – Some organisms cease to be metabolically active during stressful period. They suspend all activity and enter a period of dormancy. For example – Spores in bacteria and lower plants; and hibernation (winter sleep) and aestivation (summer sleep) in animals Similarly, zooplankton enter diapause, a stage of suspended development during unfavourable conditions.

Adaptations

- **Adaptations** are certain characteristics that organisms develop in order to survive and reproduce better in their habitat.

- These adaptations can be physiological, behavioural, or morphological.

- Some of the adaptations are:

- **Desert plants** have thick cuticle on their leaf surface and stomata arranged in deep pits to reduce water loss. Their special photosynthetic pathway CAM enables their stomata to remain closed during day time. Their leaves are reduced to spines and photosynthesis is carried out by flattened stems.

- **Animals of colder regions** have shorter limbs and ears to minimise heat loss (Allen's rule) and the body is covered by thick fur to reduce the heat loss. Their body has a thick layer of fat (blubber) below their skin that acts as an insulator to minimise heat loss.

- **People living in high altitudes** have high RBC production and increased breathing rates.
- Some **desert animals** are capable of burrowing in order to escape the heat. In addition, some desert animals such as kangaroo rat are able to meet their water requirement through internal fat oxidation. They also have ability to concentrate their urine.

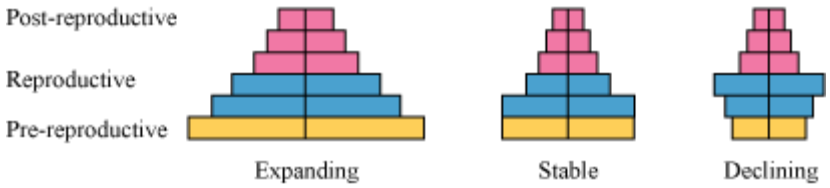
Population

Population:

- It is a group of similar individuals living in a geographical area, sharing similar resources, and capable of interbreeding.
- Population has certain attributes, which individual organisms do not possess:
- **Birth rate** *per capita* births
- **Death rate** *per capita* deaths
- **Sex ratio –** Ratio of number of males to females in a population
- **Demography**: It refers to the statistical study of human population considering the following factors:
- Distribution of population
- Size and Density of population
- Birth rate
- Death rate
- Growth rate of population (Growth rate = Birth rate - Death rate)

Age distribution

- A population can be composed of individuals of different age groups.
- Age distribution plot for a given population is given by the age pyramid.
- The structure of the age pyramid determines the growth status of the population, whether it is growing, stable, or declining.



Population size, more technically, is referred to as population density (N), which indicates the number of individuals inhabiting a particular niche.

If the population is huge, then relative density is measured instead of absolute density whose measurement is time-consuming.

- The size of a population is an ever-changing aspect since it depends upon availability of food, predation, weather conditions, etc.
- This gives us an idea whether a certain population is growing or declining.
- Some of the reasons for the increase or decrease in population:
- Natality (B) − Number of births during a given period in the given population
- Mortality (D) − Number of deaths during a given period in the given population
- Immigration (I) − Number of individuals of the same species who have come into the habitat from elsewhere during a given period
- Emigration (E) − Number of individuals of the same species who have left the habitat and gone elsewhere during a given period
- If N is the population at time t, then its density at t + 1 is

$$N_{t+1} = N_t + [(B + I) - (D + E)]$$

Growth Models

- **Exponential Growth** − When the resources are unlimited, population tends to grow in an exponential pattern.
- If the population size is N and the birth and death rates (not *per capita*) are b and d respectively, then increase or decrease in N at t (time period) is given by,

$$dN/dt = (b - d) \times N$$

If $(b - d) = r$, then

$$dN/dt = rN$$

r is the "intrinsic rate of natural increase".

