RIZVI COLLEGE OF ARTS SCIENCE AND COMMERCE

Chap 13 – Organisms and Populations

Class : SYJC Science

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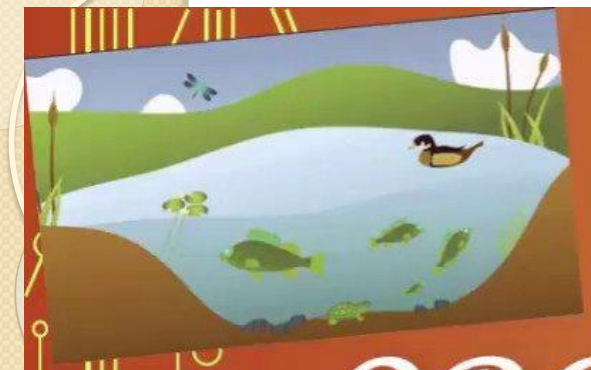


ORGANISMS AND POPULATIONS

Prepared by – Mrs. Madhuri Mane

Total Marks – 3(4)

→Natural world around us shows amazing diversity of forms and complexity of relations.

→To understand this we have to study levels of organizations in the living world, macromolecules, population, communities, ecosystem and biomes.

→Ecological grouping of organisms is nothing but ecological hierarchy.

There are four sequential levels with increasing complexity of ecological (biological) organizations, that is organism, populations, communities and biomes.

1. **Organism** – Individual organism is the **basic unit** of ecological hierarchy.
2. **Population** – **Organism of same kind** inhabiting a geographical area constitute population.
3. **Community** – **Several population** of **different species** in a particular area constitute community that interact with one another in several ways.
4. **Biome** – Constitutes a **large regional terrestrial unit** delimited by a **specific climatic zone** having major **vegetation zone** (plant communities) and the associated **fauna**.

There are **six** major groups of **terrestrial biomes**.

We shall explore first two levels that is **organism** and **population**.

Organisms and the environment around

→**Ecology** at the level of organism is basically the **study of animal or plant physiology** which helps us to understand how the **organisms are adapted** to their **environment**, not only for their **survival** but also for **propagation**. (multiplication)

→**Seasons** with annual variation in **precipitation** in the form of **rain** and **snow**, gives rise to formation of **major biomes** of the earth like **desert, rain forest, grass land, tundra,** etc.

→**Regional and local variation** within each **biome** lead to the formation of a **variety of habitats**.

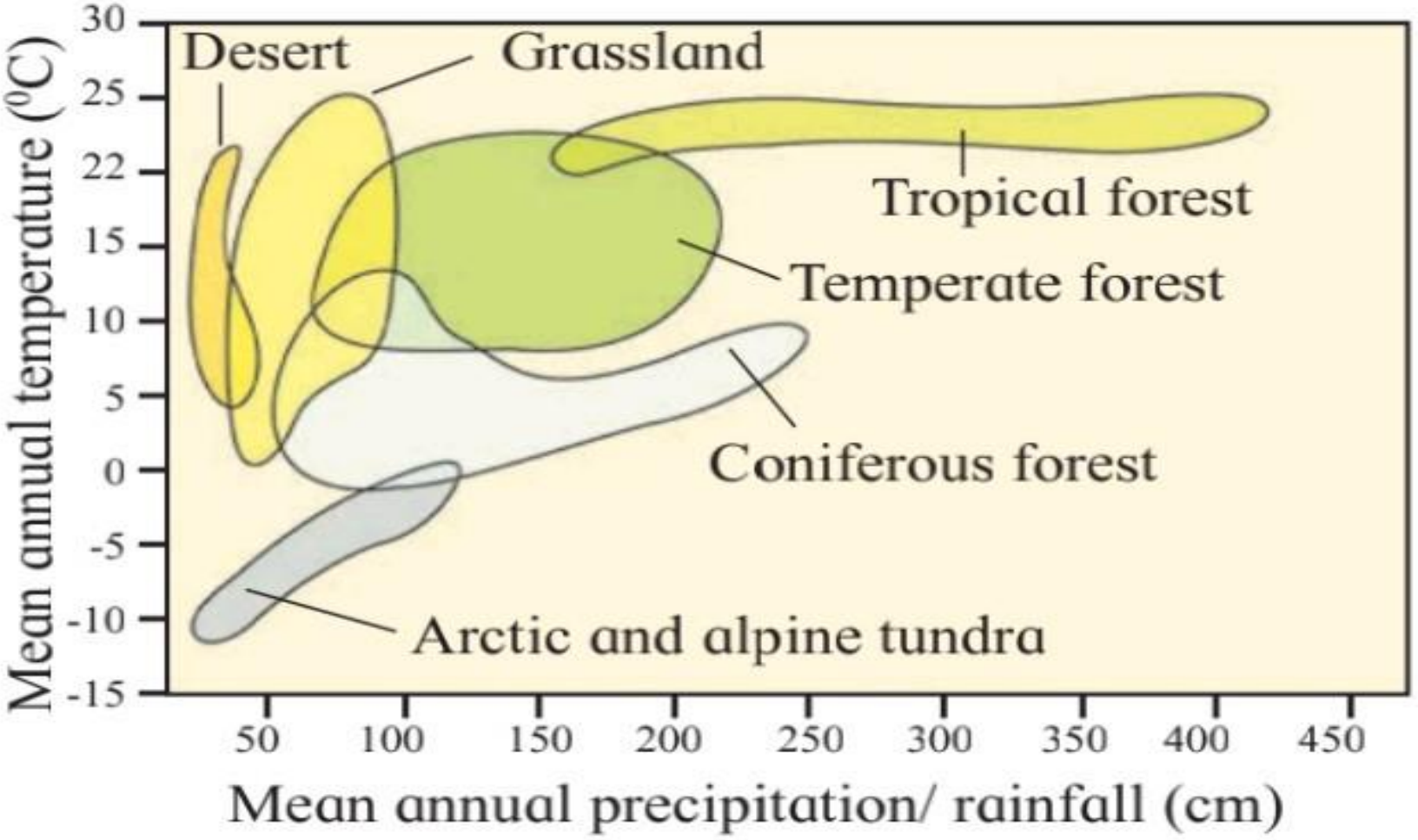


Fig. 13.1 : Distribution of major Biomes with respect to annual temperature and precipitation

