Ecosystem

Ecosystem

- It is the interaction of living things among themselves and with their surrounding environment.
- There are two basic ecosystems – terrestrial and aquatic.

Structure of Ecosystem

- The interactions between the various biotic and abiotic factors of an ecosystem lead to the maintenance of the ecosystem.
- Stratification is the vertical distribution of the different species occupying the different levels. For example, trees occur at a higher level then shrubs.
- The various aspects taken into consideration to study the functioning of ecosystem are:
- Productivity
- Decomposition
- Energy flow
- Nutrient cycling

Productivity

- A constant supply of sunlight is required for the proper functioning of any ecosystem.
- The amount of biomass produced per unit area over a time period by plants during photosynthesis is defined as the **primary productivity**.
- It is expressed as weight (g^{-2}) or energy (Kcal m^{-2}).
- Productivity can be mainly divided into gross primary productivity (GPP) and net primary productivity (NPP). GPP is the rate of production of organic matter during photosynthesis.

  NPP = GPP – Respiratory losses (R)

- **Secondary productivity** is defined as the rate of formation of new organic matter by consumers.
- Primary productivity depends upon
- type of plant species inhabiting a particular area

- photosynthetic capacity of plants
- nutrient availability
- Annual net productivity for whole biosphere is about 170 b tons of organic matter.

Decomposition

- It is the process of breakdown of complex organic matter into inorganic substances such as carbon dioxide, water, nutrients, etc.
- **Fragmentation** – Breaking down of detritus (dead plant and animal remains, faecal matter) into smaller particles by detritivores (decomposers)
- **Leaching** - Process by which these inorganic matters enter the soil
- **Catabolism** – Process by which detritus is degraded into simpler inorganic substances by bacterial and fungal enzymes
- **Humification** – Accumulation of humus in the soil.
  Humus is resistant to microbial action and decomposes at an extremely slow rate. It acts as a reservoir of nutrients.
- **Mineralization** – Process by which humus further degrades to release minerals into the soil
- It is an oxygen consuming process and is controlled by the chemical composition of detritus and climatic conditions.

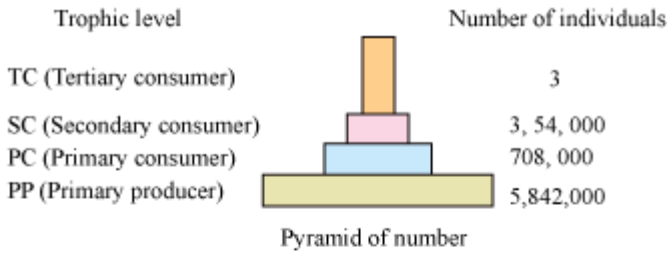
Energy Flow

- Sun is the sole source of energy for all ecosystems on the earth.
- Plants and other photosynthetic organisms utilize less than 50% of the solar radiation known as the **photosynthetically active radiation (PAR)**.
- In an ecosystem, plants are called **producers** and all animals depend upon the plants directly or indirectly for their food. Hence, they are known as consumers or heterotrophs.
- The consumers can be further divided into primary consumers (herbivores), secondary consumers (primary carnivores), and tertiary consumers (secondary carnivores).
- **Food chain** – The energy flow among the various constituent animals is known as the food chain.
- **Food web** – The interconnection of the various food chains is called the food web.

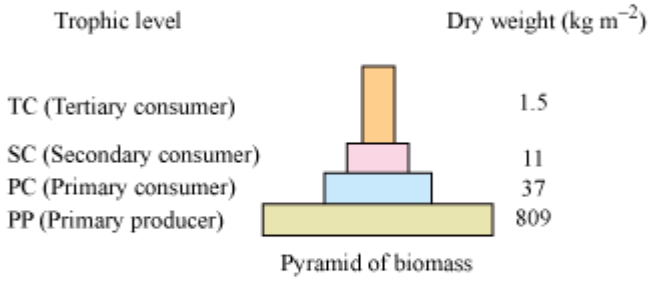
- **Trophic level** – Every organism occupies a specific level in their food chain known as the trophic level.
- **Standing crop** – Each trophic level contains a certain amount of living material at a certain time known as the standing crop.
- The number of trophic levels in a food chain is restricted since the energy transfer follows the 10 percent law i.e., only 10% of the energy is transferred from a lower trophic level to a higher one.

