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ENVIRONMENT, ECOLOGY AND BIODIVERSITY

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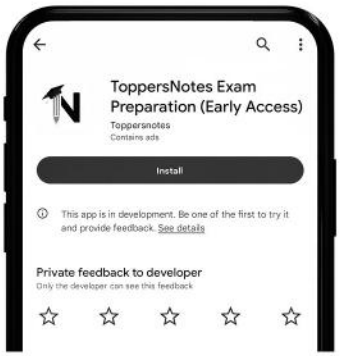

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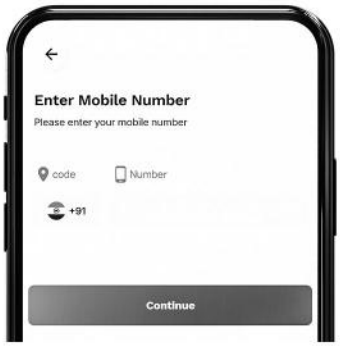

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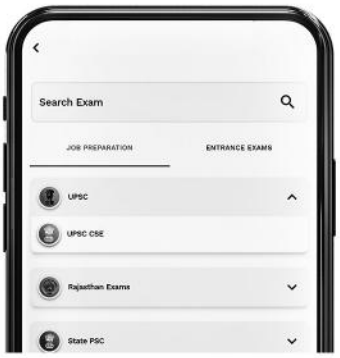

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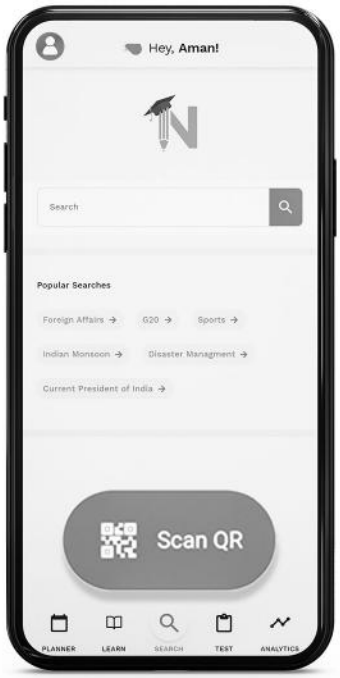

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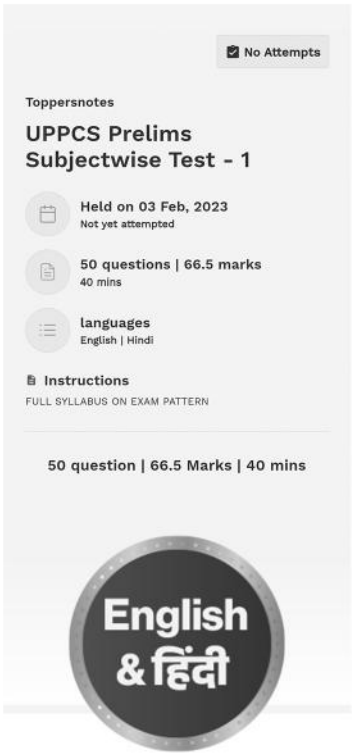

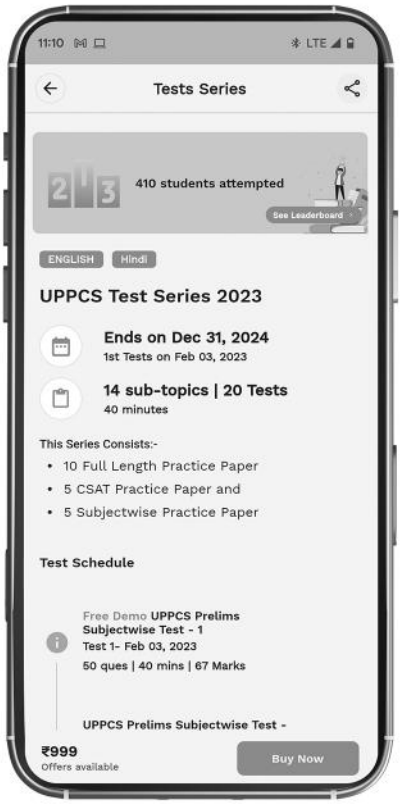

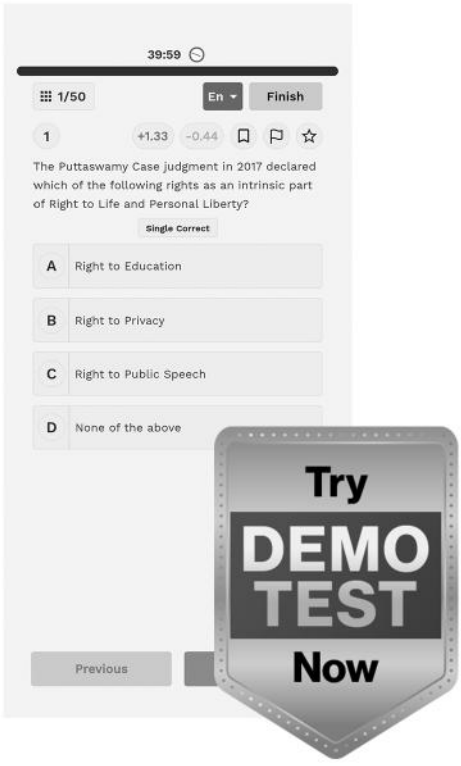

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1 CHAPTER Ecosystem

- A **functional unit where organisms interact** among themselves and with the surrounding physical environment.
  - **Can be of any size** but usually **encompasses specific and limited species.**
  - **Every organism** in an ecosystem is **dependent on other species and elements** in that ecological community.
  - **If one part of an ecosystem is damaged , it has an impact on everything else.**

Components of an Ecosystem

Ecosystem	
Biotic Components	**Abiotic Components**
• Autotrophs/Producers • Heterotrophs/ Consumers • Saprotrophs/Decomposers	• Light • Temperature • Water • Atmospheric gases • Wind • Soil/Edaphic factors • Physiographic factors

Biotic Components

- Consist of all living things in a particular area.

