ECOSYSTEM

INTRODUCTION

- **A.G.Tansley –** The term "ecosystem" was coined by A.G. Tansley.

  According to Tansley – Ecosystem is the symbol of structure and function of nature.
- **E.P. Odum –** Father of ecosystem ecology.

  According to E.P. Odum – Ecosystem is the smallest structural and functional unit of nature or environment.
- **Karl Mobius –** Used the term biocoenosis for ecosystem
- **Homeostasis–** Ecosystem is a dynamic (functional) system because continuous interaction is going on in between abiotic or biotic components so ecosystem remains in an equilibrium position. This feature of system is known as homeostasis. Ecosystem is also self maintainable and selfregulatory system, it means an ecosystem maintains a balance in between different trophic levels. Each trophic level controls the other trophic level in an ecosystem.

TYPES OF ECOSYSTEM

Natural Ecosystem

(i) **Terrestrial Ecosystem**

e.g. forest, grassland, tree, desert ecosystem

(ii) **Aquatic ecosystem**

e.g. lake, pond, swamp, river & spring etc.

Artificial Ecosystem – Man made e.g. cropland, Gardens etc.

STRUCTURE OF ECOSYSTEM

(A) Biotic components **(B) Abiotic components**

Biotic Components

(I) **Producers**

All the autotrophs of ecosystem are called producers. Producers absorb solar energy and convert it into chemical energy so producers are also called transducers or converters.

(II) **Consumers**

All the heterotrophs of the ecosystem are known as consumers. They directly (herbivores) or indirectly (Carnivores) depend on the producers for food.

Types of consumers

(a) **Primary consumers –** Such living organisms which obtain food directly from producers orplants are known as primary consumers.

e.g. herbivores, zooplanktons etc.

(b) **Secondary consumers or primary cornivores –** Animals which feed upon primary consumers and obtain food. Those carnivores which kill and eat other animals are called predators.

e.g. Dog, Cat, Snake etc.

Note– The organisms which completely depends on dead animals are known as scavangers.

e.g. Vulture, crow, fox etc.

(c) **Top Consumers –** Those animals which kill other animals and eat them, but they are not killed & eaten by other animal in the ecosystem.

e.g. Lion, Man, Hawk, Peacock.

Abiotic Components

- These are the non-living components of an ecosystem. They are of two forms:
  (i) **Climatic–** Temperature, humidity, precipitation, light etc.
  (ii) **Edaphic–** Topography, pH, minerals, background.

FUNCTIONS OF ECOSYSTEM

There are four basic functions of ecosystem– (i) Productivity, (ii) Decomposition ,(iii) Energy flow and (iv) Mineral recycling.

Productivity

The rate of synthesis of energy containing organic matter or biomass by any trophic level per unit area in unit time is described its productivity. It is measured as weight (e.g., g/m^2/yr) or energy (e.g., Kcal/m^2/yr).

Primary productivity – Productivity due to photosynthesis is known as Primary productivity. It can be divided into GPP and NPP.

(i) **Gross primary productivity (G.P.P.) –**

GPP = Total photosynthesis

(ii) **Net primary productivity (N.P.P.) –**

NPP = GPP – R (R = Respiration + Metabolic activities)

NPP is the available biomass for the consumption to heterotrophs.

Secondary Productivity– The rate of resynthesis of organic matter by the consumers is known as secondary producivity. It can also be divided into GSP and NSP.

Some important facts related to productivity

(i) The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of the organic matter. Productivity of the ocean are only 55 billion tons (32%).