Ecological Pyramids

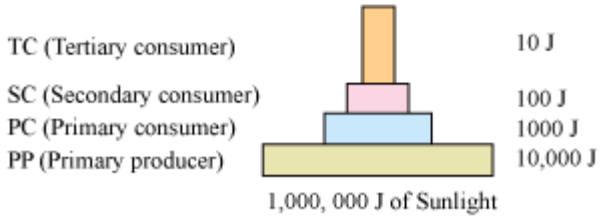
- The energy relationship between the different trophic levels is represented by the ecological pyramids.
- Their base represents the producers or the first trophic level while the apex represents the tertiary or top level consumer.
- Ecological pyramids are of 3 types:
- Pyramid of number
- Pyramid of biomass
- Pyramid of energy



Pyramid of number



Pyramid of biomass



Pyramid of energy

- In most ecosystems, the three pyramids are upright except in some cases:
- The pyramid of biomass is inverted in an ocean ecosystem since a small standing crop of phytoplankton supports a large number of zooplankton.
- The pyramid of number can be inverted when, say, a large tree is eaten by small insects.
- However, the pyramid of energy is always upright.
- A trophic level represents a functional level and not a single species as such. Also, a single species may become a part of more than one trophic level in the same ecosystem at the same time depending upon the role it plays in the ecosystem.
- Limitations of ecological pyramids:
- The ecological pyramids do not take into account the same species belonging to more than one trophic level.
- It assumes a simple food chain that almost never exists in nature. It does not explain food webs.
- Saprophytes are not given a place in ecological pyramids even though they play a vital role in ecosystem.

Ecological Succession

- The composition of all ecosystems keeps on changing with change in their environment. These changes finally lead to the climax community.
- **Climax community** – It is the community which is in equilibrium with its environment. Gradual and fairly predictable change in the species' composition of a given area is called ecological succession.
- **Sere(s)** – It is the sequence of communities that successively change in a given environment. The transitional communities are called seral stages or seral communities.
- Succession happens in areas where no life forms ever existed as in bare rocks, cool lava, etc. (**primary succession**), or in areas which have lost all life forms due to destructions and floods (**secondary succession**).
- Primary succession takes hundreds to thousands of years as developing soil on bare rocks is a slow process. Secondary succession is faster than primary succession since the nature does not have to start from scratch.
- During succession, any disturbances (natural/man-made) can convert a particular seral stage to an earlier one.
- **Hydrarch succession** – It takes place in wet areas and converts hydric conditions to mesic.
- **Xerarch succession** – It takes place in dry areas and converts xeric conditions to mesic.
- **Pioneer species** – These are the species that first invade a bare area. On land, these could be lichens that secrete enzymes to dissolve the rock surfaces for soil formation while in water, pioneer species could be phytoplanktons.
- The ultimate result of all successions is a climax community, a mesic.

Biogeochemical Cycles

Biogeochemical Cycles

We know that plants absorb nitrogen from the soil. Assuming that all plants do so, the nitrogen in the soil should have been completely exhausted ages ago. However, this is not the case.

Similarly, organisms breathe in oxygen and breathe out carbon dioxide. Since all organisms inhale oxygen from the atmosphere, this oxygen should have got used up long time back. However, once again, this is not true.

To maintain the concentrations of different naturally occurring substances in the environment, there are mechanisms that constantly recycle these substances. These recycling mechanisms are called **biogeochemical cycles**. So, biogeochemical cycles are the cyclic flow of nutrients between non-living environment and living organisms.

The two important components of biogeochemical cycle are:

Reservoir pool: It is the component of the biogeochemical cycle where the given substances are stored in the biosphere. In this component of the cycle, the movement of substances is very slow and involves non-living components. For example, atmosphere, hydrosphere and lithosphere.

Exchange pool: It is the component of the biogeochemical cycle where the movement of given substances is very fast and involves living components like bacteria, fungi, plants and animals.

The movement of substances from the reservoir pool to exchange pool is referred to as **fixation** and the return of substances from the exchange pool to reservoir pool is called **recycling**.