→On earth, life exists even in **extreme** and **harsh** habitats like scorching **deserts of Rajasthan**, perpetually **rain-soaked forests of North Eastern states** and **high mountain tops of Himalayas**.

→Not only **abiotic** (non-living) components that make up the **habitat** of an organism, but the habitat also includes **biotic** components like **plants, pathogens, parasites and predators** of the organism.

→Over the period of time, the organisms had through **natural selection**, evolved adaptations to **optimize its survival** and **reproduction** in its habitat.

HABITAT AND NICHE

Habitat

It is the place or set of **environmental conditions** around the **organism** to which it must adapt to **survive and prosper.**

Niche

It is the **functional role** played by an organism in its environment.

Table 13.2 : The differences between Habitat and Niche can be summarized as :

Habitat	Niche
A habitat is an area, where a species lives and interact with the other factors and prosper.	A niche is a concept, of how an organism lives or survives in the environmental conditions.
Habitat consists of numerous niches.	Niches do not contain such components.
Effect of temperature, rainfall and other abiotic factors.	Flow of energy from one organism to other through ecosystem.
Habitat supports numerous species at a time.	Niche supports a single species at a time.
Habitat is a physical place.	Niche is an activity performed by organisms.
Habitat is not species specific.	Niche is species specific.

Definition of Habitat

→**Habitat** – Place or area where a particular species lives.

→Factors like **sunlight, average rainfall, annual temperature, type of soil** present and other **abiotic** factors affect the presence of organisms.

→Factors help in **determining** the presence of the particular type of **species** in the **environment.**

→**Eg.** – **Pond, river, ocean**

→**Types of habitat** – **Arboreal, terrestrial, aerial, aquatic** etc.

→**Microhabitat** – **Immediate surrounding** of an organism, when working with sedentary or weakly motile organisms.

Definition of Niche….J.Grinnell

→Term ecological niche is still not well understood.

→**Niche** is described as a **position of a species** in the **environment** like, *what they do for their survival? How they fulfill their needs of shelter, food? Etc.*

→Niche deals with the **flow of energy** from one organism to another.

→As soon as the niche is **left vacant**, other **organisms** **fill** that **position**.

→Niche is **specific** to each **species**, which means **no two species** can **share** the **same niche**.

→If the **species creates** its own **unique niche** in an ecosystem, it would help in **reducing competition** for resources among the species.

→Eg. Birds differ in their eating habits, where some birds eat only insects, some only fruits and some can eat both and anything they come across.

So here we can conclude that these birds living in the **same habitat differ** in their **niches** because of **different eating habits**.

Three types of Niches are found

a. **Spatial or habitat niche**

Deals with the physical space occupied by the organisms.

b. Trophic niche

It is on the basis of trophic level of an organism in a food chain.

c. Multidimensional or hyper volume niche

It considers number of environmental factors (**both biotic and abiotic**), the resulting space will be a hyper volume, *not something that can be perceived by the human mind*. This space is called hyper volume niche.

MAJOR ABIOTIC FACTORS.

1. Temperature

→Most ecologically relevant environment factor.

→Average temperature on land varies from **subzero levels** in **polar areas** and high altitudes, upwards upto **50°C** in **tropical deserts** in summer.

→Temperature also varies **seasonally**.

→It **decreases progressively** from the **equator towards** the **poles** and from **plain** to the **mountain tops**.

→Unique habitats such as **hot springs** (**80°C to 100°C**) and **deep sea hydrothermal vents** where average temperature usually **400°C**.

→**Ambient temperature** affects the **metabolism** and other **physiology** of organisms.

→**Eurythermal** – Organisms can **tolerate** and **thrive** in a **wide range** of temperature.

→**Stenothermal** – Organisms that are **restricted** to a **narrow range** of temperature.

2. Water

→**Life** on earth originated in water, its **availability** is **so limited** in **desert** that only **special adaptations** are required to survive there.

→**Productivity** and **distribution** of plants are also heavily dependent on water.

→Organisms living in **oceans, lake** and **rivers** have their own water related problems.

→For **aquatic organisms** the **chemical composition** and **pH** of water are important.

→**Dissolved salt** concentration is less than **5ppt in fresh waters** of stream, lake and rivers, and **30-35ppt in the seas** and **oceans.**

→Salt may go up to **100ppt** in some hyper saline **lagoons.**

→**Eurohaline** – Organisms that can tolerate **wide range** of salanities.

→**Stenohaline** – Organisms that are restricted to a **narrow range** of salanity.

3. Light

→Plants use light for **photosynthesis**, that is the only **source of energy** for the entire ecosystem.

→Many species of **small plants** (herbs and shrubs) growing on **forest floor** are adapted to perform photosynthesis optimally under very **low light** conditions because they are constantly **overshadowed** by **tall trees**.