(ii) In per unit area maximum productivity is found in **tropical rain forest.**

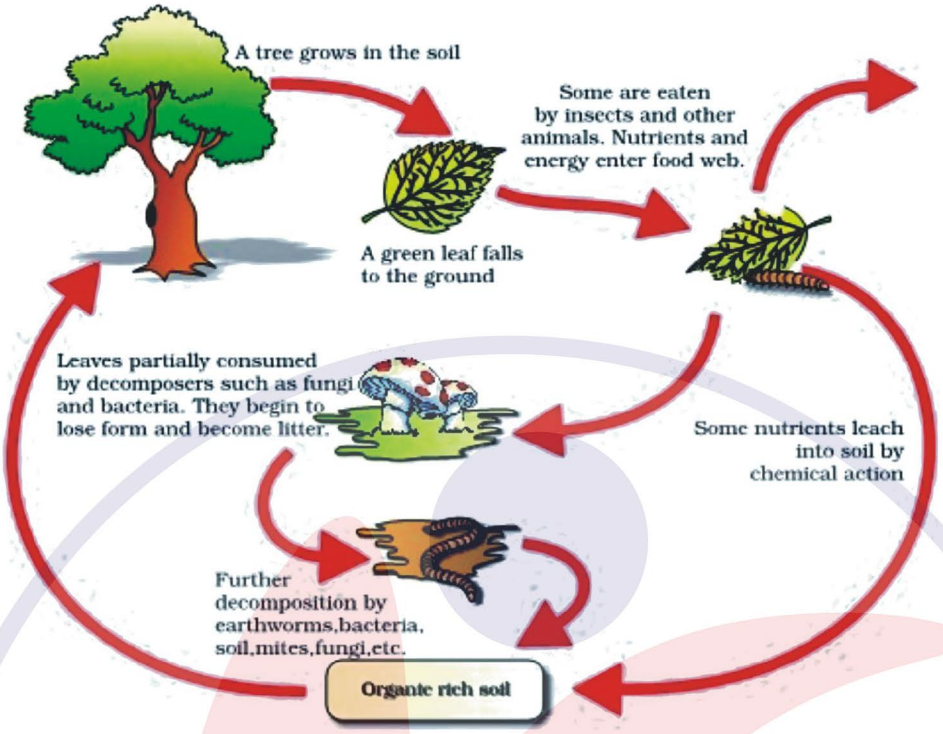
(iii) In land – Maximum productivity is of Tropical rain forest (20 ton/h/year).

– Lowest productivity is of Deserts, tundra (< 1 ton/h/year).

(iv) Most productive Agro-ecosystem is Sugar cane and rice ecosystem (3-4 kg./m^2/year).

Decomposition

- Decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition. The important steps in the process of decomposi tion are fragmentation, leaching, catabolism, humification and mineralisation.
- Detritivores (e.g. Earthworm) break down detritus into smaller particles. This process is called fragmentation. By the process of leaching, water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts. Bacterial and fungal enzymes degrade detritus into simple inorganic substances, This process is called as catabolism.
- It is important to note that all the above steps in decomposition operate simultaneously on the detritus. Humification and mineralisation occur during decomposition in the soil. Humification leads to accumulation of a dark coloured amorphous substance called humus that is 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 mineralisation.



Diagrammatic representation of decomposition cycle in a terrestrial ecosystem

- ***Factors affecting decomposition*** -
  - (i) Aerobic condition
  - (ii) Chemical composition of dead organic metter
  - (iii) Temperature → should be warm
  - (iv) Soil moisture → should be moist