Or,

$N_t = N_0 e^{rt}$

Where,

N_t – Population density at time t

N_0 – Population density at time 0

r – Intrinsic rate of natural increase

e – Base of natural logarithms (2.71828)

- **Logistic growth** – When the resources are limited leading to competition between individuals and survival of the fittest, the population tends to grow in a logistic manner.
- In this kind of growth, there is an initial lag phase followed by acceleration or deceleration phases and finally asymptote, when it reaches its carrying capacity (K).
- When N in relation to t is plotted, it results in a sigmoid curve called the Verhulst – Pearl Logistic growth given by,

$$dN/dt = rN\left(\frac{K-N}{K}\right)$$

N – Population density at time t

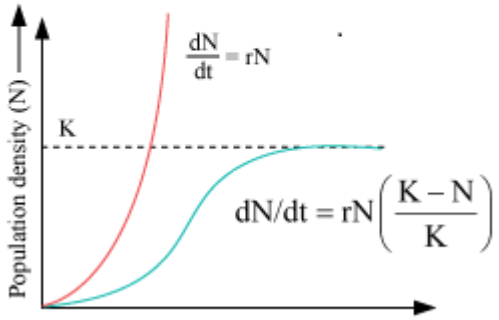
r – Intrinsic rate of natural increase

K – Carrying capacity

N – Population density at time t

r – Intrinsic rate of natural increase

K – Carrying capacity



Life History Variations

- Populations tend to increase their reproductive fitness in order to survive better. This is known as Darwinian fitness (high r value).
- Some of the trends they follow in course of achieving this:
- Some organisms breed only once in their lifetime. Example - Salmon, Bamboo
- Some breed many times. Example - Birds, mammals
- Some produce a large number of small-sized offsprings. Example - Oyster
- Some produce small number of large-sized offsprings. Example - Birds, Mammals

Population Interactions

- A natural habitat consists of many organisms living together and these organisms communicate and interact with each other. For example, plants depend on insects for pollination.
- Interspecific interactions are interactions between two different species of organisms. They can be either beneficial or harmful to one or both partners.

Interspecific interactions

- **Predation** – It is beneficial to the predator while the prey is harmed.
- It acts as a means of transfer of energy to the next higher trophic level and of maintaining balance in the ecosystem.
- For plants, herbivores are predators and some plants produce secondary metabolites, thorns, or poisonous chemicals to ward off predators.
- Similarly, animals also camouflage themselves to protect themselves from predators. Some preys are poisonous or distasteful (Monarch butterfly is highly distasteful because of a special chemical it acquires during its caterpillar stage by feeding on poisonous weeds) so as to avoid predators.
- **Competition** – It occurs only in closely related species wherein they share the same type of habitat and food resources.
- However, for competition to take place resources need not be always scarce and competition does not necessarily take place between same species.

- In competition, the fitness of one species is significantly lower in presence of another species and survival of fittest ultimately takes place.

- Gause's *Competitive Exclusion Principle* states that two closely related species competing for the same resource cannot co-exist indefinitely and the competitively inferior will be eliminated eventually.

- Moreover, some species may develop mechanisms to facilitate their co-existence.

- **Parasitism** – In this interaction, one of the partners is benefited because it resides outside or inside the body of the host and gets free accommodation and food while the host is affected due to loss of nutrients.

- Parasites in nature have developed a wide variety of adaptations such as hooks and suckers for attachment, loss of digestive system, high reproducing capacity, etc.

- Parasites can live either outside (ectoparasites) or inside (endoparasites) the body of the host organisms.

- Brood parasitism is seen in birds in which the parasitic bird lays its egg in the nest of the unassuming host bird, which takes care of them until they hatch. For example, Koel lays its eggs in the nest of the crow.

- **Commensalism** – In this interaction, one of the partners is benefited while the other is neither benefited nor harmed.

    For example, an orchid growing as an epiphyte on the mango tree

    The orchid gets support while the mango tree is unaffected.

- **Mutualism or symbiosis** – In this interaction, both the partners are benefited.

    For example, lichens, interaction of algae and fungi, where both are benefited

    The fungi give support to the algae while the algae prepare the food for the fungi.