TARGET PRELIMS 2024
BOOKLET-11; EB&CC-1
ENVIRONMENTAL ECOLOGY - BASICS

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2. SOME BASIC FACTS

1) RAMDEO MISRA

- He is considered the **father of ecology in India**. He was born in 1908 and obtained Ph.D. in Ecology (1937), from LEEDS University in UK.

- He established teaching and research in ecology at the Department of Botany of the Banaras Hindu University (BHU).

- His research laid the **foundations for understanding of tropical communities and their succession**, environmental responses of plant populations and productivity and nutrient cycling in tropical forest and grassland ecosystems.

- He formulated **first post graduate course in ecology in India**.

- Due to his efforts, the GoI established the **National Committee for Environmental Planning and Coordination (1972)** which, in later years, paved the way for the establishment of the Ministry of Environment and Forest (1984).

3. ORGANISMS, POPULATION, ECOSYSTEM AND ECOLOGY

- **Ecology** is the study of the relationships of living organisms with the abiotic (physical-chemical factors) and biotic components (other species) of their environment. It is concerned with four levels of biological organization – **Organisms, Populations**, **Communities** and **Biomes**.

1) ORGANISM AND ITS ENVIRONMENT; ECOLOGY AND ECOSYSTEM

- **Environment**: Everything that surrounds an organism is its environment.

  - » In simple terms, environment of an organism refers to the **physical, chemical, and biological conditions and factors** that surround and influence the life of an organism. It includes all the living **(biotic components)** and non-living things **(abiotic componets)** that an organism interacts with, such as the air, water, soil, light, temperature, other organisms, and the physical structure in its surroundings.

  - » The environment of an organism is critical for its survival and protection as it affects many aspects of its life including metabolism, behaviour, growth and development.

  - » **Understanding Environment of organism** is very important because:

    - Environment is critical for the survival and protection.
    - Different organisms have different environmental requirements and adaptations. Some may be more tolerant or adaptable to change in their environment than others.

- By studying environment of an organism, scientists can gain insights into how it has evolved and adapted to tis surroundings and how it may respond to future changes in environment.

- **Ecology** is the study of relationship between livings organisms, including humans and their environment. It seeks to understand the vital connections between plants and animals and the world around them. It seeks to understand how organisms interact with each other and with their physical environment, and how these interactions affect the sustainability of the entire system.

2) LEVEL OF ORGANISATIONS IN ECOSYSTEM

Ecosystems are complex and dynamic systems that can be studied at different levels of organization each provide a different perspective on the ecosystem. The level of organizations in ecosystem include:

1) **Individual Organisms**: The smallest unit of an ecosystem is the individual organism, such as a single plant, animal or microbe.
2) **Population**: A population is a group of individuals usually of the same species living in the same area and interacting with each other.
3) **Community**: It is a group of populations of different species living in the same area and interacting with each other. It consists of all the biotic factors of an area.
   - Communities in most cases are **named after the dominant plant from** (species). E.g. **Grassland community** is dominated by grasses. Though it may contain herbs, shrubs, some trees, and other animals. It is named after grasses.
   - **Communities can be classified** into – **Major Community** vs **Minor Communities**

Features:	**Major Community**	**Minor Community**
Definition:	These are large sized, well organized, and relatively independent (self-sustaining) and depend on only sun's energy and is independent of inputs and outputs from adjacent community. E.g. Grasslands; Deserts; Evergreen rain forests etc.	These are smaller and are dependent on neighbouring communities. These are **secondary congregation within a major community** and are not therefore completely independent units as far as energy and nutrient dynamics are concerned. E.g. (stream within a forest; mat of lichen on a cow dung pad)
Size	Large	Small; localized area
Self-sustainability	Yes	No; depends on resources from other neighbouring communities
Impact of disturbance	More resilient due to larger size and diversity	More vulnerable to disturbance due to smaller size and dependence on other community.

4) **Ecosystem**: It includes all the biotic and abiotic components in the given area and the interactions between them.

5) **Biome**: A biome is a large geographical area characterized by a specific set of climatic conditions and plant and animal communities.
6) **Biosphere**: The biosphere is the portion of the Earth that supports life, including all of the ecosystems on the planet

Each level of organization in an ecosystem is interconnected and interdependent, and changes at one level can have cascading effects on the other levels. Understanding the different levels of organization in an ecosystem can help us better understand how ecosystem function, how they respond to disturbance, and how we can manage them for sustainability.

3) ECOSYSTEM AND VARIOUS COMPONENTS OF AN ECOSYSTEM

- An ecosystem is a community of living organisms (plants, animals, and microorganisms) that interact with each other and with the non-living components (such as air, water, and soil).

- Ecosystem **can vary in size**, from a small pond to a vast forest. Each ecosystem is a **functioning unit of nature**.
  - Every organism in an ecosystem is dependent on the other component of the ecosystem. Therefore, if some part of the ecosystem is damaged, it has an impact on other organisms living in that ecosystem.

- **Components of Ecosystem**:

A) ABIOTIC COMPONENTS

- Energy
- Water/Rainfall
- Temperature
- Atmosphere
- Substratum (soil and minerals)
- Latitude and Longitude

B) BIOTIC COMPONENT

- It consists of living organisms and are classified as per their functional attributes into **producers** and **consumers**:
  a) **Primary Producers (Autotrophs)**: These are organisms which are capable of making their own food using sunlight **(photosynthesis)** or inorganic compounds **(chemosynthesis)**.
     - Examples include plants, algae, and some bacteria.

  b) **Consumers** (Heterotrophs or phagotrophs)
     - They don't produce their own food and **depend on food derived from other plants, animals** and other species**.**
     - They can be divided into **macro-consumers** and **micro-consumers**.
       - **Macroconsumers**: They feed on both plants and animals and can be classified into **herbivores/primary consumers (**e.g. Deer**)** (feed mainly on plants);

carnivores/secondary consumers (e.g. wolves**)** (feed on primary consumers); **carnivores/tertiary consumers** (e.g. lion) (feed on secondary consumers) and **Omnivores** (e.g. humans, monkeys etc.) (feed on both plants and animals).

- **Micro consumers – Saprotrophs** (decomposers or osmotrohps): These are bacterias and fungi which derive their energy and nutrients by decomposing dead organic substances (detritus) of plant and animal origin. They release inorganic nutrients into environment which are used by primary producers and thus are recycled. Earthworms, and some soil organisms (such as nematodes and arthropods) are detritus feeders and help in decomposition of organic matter and are called **detrivores**.

4) ECOTONE

Ecotone refers to the transitional zone or boundary where two different ecosystems or biomes meet and integrate with each other. It is characterized by a mix of vegetation, soil and animal species from both ecosystems, creating a unique habitat with its own set of ecological dynamics.

It can be found in various terrestrial and aquatic environments, such as where a forest meets a grassland, or where a river meets a lake.

Important Characteristics of ecotones:

1) **Transitional zone**
2) **High Species Diversity** compared to either of the adjacent ecosystem, as they contain species from both ecosystems and may offer greater range of resources for organisms.
    a. **Edge Effect**: Sometimes number of species, and the population density of some of the species is much greater in this zone than either ecosystem. This is called edge effect.

    b. **Edge Species**: Edge dwelling or ecotone dependent species are those that are particularly adapted to living in the transitional zone or boundary between two different ecosystems or biomes. These organisms occur primarily or must abundantly in the ecotone zone. In terrestrial ecosystem the edge effect is most applicable on birds. Density of birds is greater in the mixed habitat of ecotone between the forest and desert.
        - E.g., of edge species: Indian Spotted eagle; Indian rock python; Golden jackal etc.

3) **Unique Species Composition**: Ecotones may contain **unique species that are specialized to the transitional habitat** and not found in either adjacent ecosystem.

4) **Abiotic Gradient**: Ecotones may be characterized by **abiotic gradient**, such as changes in soil, water, temperature, or light conditions, which create different microhabitats and ecological niches for species.
    a. This brings a **linearity** -> progressive increase in composition of one in coming community and a simultaneous decrease in species of the other outgoing adjoining community.

Significance of ecotone:

- **Support high level of biodiversity** due to greater range of resources (higher species richness and ecological resilience)

- Act as **important corridors for movement of species** between different ecosystems, allowing for a genetic exchange and maintaining population viability.
- **Important indicator of ecosystem health:** They can also be particularly sensitive to environmental changes and disturbances. Thus, they can inform conservationists about the required management efforts.

Overall, ecotones play a crucial role in maintaining the health and functioning of ecosystems, as well as providing important ecosystem services and biodiversity.

2) ECOLOGICAL NICHE

Ecological Niche refers to the **role or position of a species within an ecosystem**. It includes its interaction with biotic and abiotic factors of the ecosystem. It encompasses the species habitat requirements, food and water requirements, reproductive strategy and its relationship with other species in the ecosystem.

Niche Differentiation: Each species in an ecosystem occupies a **unique ecological niche** to minimize competition for resources. This also different species to co-exist and allows for a greater biodiversity within an ecosystem.

- For example, some species may occupy **a niche as primary producers**, converting sunlight and inorganic nutrients into organic matter, while others may occupy a niche as **herbivores or carnivores**, feeding on the primary producers or other consumers in the ecosystem

Competitive Exclusion Principle: The two species competing for same limited resources cannot coexist in the same niche at a constant population level. If the needs are identical and resources limited than one will outcompete other leading to extinction or niche differentiation.

- **E.g.-1**: **Darwin Finches** (Galapagos Finches): On Galapagos island, different finch species have evolved different beak types so that they can depend on different kind of food sources. This allowed them to co-exist even within limited resources.
- **E.g.-1**: **Competitive Dominance**: An invasive species which has some competitive advantage can lead to extinction of native species.

Fundamental vs Realized Niche:

- **Fundamental niche** refers to range of environmental conditions which will allow a species to reproduce and survive successfully, if there was **no competition or predators**. It reflects species full ecological capabilities and adaptations, assuming ideal conditions.