→**For animals** too, diurnal and seasonal variations in **light intensity** and duration are clues for timing their **foraging, reproductive** and **migratory activites.**

4. Soil

→The **nature** and **properties** of soil are dependent on the **climate**, the weathering process.

→Various characteristics of the soil such as soil **composition, grain size**, determine the **percolation** and water **holding capacity** of the soil.

→Characteristics like **pH, mineral composition** and **topography**, determine the **vegetation** of an area.

→Vegetation in turn **dictates** the type of **animal**s.

*To **survive** and **flourish** in any environment, organisms must adapt to the changes in the environment for which there are following posiibilities.*

1. **Regulate**

- Some organisms are able to maintain **homeostasis** by **physiological** and **behavioral** changes which ensure **constant body temperature**, osmotic concentration, etc.
- All birds and mammals are capable of such regulation.
- Thermoregulation and osmoregulation.

2. Conform

- Most of animals and plants **cannot maintain** a constant internal environment.
- Their **body temperature changes** with the ambient temperature.
- In **aquatic animals**, the osmotic concentration of the body fluids changes with that of the ambient water osmotic concentration.
- These plants and animals are simply **conformers.**

3. Migrate

- Organisms can **move away** temporarily from the **stressful habitat** to a more **hospitable area** and return when stressful period is over.
- Many animals, particularly **birds**, during **winte**r undertake long-distance **migrations** to more hospitable areas.

4. Suspend

- In **plants**, They **germinate** to form new plants under **favorable moisture** and **temperature** conditions.
- Seeds serve as means to **tide over** periods of stress.
- They do so by **reducing** their **metabolic activity** and going into a state of '**dormancy**'.
- In **animals**, the organism, if unable to migrate may go into **hibernation** during winter. **E.g.. Polar bear**.
- Some **snails** and **fish** go into **aestivation** to avoid summer heat.

Adaptation

→**To cope up** with **extreme variation** in the environment, some animals show **physiological adjustment** and some show **behavioral adjustments**.(migration)

→Adaptation is an attribute of the organism that enables the organism to **survive** and **reproduce** in its habitat.

EG.

1.Desert plant – **Thick cuticle** on leaf surfaces and have their **stomata** in deep pits to **minimize loss of water** through transpiration.

They have special photosynthetic pathway called **CAMs pathway.**

2.Desert plant– **Opuntia,** have their leaves reduced (modified) **to spines** and **photosynthetic function** is taken over by the **flattened stems**.

3. **Mammals** from **colder climates** generally have **shorter snout, ears, tail** and **limbs** to minimize the loss of body heat. (Allen's Rule)

4. Polar seas, aquatic mammals like **seals** have a thick layer of **fat (blubber)** below their skin acting as an **insulator** to reduce loss of body heat.

Behavioural Response.

1. **Desert lizards** manage to keep their body temperature fairly constant by behavioral adaptation.
2. They **bask in sun** and absorb heat, when their body temperature drops below the comfort zone.
3. But moves into **shade**, when the ambient temperature starts increasing .
4. Some species **burrow** into the sans to hide and escape from the heat.

Population

→In nature, we rarely find **isolated, single** individuals.

→They live in groups in a well-defined **geographical area**, share or compete for similar resources, potentially **interbreed** and thus form a population.

→A population has **certain attributes** of its own which are different from those of an individual.

Physical characteristics of population

→Size

Size speaks for the **number of individuals** in a population.

→Density

It tells about **number of individuals** present **per unit space, in a given time.**

Other characteristics include,

Natality, Mortality, Immigration, emigration, age pyramids, expanding population, population growth forms and biotic potential.

Natality

→It is **birth rate** of population.

Crude birth rate

It is used when calculating population size. (number of births per 1000 population/year)

Specific birth rate

It is relative to a specific criterion such as age.

Eg. If in a pond there were **200 carp fish** last year and through reproduction **800 new fish** are added , taking the current population to 1000, we calculate the birth rate as **800/200 = 4** offspring per carp per year.

→**Absolute Natality**

The number of births under **ideal conditions**.

(with no competition, abundance of resources such as food and water. etc)

→**Realized Natality**

The number of births when **environmental pressures** come into play.

Absolute natality will be **always more** than realized natality.

Mortality

→It is the **death rate** of population.

→it is measured of the number of deaths (**in general, or due to a specific cause**) in a particular population, in proportion to the size of that population, **per unit of time**.

→Mortality rate is typically expressed in **deaths per 1000 individuals per year.**

- **Absolute Mortality**

  The number of deaths under **ideal condition**. (with no competition, abundance of resources such as food and water.etc)

- **Realized Mortality**

  The number of deaths when **environmental pressur**e come into play.

Absolute mortality will be **always less** than realized mortality.

SEX RATIO

→Sex ratio is affected by **birth, death, immigration** and **emigration** rates.

→It is measured as the **ratio of the number or individuals of one sex to that of the other sex.**

→The males and females in a ratio of **1:1** is generally the most common evolutionary stable strategy.(ESS)

Age distribution and Age Pyramid

- Population is **composed** of individuals of **different ages.**
- If the **age distribution** is **plotted** for the **population**, the resulting structure is called on **age pyramid**.
- Entire population is divided into **three age groups** as --
  Pre-Reproductive (age 0-14 years)
  --**Reproductive** (age 15-44 years)
  --**Post-reproductive** (45-85 years)
- The population size, in natural habitat, could be as low as less than **10**(**Siberian cranes** in bird sanctuary) or go into **millions** (**Chlamydomonas** in a pond).