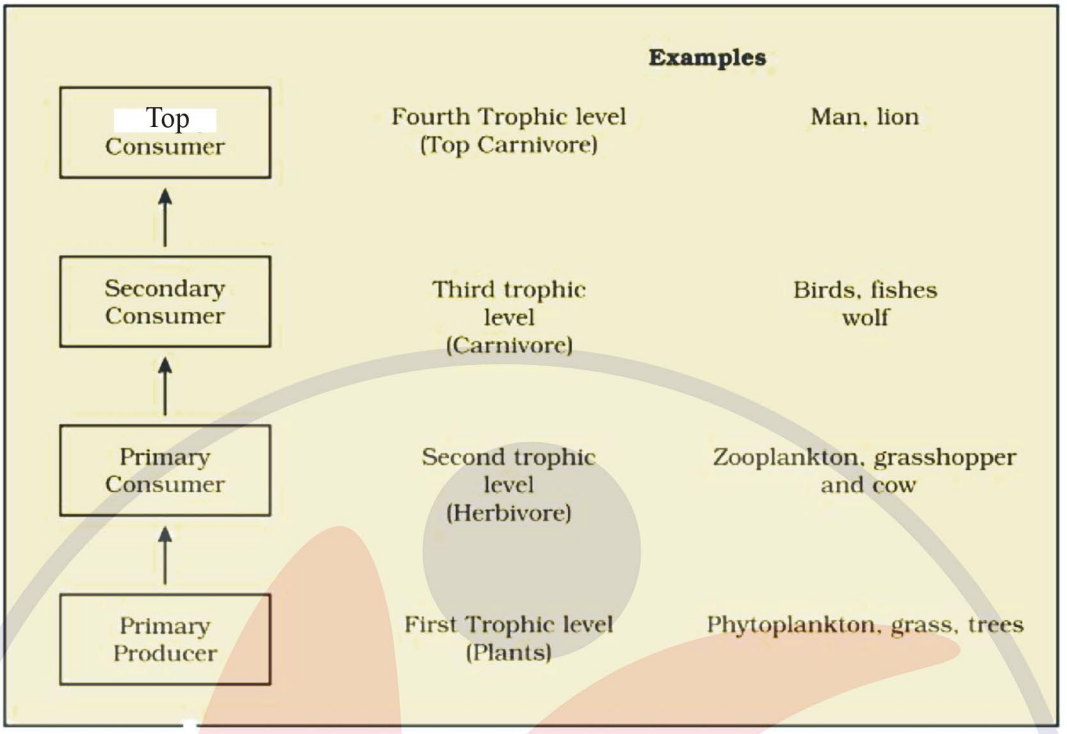
ENERGY FLOW

Except for the deep sea hydro-thermal ecosystem, sun is the only source of energy for all ecosystems on Earth. Of the incident solar radiation less than 50 per cent of it is photosynthetically active radiation (PAR). We know that plants and photosynthetic and chemosynthetic bacteria (autotrophs), fix sun's radiant energy to make food from simple inorganic materials. Plants capture only 2-10 per cent of the PAR and this small amount of energy sustains the entire living world. So, it is very important to know how the solar energy captured by plants flows through different organisms of an ecosystem. All organisms are dependent for their food on producers, either directly or indirectly. So you find unidirectional flow of energy from the sun to producers and then to consumers. The storage, expenditure, transformation of energy is based on two basic laws of thermodynamics

- First law of thermodynamics :- Energy is neither created nor destroyed but only transformed from one form to another form.
- The law of entropy – The transfer of food energy from one to another organism leads to loss of energy as heat due to metabolic activity. Further, ecosystems are not exempt from the Second Law of thermodynamics. They need a constant supply of energy to synthesise the molecules they require, to counteract the universal tendency toward increasing disorderliness/entropy.

(A) Food Chain

- In ecosystem every organism depends on other organisms for food material and all organisms are (herbivores to carnivores) arranged in a series in which food energy is transferred through repeated eating and being eaten. It is called food chain. In food chain, energy flow is in the form of food.
- In a food chain, food material or food energy transfer is from one trophic level to next trophic level (i.e. unidirectional).
- Generally the decomposers (Bacteria and Fungi) are not included in the food chain but when included then considered as the last trophic level.