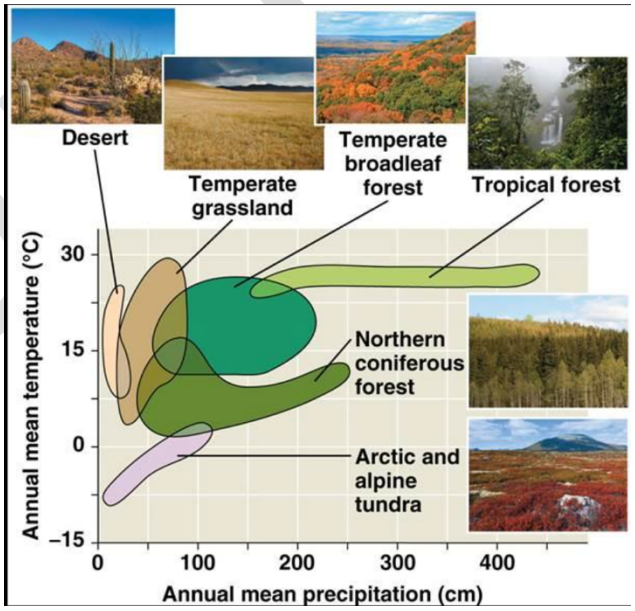
- **Realized Niche**: It refers to actual set of conditions and resources a species utilizes in the **presence of competition** from other species. Competition, Predation, and limited resources restrict the species' access to some parts of its fundamental niche. The **realized niche is always smaller than or equal to fundamental niche**. The same species can have different realized niche in different locations, depending on the local community and environment.

The **ecological niche of a species is not fixed**, but rather can change over time due to changes in the environment, competition with other species, and other factors. In some cases, two or more species may occupy similar ecological niches, leading to competition for resources and potential changes in the niche of one or both species

Understanding the ecological niche of a species is important for conservation and management efforts, as it can help to identify the key resources and environmental conditions that are necessary for the survival of the species. By protecting the ecological niche of a species, conservationists can help to maintain the biodiversity and functioning of the ecosystem as a whole.

3) BIOMES

- A biome is a large geographical area **characterized by a specific set of climatic conditions** and **plant and animal communities**. Variation in temperature, precipitation (both rain and snow) account for the formation of biomes.
- It can also be defined as a **major life zone**, that includes communities of plants and animals that have a common adaptation to that particular environment.
- **Biomes of the World**: For general understanding purpose we have divided the terrestrial biome into following types (based on NCERT). Please note that some other sources may make this division in many different ways, some going to the extent of 20 different biomes.



C) VARIOUS TYPES OF TERRESTRIAL BIOMES AND KEY FEATURES:

1) **Arctic and Alpine Tundra**:

- It is characterized by cold, dry and windy conditions.
- Most of the region is under permafrost (a thick layer of ice lying just below the shallow soil). Because of this tree cant penetrate to anchor their roots.
- **Flora**: Lichens, Mosses, grasses, shrubs etc.
- **Fauna**: Polar bears, arctic foxes, migratory birds, reindeer etc. Here reptiles and amphibians are almost absent.

2) **Taiga/ Northern Coniferous Forests/ Boreal Forests**:

- Boreal forests are full of life that are adapted to withstand frigid temperatures year around (**or very long cold winters**). They are made up of conical evergreen trees with needle like trees. These trees are called conifers because their seeds are clumped into cones. They include spruce, fir, pine etc.
- **Fauna** includes birds, hawks, fur bearing carnivores, little mink, elks, puma etc.
    - **During cold winters** mammals hibernate and birds migrate. Some animals have evolved to grow dense feathers or fur to survive the winters.
- **Taiga** is the largest land (terrestrial) biome in the world.

3) **Temperature Deciduous Forest**:

- Characterized by moderate temperatures and rainfall
- Deciduous trees, shrubs, grasses
- Fauna: Deer, bears, squirrels, birds etc.

4) **Tropical Rain Forests:**

- High temperatures and rainfall, little seasonal change,
- **Fauna:** Broad leaf evergreen trees, lianas, epiphytes, orchids. Multiple storey of broad-leafed evergreen trees are in abundance.
- **Floras**: Most animals and epiphytes are concentrated in the canopy or tree top zones. They include monkeys, sloths, jaguars, snakes etc.

Why tropical rain forests are not suitable for agriculture-> very less fertility:

- **Surface soil is heavier leached** (nutrients washed away) by running water. Here, the inferior surface soil is the limiting factor that limits the germination of seeds.
- Germinated saplings may not survive due to **lack of light** because of the dense canopy. Here, the absence of light (shade of the forest) is the limiting factor.

5) **Savannah Grasslands/ Tropical Grasslands:**
   - Most extensive in Africa
   - Warm and hot conditions with distinct wet and dry seasons
   - **Flora**: Grasses are the dominant vegetation in Savannah grasslands, with trees and shrubs scattered throughout the landscape.
     - **Acacia tree** is commonly found in African Savannahs and eucalyptus trees are found in Australian Savannahs.
     - **Enough seasonal rainfall** so that trees can grow in open groups or singly throughout.

   - **Fauna**: Large herbivores like zebra, giraffes, antelopes, as well as predators like Lions, Cheetahs, and hyenas.
   - **Fire**: It is a common characteristic of Savannah which help to maintain grassy landscapes by clearing away excess vegetation and promoting new growth.
   - **Soil**: Soil is typically nutrient poor and shallow and thus it finds difficulty in supporting trees.

6) **Temperate Grasslands:**
   - They are popularly known as prairies, steppes or pampas.
   - **Climate**: Continent climate with hot summers cold winters. They receive moderate rainfalls.
   - **Fauna**: Large herbivores such as bison, pronghorn, and deer as well as predators such as foxes, coyotes, wolves etc.
   - **Fire**: they are also characterized by frequent forest files. (The region is dry enough to cause fires and trees can't survive).
   - **Soil**: Nutrient rich due to accumulation of organic matter from the grasses. The soil is often deep, and fertilze making it suitable for agriculture.

7) **Desert:**
   - **Climate:** Low precipitation; extreme temperature fluctuations
   - **Flora**: Cacti, Succulents scrubby bushes
   - **Fauna**: Lizards, snakes, scorpions, coyotes, kangaroo rats etc.

D) VARIOUS TYPES OF AQUATIC BIOMES AND THEIR KEY FEATURES:

The aquatic biomes are divided into fresh water and marine regions.

1) **Fresh Water Biomes:**
   a. **Rivers and Lakes**: Fast moving, flowing water that originates from mountains and has high oxygen levels.
   b. **Lakes and Ponds**: Standing bodies of water with varying depths, temperatures, and oxygen level
   c. **Wetlands**: Low lying area with standing water, such as marshes, swamps.

2) **Marine Biomes:**

a. **Oceans:** The largest biome on earth, oceans are divided into zones based on depth and receive varying amount of sunlight, affecting the types of organisms that can survive in each zone
b. **Coral Reefs**: Warm, shallow waters where diverse species of corals thrive
c. **Estuaries**: Areas where freshwater meets saltwater, creating unique habitats for species adapted to changing salinity levels.

Please note: This is not an exhaustive list of terrestrial and aquatic biomes.

4) BIOSPHERE

- The biosphere is the part of the earth where life exists, which includes all living organisms and their interactions with the environment. It extends from the deepest ocean depths to the highest altitudes in the atmosphere and includes all terrestrial and aquatic ecosystems.

- The biosphere is composed of various biomes.

- The biosphere is a complex system, with numerous ecological interactions and feedback loops. It consists of various food chains and food webs.

5) HABITAT AND HOW ORGANISMS HAVE EVOLVED TO ADAPT TO OPTIMIZE ITS SURVIVAL AND REPRODUCTION IN ITS HABITAT

- **Regional and local variations** with each biome leads to formation of **habitat**.
  - » Over a period of time, the **organism had evolved to adapt to optimize its survival and reproduction** in its habitat.

A) MAJOR ABIOTIC FACTORS/ ABIOTIC COMPONENTS

- **Temperature**: It is the most important ecologically relevant environmental factor. It affects the kinetics of enzymes and through it the metabolic activity and other physiological functions of the organism. The levels of thermal tolerance of different species determine to a large extent their **geographical distribution**.

  - » A few organisms can tolerate and thrive in wide range of temperatures (they are called **eurythermal**). (e.g., Humans, Cows, Monkeys, Sheep, Goats etc.)

  - » A vast majority of organism are restricted to a narrow range of temperatures (they are called **stenothermal**). (e.g. penguins, crustaceans etc.)

- **Water**: Life on earth originated in water and can't sustain without water. In limited water conditions like deserts, special adaptations techniques are needed for organisms to live there. The productivity and distribution of plants are also dependent on water. Even aquatic organisms face water related issues as sometimes the quality, pH etc. becomes problematic. The salt concentration of water is also an important factor. Many freshwater species can't survive in ocean water for long because of the osmotic pressure that they face.
  - » Some organisms may tolerate a wide range of salinities **(euryhaline)**, but others are restricted to narrow range **(stenohaline**).

- **Light**: Autotrophs who form the first level of any food chain depend on light for generating food. Thus, light is important for all living organisms.
  - » **Some organisms** survive in less light conditions (e.g., **herbs and shrubs** growing in tropical rain forests have adapted to do photosynthesis optimally under very low light conditions because they are constantly overshadowed by tall, canopied trees).

  - » **Many plants** are dependent on sunlight to meet their photoperiodic requirement for flowering.

    - Most angiosperms (flowering plants) use photoperiodism to determine when to flower. To do that they use one of the photoreceptor protein present in their body such as cryptochrome or photochrome.

  - » **For many animals too, light is important** in that they use diurnal and seasonal variation in light intensity as cues for timing their foraging, reproductive and migratory activities.

  - » **Note:** How do deep sea organisms get their energy (since light doesn't reach there)?
    - **Three major methods** – Marine Snow; Whale Falls; Chemosynthesis.
    - **Marine Snow**: It refers to biological debris that originate from the top layers of the ocean and drift to the seafloor, providing primary source of energy for animals in the deep ocean. It primarily consists of phytoplankton produced through photosynthesis and as they sink, it collects other floating debris, including fecal material, dead or decaying animals, suspended sediments etc.
    - **Whale Fall**: When whales die and sink, the whale carcasses, or whale falls provide a sudden concentrated food source and a bonanza for organisms in the deep sea. Useful video: https://youtu.be/LUFKzP8ql_A?si=aSWIQtOw2u1xeAsi

  - » **Among the red, green and brown algae** that inhabits the sea, which is likely to be found deepest in water?
    - **How sunlight penetration varies with depth of ocean? Short wavelength/high frequency** light can penetrate sea water more easily. Thus, as depth increases, blue light reaches, green reaches less, Yellow further lesser and Red reaches the least.

- **Red algae** at the depth of the ocean thus absorbs blue green wavelength and survive at deeper layer. They have more quantity of the pigment **phycoerythrin.** It absorbs the blue-green spectrum of the visible light.