→Although **total number** is generally the most **appropriate measure** of population density, it is in some cases either **meaningless or difficult** to determine.

→In such cases, the **biomass** is a more meaningful measure of the population size, when population is **huge** and **counting** is impossible or **very time consuming.**

- →**Eg.** Number of **birds/insects** caught per trap is good enough measure of their total population density.
- →**Eg.** The **tiger census** in our national parks and tiger reserves is often based on **pug marks** and **fecal pellets.**

Population Growth

- Size of population for any species is a **dynamic parameter.**
- It keeps **changing** with time, depending on various factors including **food, predation pressure** and **adverse weather**.
- These changes in population density that give us some idea whether it is **flourishing or declining**.
- **Density** of population **fluctuates** due to changes in four basic processes.
- **New Births** (B) and **Immigration** contribute to an increase in population density.
- **Deaths** (D) and **Emigration** lead to decrease in population density.

IMMIGRATION (I)

It is the **number of individuals** of the **same species** that have **come into the habitat** from **elsewhere** during the time period under consideration.

EMIGRAITON (E)

It is the **number of individuals** of the population **who left** the **habitat** during the time period.

If N is the population density at time 't' then its density at time 't+1' can be calculated as,

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

GROWTH MODELS

1. **Exponential growth**

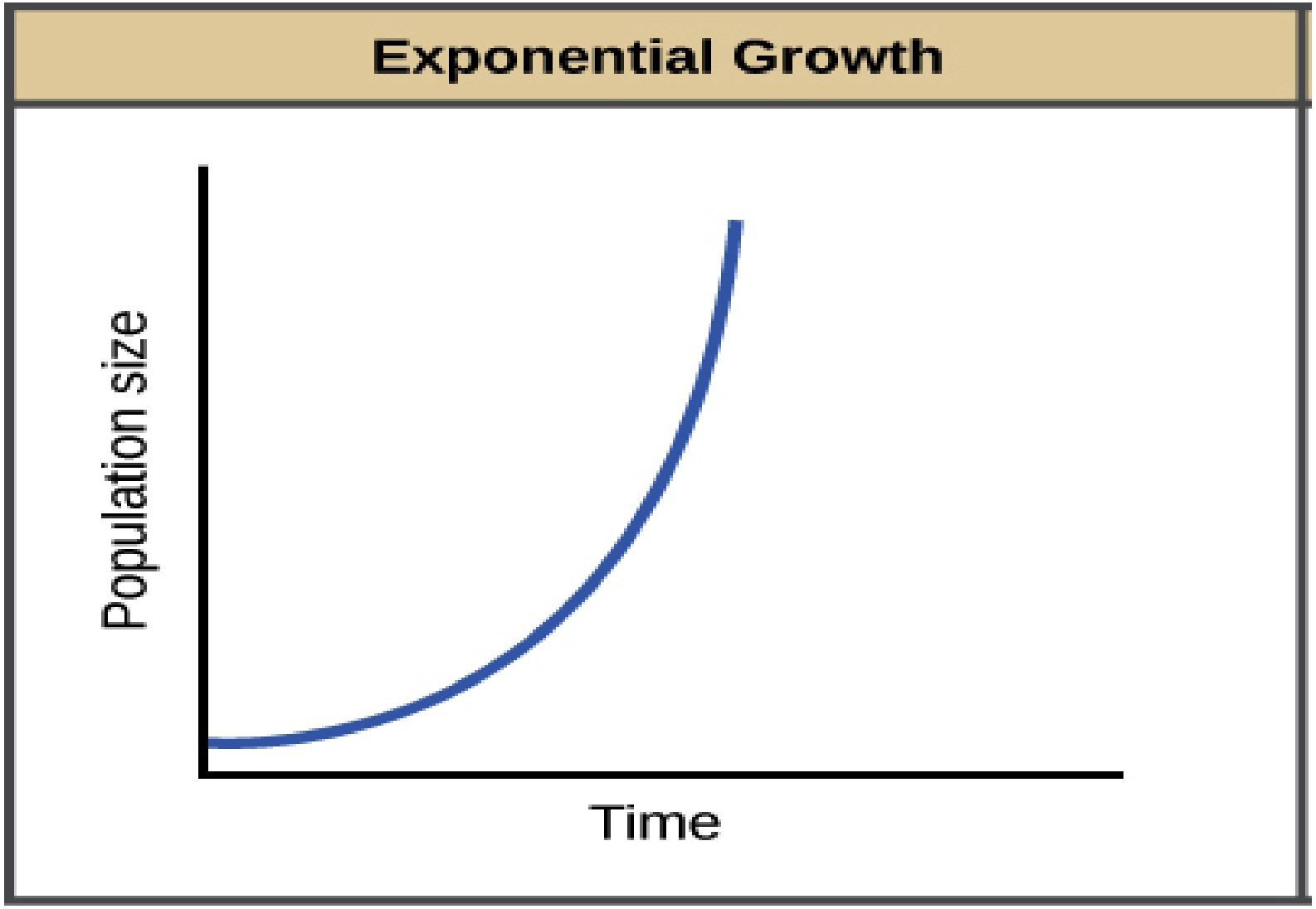
→Resources like **food, space** are essential for any growth of a population.

→when **resources** in the habitat are **unlimited**, each species has the ability to fully realize its innate potential to grow in numbers.

→Then the population grows in an **exponential** or **geometric** proportion.

→**Darwin showed** how even a **slow growing animal** like **elephant** could reach **enormous numbers**, provided **food** and **space** remain **unlimited**.