Producers/ Autotrophs • **Produce their own food** using light, water,CO_2, etc.	**Photoautotrophs:** • Use **sunlight to prepare** their own **food**
	Chemoautotrophs: • **Energy from CO_2** using inorganic energy sources
Consumers/ Heterotrophs • Take **nourishment from others.** • **Not capable of making their own food.**	**Primary consumers/ Herbivores:** • **Feed directly on plants.** • **Eg:** Cow, Goat, grasshopper, etc.
	Secondary consumer/ carnivore: • **Feed on primary consumers.** • **Flesh-eating** organisms. • **Eg**: fox, snakes, etc.
	Tertiary consumer/ Top carnivore: • **Feed on secondary consumers.** • **Eg:** hawk, tiger, lion, etc.
	Omnivores • Eat **both plants and animals.** • **Eg:** crow, rats, etc

Saprotrophs/ Osmotrophs • **Feed on dead organic matter** generated from plants and animals	**Decomposers:** ● Microorganisms such as **bacteria and fungi** that **feed on and decompose other dead organic material.** ● **Re-lease simple inorganic and organic substances** to the environment **as by-products** resulting in recycling of nutrients.
	Detritus feeders: ● Small animals like earthworms, mites, etc. that **feed on partially decomposed organic material.** ● Contribute to the breakdown of **detritus.**

Phagotrophs

- Consumers that **feed on other living organisms for their source of energy.**

Phototrophs

- **Organisms that use light energy for certain metabolic functions.**
- **Absorb photons** from light **to carry out cellular functions** such as biosynthesis and respiration.
- **2 types:**
  - **Photoautotrophs - Eg.** plants, algae and certain bacteria.
  - **Photoheterotrophs -**
    - **depend solely on light energy** as they **generate ATP through photophosphorylation.**
    - Do not rely on carbon dioxide as their sole carbon source.
    - **Eg.** purple non-sulfur bacteria, green non-sulfur bacteria, and heliobacteria.

Abiotic Components

- **Consist of non-living things**, like r**ocks, soil, minerals, water,** etc.
- **serve as sources of nutrients** essential to the growth & metabolism of an organism.
  - **Light**
    - Solar radiation = primary source of energy
    - necessary for photosynthesis

$$6CO_2 + H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \underset{\text{(Glucose)}}{C_6H_{12}O_6} + 6O_2$$

    - On the basis of light requirement plants are of following types:
- **Heliophytes:** require full Sunlight for growth (ex. Sunflower)
- **Sciophytes:** grow best in shady conditions (ex. Sandal tree)

Phototropism

- **Directional growth** of plants and other organisms **in response to light**.
  - **Positive Phototropism:** towards the source of light
  - **Negative Phototropism:** away from the source of light

Photoperiodism:

- **Physiological reaction** of organisms **to the length of day or night**.

Ex. Long-day plants (Spinach, sugar beet), Short-day plants (soybean, chrysanthemum) and day-neutral plants (sunflower, corn).

  - **Temperature**
    - affects the **kinetics of enzymes** and basic metabolism of the organism.

Depending on the temperature tolerance capability, organisms are:

- **Eurythermal:** tolerate a **wide range of temperatures** (ex. Cat, Dog, Tiger etc.)
- **Stenothermal:** restricted to a **narrow range of temperature** (ex. Penguin, Python, Crocodile etc.)

- **Water**
  - Used by plants to distribute the nutrients to survive.

On the basis of water requirement plants are of following types:

- **Hydrophytes:** adapted to grow well in water. (ex. Lotus, water lily, sea weeds)
- **Mesophytes:** average water requirements. (ex. Rose)
- **Xerophytes:** adapted themselves to survive in water scarcity like Deserts. (ex. Cactus, Pineapple)

On the basis of tolerance to salinity, organisms are of following types:

- **Euryhaline:** tolerant to a **wide range of salinity** (ex. Green crab)
- **Stenohaline:** tolerant to **narrow range of salinity** (ex. Goldfish)

- **Atmospheric Gases:**
  - important for **various biological processes** necessary for organisms' growth and survival.
    - ☞ **Oxygen** (required for respiration),
    - ☞ **Carbon dioxide** (required by plants for photosynthesis),
    - ☞ **Nitrogen** (required by plants as a macronutrient)
- **Wind:**
  - a **natural thermal regulator**
  - aids in **seed dispersal**
  - Negative effects of wind include soil erosion, forest fires.
- **Soil/ Edaphic Factor:**
  - **Acts as a provider of important nutrients** for the plants.
  - **Anchors the plants to keep them in place to grow.**
  - Soil also **absorbs and holds water** for plants and animals.
- **Physiographic Factors:**
  - **Altitude:** determines temperature- influences vegetation
  - **Slopes:** slope direction influences the availability of sunlight.

Functions of Ecosystems

- **Energy Flow**: **Facilitate exchange of energy** in various plant and animal communities of different biomes of the world. **Eg. Green leaves** prepare food and **roots** absorb nutrients from the soil → **Herbivores feed** on leaves and roots → **Carnivores** in turn **eat herbivores.**
- **Decomposition of organic materials**- **Decomposers break** down complex **organic materials into simple inorganic products, → used by producers.**
- **Homeostasis:** keep the components running together with balanced and controlled processes.
- **Provisioning services:** Provision of **food, fuel, and fiber, shelter** and **building materials**
- **Purification of air and water**
- **Detoxification** and decomposition of wastes

- **Stabilization** and moderation of the Earth's climate
- **Moderation of floods, droughts, temperature extremes**
- **Nutrient cycling-** Generation and renewal of soil fertility.
- **Pollination of plants**, including many crops
- Control of **pests and diseases**
- **Ecological Succession-** Process by which **communities o**f plant and animal species in an area **are replaced or changed into another over a period of time.**