- **Soil**: Characteristics of soil such as soil composition, grain size, and aggregation determine the percolation and water holding capacity of the soils. These characteristics along with other parameters like pH, mineral composition, and topography determine to a large extent the vegetation in any area. This in turn dictates the type of animals that can be supported. Similarly, the aquatic environment, the sediment-characteristics often determine the type of benthic animals that can thrive in the soil.

B) RESPONSES TO ABIOTIC FACTOR

- **Abiotic components** of a habitat may **vary drastically with time**.

  - » But most species have evolved to have a relatively **constant internal (within the body) environment**. This constant environment provides maximal efficiency for all biochemical and physiological functions and thus enhances the overall fitness of the organisms. This may be in terms of optimal temperature and osmotic concentration of the body fluid.
  - » **Ideally then**, the organism should try to maintain the **constancy of its internal environment** (a state called **homeostasis**) despite varying external conditions that tends to upset its homeostasis.
    - **Note:** Homeostasis is the state of steady internal, physical, and chemical conditions maintained by living environment.

- How do organisms living in such habitats **cope or manage** with such stressful conditions?
  - » **Regulate:** Some organisms are able to maintain homeostasis by physiological means (sometimes behavioral means also).
    - **All birds and mammals**, and a very few lower vertebrates and invertebrates are capable of such regulation (thermoregulation and osmoregulation).
    - Evolutionary biologists believe that **success of Mammals** is largely due to their ability to maintain a constant body temperature and thrive weather they live in Antarctica or Sahara Desert
      - **For e.g.: Human** maintain the body temperature at 37-degree C. **In summers**, we sweat to produce evaporating cooling and in winters, we shiver to produce heat and raise the body temperature.
    - **Regulation is energetically expensive**. This is particularly true for small animals like **shrews and hummingbirds**. Small animals have large surface area relative to their volume, they tend to lose their body heat very fast when it's cold outside; and they would need a **lot of energy to maintain the body temperature**. This is the reason why **very small animals are rarely found in Polar region.**
  - » **Conform**: Conformers are organisms that lack the ability to regulate their **internal body temperature** (endothermy) and instead rely on their environment to dictate their internal

temperature (ectothermy). This means that they **experience significant changes** in their body temperature along with the fluctuations in their surrounding environment.

- In aquatic animals, the osmotic concentration of body fluids changes with that of the ambient air, water osmotic concentration. These animals and plants are **conformers**.

- **E.g.** of conformers:

  - **Fish**: Many fish are conformers, meaning that their body temperature matches to their surrounding water. They adjust metabolic rates and activity levels based on the outside temperature. Some fish species like trots which prefer colder waters will migrate to deeper or cooler oceans during warmer seasons.
  - **Reptiles** are classic examples of conformers. They rely on external source of heat such as sunlight to regulate their body temperature. Basking in the sun helps them warm up, while seeking shade or burrowing underground helps them cool down.
  - **Amphibians** – most are conformers. Basking in sun, shelter in cooler areas to avoid overheating etc.
  - **Ectothermic Plants** – The metabolic activities and growth of plants are influenced by ambient temperature. For e.g., the rate of photosynthesis in plants increase at higher temperature and decreases with low temperature.

- **Why didn't these animals and plants become regulators?**
  - Thermoregulation is **energetically expensive** for many organisms.
  - During evolution, **the cost and benefit of maintaining a constant internal environment are taken into consideration**. Some species have evolved the ability to regulate, but only over a limited range of environment, beyond which they simply conform.

- **Migrate**: If the stressful external condition is localized or remain only for short duration, the organisms have two other alternatives for survival **Migration or Suspension**.

  - **Migration**: In migration, organism move temporarily from the stressful habitat to a more hospital area and return when stressful period is over. (E.g., Siberian crane coming to Rajasthan in winters)

  - **Suspension**:
    - In bacteria, fungi and lower plants, **various kinds of thick-walled spores** are formed which help them to **survive unfavorable conditions** – these germinate on availability of suitable environment.

    - **In higher plants**, **seeds and some other vegetative reproductive structures** serve as means to tide over periods of stress besides dispersal – they germinate to form new plants under favorable moisture and temperature condition. They do so by reducing their metabolic activity and going into a state of '**dormancy**'.

- **Animals** which are unable to migrate, may escape in time (i.e., **hibernate** during winters). Some animals go into **deep sleep** for extended period of time, while others will **just slow down** but **remain active**. Some will go into a combination of both, known as **Torpor**.
  - » Animals like bats, Squirrels, Marmot, Lemurs, Hedgehog, Earthworms, Toads, Bees, bears etc. **hibernate in a warm place during winters**.
  - » **Bears** living in cold climate hibernate during winters – when the food is scarce, but the bear in warmer climate can find plenty of food all year long so they don't have any reason to hibernate. **Bears** are **true hibernators** and sleep heavily never to wake up again till the spring arrives. Only the Mama Bear wakes up in Jan/Feb to give birth to the new cubs, and the babies will be happy nestling with Mamma until she can take them out on their first adventure.
  - » **Bats also hibernate** (again the once in warmer areas don't).
  - » **Some snakes** also hibernate.

- **Some snails and fish** go into ***aestivation*** to avoid summer-related problems-heat and desiccation.
  - » **Note:** Aestivation or estivation is a state of dormancy that some animals enter during hot and dry periods. It is similar to hibernation, which is a state of dormancy during cold and harsh conditions.

- Under unfavorable conditions, many zooplankton's species in lakes and ponds are known to enter **diapause**, a stage of suspended development.

- **Dieback**: It refers to the progressive dying, usually backwards from the tip of any portion of the plant. This is one of the adaptive mechanisms to avoid adverse conditions like droughts. In this mechanism, the root remains alive for years together, but the shoots die. E.g., Sal, Red Sanders, Silk-Cotton etc.

C) ADAPTATION

- Adaptation is any attribute of the organism (morphological, physiological, behavioral) that enable the organism to **survive and reproduce** in its habitat.

Many adaptations have evolved over long evolutionary time and are genetically fixed. In the absence of external source of water, the **Kangaroo rat**, in North American deserts is capable of meeting all its water requirements through its internal fat oxidation (in which water is a byproduct). It also has the ability to concentrate its urine so that less water is lost	

- **Desert plants** have adapted to following features to survive in water scarce conditions:

- » **Reduced Leaf Size**: Smaller leaves minimize water loss through transpiration.
- » **Thick Cuticles**: Desert plants have a thick waxy layer on the surface of their leaves and steps to reduce water loss.
- » **CAM Photosynthesis**: Some desert plants, such as cacti and succulents, use a special type of photosynthesis called **Crassulacean Acid Metabolism** (CAM), which allows them to conserve water during photosynthesis.
  - In this system, CO_2 is fixed at night when temperature is cooler, and stomata (pores in leaves) can remain open without excessive water loss. Here CO_2 is converted into malate (a four carbon acid) which will be used during day time for photosynthesis.
  - E.g. of CAM mechanisms: Succulents like aloe-vera and Jade plant; some orchids; Crassula, a genus of flowering plants giving CAM its name.
- » **Deep Roots**: To access water from deep underground.
- » **Efficient Water Use**: Desert plants have adapted to use water efficiently by closing their **stomata** during the day and opening them at night to reduce water loss.
- » **Succulent Tissues**: Some desert plants have fleshy, water storing tissues that allow them to survive for long periods without water.
- » **Spines or Thorns**: To deter herbivores and to reduce water loss from leaf surface.

- **Allen's Rule**: Mammals from colder climate, generally **have shorter ears and limbs** to **minimize heat loss** (This is called Allen's Rule).

- In the **polar seas**, aquatic mammals like **seals**, have a thick layer of **fat** (blubber) below their skin that acts as **insulator** and **reduces loss of body heat**.

- **Tribes living in high altitude region**, normally have **higher RBC count** (or total hemoglobin) than people living in plains. Why?
- **Some microbes** (archaebacteria) flourish in hot springs and deep-sea hydrothermal vents where temperature far exceeds 100-degree C.
  - » Microbes which can live at such high temperature are called **thermophiles**. They are able to survive in such high temperatures because their bodies have adapted to such environmental conditions. They contain specialized thermo resistant **enzymes**, which carry out metabolic functions that don't get destroyed at such high temperatures.

- **How do fish in Antarctic water prevent their body fluids from freezing?**
  - They have developed **proteins** that act as **anti-freeze**. These anti-freeze proteins are a group of unique macromolecules that help some polar and subpolar marine bony fishes avoid freezing in their icy habitat. These **proteins bind to and inhibit growth of ice crystals** within body fluids through an absorption-inhibition process. These proteins attach to small ice crystals stemming their growth.

- **How do deep sea organisms live under high pressure?**
  - Most living thing in the deep sea are largely water and water is incompressible. **Without gas filled spaces** like lungs or bladders, organisms in the great deep are less affected by pressure than we imagine. Further, they have "**piezolytes**" – small, organic molecules which have only recently been discovered. These piezolytes stop the other molecules in the creatures' bodies, such as membranes and proteins, from being crushed by the pressure.

5) POPULATIONS

- Majority of organisms live in groups in a well-defined geographical area, share or compete for similar resource, **potentially interbreed (same species)**, and thus constitute **a population**.

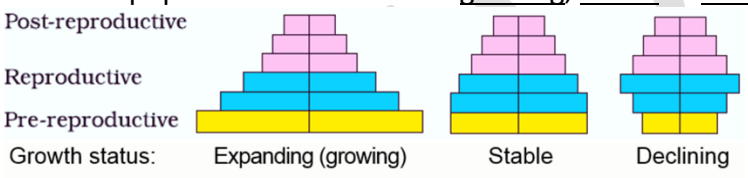
- Although the term interbreeding may imply sexual production, a group of individuals resulting from even asexual reproduction is also generally considered a population.

  » E.g.: Rats in an abandoned dwelling; bacteria in a culture plate, lotus plants in a pond etc.

- So far, we had studied that Individual organism is the one that has to cope with a changed environment, it is at population level that **natural selection operates to evolve the desired traits**. Population ecology is, therefore, an important area because it links ecology to population genetics and evolution.

Individual	**Population**
Individuals don't show attributes	Population has certain attributes
Individual may have births and deaths	Population has birth rates and **death rates**
Individual may be male/female etc.	Population can have sex ratio.

- **Age distribution of a population** forms what is called **Age Pyramid**. The shape of the pyramid reflects the growth status of population. Weather it is growing, stable or declining.



- The size of the population tells us a lot about the habitat.

