# Chapter 13
# ORGANISMS AND POPULATIONS

**ORGANISM AND ITS ENVIRONMENT**

Ecology is the branch of science that deals with the relationship between the organism and the environment. There are different levels of organization, such as-

- Organism- each individual of the species.
- Population- it is defined as group of organisms that can interbreed.
- Communities- different population combine to form communities.
- Biomes-large unit of flora and fauna in a specific climatic zone.

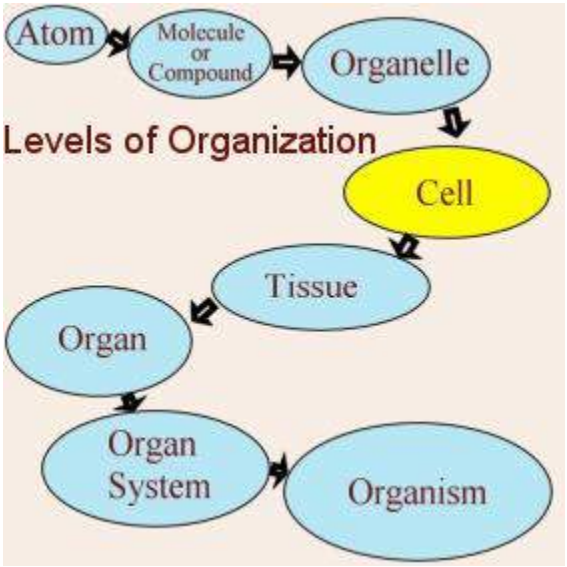


**Fig.1. Levels of organization**

**Major Biomes in India**

**Tropical Rain Forest Biome**

**Deciduous Forest Biome**

**Desert Biome**

**Sea coast Biome**

**Major abiotic factor**

**Temperature** is the most important abiotic factor that affects the organism as well as the environment. Average temperature decreases as we move from the equator towards the poles. It ranges from subzero levels in polar areas and high altitudes to >500C in tropical deserts in summer. Temperature affects the physiology of the body as it affects enzyme kinetics and therefore the basal metabolism rate. Some organisms can tolerate wide range of temperature, they are known as **eurythermal**. E.g., cat, dog, red algae, etc. But vast majority of organisms are restricted to narrow range of temperature, they are known as **stenothermal**. E.g., crocodile, python, penguin Tolerance of temperature determines the geographical distribution of the species.

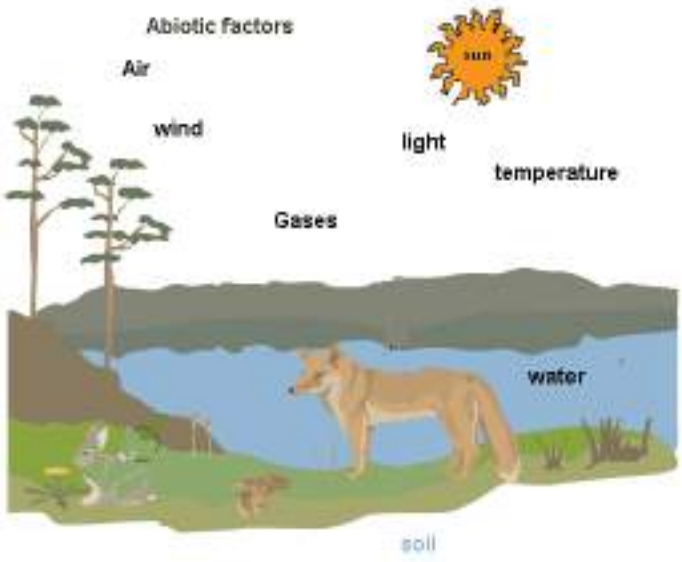


**Fig.2. Different abiotic factors**

**Water** is another important abiotic factor. Though life originated in water some parts such as deserts have limited supply of water. So only organisms that have special adaptation can survive. The productivity and distribution of plants is also heavily dependent on water. For aquatic organisms, pH and composition of water is very important. Some organisms can

tolerate wide range of salinity, they are known as **euryhaline** like the molly fish and the green crab. Some can tolerate only a narrow range of salinity, they are known as **stenohaline** like goldfish, haddock, etc. Many freshwater animals cannot live for long in sea water and vice versa as each is adapted to their respective osmotic environment.