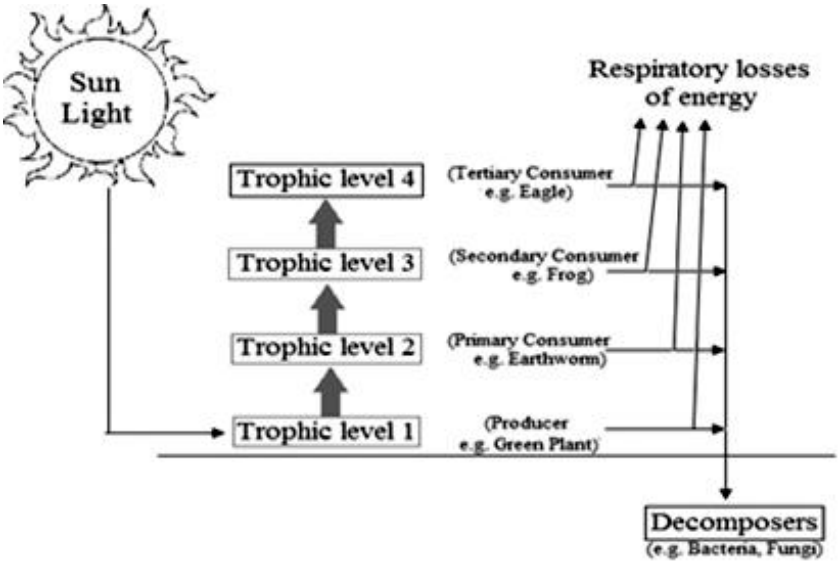
Attributes of Ecosystem

Energy Flow

- **Vital** for **all the metabolic activity** in plants and animals
- **Plants and trees** are autotrophic and so **convert the solar energy into a usable form** of energy
- **Animals depend on plants** and other animals for their energy needs.
- flow of energy through living things in an ecosystem is conserved **(Law of energy conservation)**
- **Sources of Energy:**
  - **Sun** (Major)
  - Deep-sea **hydro-thermal ecosystem** (Minor)
- **< 50%** of **total incident solar radiation** is **photosynthetically active radiation** (**PAR**).

> **Photosynthetically Active Radiation (PAR)**
> - Light in the **400-700 nano-meter wavelength** range, **available for photosynthesis**
> - **Plants capture only 2-10% of the PAR** which sustains the entire living world.

- Energy flow is **unidirectional.**
- **Energy decreases from the first trophic level upwards due to loss of energy in the form of heat at each trophic level.**



- **Producers** consume about **20% assimilated energy** in respiration.
- **Herbivores** consume about **30% assimilated energy** in respiration
- **Carnivores** consume **60% assimilated energy** in respiration

Trophic Levels

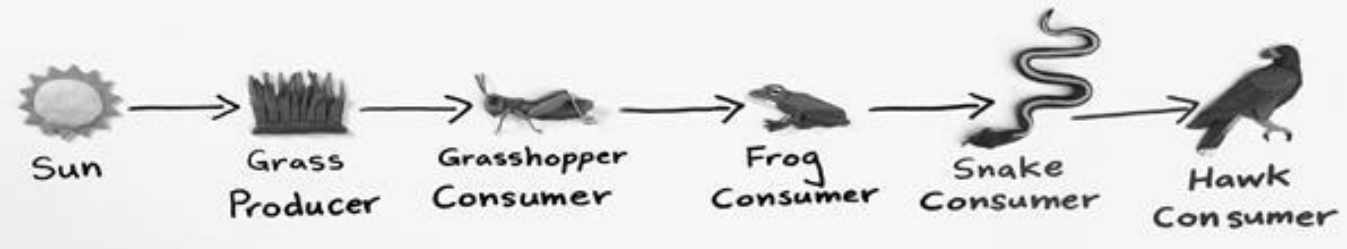
- Representation of energy flow in an ecosystem.
- The **trophic level** of an organism = **position it occupies in a food chain.**
- Trophic level interaction deals with how the members of an ecosystem are connected based on nutritional needs.

Autotrophs	Green plants (Producers)
Heterotrophs	Herbivore (Primary consumers)
Heterotrophs	Carnivores (Secondary consumers)
Heterotrophs	Carnivore (Tertiary consumers)
Heterotrophs	Top carnivores (Quaternary consumers)

- **Energy level decreases from the first trophic level** upwards therefore, **usually not more than four-five trophic levels**.

Food Chain

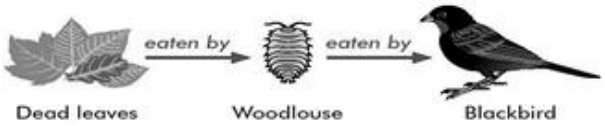
- Defined as **transfer of energy and nutrients via a succession of organisms** through repeated processes of eating and being eaten.
- **Green plants trap in solar energy and convert it into chemical energy → stored** as carbohydrates, fats and proteins.
  - all other **living organisms depend upon green plants** for their energy.
  - Efficiency of plants in any given area in capturing solar energy sets the upper limit to long-term energy flow and biological activity in the particular community.
- **Solar Energy → Green Plants → Herbivores → Carnivores**
- In this way one form of life transfers energy to the other life.
- In a food chain, the **first link is a green plant or producer** which produces chemical energy available to consumers.



Types of Food Chain

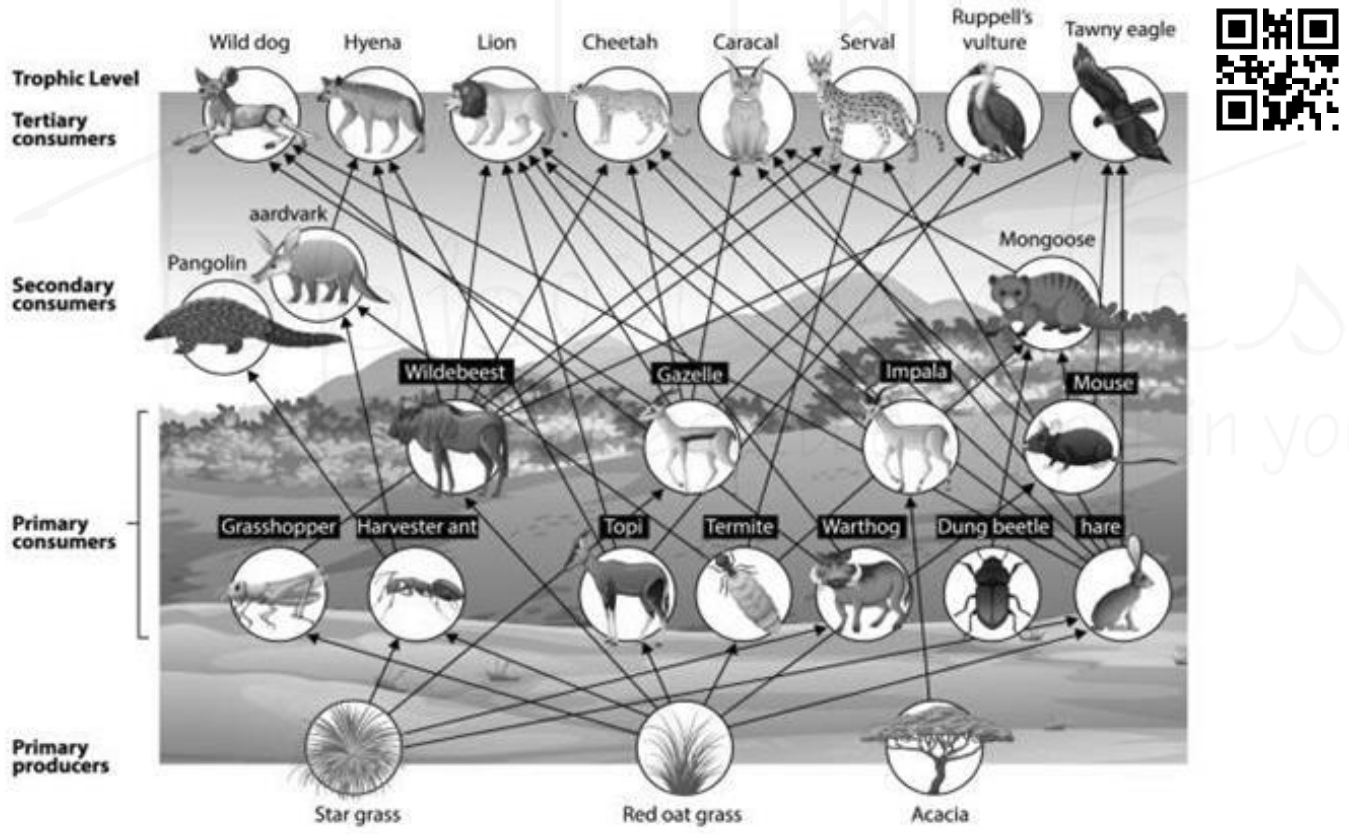
1. **Grazing Food Chain**
   - **Green plants** (autotrophs) → **herbivores** (primary consumers) → **primary carnivores** (secondary consumers) → **secondary carnivores** (tertiary consumers) and so on.
2. **Parasitic Food Chain**
   - Starts from **herbivores → large organisms → smaller organisms without direct killing a**s in the case of predators.
   - **Eg: mosquitoes** survive on blood obtained from humans.