A) POPULATION GROWTH

- The density of a population in a given habitat during a given period, fluctuates due to changes in four basic processes: **Natality and Immigration** contribute to an increase in population. And **Mortality and Emigration** contribute to decrease in population.

B) LIFE HISTORY VARIATION

- Populations evolves to maximize their reproductive fitness, also called **Darwinian fitness** (high r value), in the habitat in which they live. Life history traits of organisms have evolved in relation to the constraints imposed by the abiotic and biotic components of the habitat in which they live. They develop the most efficient reproductive strategy.

  For e.g. – Some organisms breed only once (for e.g., Pacific Salmon fish, Bamboo); while others breed many times during their lifetime (most birds and mammals)

C) POPULATION INTERACTION:

- In nature, animals, plants and microbes don't and cannot live in isolation but interact in various ways to form a biological community. Even in minimal communities, many interactive linkages exist, although all may not be readily apparent.

- Interspecific interactions arise from the interaction of population of **two different species**. This interaction could be **beneficial** (+), **neutral** (0) or **detrimental** (-) to one of the species or both. All possibilities are given below:

Species A	Species B	Name of Interaction
+	+	**Mutualism**
-	-	**Competition**
+	-	**Predation**
+	-	**Parasitism**
+	0	**Commensalism**
-	0	**Amensalism**

- In **parasitism and predation** only one species benefits (parasite and predator, respectively) and the interaction are deterimental to other species (host and prey, respectively).

- **Mutualism, Predation, Parasitism, and Commensalism** share a common characteristic, the interacting species live closely together.

MUTUALISM

- The interaction confers benefits to both the interacting species.
- E.g.
  - » **Lichens** (intimate mutualistic relationship between fungus and photosynthesizing algae or cynaobacteria)
  - » **Mycorrhizae** are associations between fungi and the roots of higher plants. The fungi help the plant in the absorption of essential nutrients from the soil, while the plant in turn provides the fungi with energy yielding carbohydrates.
  - » **Plant Animal Relationship**: Plants need animals for pollinating their flowers and dispersing the seeds, whereas plants given them in return, honey fruits etc.
  - » Now you can see **why plant-animal interactions often involve *co-evolution* of the mutualists**, that is, the evolutions of the flower and its pollinator species are tightly linked with one another.
  - » In **many species of fig trees, there is a tight one-to-one relationship with the pollinator species of wasp**. It means that a **given fig species can be pollinated only by its 'partner' wasp species** and no other species. The female wasp uses the fruit not only as an oviposition (egg-laying) site but uses the developing seeds within the fruit for nourishing its larvae. The wasp pollinates the fig inflorescence while searching for suitable egg-laying sites. In return for the favour of pollination the fig offers the wasp some of its developing seeds, as food for the developing wasp larvae

COMPETITION

- Competition occurs when closely related species compete for the same resources that are limiting.
  - » But totally unrelated species may also compete (for e.g., visiting flamingoes and resident fishes compete for their common food, the zooplanktons in a lake).
  - » Even in case of abundant resources, competition may occur, in **interference competition**, the feeding efficiency of one species might be reduced due to interfering and inhibitory presence of the other species.

- **Therefore, competition is best defined as "**a process in which **fitness of one species**, is **significantly lower in the presence of another species**".

- E.g., **Abingdon tortoise in Galapagos Islands** became extinct within decade after goats were introduced on the island, apparently due to the greater browsing efficiency of the goats.

- **Species facing competition might also evolve mechanisms that promote co-existence rather than exclusion**. One such mechanism is "**resource partitioning"**. Here species avoid competition by choosing for instance, different time for feeding on different foraging patterns.

PREDATION:

- » **Significance:** Transferring the energy to higher trophic levels; Keeping prey population under control and contribute to ecosystem stability; they also help in promoting species biodiversity in a community, by reducing the intensity of competition among competing prey species.
  - ▫ In the absence of predator, a prey may become invasive and damage the ecosystem. E.g., when prickly pear cactus was introduced in Australia in the early 1920s, they caused havoc by spreading rapidly to millions of hectares. It was only when a cactus feeding predator (a moth) was introduced, the population could be controlled and damaged could be reduced.

  - ▫ **Predators by nature are prudent**. Because if the overexploit and prey population reduces drastically, predators would also suffer.

  - ▫ **Prey species** have also evolved various mechanisms to protect themselves from predators – e.g., insects and frogs are **cryptically colored** (camouflaged) to avoid being detected easily by predator. Some are **poisonous** and thus are avoided by Prey. **Monarch Butterfly** is highly distasteful to its predators (birds) because of a special chemical present in its body.

  - ▫ **For Plants**, herbivores and predators, so plants also develop various mechanisms to protect themselves.
    - » **Thorns** (Acacia, Cactus) are the most common morphological means of defence.
    - » Many plants produce **chemicals that make herbivore sick** when they are eaten, inhibit feeding or digestion, disrupt its reproduction or even kill it.
      - i. **E.g., Calotropis** (they grow in abandoned fields, and they produce highly poisonous cardiac glycosides and that is why you never see any cattle or goats browsing on this plant.

ii. **A wide variety of chemical substances** that we extract from plants on a commercial scale (nicotine, caffeine, quinine, strychnine, opium, etc.) are produced by them actually as defences against grazers and browsers.

PARASITISM

- **Majority of the parasites harm the host**. They may reduce the survival, growth and reproduction of the host and reduce its population density. They may also render the host more vulnerable to predation by making it physically weak.

- **Ectoparasites**: Parasites feeding on the external surface of the host organisms.
  - » E.g., lice on humans, ticks on dogs.
  - » Many fish species are infested by ectoparasitic copepods.
  - » **Cusucta,** a parasitic plant, has lost its chlorophyll and leaves in the course of evolution. It derives its nutrition from the host plant that it parasites.
  - » **Note:** The female mosquito is not considered a parasite, although it needs our blood for reproduction. Why?
    - Because it needs blood for reproduction not for nutrition. Human blood is required for nourishment of the offspring. A parasite depends for its entire lifespan or at least for a considerable period within a host body and completely depends on the host for nutrition and habitat.

- **Endoparasites:** Parasites that live inside the host body at different sites (liver, kidney, lungs, red blood cells, etc.)
  - » The lifecycle of endoparasites is more complex because of their extreme specialization. Their morphological and anatomical features are greatly simplified while emphasizing their reproductive potential.

- **Brood Parasitism:** Here parasitic bird lays its eggs in the nest of its host and lets the host incubate them. During the course of evolution, the eggs of the parasite bird has evolved to resemble the host's eggs in size and color to reduce the chances of the host bird detecting the foreign egg and ejecting them from the nest.
  - » Asian Koel, like many of its related cuckoo kin is a brood parasite that lays its eggs in the nests of crows and other hosts, who raise it young.

COMMENSALISM

- Interaction in which one species benefit, the other is neither harmed nor benefited.
- E.g.
  - » Orchid growing as an epiphyte on mango branch.
  - » Barnacles growing on the back of a whale. They don't harm whales or feed on them. They don't serve any obvious advantage to whale, but they give helpful lice a place to hang onto the whale without getting washed away in water.

» The **cattle egret** and the grazing cattle is a classic example of commensalism. The egrets always forage close to where ethe cattle is grazing because the cattle, as they move, stir up and flush out insects from the vegetation that otherwise may be difficult for egrets to find.

4. FUNCTIONS OF AN ECOSYSTEM

Ecosystems perform some basic functions which are essential for supporting life on earth and maintaining ecological balance. These functions can be categorized under the following heads**:**

1) **Primary Production:** This refers to the production of food by autotrophs through the process of photosynthesis (plants, algae, bacteria etc.) and chemosynthesis (in some bacterias). Primary production provides energy and nutrients for all other organisms within the ecosystem.
2) **Energy Flow**: This refers to one-way transfer of energy from producers to consumers and eventually to decomposers through food chain. At each level some energy is lost as heat.
3) **Nutrient Cycling**: Essential nutrients, like nitrogen, phosphorus, carbon etc. are constantly recycled in the ecosystem. This continuous cycle ensures the availability of these vital elements for all organisms.
4) **Water Cycle/Water Regulation** : Ecosystems regulate the water cycle, which is essential for the survival of living organisms.
5) **Habitat Provisions**: Ecosystem provides diverse habitats for various species. Each habitat, with its particular set of features support unique set of species.
6) **Environmental Provisions**: Regulation of **climate, air quality and water quality**.
    - Absorbing Carbon, reducing global warming and mitigating effects of climate change
    - Plants also filter air pollutants and release oxygen through photosynthesis.
    - Wetlands and forests act as natural filters and help in removing sediments and pollutants from water as it flows through them. This helps in maintaining of clean water for humans and other organisms.

6) **Ecological Succession:** Ecological succession is the process by which **natural communities replace (or succeed)** one another over time.
7) **Soil Formation**
8) **Cultural and Recreational Services**

In this chapter, we will primarily focus on three important functions of ecosystem – **Energy Flow; Nutrient Cycling** and **Biogeochemical Cycles:**

1) ENERGY FLOW THROUGH AN ECOSYSTEM

Energy flow through an ecosystem refers to transfer of energy from one organism to another within a food chain or food web. The sun is the primary source of energy in most ecosystems, and it's captured by plants through photosynthesis. This energy flows through the ecosystem as one organism consume other organism for food.

A) TROPHIC LEVEL:

- Trophic level refers to different levels of food chain where organisms obtain energy and nutrients. There are primarily **four main trophic levels** – Producers; Primary Consumers; Secondary Consumers; Tertiary Consumers. The **energy flow** through the trophic levels from producers to subsequent trophic levels is **unidirectional**.

- Each trophic level represents a transfer of energy and nutrients from one group of organisms to another. As organisms consume other organisms, they extract energy and nutrients from their food, and **some of this energy is lost as heat**. This means that there is typically less energy available at higher trophic levels, which is why **food chain tend to be relatively short**.

- The trophic level interaction involves **three concepts** viz. Food Chain, Food Web and Ecological Pyramids.

B) FOOD CHAIN:

- Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten link is called a food chain. A food chain starts with producers and ends with top carnivores. The trophic level of an organism is the position it occupies in a food chain.

    - E.g., **Grassland Ecosystem**:
        - **Grasses-Grasshopper-Frog-Snake-Hawk/Eagle**.

    - **E.g., Aquatic Ecosystem**:
        - **Algae** -> Zooplankton (smaller animals and immature stages of large animals) -> Small fish -> large fish -> Shark

- **Diatom** (microscopic algae) -> **Crustaceans -> Herring -> Shark**
  - **Note:** Crustaceans such as copepods are typically herbivores that feed on phytoplankton, including diatoms**.** Herring are small fish that feed on zoo planktons, including Crustaceans.