Diagrammatic representation of trophic levels in an ecosystem

Types of Food Chains

In nature three types of food chains are present

(i) **Grazing Food Chains (GFC) or Predatory Food Chain (PFC):** Most of food chains in nature are of this type. This food chain begins with producers (plants) and in successive orders it goes from small organism to larger organism e.g.,

Aquatic ecosystem :

Eg. Phytoplankton → Zooplankton → Small Crustaceans → Predator Insects → Small fish → Larger Fish → Crocodile

Phytoplankton → Zooplankton → Small Crustaceans → Predator Insects → Small fish → King Fisher

Grass land ecosystem :

Eg. Grass → Grass Hopper → Frog → Snake → Peacock / Falcon

Vegetation → Rabbit → Fox → Wolf → Tiger

Vegetation → Insect → Predator Insect → Insectivorous Bird → Hawk

(ii) **Parasitic Food Chain –** This food chain also starts from producers but in successive orders it goes from bigger organism to the smaller organism.

Eg. Tree ecosystem : Tree → Birds → Parasites

(iii) **Detritus Food Chain (DFC) or Saprophytic Food Chain (SFC)–** This food chain begins with decomposition of dead organic matter by decomposers so it is also known as saprophytic food chain. In this food chain primary consumers are bacteria and fungi.

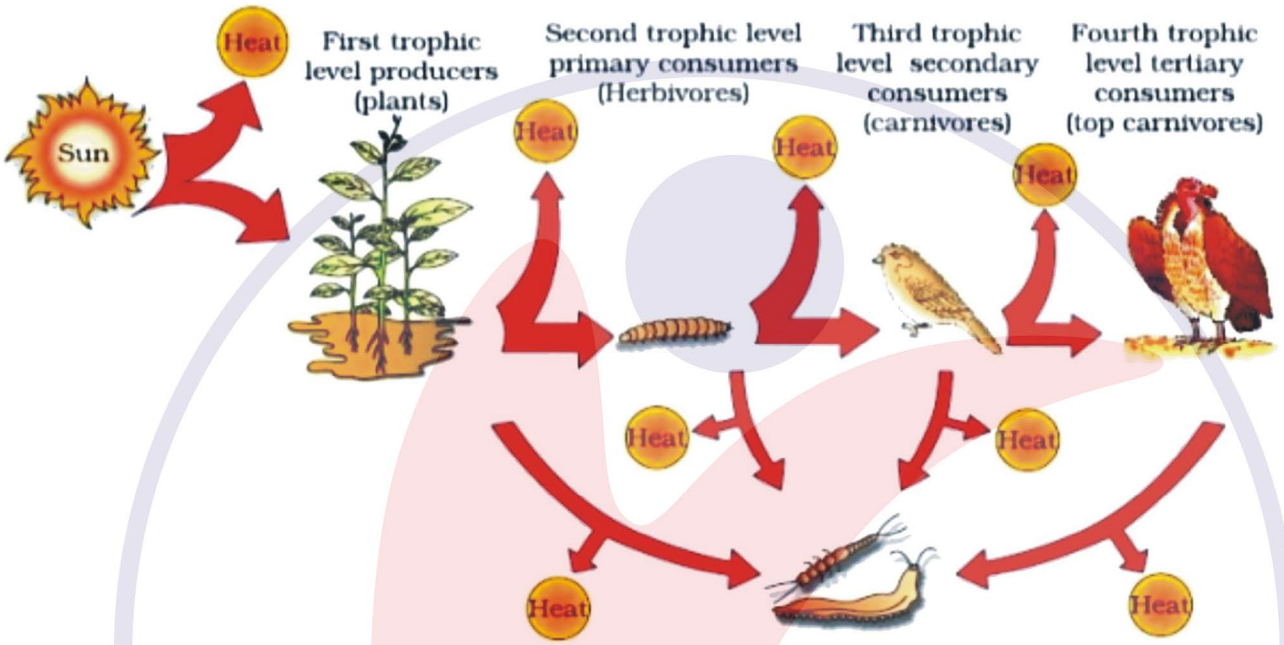
Eg. Detritus → Earthworm → Sparrow → Falcon

Detritus → Frog → Snake → Peacock

- In an aquatic ecosystem, GFC (Grazing Food Chain) is the major conduit (source) of energy flow. As against this, in a terrestrial ecosystem, a much larger energy flow occurs through the detritus food chain.
- In Sunderbans, Tigers feed on the Fishes and Crabs in the absence of their natural prey.