EXPONENTIAL GROWTH



2.LOGISTIC GROWTH

→**Competition** between individuals for **limited resources** will **weed out** the **weaker ones**.

→Only the **fittest** individuals will **survive** and **reproduce**.

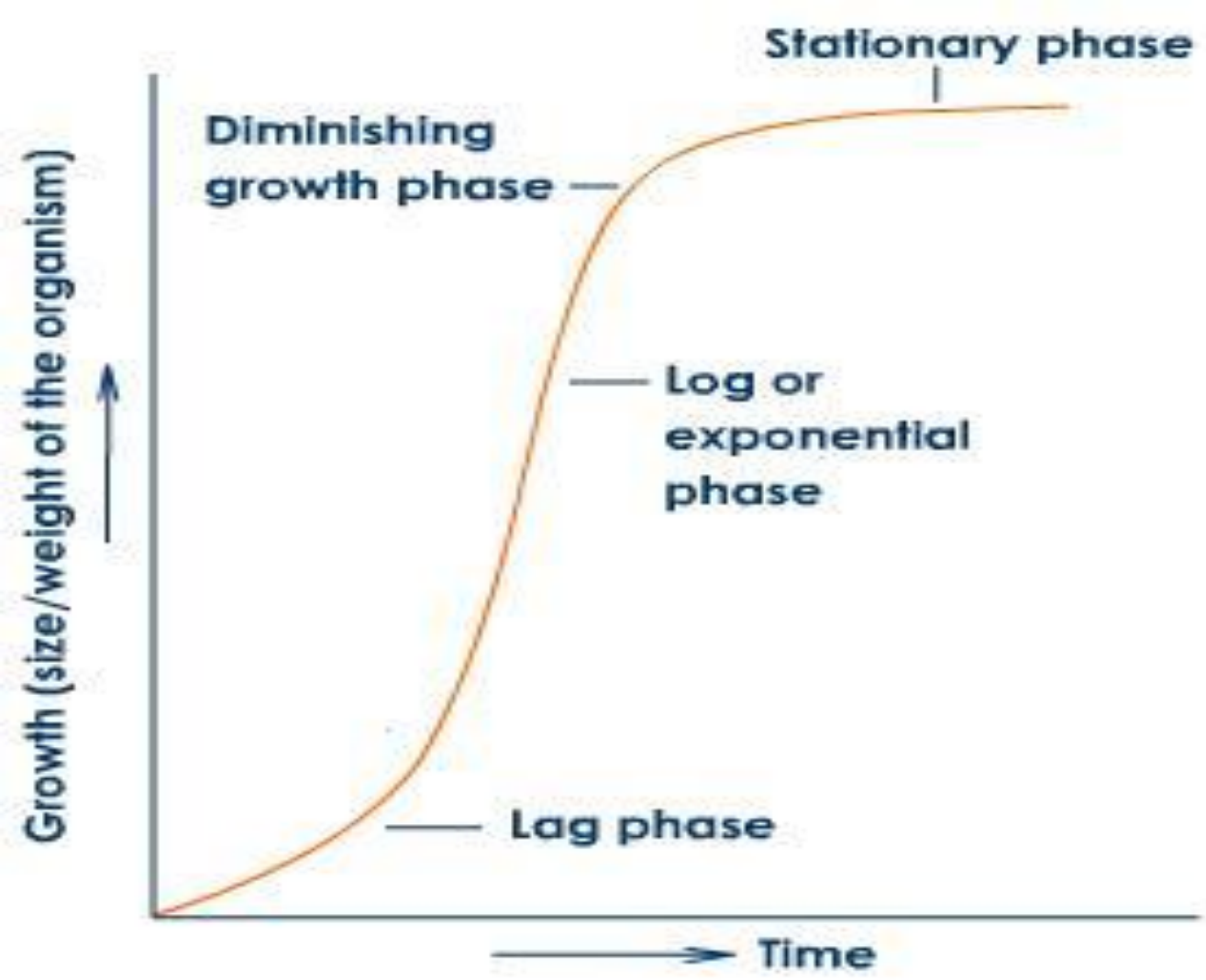
→In nature, a given habitat has **enough resources** to support a **maximum possible** number, beyond which **no further growth** is possible.

→A population growing in a habitat with limited resources show initially a **lag phase**, followed by **phases of acceleration** and **deceleration** and finally an asymptote, when population density reaches the carrying capacity.

→A plot of population density (N) in relation to time (t) results in a **sigmoid curve**.

→This type of population growth is called **Verhulst-Pearl Logistic Growth.**

LOGISTIC GROWTH



POPULATION INTERACTION

- There is **no natural habitat** , which has only one **species** or **animals** or **plants**.
- It is obvious that in nature, animals plants and microbes do not and **cannot live in isolation** but **interact** in many ways to form a biological community.

Types of Interactions

→ **Intraspecific Interaction**

Existing between organisms of **same population**.

→ **Interspecific Interaction**

Exist between organisms of **different species**.

→ Mutualism – Both the species are benefited.