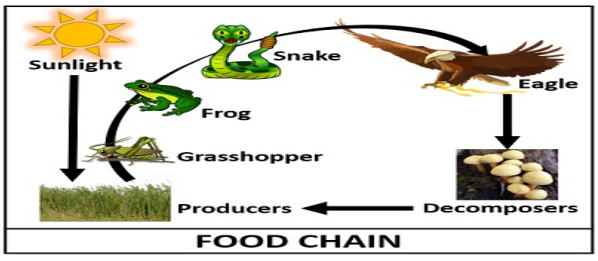
- **E.g.,** Forest Ecosystem
  - **Trees** – Caterpillar – Blue Jay (small bird) – Hawk
- **E.g.,** Desert Ecosystem
  - **Cactus** -> Grasshopper -> Lizard -> Snake -> Eagle
- **E.g., Arctic Ecosystem**
  - Phytoplankton's -> Krill (crustacean)-> Arctic Cod (fish) -> Seal (mammal) -> Polar Bear (Mammal)

Types of Food Chains:

1. Grazing Food Chain
2. Detritus Food Chain

Grazing Food Chain:

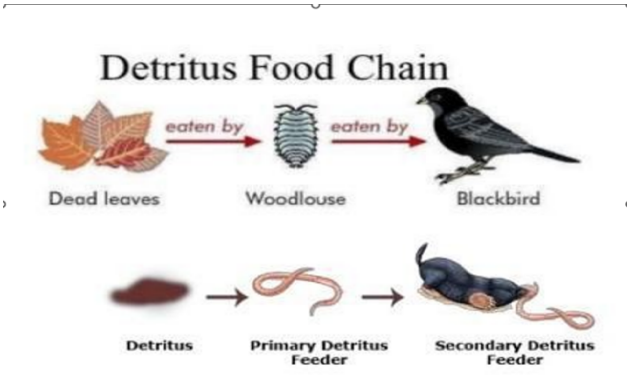
- The consumers which start the food chain, utilizing the plant or plant part as their food, constitute grazing food chain.



Detritus Food Chain:

- **Starts from organic matter of dead and decaying animals and plant bodies** from the grazing food chain.

  E.g.: Forest Floor Deteritus food chain: Leaf litter → Fungi → Mites → Beetles → Salamanders



E.g.: Aquatic Detritus Food chain: Dead algae and other organic matter → Bacteria → Zooplankton → Small fish → Larger fish

- In aquatic ecosystems, the grazing food chain is the major conduit for energy flow.
- In terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than through the grazing food chain.

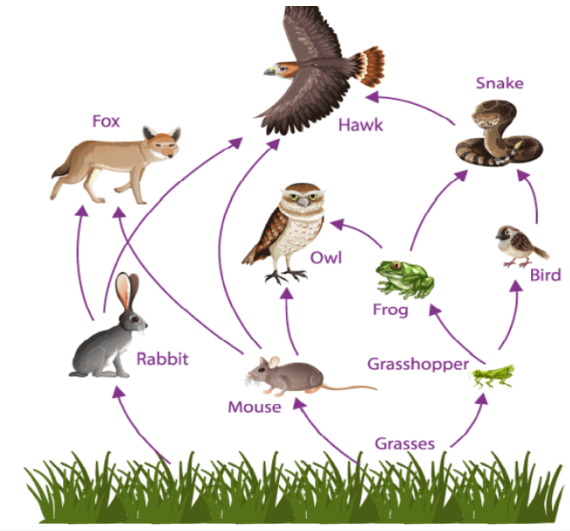
NOTE:

1) **Detritus Food Chain is important** because it increases the soil process/fertility by the process of 'Humification'.
    a. **Humus:** It is a dark, organic rich substance that forms as a result of decomposition of plant and animals and animal material in soil. It is a complex mixture of organic compounds, including carbon, nitrogen, phosphorus, and sulfur, as well as minerals such as calcium, magnesium and potassium. It is key to healthy soil and can help to improve soil structure, retain moisture, and provide a source of nutrients for plants. In addition, it can help restore carbon in soil.
2) **Catabolism**: It is a set of metabolic processes that involve the breakdown of complex molecules into simpler ones, releasing energy in the process. The term catabolism is often used in contrast to anabolism, which refers to the set of metabolic activities that involve the synthesis of complex molecules from simpler ones, using energy.

3) **Humification and mineralization** occur during decomposition in the soil. Humification leads to accumulation of a dark-colored amorphous (formless) substance called humus viz. highly resistant to microbial action and undergoes decomposition at an extremely slow rate. The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as mineralization.

C) FOOD WEB:

- Multiple interlinked food chains make a food web. Food web represents all the possible paths of energy flow in an ecosystem.
- If any of the intermediate food chains is removed, the succeeding links of the chain will be affected largely.
- The **food web provides more than one alternative for food to most of the organisms in an ecosystem** and therefore increases their chance of survival.



D) ECOLOGICAL PYRAMIDS

The **pyramidal representation of trophic levels of different organisms** based on their ecological position (producer to final consumer) is called as Ecological Pyramid.

The ecological pyramids are of three categories:

1. Pyramid of Numbers
2. Pyramid of Biomass, and
3. Pyramid of Energy or Productivity

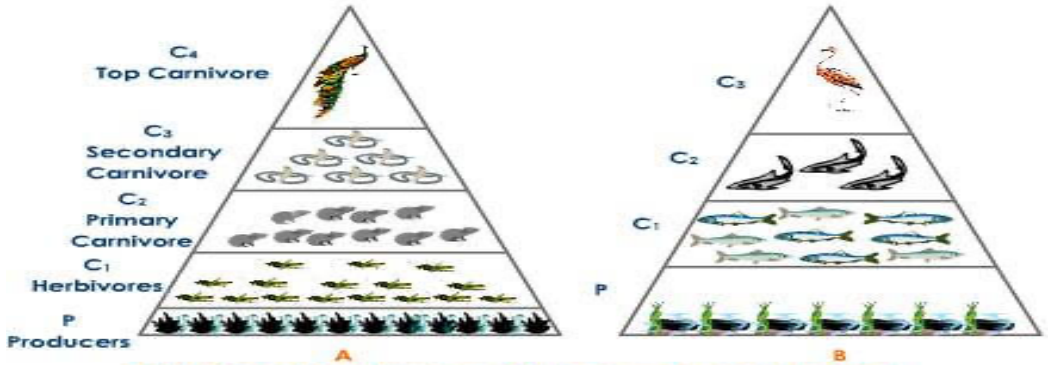
PYRAMID OF NUMBERS:

- It represents the total number of individuals of different species (population) at each trophic level.
- Depending upon the size, the pyramid of numbers may not always be upright, and may even be completely inverted.

(a) Upright:

In this pyramid, the number of individuals is decreased from lower level to higher trophic level.

This type of pyramid can be seen in the Grassland Ecosystem and Pond Ecosystem.

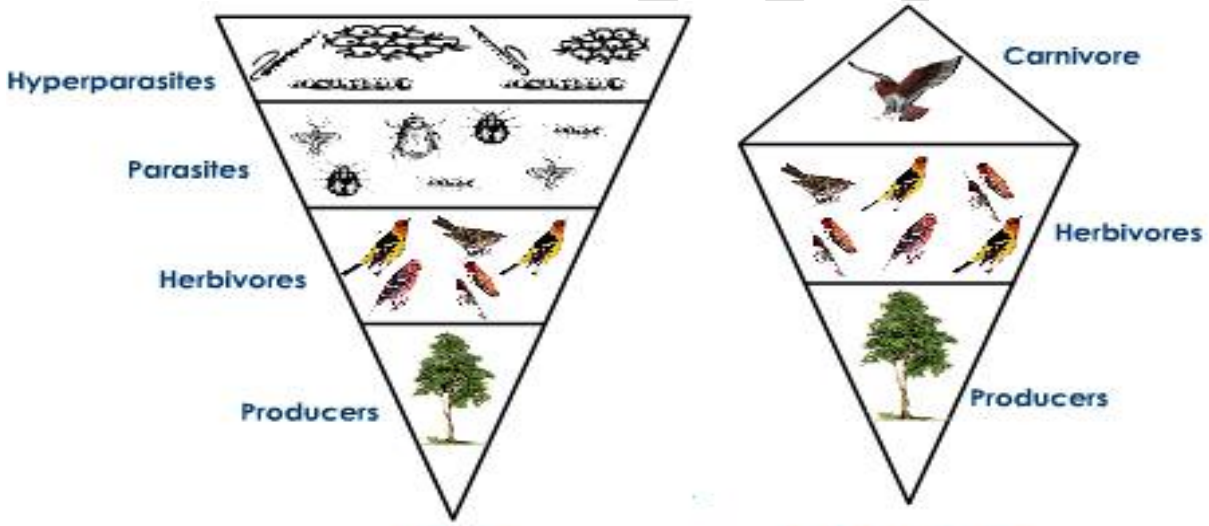


Upright Pyramids of Numbers. (A) In a Grass Land (B) In a Pond

(b) Inverted:

In this pyramid, the number of individuals is increased from lower level to higher trophic level. E.g., Tree Ecosystem

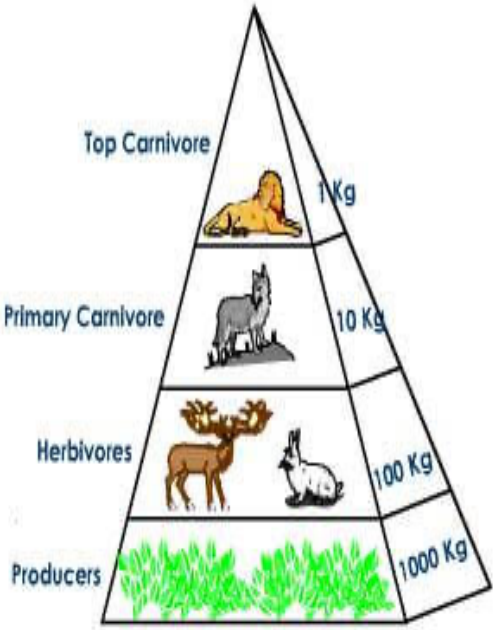
NOTE: Pyramid of Number is ALWAYS Upright in Aquatic Ecosystem, but it may be Upright as well as Inverted in Terrestrial Ecosystem.