(B) Food Web

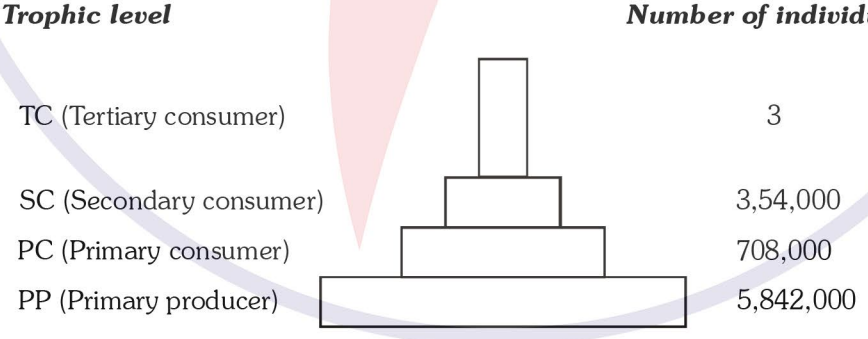
- In larger ecosystems many food chains are interlinked together on different trophic levels to form the food web. In food web transfer of food energy is unidirectional but form many different alternative pathways.
- In food web members of a particular trophic level obtain their food according to their choice and taste but that type of facility is not present in food chain.
- As much as food web is complex that ecosystem is more permanent or stable.



(C) Ecological Pyramids or Eltonian Pyramids

- Graphical representation of ecological parameters (Number, Biomass and Energy) at different trophic levels in an ecosystem is called ecological pyramid. First of all, pyramid was formed by **Charls Elton** ; So these are also known as Eltonian pyramids.

(i) Pyramids of Number

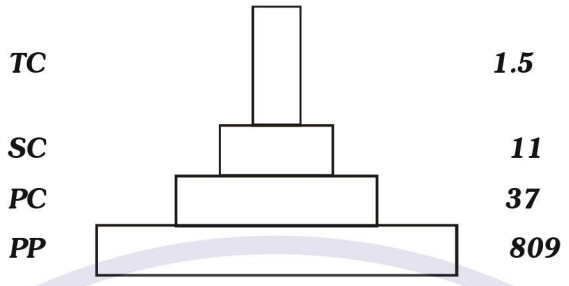


Pyramid of numbers in a grassland ecosystem

Grassland Ecosystem → Upright
Aquatic ecosystem → Upright
Tree Ecosystem (Parasitic food chain) → Inverted
Tree Ecosystem [Predarory food chain] → Spindle shaped

In the tree ecosystem the pyramid of numbers is usually inverted due to parasitic Food Chain but it becomoes spindle shaped if food chain is predatory.

(ii) Pyramid on the Basis of Biomass



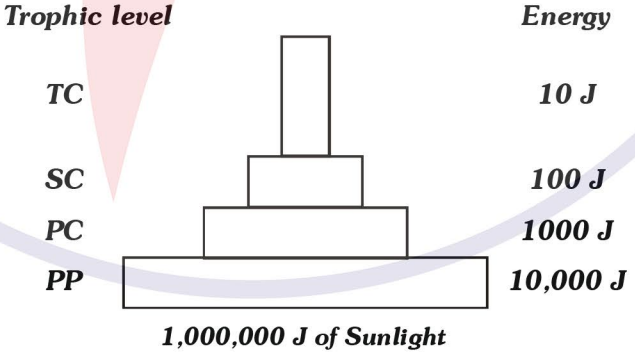
Pyramid of biomass shows a sharp decrease in biomass at higher trophic levels

Inverted pyramid of biomass-small standing crop of phytoplankton supports large standing crop of zooplankton

Grassland ecosystem → Upright
Tree ecosystem → Upright
Aquatic ecosystem → Inverted
Pyramids of biomass in **aquatic ecosystem** is inverted because in it producers are micro-organisms and their biomass is very less.