3. Detritus Food Chain



- The **energy contained in detritus is not lost** in the ecosystem → serves as a **source of energy for** a group of organisms called **detritivores or decomposers** that are **separate from the grazing food chain.**
- **Eg: microscopic organisms** like bacteria, fungi feed on dead animals.
- In some ecosystems **more energy flows through the detritus food chain than through grazing.**
- Also in the detritus food chain the **energy flow remains continuous instead of a stepwise flow** between discrete entities.

Food Web



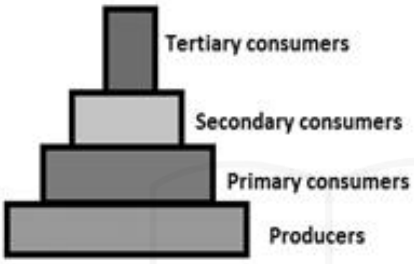
- **Organisms are interconnected** with each other **via the multiple feeding relationships** of nutrient and energy transfer k/a **Food Web.**
- **demonstrates all possible flow** of energy as well as nutrients among organisms **within an ecosystem**
- **Provides multiple alternatives for the food** to organisms.
- Vital for the very existence of an ecosystem.
- **Eg,** a tiger which is not having deer as a food due to lack of deer in that region or other factors may resort to other alternatives thus giving origin to another food chain and in turn more complex Food Web.

Ecological Pyramid

- **Idea given by C.E. Elton** (1927).
- **graphical representation of the relationship between the different living organisms at different trophic levels.**
- In each ecological pyramid, the **producer level forms the base and successive levels make up the apex.**

Pyramid of numbers

- Depicts the **numbers of individuals in producers** and **in different orders of consumers** in an ecosystem.



- **Base- Producers -** most abundant.
- **Successive levels -** number of organisms goes on decreasing rapidly.
- **Indicates** that the **producers are ingested in large numbers by smaller numbers of primary consumers.**
- These **primary consumers** are **eaten by a relatively smaller number of secondary consumers** and these **secondary consumers,** in turn, are **consumed by** only a few t**ertiary consumers.**

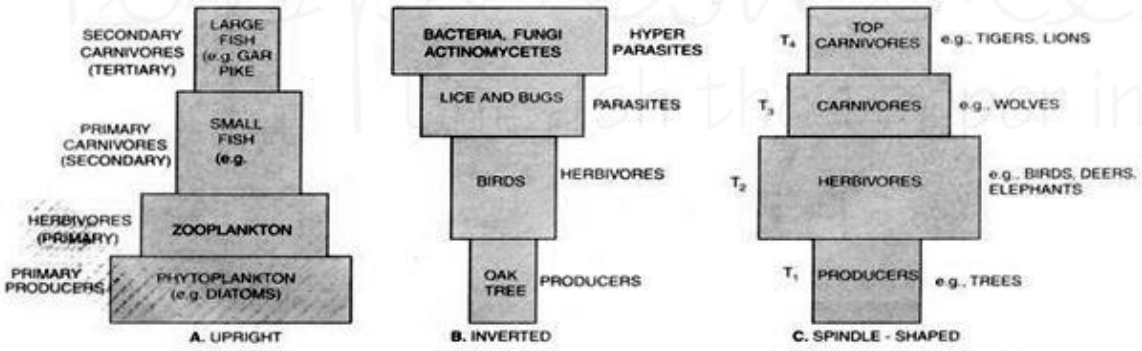


Figure : Pyramids of numbers : A. In pond ecosystem, B. In parasitic food chain, C. Tree ecosystem

- An **inverted pyramid of numbers** may be **found** in an ecosystem **where the community contains parasites.**

Pyramid of Biomass

- **Biomass - renewable organic material** that **comes from plants and animals.**
- **Measured in** units such as **grams of biomass per square meter** (g/m2).
- **Quantifies the amount of biomass present at each trophic level** at a certain point in time, and represents the standing stock of each trophic level.
- **Indicates the decrease of biomass in each trophic level** from base to apex,
- **Eg.,** the total **biomass of producers** > total biomass of the **herbivores.**