**Light** is very important for photosynthesis and is another important abiotic factor. The importance of photosynthesis can be well understood in autotrophs. Some species can survive well in low light conditions but some need light of high intensity. Based on required light, plants are divided into short day plants and long day plants. Sun is the source of light on earth. Even in animals the diurnal and seasonal variation in light affects their functions as light is the cue for their activities like reproduction, migration and foraging. The spectral quality of solar radiation is also important for life. The UV component of the spectrum is harmful to many organisms while not all the color components of the visible spectrum are available for marine plants living at different depths of the ocean.

Soil is another important abiotic factor that affects the organism and population. The nature and properties of soil are dependent on the climate, the weathering process, on weather soil is transported or sedimentary and how soil development occurred. Apart from this, other parameters such as pH, mineral composition and topography determine the vegetation in any area. This in turn dictates the type of animals that can be supported.

**Responses to Abiotic Factors**

Organisms have different responses towards different abiotic factors. The different responses to abiotic factors can be described as follows:

- **Regulators**: Organisms with the ability to maintain **homeostasis.** This is achieved by physiological means. This ensures constant body temperature, constant osmotic concentration, etc. All birds and mammals, and a very few lower vertebrate and invertebrate species are capable of homeostasis and regulation. Other organism cannot regulate their body homeostasis. Humans maintain a constant body temperature of $37^0$C. In summer, when outside temperature is more than our body temperature, we sweat abundantly. The resulting evaporative cooling, similar to what happens with a desert cooler in operation, brings down the body temperature. In winter when the temperature is much lower than $37^0$C, our body tries to raise body heat by shivering of the muscles. Plants do not have such mechanisms to maintain internal temperatures.

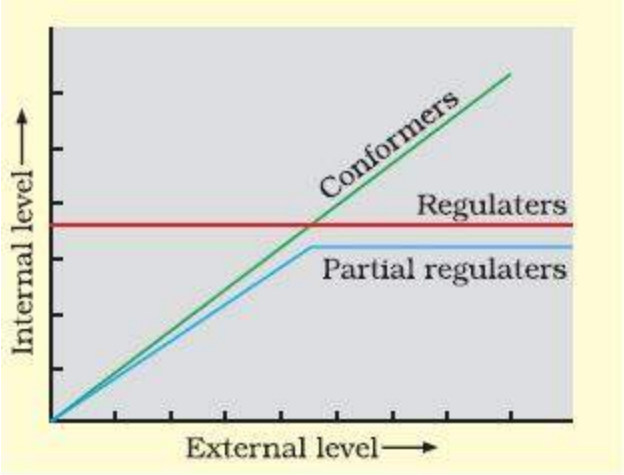


**Fig.3. Diagrammatic representation of organismic response**

- **Conformers** are the organisms which cannot regulate their body temperature. There is an advantage of constant body temperature. Thermoregulation is an energetic process. Heat loss or heat gain is a function of surface area. Small animals have large surface to volume ratio, so they can lose body heat very fast. That is why polar regions do not have small animals. During the course of evolution, the costs and benefits of maintaining homeostasis are taken into consideration.
- **Partial regulators:** Those species that have evolved the ability to regulate but only over a limited range of environmental conditions. Beyond this they simply conform.
- Some organism moves temporarily from the stressful habitat to friendlier place. This is known as **migration**. Every winter the famous Keoladeo National Park (Bharatpur) in Rajasthan host thousands of migratory birds coming from Siberia and other extremely cold northern regions.
- Some organisms suspend their growth and functions during unfavorable conditions. Bacteria, fungi and some lower plants form **thick walled spores** to survive unfavorable conditions. During winter, animals undergo **hibernation (winter sleep)** and in summer, **aestivation (summer sleep).**

**Adaptations**

Adaptation is defined as any attribute of an organism that enables the organism to survive and reproduce in its habitat. Adaptation is genetically fixed. Organisms adapt themselves according to the environment. For example, desert plants have thick cuticle, sunken stomata to minimize the transpiration. They photosynthesize using CAM pathway. Some plants such as *Opuntia* have reduced leaves into spines. Physiological adaptation is also present in living organisms. For example, some people exhibit altitude sickness. They have symptoms such as fatigue, nausea, and heart palpitations. But after some time, they **acclimatized** according to the prevailing conditions. The body also compensates by producing more red blood cells, decreasing binding affinity of oxygen with hemoglobin, and by increasing breathing rate. Some organisms show behavioral responses to cope with variations in their environment.