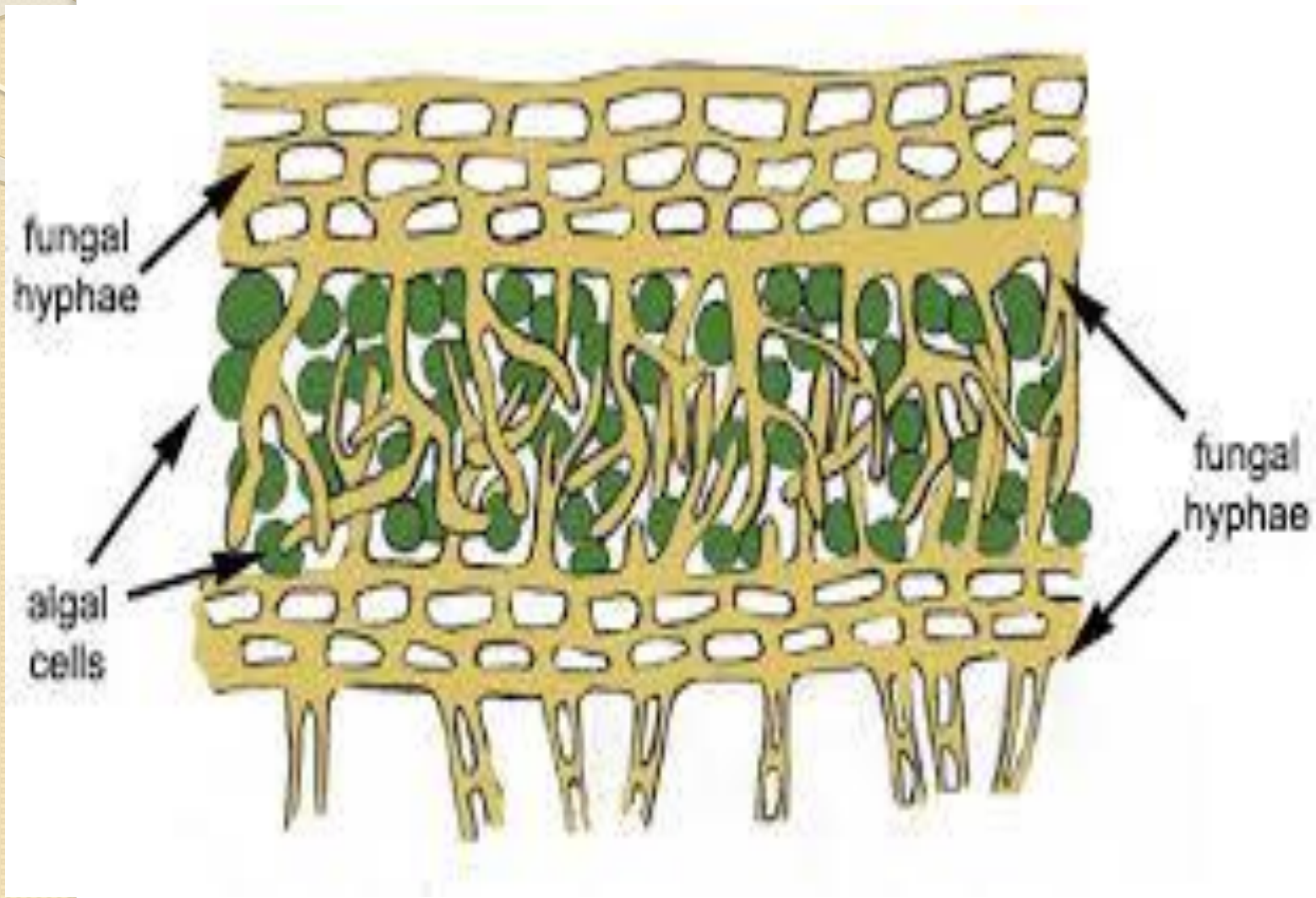
→ Competition – Both the species are harmed.

→ Parasitism and Predation – Only one species is benefited and other is harmed.

→ Commensalism – Interaction in which one species is benefitted and the other is neither benefitted nor harmed.

→ Amensalism – Interaction in which one species is harmed whereas the other is unaffected.

Mutualism



MUTUALISM

→Interaction is **obligatory** and **interdependent**.

→Benefits **both** the species.

→**Lichen** represent an intimate, mutualistic relationship between a **fungus** and **photosynthetic algae**.

→Most fascinating example of mutualism are found in **plant-animal relationship.**

→**Plants** need **help** of animals for **pollinating their flowers** and **dispersing their seeds**.

→**Animals** are obviously **rewarded** with **pollen, nectar**, **nutritious fruits** for seed dispersers.

→Plant-animal interactions often involve **co-evolution** of the **mutualists**, that is evolutions of the flower and its pollinator species are tightly linked with one another.

Competition

Coevolution Example

- Hummingbirds and the flowers they pollinate.
  - The longer the beak of the hummingbird, the more food it will get.
  - The farther away the food in the flower, the better the flower gets pollinated.

COMPETITION

1. Intraction where **both the species are at loss**.
2. Totally **unrelated species** may **compete** for the same **resource**.

Eg. In **shallow creeks** on the west coast of **Mumbai**, visiting **flamingos** and **resident fish** compete for their common food , **zooplankton**.

3. **Resouce** need not always be **limiting factor** for competition to occur.
4. The **feeding efficiency** of the **one species** is **reduced** due to the **interference** or inhibitory presence of other species.

Eg- **Leopards** do not hunt in **close proximity** of the **lion pride**.

6. **Gause's Competitive Exclusion Principle states–**

Two closely related species **competing** for the **same resources** cannot **coexist indefinitely** and competitively **inferior one** will be **eliminated** eventually.

7. In **interspecific competition** with **sufficient resources**, **species facing competition** will **evolve mechanism** that promote **co-existence** rather than **exclusion**.