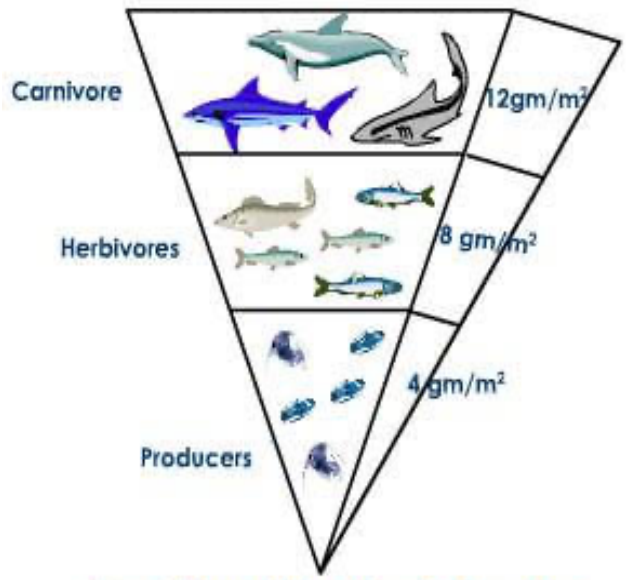
Pyramid of Numbers

PYRAMID OF BIOMASS:

- Biomass means the weight of an organism in a given area and volume. To calculate the biomass of pyramid, we consider the '**dry weight'**.
- **NOTE:** Pyramid of Biomass is ALWAYS Upright in Terrestrial Ecosystem, but in Aquatic Ecosystem, as Producers are microscopic, small phytoplankton's, they do not have much weight. Hence, pyramid of biomass is Inverted.



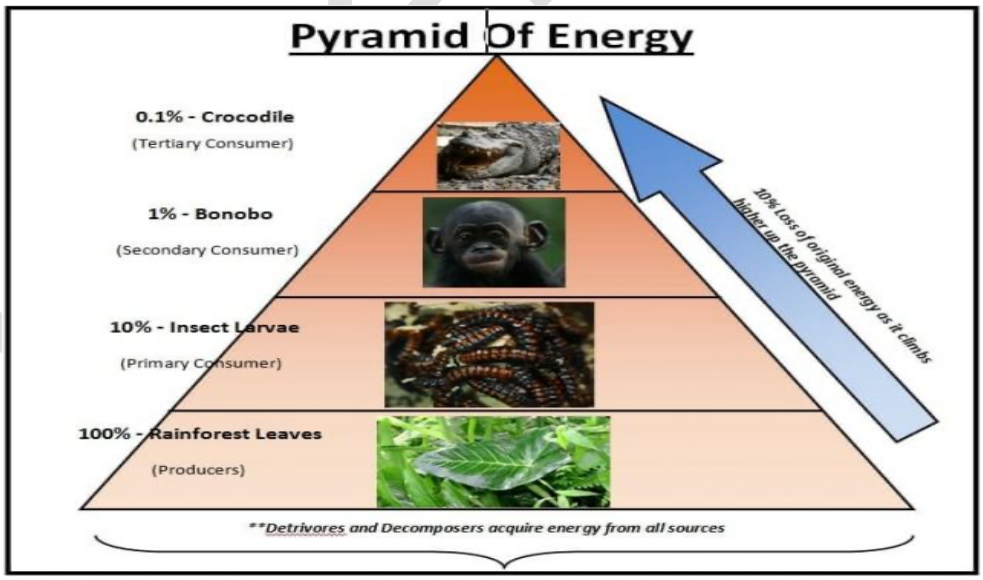
Upright Pyramid of biomass in a Terrestrial Ecosystem



Inverted Pyramid in an Aquatic Ecosystem

PYRAMID OF ENERGY:

- It is **most important pyramid** because it represents the amount of energy at each trophic level.
- As per Lindeman's law, **only 10 % of Energy** is transferred from lower to higher trophic level.
- At each trophic level, energy lost in respiration or in metabolism or in locomotion. **Therefore, pyramid of energy is ALWAYS uni-directional & Upright**.



NOTE: As ecological efficiency is LOW, therefore, organisms higher in food chains are LESSER in Number then they require more food.

As they require more food, Higher Organism in food chains, then there is GREATER chance of Biomagnification & Bioaccumulation.

E) POLLUTANTS AND TROPHIC LEVELS

- Pollutants, especially the non-degradable ones move through various trophic levels in an ecosystem.
- Because of the mechanisms of bioaccumulation and biomagnification even small concentrations of chemicals in the environment find their way into organisms in high enough dosages to cause problems.

BIO-ACCUMULATION

- It refers to entry of a pollutant or toxic substance in the food chain. It actually is gradual accumulation of substances like pesticides or other chemicals, in an organism's body over time.
- It will take place when rate of absorption of pollutant is more than the rate of elimination (metabolism or excretion).

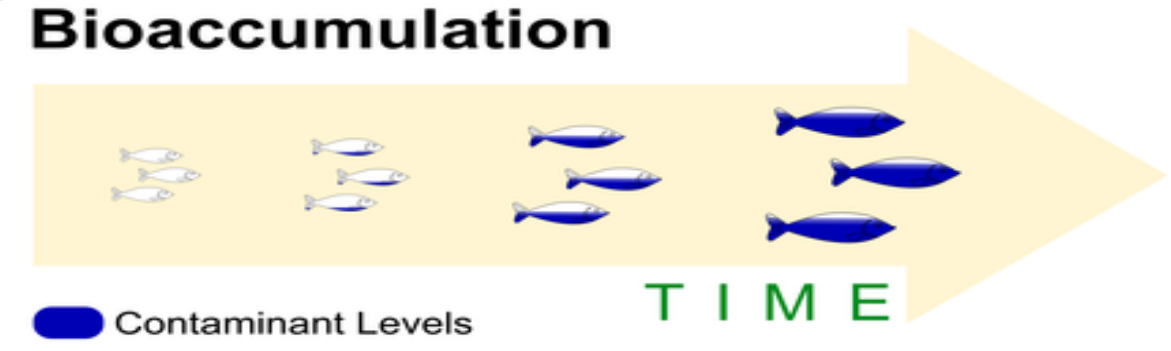
- Bioaccumulation typically occurs within individual organism, particularly those at lower trophic levels of a food chain. The concentration of pollutants in the organism may increase with repeated exposures or with prolonged exposures to contaminated environments.

- **Note**: Bioaccumulation doesn't necessary mean higher concentration of pollutant at higher trophic levels.

- **Source of pollutant** may be food, soil, water, air etc.

- **Substances which are likely to bioaccumulate**: Long lives (doesn't easily break/destroy); Mobile; fat soluble and biologically active (thus causes damage)

- **E.g.**: **Mercury in Fish** (Mercury is absorbed by algae and plankton, which are then consumed by small fish. Here mercury accumulate in the tissue of the fish.

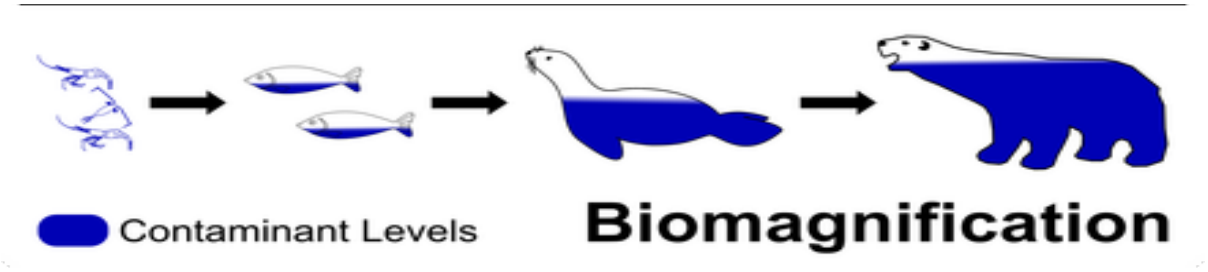


BIO-MAGNIFICATION

Bio-Magnification: The tendency of pollutant to **increase in concentration as it moves from lower to higher trophic level**, is known as Bio-magnification. This usually occurs across the entire food chain and affects all the organisms in the food chain. The animals at the higher trophic levels are affected more.

E.g.: **DDT**: it is a pesticide which is non-biodegradable. It gets incorporated in the food chain and gets deposited in the tissues of the organisms. When DDT enters water bodies, it gets accumulated in the body of fish (bioaccumulation) and when these fish are eaten by bigger fish, the concentration of DDT increase at each successive step (biomagnification).

Note: Biological magnification specifically refers increasing concentration of material in each higher connecting link in the food chain. However, bioaccumulation examines the increased presence of particular substance in a single organism.



Causes of Bio-accumulation & Bio-magnification:

1. **Agricultural Products**: Highly toxic substances such as herbicides, pesticides, fungicides etc. and these substances can also penetrate into the soil.
2. **Organic Contaminants**: Bio-solids used in agriculture farms are treated using toxic chemicals that may contain heavy metals.
3. **Plastic Pollution**: Disposal of plastic waste near or in water bodies. It is caused by 'Ghost Nets' for fishing nets. For instance, Bisphenol A is one of the major contaminants released into the water bodies.
4. **Mining**: Zinc, Copper, Lead and other chemicals may be released into the aquatic and farm environment.
5. **Toxic Gases and Air Pollution:** Exhaust gases from vehicles, refineries industries can be dissolved by the rainwater and fall as acidic rain. These chemicals are absorbed by soil and water bodies.

Effects of Bio-accumulation and Bio-magnification:

1. **On Human Health**: Accumulation of mercury and Polycyclic Aromatic Hydrocarbons affect the tissues of marine organisms. Therefore, in recent years, the consumption of seafood has been linked to certain types of cancer, kidney failure, brain damage etc.
2. **On aquatic animals**- Toxic chemicals such as selenium and mercury include effects on reproductive process of fish.

Some Important Bio-accumulators:

1. **DDT**: It is pesticide and insecticide, generally used for control the malaria population (i.e., mosquito population).
   (a) DDT has been banned under Stockholm Convention, but it is used in tropical countries like India to control the spread of growth of malaria, dengue etc.
   (b) Effects: Headache, Noroviral disorder, thinning of egg-shells & loss of fertility which ultimately result to Cancer.
2. **Endosulfan**: It is an insecticide which is used in Cashew, Rubber & Plantation agriculture (tea plantation).
   (a) It is cheap but dangerous bioaccumulate because it is associated with birth defects including cryptorchidism (absence of testis in male), neurological disorder including autism (mental retardness), cancer etc.
   (b) Endosulphane was added to the list of POPs in the year 2011. Government of India has banned the use of endosulphane, but the matter is in sub-judice.