## Populations

### Population attributes

Population is defined as group of individuals of a species that can interbreed and produce fertile offspring. A population has certain attributes. A population may have death rate or birth rate. Increase in population per capita is known as **birth rate** whereas decrease in population is known as **death rate**. Another attribute of population is known as sex ratio. Age distribution is also an attribute of population. Age distribution is presented in the form of age pyramid. The shape of the pyramid reflects the status of the population. The population can be expanding, stable and declining. **Expanding population** is the characteristics of growing population where number of young individuals are more than the old individuals. When the young and old individuals are equal, it is known as **stable population**. When old individuals are more compare to young individuals, then the population is said to be **declining**.

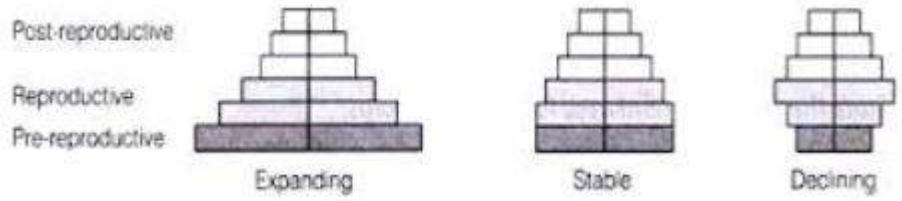


**Fig.4. Representation of age pyramids for human population**

### Population growth

The size of the population for any species is not static. It changes according to food availability, predation pressure and adverse weather. Population density changes because of the four main reasons-

- **Natality** is defined as number of births in a given period of time.
- **Mortality** is defined as number of deaths in a given period of time.
- **Immigration** is defined as when the number of individuals of the same species have come into the habitat for a period of time.
- **Emigration** is defined as when the number of individuals of the same species move to somewhere else for a period of time.

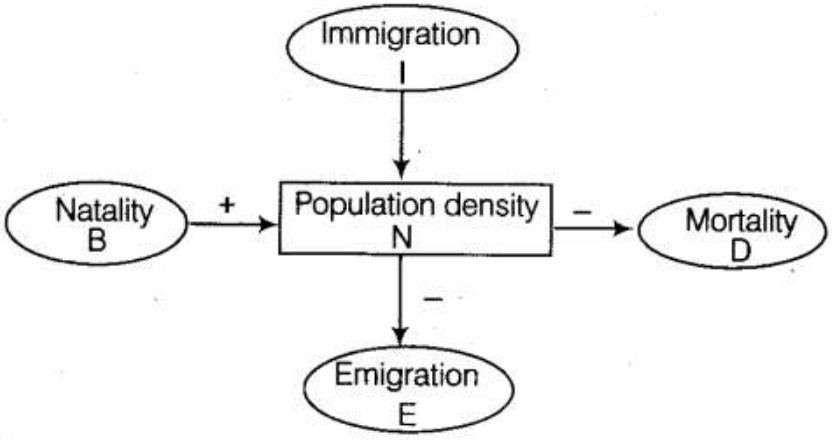


**Fig.5. Population attributes that affects population density**

Population density represented by N, is given as-

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

N is the population density at time t, B+I represent birth rate and immigration, D+E represents death rate and emigration.

**Growth models**

- Exponential growth

Exponential growth is observed when the nutrients are available in excess quantity. If in a population of size N, the birth rates (not total number but *per capita* births) are represented as *b* and death rates (again, *per capita* death rates) as *d*, then the increase or decrease in N during a unit time period t (dN/dt) will be-