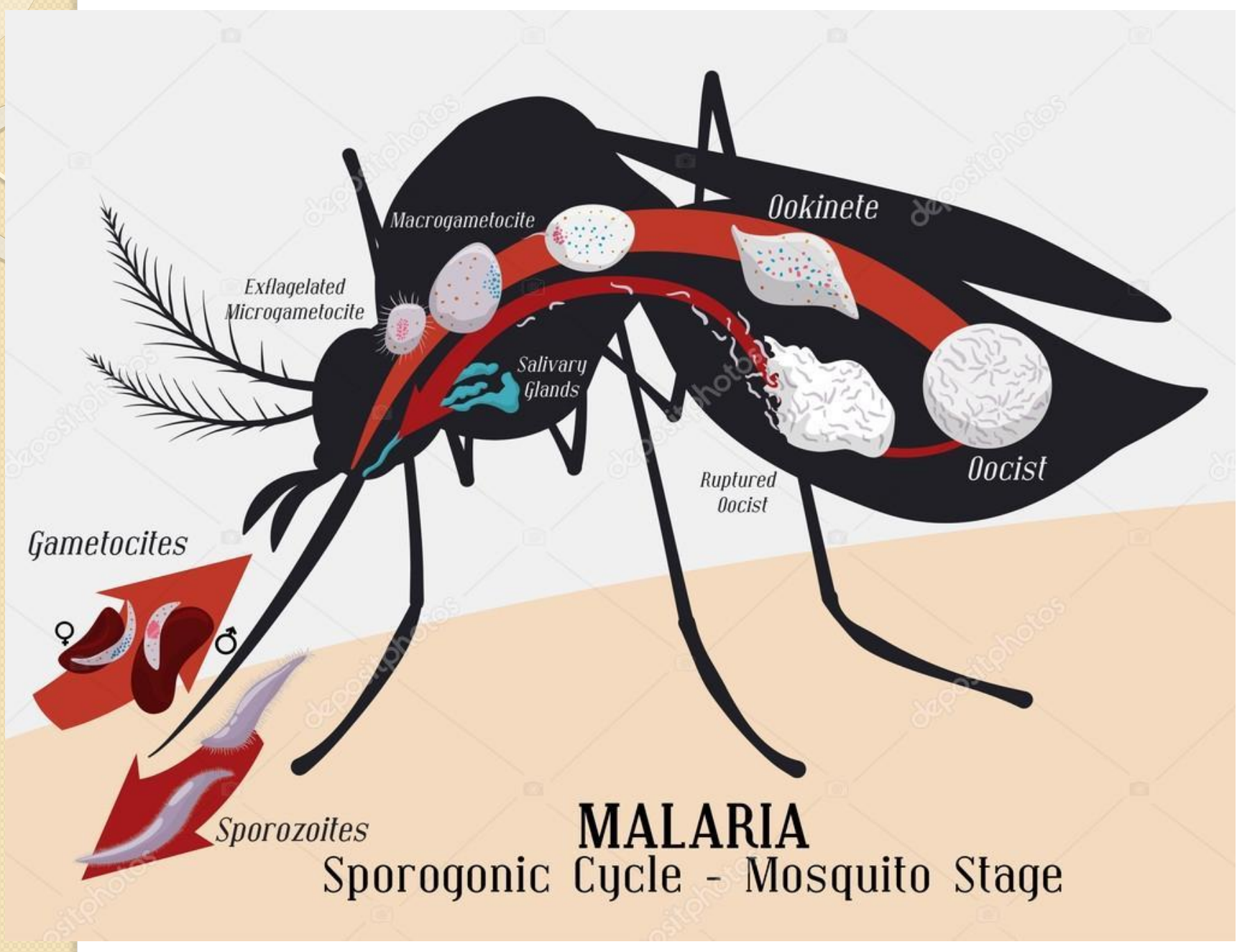
E.g. One such mechanism is '**resource partitioning**'. If **two species** compete for the **same resource**, they could **avoid competition** by **choosing different** times for **feeding**.

Parasitism

1) Types of Parasites – **Endoparasite** and **Ectoparasite**.
2) **Endoparasite** – **special adaptations** – **Loss of unnecessary sense organs, presence of adhesive organs or suckers to cling on to the host, loss of digestive system and high reproductive capacity.**
3) They need **intermediate hosts** to facilitate transfer to host.
   Eg.Malarial parasite **Plasmodium vivax** needs a **vector** (mosquito) to spread to other hosts.
4) Majority of the **parasites harm the host**, thus reducing its population density.
5) **Ectoparasites** – Feed on **external surface** of the host organisms.
6) **Eg. Lice on humans** and **ticks on dogs**.

   Many **marine fish** are infested with **ectoparasitic copepods**.

   Cascuta, a parasite plant that is commonly found growing on hedge plants , has **lost its chlorophyll** and **leaves** in the course of evolution. It derives its nutrition from the **host plant** which it parasitizes.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Ookinete
Exflagelated
Microgametocite
Salivary
Glands
Ruptured
Oocist
Oocist
Gametocites
♀
♂
Sporozoites
MALARIA
Sporogonic Cycle - Mosquito Stage

Marine fish and Copepods

Parasitism -- Cascuta

Brood Parasitism

a) It is an fascinating example, in which the parasitic bird lays its eggs in the nest of its host bird and lets the host bird incubate them.

b) During the course of evolution, the eggs of the parasitic bird have evolved to resemble the hosts egg in size and colour to reduce the chances of the host bird detecting the foreign eggs and ejecting them from the nest.

c) Eg. Eggs of parasitic bird (Asian Koel) hatch before that of its host (common crow).