Types of Biogeochemical Cycles

There are two major types of biogeochemical cycles

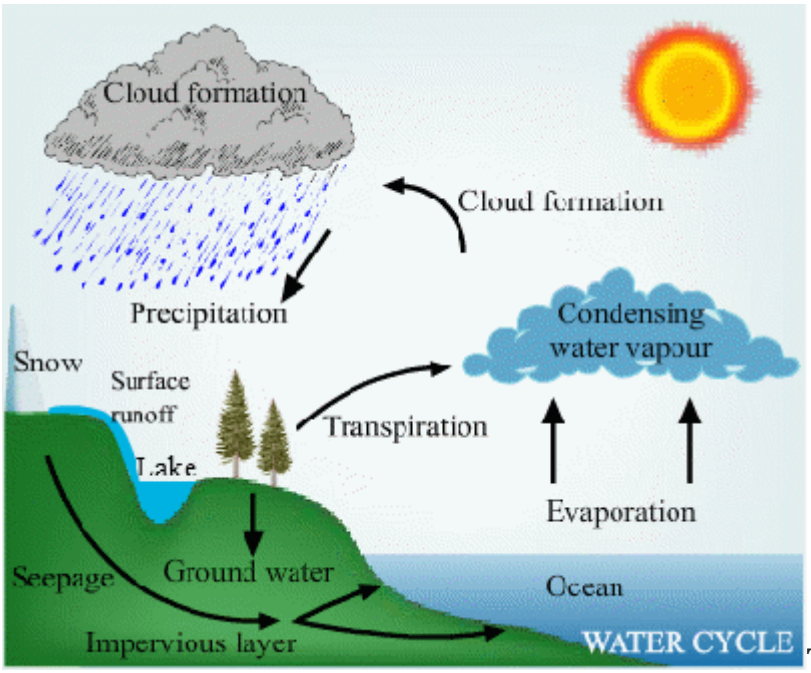
1. Gaseous cycle: These are the biogeochemical cycles in which the reservoir pool is the atmosphere or hydrosphere. For example, carbon cycle, nitrogen cycle etc.

2. Sedimentary cycles: These are the biogeochemical cycles in which the reservoir pool is generally lithosphere. For example, Phosphorous cycle, Sulphur cycle etc.

Some important Gaseous biogeochemical cycles existing in nature are:

- Water cycle
- Nitrogen cycle
- Carbon cycle
- Oxygen cycle

Water Cycle



The earth has a limited amount of water which gets recycled continuously. This recycling of water is called the water cycle. Broadly, water cycle comprises evaporation of water, its falling on land as rain and its flowing into the sea via the rivers.

To understand the water cycle, we should know:

- How water is lost from the environment
- The processes of change and the different states of water
- The method by which water is returned to the environment

Steps involved in the water cycle are:

- Evaporation and transpiration
- Condensation
- Precipitation
- Surface runoff

Water Cycle

Step 1: **Evaporation and transpiration**

Water molecules change into water vapours and move up the atmosphere by the process of **evaporation**. The excess water absorbed by plant roots is released through the pores on the surface of leaves by the process of **transpiration**.

Step 2: **Condensation**

The process by which water vapours move upward, cool down in the higher atmosphere and form clouds is called **condensation**.

Step 3: **Precipitation**

As condensation proceeds, water vapours change into water droplets. When enough water droplets accumulate, they fall down as rain. This process is called **precipitation**.

Step 4: **Surface runoff**

Rains replenish the water in the ponds, lakes, rivers and oceans. The process wherein rainwater enters the soil is known as infiltration. The process in which rainwater flows over the surface of land before entering different water bodies is called surface runoff.

At very low temperatures, water droplets freeze and fall down as hail, snow or sleet.