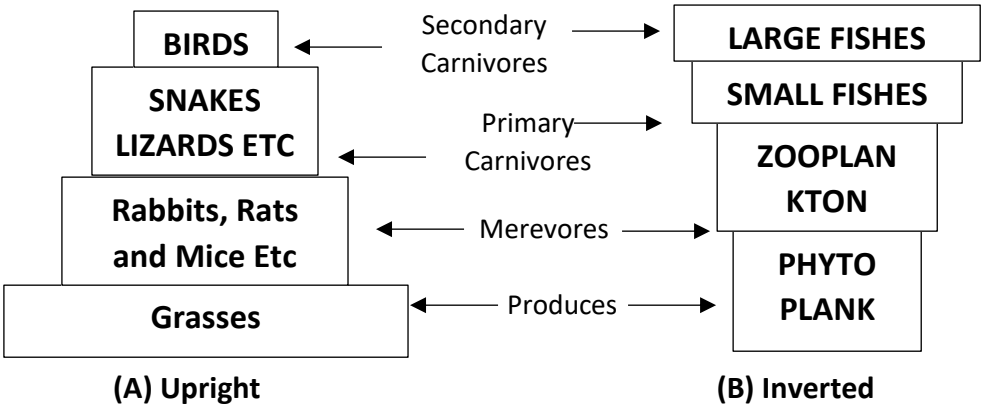


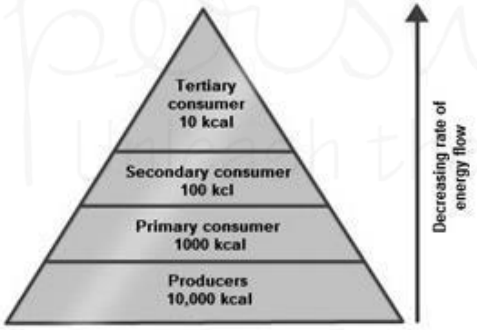
Figure : Pyramids of biomass

(A) In grassland ecosystem (B) In a pored ecosystem

- Pyramid of biomass in the **Pond Ecosystem** is **inverted** as the **biomass of fishes far exceeds that of phytoplankton.**

Pyramid of Energy

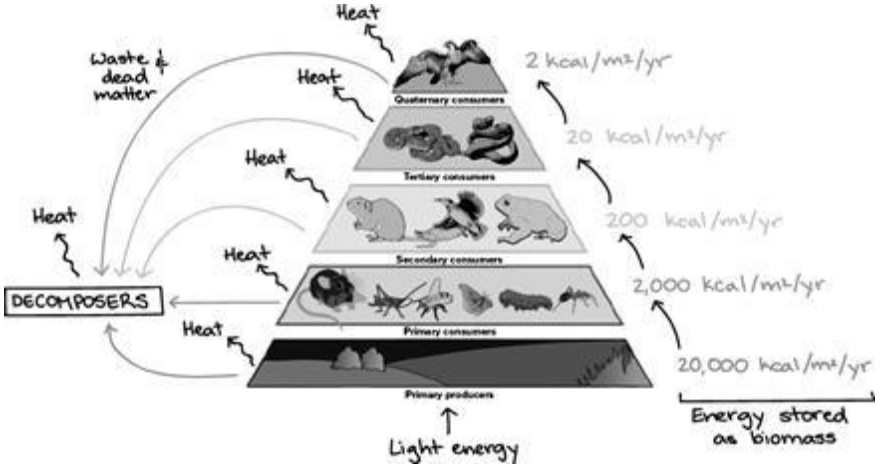
- Shows **total quantity of available energy stored in the biomass of organisms** at **each level** in the food chain of an ecosystem per year.
- **Producer** total energy >> energy at the successive higher trophic level.
- **Higher trophic levels - more efficient in energy utilization** but much **heat is lost in energy transfer (Lindeman's 10% Law)**
- **Energy loss by respiration** also progressively **increases from lower to higher trophic levels.**
- Pyramid of energy is **always upright- never inverted**



Pyramid of Energy

Lindeman's 10% Law

Only 10% of the energy is transferred to each trophic level from the lower trophic level.

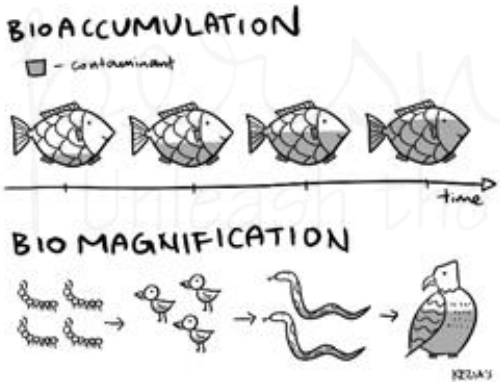


Limitations of Ecological Pyramids

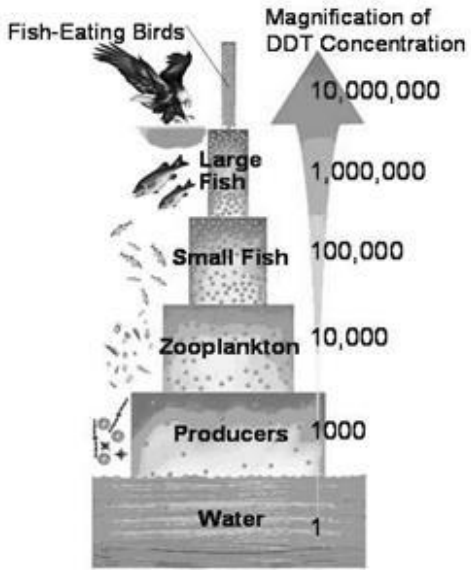
- **Does not consider the same species belonging to two or more trophic levels.**
- **Assumes a simple food chain**, something that seldom exists in nature; it **does not accommodate a food web.**
- **Saprophytes** (plant, fungus, or microorganism that lives on decaying matter) are **not given any place in ecological pyramids** even though they play a vital role in the ecosystem.

Pollutants and Trophic level

- **Pollutants move through the various trophic levels** in an ecosystem.
- **Non-degradable pollutants** (persistent pollutants)- **cannot be broken down** by detritivores- **move through the various trophic levels** and **remain in that trophic level** for a very **long duration.**
- **Chlorinated Hydrocarbons (Organochlorides)** - **most damaging non-degradable pollutants**.
- Movement of pollutants involves two main **processes**:
  1. **Bioaccumulation**
     - An **increase in concentration of a pollutant** from the environment **to the first organism in a food chain**.
  2. **Biomagnification**
     - **Tendency of pollutants to concentrate as they move from one trophic level to the next.**
     - An increase in concentration of a pollutant from one link in a food chain to another.