Brood parasitism – Crow feeding Koel babies in its own nest

PREDATION

a. First example coming to out mind is **tiger and deer**, but **sparrow eating** any **seed** is not less than a predator.
b. **Grazers** are animals eating plants, classified as herbivores, they are, not very different from predators.
c. Predator play important role in **controlling prey population.**

Eg. In absence of frogs, **locusts increase** in density and destroy large tracts of agricultural lands.

d. When **exotic species** are introduced accidentally or intentionally into a new geographical area, they become invasive and start spreading rapidly due to **absence** of **natural predator**,

Eg. Zebra mussels in the intertidal of North America.

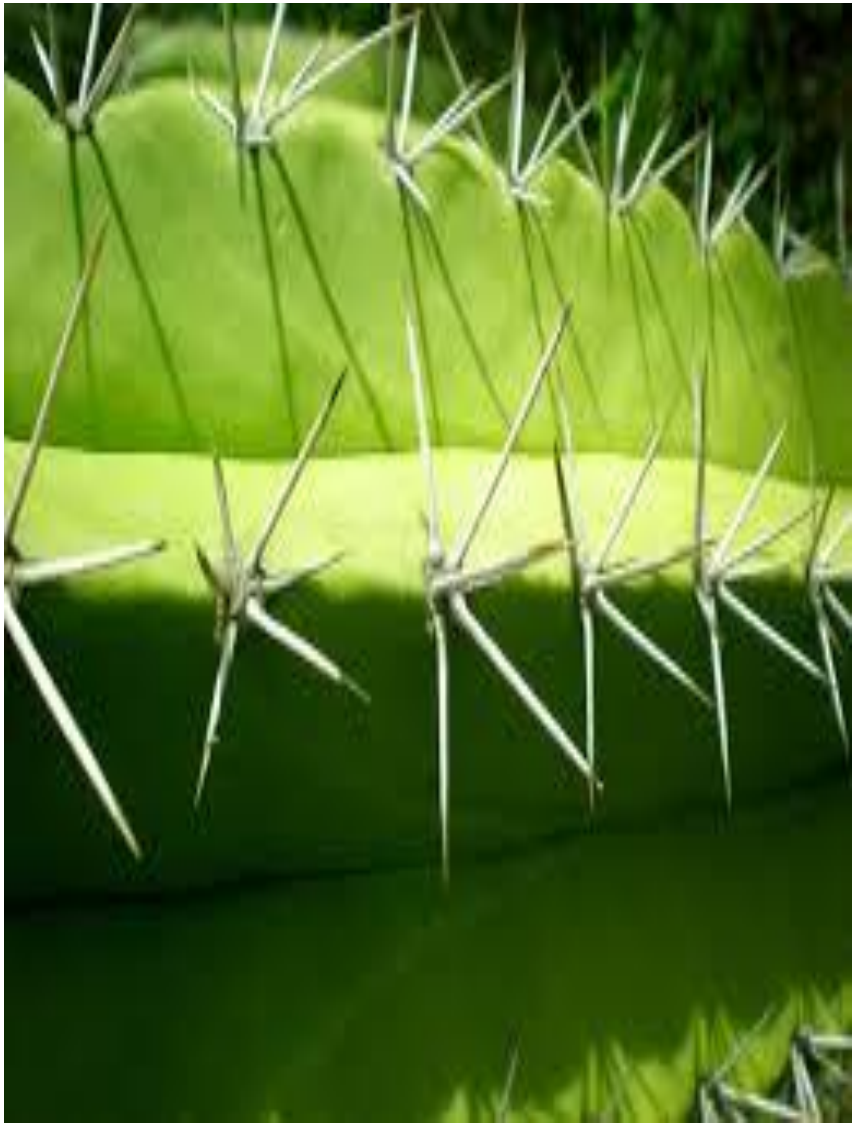
Zebra Mussels

- If predator **over exploits** its prey, then the prey might become extinct and following it the predator.
- Prey species have evolved **various defenses** to reduce impact of predation.
- **Eg. Insects** and **frogs** are cryptically coloured (camouflaged) to **avoid** being **detected easily**.
- **Eg**. **Monarch butterfly** is highly distasteful to its predator bird because of special **chemicals** present in body. Butterfly acquires this chemical during its **caterpillar stage** by **feeding** on a **poisonous weed**.

Adult Monarch Butterfly displaying warning colour pattern

- **For plants, herbivores are predators**.
- Therefore, plants have evolved variety of **morphological and chemical defenses** against herbivores.
- **Eg. Acacia** and **Cactus** → **Thorns**
- Many plant produce **chemicals** that make herbivore sick. Chemical inhibit the **feeding** and **digestion** of predator and **disrupt reproduction** or even **kill** it.
- **Calotropis** → Produces highly **poisonous cardiac glycosides .**
- **Plants** -- chemical substances – **Nicotine, cafffeine, quinine, strychnine, opium** are secondary metabolites produced as defences against grazers and browsers.

ACACIA AND CACTUS



Calotropis

COMMENSALISM

- Interaction in which one species benefits and the other is neither harmed nor benefited.
- Eg.– Orchid growing as an epiphytes on branch of mango tree.
- Eg.– Cattle egret and grazing cattle in close association is classic example of commensalism. Cattle egrets always forage close to cattle, as cattle move they flush out insects that might be difficult for the egrets to find and catch.
- Eg.– Sea anemone that has stinging tentacles and the clown fish that lives among them. Fish gets protection from predators which stay away from the stinging tentacles. Anemone does not appear to derive any benefit by hosting the clown fish.

Eg.– Orchid growing as an epiphytes on branch of mango tree.

Commensalism – Cattle egret with Buffalo

Clown fish in the tentacles of Sea anemone


Thank you!