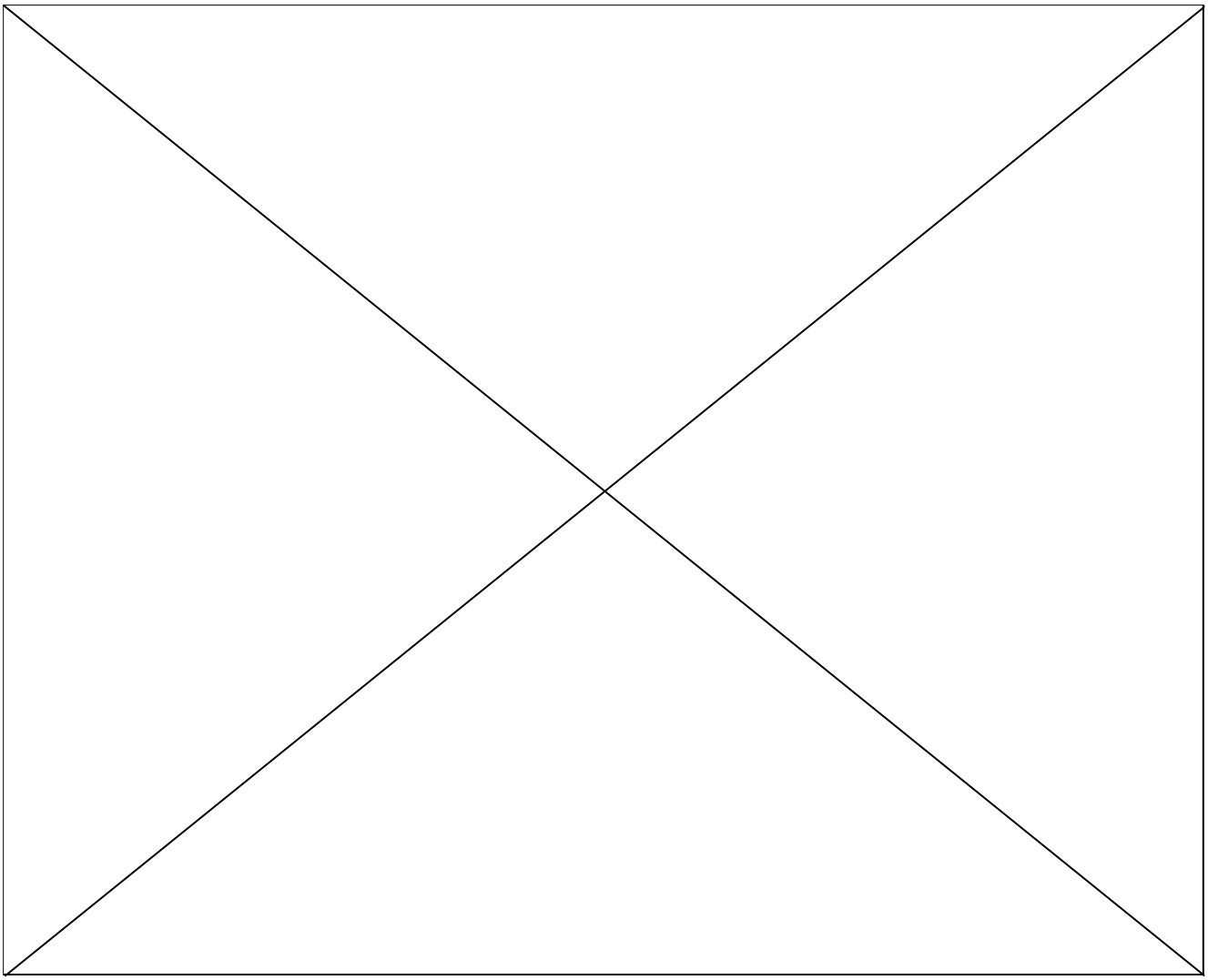
Did You Know?

There is another aspect to the water cycle.

The water cycle also helps in the movement of nutrients from one place to another. As water flows through or over rocks containing soluble minerals, some of them get dissolved in the water. This nutrient-containing water is then carried off by the rivers to the sea and there the dissolved nutrients are used by marine organisms.

Water Cycle: In Depth

Create Water Cycle



Nitrogen Cycle

The concentration of nitrogen in the atmosphere is about 78%. Nitrogen is essential for all life forms. It is a structural component of many important bio-molecules such as DNA, RNA and vitamins.

Animals obtain nitrogen by eating plants, but how do plants obtain nitrogen? Plants cannot absorb atmospheric nitrogen. Instead, they depend upon biological nitrogen fixers, physical processes and fertilizers for nitrogen. The process whereby atmospheric nitrogen is converted into usable forms such as nitrates and nitrites is called nitrogen fixation.