     - **Conditions for biomagnification,** pollutant must be:
       - **long-lived,**
       - **mobile,**
       - **soluble in fats,**
       - **biologically active.**
  - If a **pollutant** is **not active biologically**, it **may biomagnify**, but we really don't worry about it much, since it probably won't cause any problems **Examples : DDT**



Biogeochemical/Nutrient Cycles

- refer to the **movement of nutrients** and other elements **between biotic and abiotic factors**
- These nutrients are required by living beings to produce organic matter.

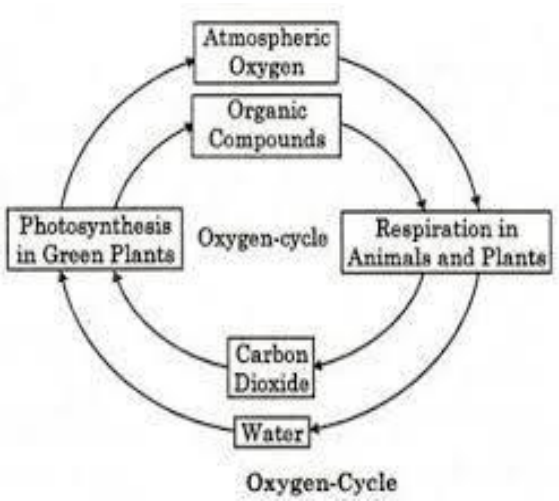
Macronutrients	needed by plants in **large quantities**	oxygen, carbon, hydrogen, nitrogen, phosphorus, sulfur, calcium, magnesium, and potassium
Micronutrients	needed in **minute amounts**	iron, zinc, boron, manganese, copper, molybdenum, etc.

- Nutrient cycles have two components-
  1. **Reservoir pool-** A large, slow-moving non-biological component.
  2. **Exchange pool-** A smaller, more active portion where the nutrient is exchanged between biotic and abiotic parts of the ecosystem.

Types of Nutrient Cycle

1. **Based on nature of reservoir-**
   - **Gaseous cycle- Reservoir pool - atmosphere or hydrosphere- Include:**
     - Water cycle
     - Nitrogen cycle
     - Carbon cycle
     - Oxygen cycle
   - **Sedimentary cycle- Reservoir pool - Earth's crust- Include:**
     - Sulphur cycle
     - Phosphorus cycle
2. **Based on the replacement period-**
   - **Perfect cycle-** in this cycle, **nutrients are replaced as fast as they are utilized**. **Example- Gaseous cycle.**
   - **Imperfect cycle-** there is a **delay in nutrient cycling** as some nutrients are lost in the process. **Example- Sedimentary cycles.**

Oxygen Cycle



Oxygen-Cycle

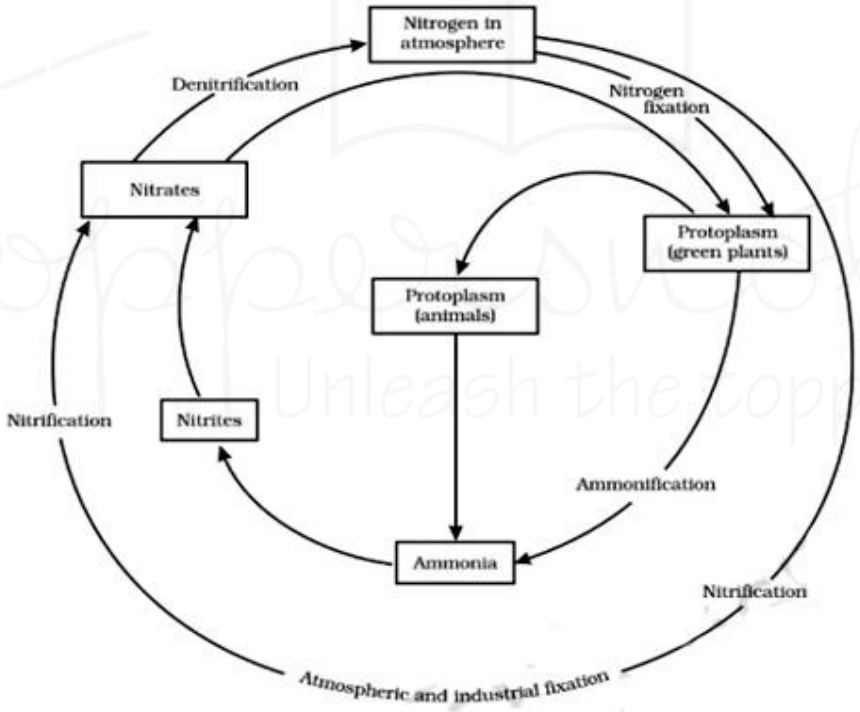
- **Oxygen** - most vital element on Earth - roughly **21 % of the atmosphere.**
- **Processes that produce oxygen-**
  - **Photosynthesis i**n plants
  - **Sunlight** + **water vapor** = **some oxygen** is produced.

- **Processes that consume oxygen-**
  - Breathing
  - Decomposition
  - Combustion
  - Rusting

Cycling of oxygen

- Highly complex process.
- **Oxygen + nitrogen = nitrates.**
- **Photosynthesis - oxygen is released as a byproduct.**
- **Animals and humans consume oxygen** during respiration and **release carbon dioxide** into the atmosphere.
- This **carbon dioxide is** then again **utilised by plants for photosynthesis and thus the cycle moves on.**

Nitrogen Cycle



- **Nitrogen - most abundant element in atmosphere**
- **Major constituent of protein, amino acids, living tissues.**
- **Limiting factor between plants and microorganisms** in soil as both require nitrogen for survival.
- Atmospheric nitrogen cannot be used directly by most plants and needs to be "fixed" or converted into a chemical compound such as ammonia, nitrites, or nitrates before use.

Nitrogen fixation:

- Process by which **nitrogen in the atmosphere is converted into ammonia** (another form of nitrogen) by certain bacterial species like Rhizobium, Azotobacter, etc. and by other natural phenomena.
- **3 ways** of nitrogen fixation:

- **By microorganisms** like bacterias and blue-green algae
- **Through industrial processes** like fertilizer factories
- **Atmospheric phenomena** like **lightning** and **thunder** (to a certain extent).

N_2-fixers:

- Microbes that **convert nitrogen to ammonia.**
- Include:
  - **free-living nitrogen-fixing bacteria** (aerobic Azotobacter; anaerobic Clostridium and Rhodospirillum)
  - **symbiotic nitrogen-fixing bacteria** (like Rhizobium) that live in association with leguminous plants and non-leguminous root nodule plants
  - Certain **cyanobacteria** (like blue green algae- Nostoc, Anabaena, Spirulina).