(iii) Pyramids on the Basis of Energy

- It represents amount of energy at different trophic levels. Energy pyramids are always upright or erect because there is a gradual decrease in energy at successive trophic levels.
- According to the 10% law of Lindeman, the 90% part of obtained energy of each organism is utilized in their various metabolic activities and is lost in the form of heat, so only 10% energy is transferred to the next trophic level. Therefore top consumers like Lion etc. are ecologically weak est but physically they are strong.



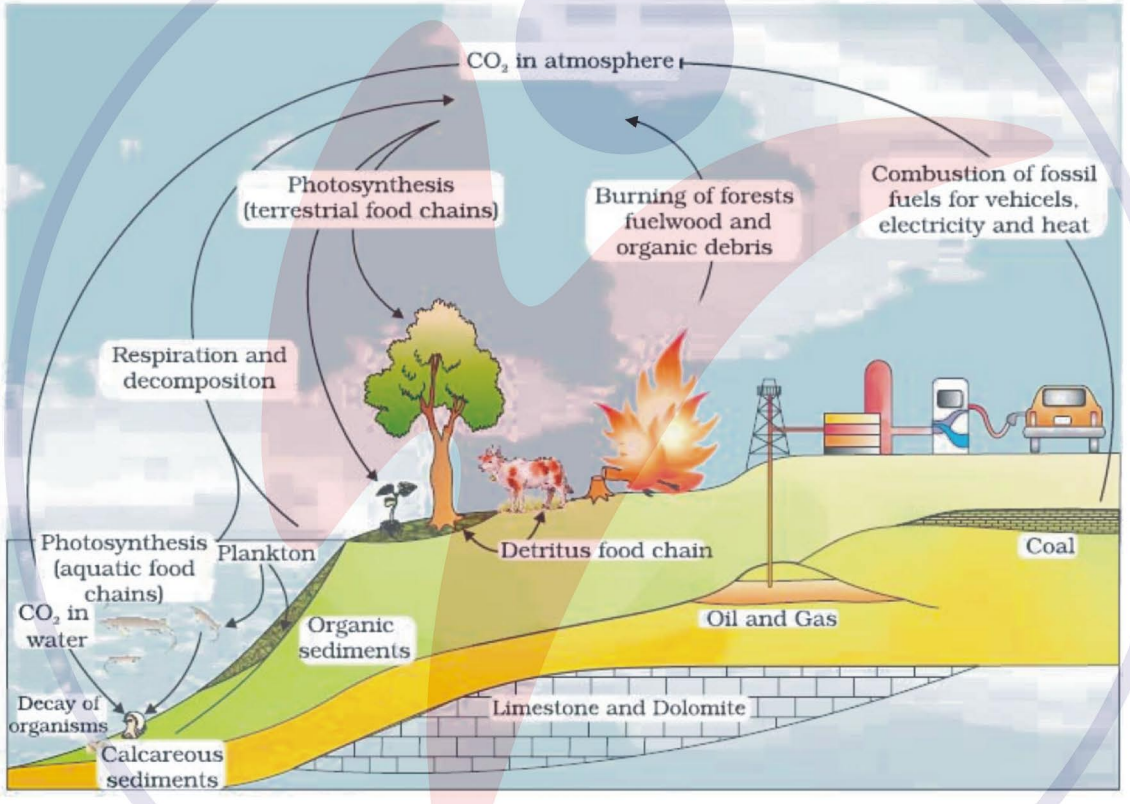
An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP

- **Limitations of Ecological Pyramids**
  (i) These are based on the food chains and do not accommodate a food web.
  (ii) It does not take into account the same species belonging to two or more trophic lavels.
  (iii) Decomposers and Saprophytes are not given any place.