2) BIO-GEO-CHEMICAL CYCLING OR NUTRIENT CYCLING

- "Nutrient Cycle" or "Biogeochemical cycle" refers to the movement or exchange of nutrients among the living and non-living constituent of an ecosystem. Nutrient Cycling is the process through which components change into different forms and then return to their original state.
- Based on t**he nature of reservoir**, a nutrient cycle is divided into **two types of cycles** viz. **Gaseous cycle**; and **Sedimentary Cycle**.

  - **Gaseous Cycle**: In Gaseous cycle, atmosphere or hydrosphere acts as the primary reservoir and elements primarily cycle through the atmosphere and living organisms, with minimal

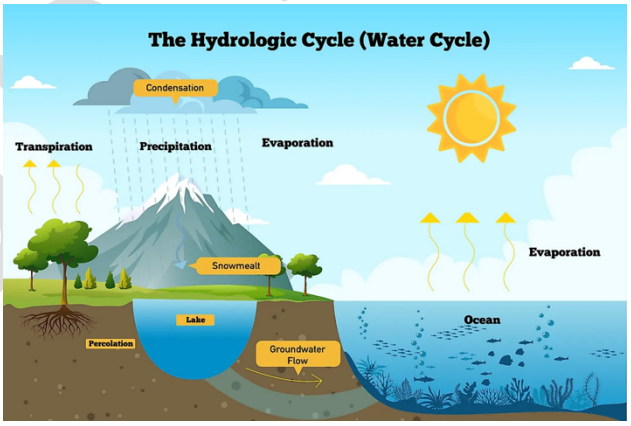
involvement of soil or sediments. It includes, water cycle (hydrologic); carbon cycle; nitrogen cycle etc.

- **Sedimentary Cycle**: In this cycle, earth's crust act as the primary reservoir. It includes phosphorus cycle; sulphur cycle etc.

- **Biogeochemical Cycle (Nutrient Cycle)** can also be divided into perfect nutrient cycle and imperfect nutrient cycle.
  - **Perfect Nutrient Cycle** is one in which nutrients are replaced as fast as they are utilized. Most of the gaseous cycles are generally perfect cycles.
  - **Imperfect Nutrient Cycle** sees loss of some nutrients from cycle and the nutrients get **locked into sediments** and so become unavailable for immediate cycling.

A) WATER CYCLE (HYDROLOGIC CYCLE)

- Water Cycle is the continuous circulation of water in the Earth-Atmosphere system which is driven by solar energy. There are various reservoirs of water on earth including ocean, atmosphere, lakes, rivers, soils, glaciers, snowfields, and groundwater. Water moves from one reservoir to another through the process of evaporation, transpiration, condensation, precipitation, percolation, ground water flow, deposition etc.

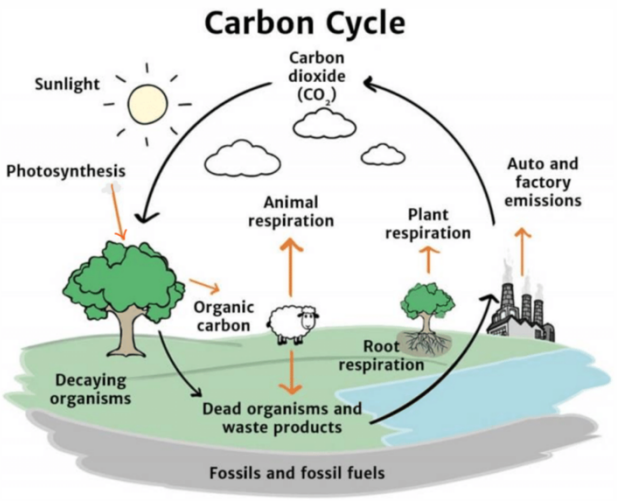


B) CARBON CYCLE

- The carbon cycle is the process that **circulates the carbon** between plants, animals, and microbes; minerals on earth; and the atmosphere.

- **Photosynthesis** leads to carbon from atmosphere moving to green plants and then to animals. **Respiration and decomposition** of dead organic matter leads to return of carbon back to atmosphere. This is usually a **short-term cycle**.

- **Some carbon** also enters a long-term cycle. It accumulates an undecomposed carbon in the peaty layers and as insoluble carbonates in the bottom sediments of aquatic systems. In the deep ocean, carbon can remain buried for millions of

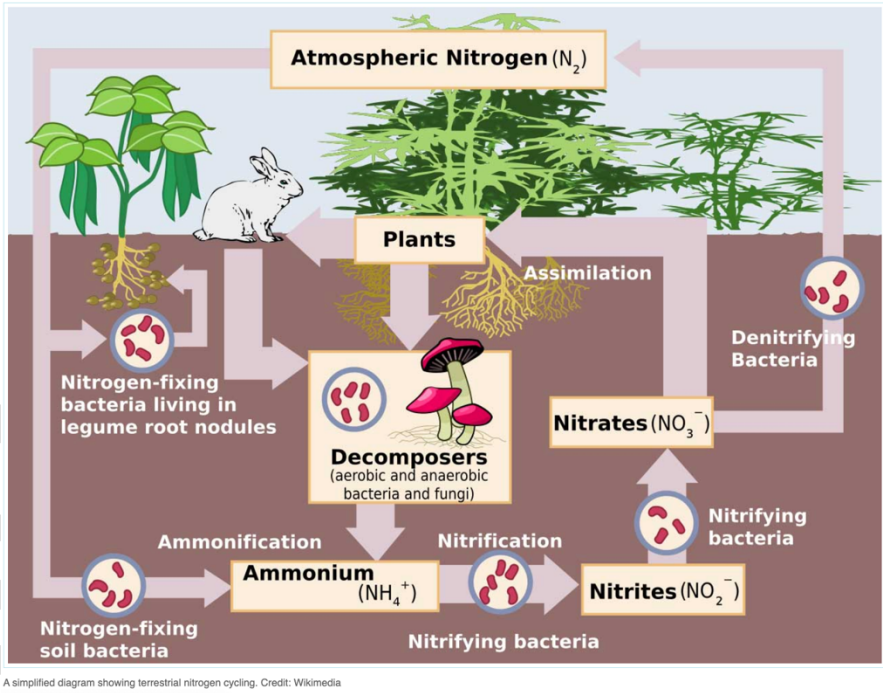


years until geological movement uplifts the rocks and erosion releases carbonates and bicarbonates. Fossils also trap carbon for millions of years.

C) NITROGEN CYCLE

- **Nitrogen** is the key component of the bodies of living organisms. Nitrogen atoms are found in all proteins and DNA.
- **Though**, Nitrogen is the most abundant element in the atmosphere (N_2 is 78% of atmosphere), it is still a **limiting nutrient** in nature and agriculture. It is because it is not available in atmosphere in usable form.
    - **Note**: A limiting nutrient is the nutrient that's in the shortest supply and limits growth.

- **Nitrogen Fixation**: It is the process by which bacterial and other single celled prokaryotes convert atmospheric nitrogen (N_2) into **biologically usable form i.e. ammonium ion (NH_4^+)**.
    - Some species of **nitrogen fixing bacterias** are free living in soil or water (aerobic Azotobacter and anaerobic Clostridium), while others are symbiotic nitrifying bacteria (living in association with leguminous plants) and symbiotic bacteria living in non-leguminous root nodule plants (e.g. Rhizobium) as well as blue green algae (e.g. Anabaena, Spirulina).



A simplified diagram showing terrestrial nitrogen cycling. Credit: Wikimedia

    - **Ammonium ion** can directly be taken up as a source of nitrogen by some plants, or are oxidized to nitrites or nitrates by two groups of specialized bacterial:
        - Nitrosomonas bacteria promote transformation of ammonia into nitrite.
        - Nitrobacter bacteria convert nitrite into nitrate.
    - **Nitrates** synthesized by bacteria in the soil are taken up by plants and converted into amino acids, which are the building blocks of proteins. This can further go to higher trophic levels.

    - **Organic Nitrogen** will again be converted into N_2 gas by bacterial. Nitrogenous compounds from dead organisms or wastes are converted into ammonia-NH3 – by bacteria, and the ammonia is converted into nitrite and nitrates. In the end, the nitrates are made into N_2 gas by denitrifying prokaryotes (e.g. Pseudomonas). This nitrogen escape into atmosphere, thus completing the cycle.

Note: **Nitrogen fixation** also happens by other mechanisms:

1) **Industrial Process** (fertilizer factories)

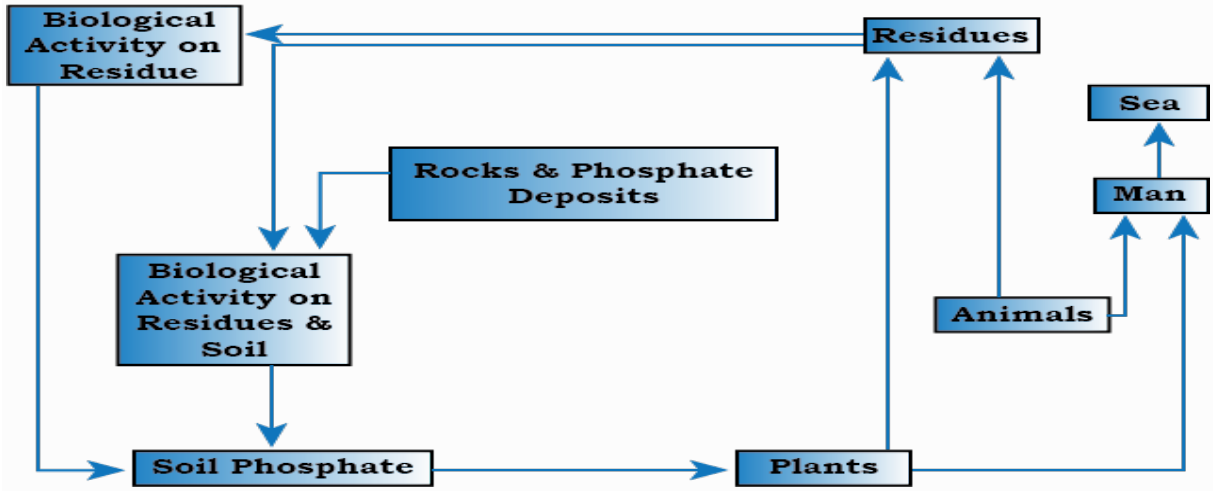
2) **Atmospheric phenomenon** (thunder and lightning): The periodic thunderstorms convert the gaseous nitrogen into the atmosphere to ammonia and nitrates which eventually reach the earth's surface through precipitation and then into the soil to be utilized by plants.