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

Let (b–d) = r, then

$$dN/dt = rN$$

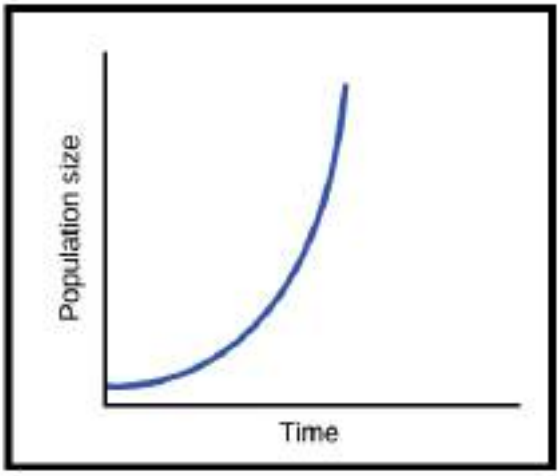

**Fig.6. Exponential growth**

The r in this equation is called the 'intrinsic rate of natural increase. The exponential or the geometric growth pattern of population results in J-shaped curve. The final equation obtained is given as-

$$N_t = N_0 e^{rt}$$

$N_t$ = Population density after time t

$N_0$ = Population density at time zero

r = intrinsic rate of natural increase

e = the base of natural logarithms

- Logistic growth

When the resources are limited, then the population growth curve is logistic in nature. When the resources are limited, competition between the individuals occurs. When growing in limited resources, a population initially goes through lag phase, followed by phases of exponential growth and deceleration and finally asymptote.

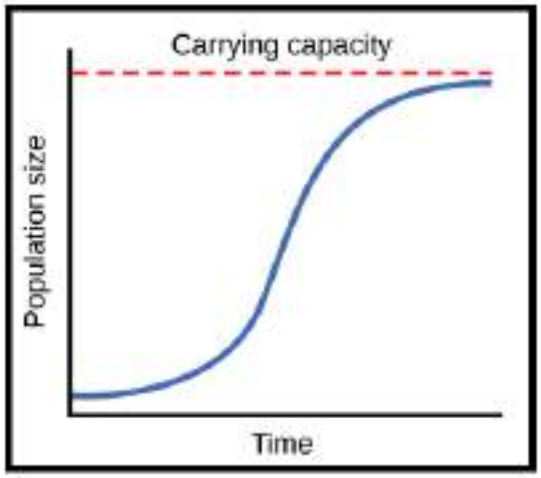


**Fig.7. Logistic growth curve**

The curve obtained is sigmoid in shape. This type of population growth is known as *Verhulst-Pearl Logistic Growth*, given by the following equation-

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

N = Population density at time t

r = Intrinsic rate of natural increase

K = Carrying capacity

**Population interactions**

There are two main interaction-**interspecific interactions and intraspecific interactions**. Intraspecific interaction occurs between the same species whereas interspecific interactions occurs between the different species.

| Type of Interaction | Response | |
|---|---|---|
| | Species A | Species B |
| Neutralism | 0 | 0 |
| Mutualism | + | + |
| Commensalism | + | 0 |
| Competition | - | - |
| Amensalism | - | 0 |
| Predation | + | - |
| Parasitism | + | - |
| Parasitoidism | + | - |

**Fig.8. Types of population interaction**

- **Predation** is an interspecific interaction where predator kills and consumes the prey. This is important interaction to maintain the prey species. For plants, herbivores are predators. Plants have different adaptations to prevent the attack of the predators. Some have thorns for defense. Some plants produce toxic glycosides as defensive agent. Nicotine, caffeine, quinine etc. are the defensive chemicals produced by the plants which are of commercial importance.
- **Competition** can be interspecific as well as intraspecific. Competition occurs between closely related species for food, shelter, etc. It occurs when the resources are limited. Gause's principle of **Competitive Exclusion** states that two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eliminated eventually. This may be true if resources are limiting, but not otherwise.
- **Parasitism** is an interaction where one species is dependent on the other species for food. In this relationship, one organism is parasite is benefitted whereas the other organism is harmed. Parasites that feed on the external surface of the host organism are called ectoparasites. Many marine fish are infested with ectoparasitic copepods. *Brood parasitism* in birds is a fascinating example of parasitism in which the parasitic bird lays its eggs in the nest of its host and lets the host incubate them.
- **Commensalism** is an interaction in which one species benefits the other species is neither harmed nor benefitted. An orchid growing as an *epiphyte* on a mango branch is an example of commensalism.

- **Mutualism** is an interaction where both the species interacting will benefit each other. Lichens and mycorrhiza are most important example of mutualism. Lichens is mutualistic relationship between algae and fungi. Mycorrhiza is relation between the fungi and the roots of the higher plants.
- **Amensalism** is a relationship in which one species is harmed and other interacting species is neither harmed nor benefitted.