Mineral recycling (Biogeochemical cycles)

- All the types of materials required by ecosystem in addition of energy, are available continuously to the system through recycling. Thus there is a constant exchange of materials between the living organism and their abiotic environment through the recyling of materials. These pathways are known as Bio-geo chemical cycles.
- In Bacteria and fungi, process of decomposition completely takes place outside the body. They release enzymes from their body on dead remains and decompose it into simpler organic substances and then absorb it so these are called osmotrophs (absorptive).
- **Nutrient Immobilisation-** In the process of decomposition, some nutrients get tied up with the biomass of microbes and become temporarily unavailable to other organisms. Such incorporation of nutrient in living microbes (bacteria & fungi) is called nutrient immobilisation.
- **Types of cycles– On the basis of reservoir.**
  - (i) **Gaseous Cycle –** C, H, N, O cycles. Reservoir is the atmosphere (air) or in Hydrosphere(water).
  - (ii) **Sedimentary cycle –** P, S, Ca cycles. Reservoirs is earth's crust (lithosphere).

(A) Carbon Cycle



Simplified model of carbon cycle in the biosphere

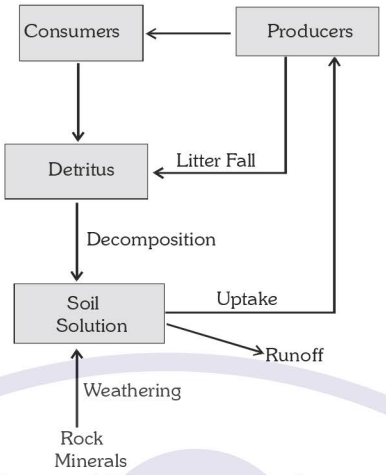
- If we look at the total quantity of global carbon, we find that **71 per cent** carbon is found dissolved in oceans. This oceanic reservoir regulates the amount of carbon dioxide in the atmosphere.
- Carbon cycling occurs through atmosphere, ocean and through living and dead organisms.
- According to one estimate **4×10^{13} kg** of carbon is fixed in the biosphere through photosynthesis annually.

(b) Phosphorus cycle

Sometimes some of the elements like phosphorus and calcium reach into the sea through water, from where they transform into rocks. They separate from the cycle for a long time so it is also known as **sedimentary cycle.**

But when these rocks break after sometime then this phosphorus is again made available to the sea plant or sea weeds, which passes into fish and sea birds. The excretory materials of birds on the rocks of sea shore is called **Guano** and it is a source of phosphorus.

Note: Plants absorb phosphate from the soil in the form of orthophosphate (PO_4^{3-})



- **Differences between Carbon and Phosporus cycle**

(i) Atmospheric inputs of phosphorus through railfall are much smaller then carbon.

(ii) Gaseous exchanges of phosphorus between organism and environment are negligible.

ECOLOGICAL SUCCESSION

- The gradual and fairly predictable change in the species composition of a given area is called ecological succession.
- During succession some species colonise an area and their populations become more numerous, whereas populations of other species decline and even disappear.
- **Pioneer community–** The community that invade a bare area are called pioneer community.
- **Seral communities–** The entire sequence of communities that successively change in a given area are called sere(s). The individual transitional communities are termed seral stages or seral communities. In the successive seral stages there is a change in the diversity of species of organisms, increase in the number of species and organisms as well as an increase in the total biomass.
- **Climax community–** Successional changes lead finally to a community that is in near equilibrium with the environment and that is called a climax community. The climax community remains stable as long as the environment remains unchanged.
- Succession and evolution are parallel processes.
- Description of ecological succession usually focuses on changes in vegetation. However, these vegetational changes in turn affect food and shelter for various types of animals. Thus, as succession proceeds, the numbers and types of animals and decomposers also change.
- All succession whether taking place in water or on land, proceeds to a similar climax community – the mesic.

Types of succession

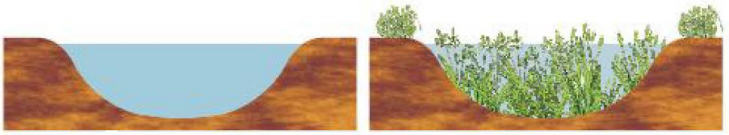
On the basiss of area on which succession occurs, it is of two types– Primary and Secondary.