Note1: Water Cycle, Carbon Cycle and Nitrogen Cycle were Gaseous Cycle.
Note2: Phosphorus, Calcium, Magnesium and sulphur circulate using sedimentary cycle. The elements involved in sedimentary cycle generally follow a pattern of Erosion -> Sedimentation -> Mountain Building -> Volcanic Activity and biological transport through the excreta of marine birds.

D) PHOSPHOROUS CYCLE

Unlike carbon and nitrogen, phosphorus occurs in large amounts as a mineral in **phosphate rocks** and enters the cycle from **erosion and mining activities**.
By the process of weathering and erosion, phosphate enter rivers and streams that transport them to ocean.
In Ocean, phosphorus will accumulate on **continental shelves** in the form of insoluble deposits. After millions of years, the crustal plates rise from the sea floor and expose the phosphates on land. After more time, weathering will release them from rock and the cycle's geochemical phase begins again.

Note: Phosphorus is a primary nutrient that causes eutrophication in lakes causing algal blooms.



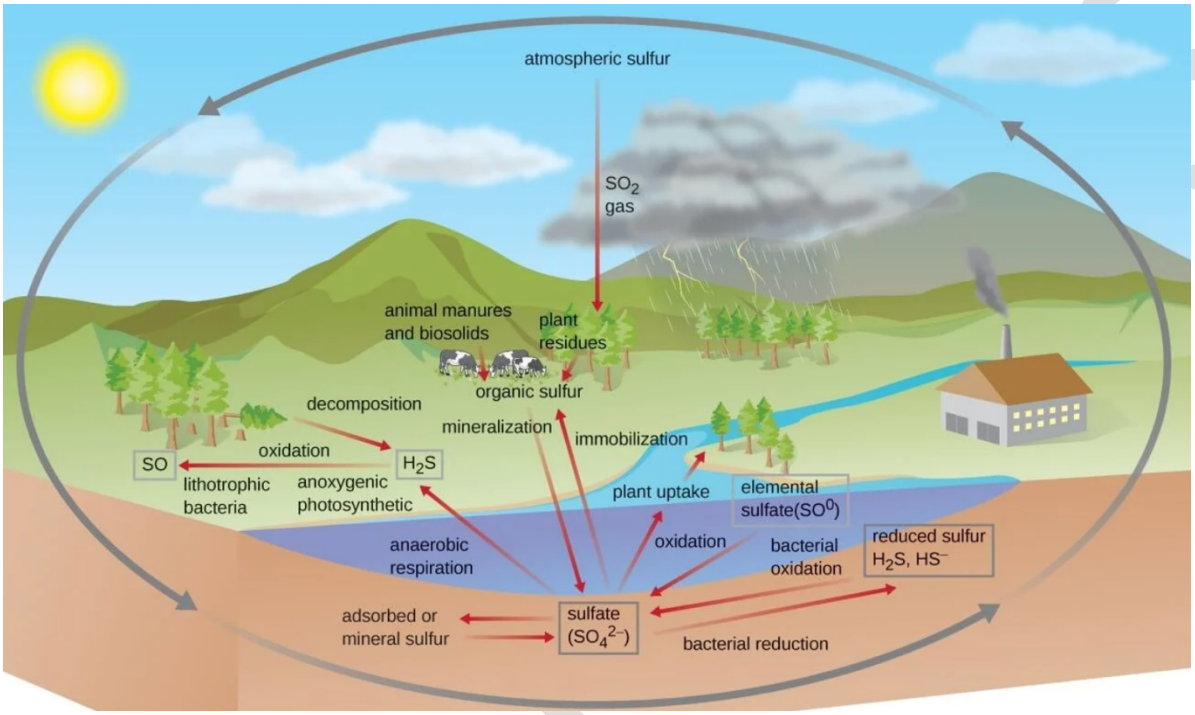
F) SULPHUR CYCLE:

- **Sulphur Reservoir** is in the soil and sediments where it is locked in organic (coal, oil and peat) and inorganic deposits (pyrite rock and sulphur rock) in the form of sulphates, sulphides and organic sulphur.

- **Release**: Weathering of rocks; Erosional runoff and decomposition of organic matter. It is carried to terrestrial and aquatic ecosystem in salt solutions.

- **Note**: The sulphur cycle is mostly sedimentary except two of its compounds Sulphur dioxide (SO_2) and Hydrogen Sulphide (H_2S) which add gaseous component to its sedimentary cycle.

- **Various ways in which Sulphur enters atmosphere**: Volcanic eruption, burning of fossil fuels, from surface of ocean and from gases released by decomposition. Atmospheric hydrogen Sulphide (H_2S) also gets oxidized to sulphur dioxide and is carried back to earth as Acid Rain.



3) ECOLOGICAL SUCCESSION:

- The process by which communities of plant and animal species in an area are replaced or changed into another over a period of time is known as ecological succession. Succession is a universal process of directional change in vegetation, on an ecological time scale. The process involves a progressive series of changes with one community replacing another until a stable, mature, climax community develops.

(A). Stages in Ecological Succession:

1. Pioneer Species: The first plant to colonize an area. Pioneer Species will occupy the bare rocks. E.g., Bacteria, Fungus, Weeds, Moss, Lichens and in Tundra region, Rhododendrons.

2. Climax Community: The final stage of succession is called climax community. A climax community is stable, mature, more complex and long-lasting.

- E.g.: Temperature Deciduous forests; Tropical Rain forests etc.

3. Seral Community: A seral community is temporary and transitional stage in ecological succession, leading to the development of a stable and self-sustaining climax community. During ecological succession, a seral community represents a stage where a specific set of plant and animal species are dominant, but **they are not the final or permanent community**.

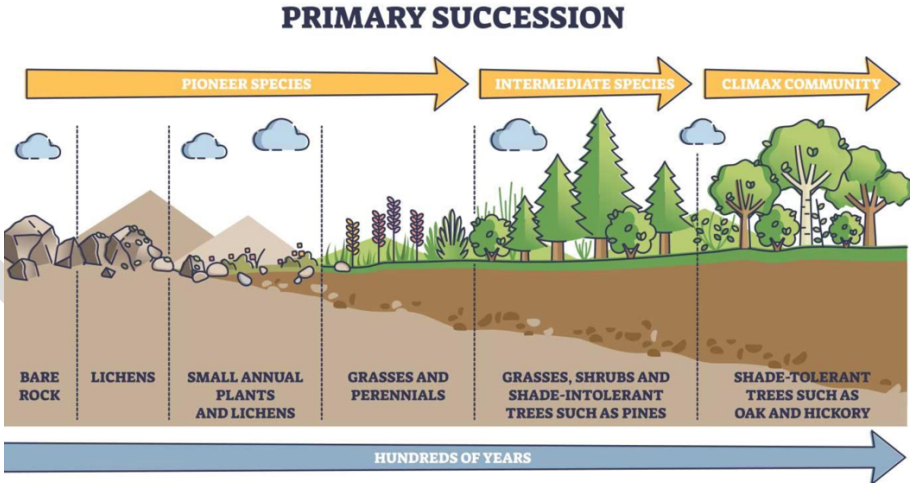
NOTE: Each ecological succession is characterized by **the increased productivity**, the shift of nutrients from the reservoirs, increased diversity of organisms, and a gradual increase in the complexity of food webs.

A) TYPES OF ECOLOGICAL SUCCESSION:

1. Primary Succession
2. Secondary Succession

PRIMARY SUCCESSION:

- Primary succession takes place an over where no community has existed previously. Such areas include rock outcrop, newly formed deltas and sand dunes, emerging volcano islands and lava flows, glacial moraines etc.
- In primary succession on a terrestrial site, the new site is first colonized by a few hardy pioneer species that are often microbes, lichens and mosses.



SECONDARY SUCCESSION:

- Secondary succession is the sequential development of biotic communities **after the complete or partial destruction of the existing community**.

- A mature or intermediate community may be destroyed by natural events such as floods, droughts, forest fires etc. or anthropogenic activities such as deforestation, agriculture, overgrazing etc.

- This abandoned land is first invaded by hardy species of grasses that can survive in bare, sunbaked soil.
- These grasses may be soon joined by tall grasses and herbaceous plants. These dominate the ecosystem for some years along with mice, rabbits, insects etc. Eventually some trees come up in this area, seeds of which may be brought by wind or animals.
- And over the years, a forest community develops. Thus, an abandoned land over a period becomes dominated by trees and is transformed into a forest.

ECOLOGICAL SUCCESSION IN WATER/AQUATIC:

- In primary succession in water, the **pioneers are the small phytoplankton**, and they are replaced with time by **free-floating angiosperms**, then by rooted hydrophytes (aquatic plants), grasses and the finally, trees.
- The **climax again would be a forest**. As the time passes, the **water body is converted into land**.

NOTE:

1. All the succession whether taking place in water or on land, **proceeds to a similar climax community**-the mesic.
2. **Secondary Succession is faster** process than the primary succession because the secondary succession starts on a well-developed soil already formed at the site.
3. **Succession would happen faster in the area existing** in the middle of the large continent. Here seeds related to various species would reach much faster, establishing and ultimately resulting in climax community.
4. **In Savanna or Grasslands**, Succession do not take place due to water and fire limits.
5. In **Tropical Evergreen forests**, original dense forest/vegetation does not re-grow once it is cleared because the soil is deficient in nutrients due to intense leaching.
6. In Tundra region, natural vegetation consists of Moss, Lichens & Rhododendrons, because in such tough conditions, only pioneer species can survive.

7. **Human beings affect 'secondary succession'** by causing 'soil erosion, global warming, loss of biodiversity, introduction of invasive alien species etc.' E.g., Due to introduction of invasive alien species such as pine, wattle, eucalyptus in Shola Forests of Western Ghats, forest fires (canopy fires occurs in Western Ghats) are increasing.
8. **Autogenic and Allogenic Succession**:
    a. **Autogenic**: Succession brought about by living inhabitants of the community itself, the process is called autogenic succession.
    b. **Allogenic**: Succession brought by outside forces.
9. **Autotrophic and Heterotrophic Succession:** Succession in which, initially the green plants are much greater in quantity is known as autotrophic succession; and the ones in which the heterotrophs are greater in quantity is known as heterotrophic succession.