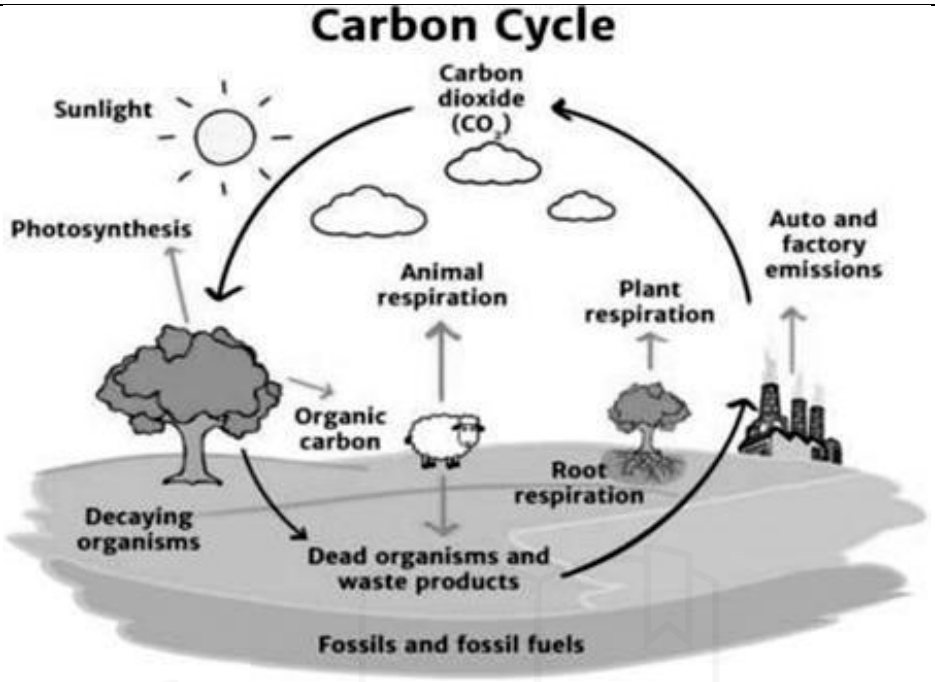
Nitrification:

- **Process by which ammonia can be directly used by plants as a source of nitrogen** or it can be further **converted into nitrites or nitrates**.
  - **Nitrosomonas/ Nitrococcus** - **Ammonium ions are oxidized to nitrite** b.
  - **Nitrobacter** is responsible for **further oxidation of nitrite to nitrate.**

Assimilation:

- **Process by which nitrates are absorbed by plants and passed through the food chain.**
- **Plants absorb nitrogen compounds** in the form of **ammonia, nitrite ions, nitrate ions, or ammonium ions** from the soil into their roots. These are then **used in the formation of plant and animal proteins.**
- **If all the nitrates are not absorbed** by the plants, then,
  - **Either leach from the soil to shallow marine sediments** (returned as nitrogenous waste products such as urea and uric acid in the droppings of marine birds which are converted back into inorganic ammonia and ammonium ions through a process called **ammonification**) or,
  - maybe lost from the soil by being **broken down by denitrifying bacterias** like Pseudomonas and Thiobacillus (**denitrification**), and the nitrogen contained in them being released back into the atmosphere.

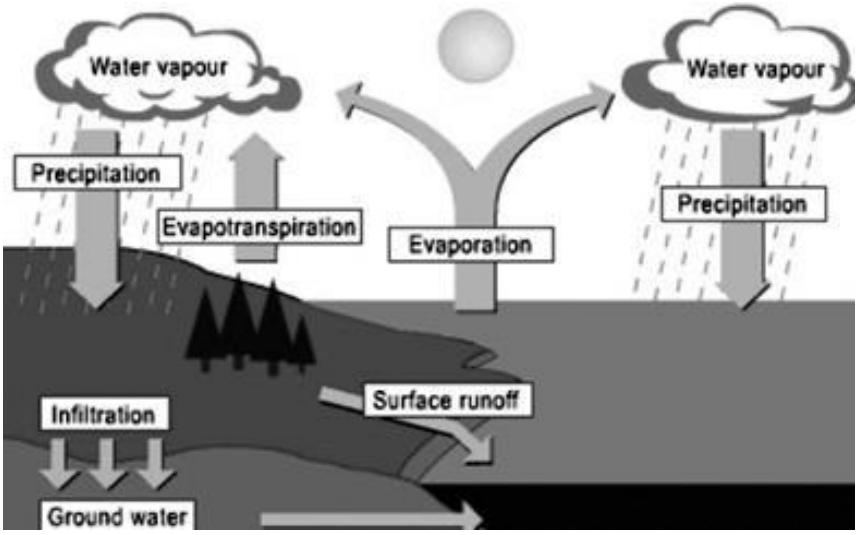
Carbon Cycle



- Involves a **continuous exchange of carbon** (as carbon dioxide) **between the atmosphere and organisms.**
- **Facilitated through fixation of carbon dioxide** by green plants **through photosynthesis.**
- **Results in production of carbohydrates and glucose** which are further utilized to produce organic compounds required by green plants.
- **Respiration** (herbivores eating green plants and releasing CO_2) and **decomposition** of dead organic matter (by microorganisms) → **some carbon dioxide is released back into the atmosphere.**
- **Some organic matter is left undecomposed** and remains as insoluble carbonates in the bottom sediments of aquatic systems which take years to release back into the atmosphere → **subsequently transformed into fossil fuels. Eg- coal, oil, and natural gas.**
- **When these fuels are burned**, carbon dioxide is released.