(i) **Primary Succession–** It starts where no living organisms are there – these could be areas where no living organisms ever existed e.g. newly cooled lava, bare rock, newly created pond or reservoir. The establishment of a new biotic community is generally slow, it takes several hundred to several thousand years to produce fertile soil on bare rock. Succession, particularly primary succession, is a very slow process, taking maybe thousands of years for the climax to be reached.

(ii) **Secondary Succession –** Secondary succession begins in areas where natural biotic communities have been destroyed such as in abandoned farm lands, burned or cut forests, lands that have been flooded. Since some soil or sediment is present, succession is faster than primary succession.

Hydrosere

- Hydrosere or hydrarch succession takes place in wetter areas and the successional series progress from hydric to the mesic conditions.
- In primary succession in water, the pioneers are the small phytoplanktons, they are replaced with time by free-floating angiosperms, then by rooted hydrophytes, sedges, grasses and finally the trees. The climax would be a forest. With time the water body is converted into land.



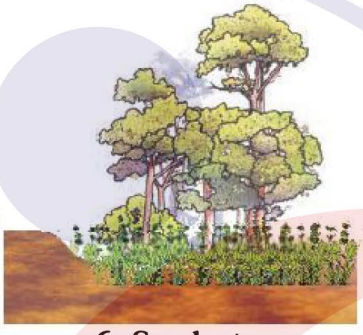
1. Phytoplankton

4. Reed-swamp stage

2. Rooted submerged plant stage

5. Marsh-meadow stage (Sedge)

3. Submerged, free floating plant stage



6. Scrub stage

7. Forest

Xerosere

- In primary succession on rocks these are usually lichens which are able to secrete acids to dissolve rock, helping in weathering and soil formation.
- These later pave way to some very small plants like bryophytes, which are able to take hold in the small amount of soil. They are, with time, succeeded by bigger plants, and after several more stages, ultimately a stable climax forest community is formed.
- With time the xerophytic habitat gets converted into a mesophytic one.

Lichen → Moss → Annual grasses → Perennial grasses → Shrub → Climax (forest)

Changes during succession

I. Increase in structural complexity

II. Increase in biodiversity

III. Increase in biomass

IV. Increase in stability

V. Increase in food chain complexity

ECOSYSTEM SERVICES

- Healthy ecosystem is the base for a wide range of economic, environmental and aesthetic goods and services. The products of ecosystem processes are named as Ecosystem services, for example, healthy forest ecosystems purify air and water, mitigate (minimise) droughts and floods, recycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values. Though value of such services of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a hefty (bulk) price tag.
- Robert Constanza and his colleagues have very recently tried to put price tags on nature's life-support services. Reserchers have put an average price tag of US $ 33 trillion a year on these fundamental ecosystems services, which are largely taken for granted because they are free. This is nearly twice the value of the global gross national product GNP which is (US $ 18 trillion)

  Out of the total cost of various ecosystem services, the soil formation accounts for about 50 percent, and contributions of other services like recreation and nutrient cycling, are less than 10 percent each. The cost of climate regulation and habitat for wildlife are about 6 percent each.

GOLDEN KEY POINTS

- **Standing crop –** Total amount of **living organic matter** present in particular area in particular time in an ecosystem is known as standing crop. It may be expressed in terms of weight per unit area. The pyramids of biomass show the **standing crop** of ecosystem.
- **Standing quality or Standing state** – Total amount of **inorganic substances** such as P, S, N, H present in particular area at a particular time in an ecosystem is known as standing state.
- The respiratory cost also increases sharply along successive higher trophic levels. On producer level, its cost is 20%, Herbiveres level 30% and carnivares level 60%. So net productivity decreases towards the higher trophic levels.
- Phosphorus rich faeces (Guano) are deposited on land by sea-birds.