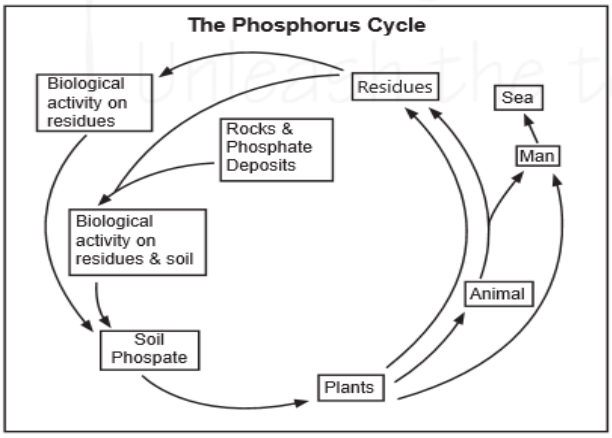
Water/ Hydrological Cycle

- A continuous **circulation of water in liquid, solid, and the gaseous phases** from ocean to land and land to the ocean.
- **Driving forces- Solar radiation** and **gravity.**
- Around 70 % of earth's water is stored in oceans.
- Rest found as freshwater in glaciers and ice caps, groundwater sources, lakes, soil moisture, atmosphere, streams, and within life.
- **Water from one reservoir moves to another through** the process of **evaporation**, **condensation, transpiration, surface runoff, infiltration, precipitation, deposition,** and **groundwater flow.**
- **Evaporation and precipitation alternate** with each other during the process.



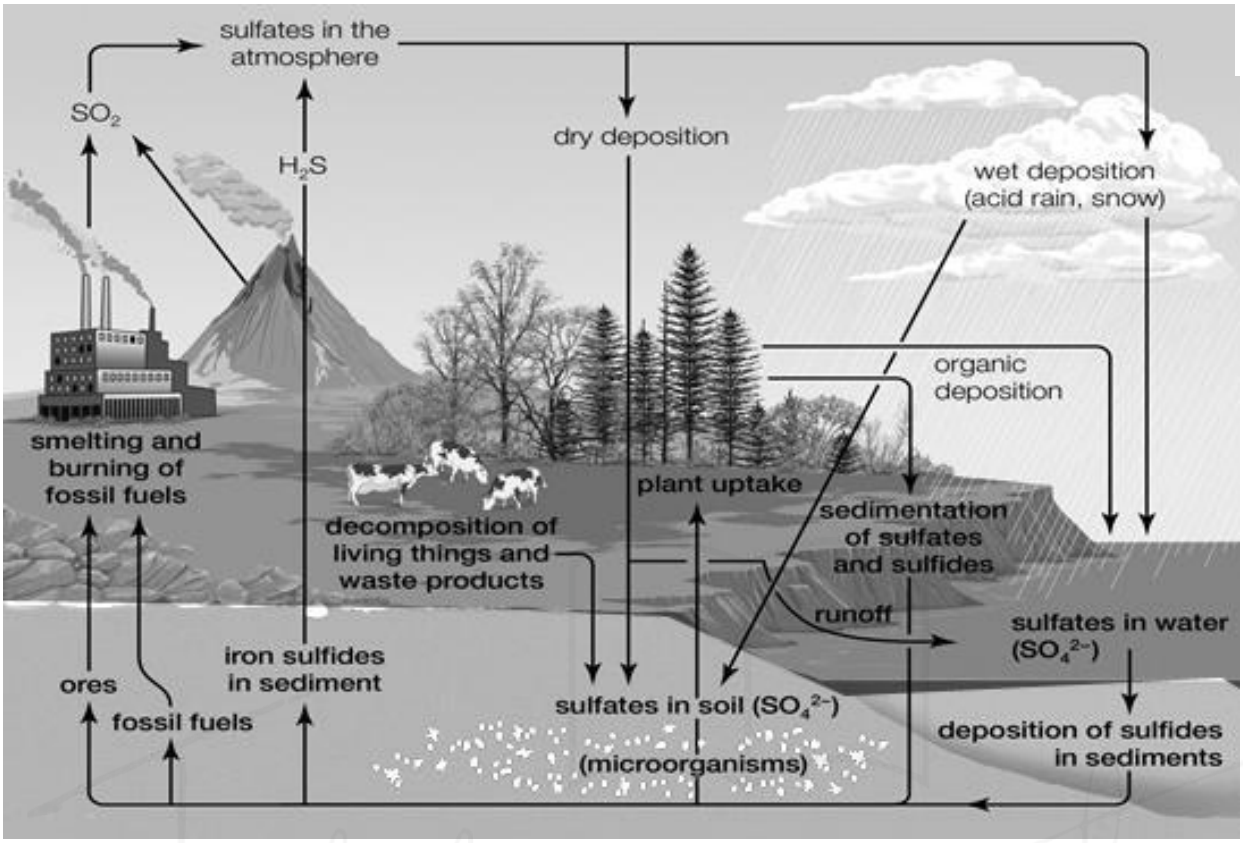
Phosphorus Cycle

- **Phosphorus - mainly present as a mineral in phosphate rocks and soil.**
- **Main storage** of phosphorus - **crust**.
- **Present only on land**, thus the **atmosphere plays no significant role** in the phosphorus cycle.
- **Very slow process** of circulation.
- **Phosphate salts present on rocks are broken down and are washed away** into the ground where they mix in the soil. Soil phosphorus is utilized by plants for protein synthesis.
- The amount of **phosphorus in soil is very less** and thus **phosphate fertilizers are used** in agriculture to support plant growth.



- **Erosion and weathering- phosphates enter rivers and streams** and are moved to oceans, thus incorporating **into marine sediments.**
- Ocean currents **upwelling - phosphorus is returned to the surface waters,** where it is taken into marine food chains.
- **Decomposition** of aquatic plants and animals - **organic form of phosphorus is converted into the inorganic form**, which is **recycled to soil and water** which will end up in sediments and rocks, which will **again release phosphorus by process of weathering.** Thus, the phosphorus cycle starts over.

Sulphur Cycle



- **Sulphur - abundant element found on earth -** found in soil and organic (coal, oil, peat) and inorganic (pyrite rock, sulphur rock) deposits.
- **Sulphur + air = sulphates** (by chemolithotrophic bacteria) → **taken up by plants and microorganisms** → converted **into organic sulphur.**
- **Organic sulphur is consumed by animals** through their food and thus moves up the food chain.
- Upon the **death of animals**, some **sulphur is released back by decomposition** of dead organic matter to the soil or bottom of lakes and ponds while some enter the tissues of microbes.
- **Sulphates are reduced to hydrogen sulphide by** the action of **Desulfotomaculum bacteria**, which adds a gaseous component to the sedimentary cycle.
- This **hydrogen sulphide gets oxidised into sulphur dioxide** which falls on earth with rainfall as weak sulphuric acid (Acid Rain).
- **Natural sources - volcanic eruptions, combustion of fossil fuels, evaporation of water, and breakdown of organic matter in swamps,** release sulphur directly into the atmosphere.