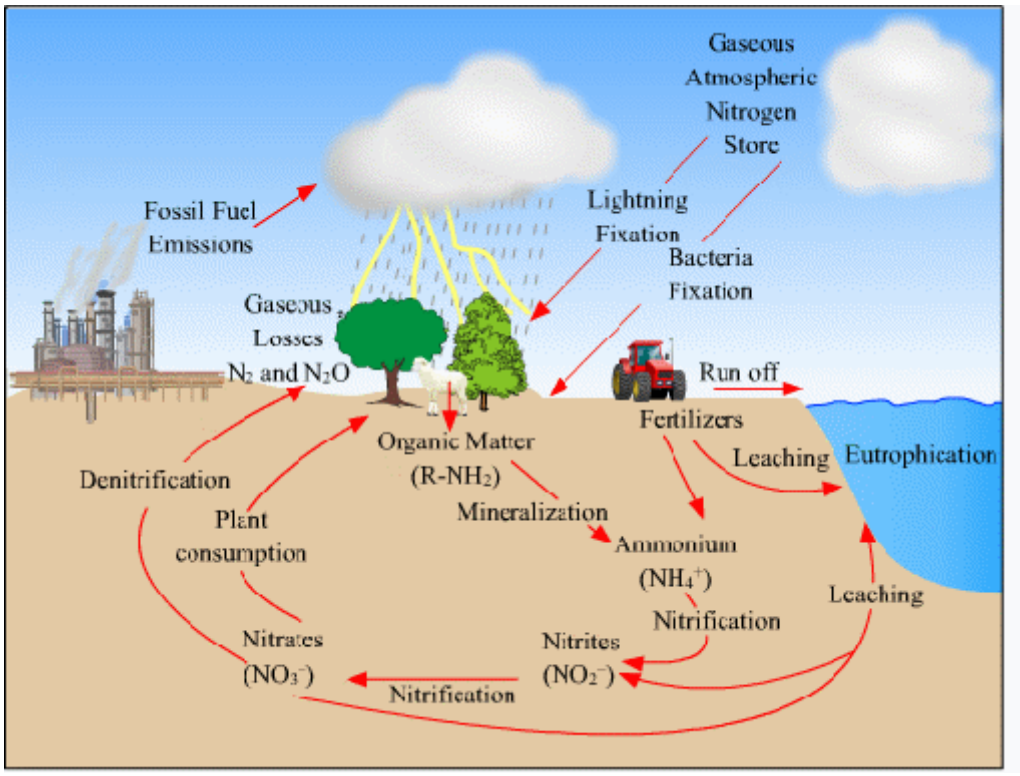
Methods of nitrogen fixation

- **Physical process:** During lightning and thunder, the high temperature and pressure in the air convert atmospheric nitrogen into oxides of nitrogen. These oxides can dissolve in water to produce nitric and nitrous acids. The acids fall along with rain and are then utilised by various life forms.
- **Biological process:** Certain forms of bacteria and other organisms such as algae are able to convert atmospheric nitrogen into usable forms such as nitrates and nitrites. Nitrogen-fixing bacteria are commonly found in the roots of legumes (plants of pulses), inside special structures called root nodules. Some nitrogen fixers also live freely in the soil. These usable forms of nitrogen are absorbed by plants to produce many compounds such as amino acids, which in turn form proteins.

  When plants and animals die, they start decomposing after some time. During this process, proteins are converted into nitrates and nitrites by the action of decomposing bacteria. Certain other forms of bacteria convert nitrates and nitrites into elemental nitrogen. Thus, nitrogen flows between the various components of the biosphere in a cyclical manner.

Nitrogen Cycle

The nitrogen cycle involves conversion of nitrogen from its elemental form in the atmosphere into simpler molecules in the soil and water. These further get converted into more complex molecules in living beings. Finally, the complex molecules are reduced and released back into the atmosphere as simple nitrogen molecules.



Nitrogen Cycle

There are basically five steps involved in the fixing of atmospheric nitrogen.

1. **Nitrogen fixation: $N_2 \longrightarrow NO_3^-$ or NH_4**

   It is the process wherein atmospheric nitrogen is converted into water-soluble nitrates. This step is performed by organisms like *Rhizobium*, *Azotobacter* and blue-green algae.

2. **Nitrification: $NH_3 \longrightarrow NO_2^- \longrightarrow NO_3^-$**

   It is the process in which ammonia is first converted into nitrites and then into nitrates. This step is performed by nitrifying bacteria like *Nitrosomonas* and *Nitrobacter*.

3. **Assimilation: In this step, NH_3 and NO_3 are incorporated into the biological tissues.**
4. **Ammonification: Organic nitrogen compounds $\longrightarrow NH_4^+$**

   It is the process in which complex, dead organic matter is decomposed into ammonia. This step is performed by organisms like decay bacteria and fungi.

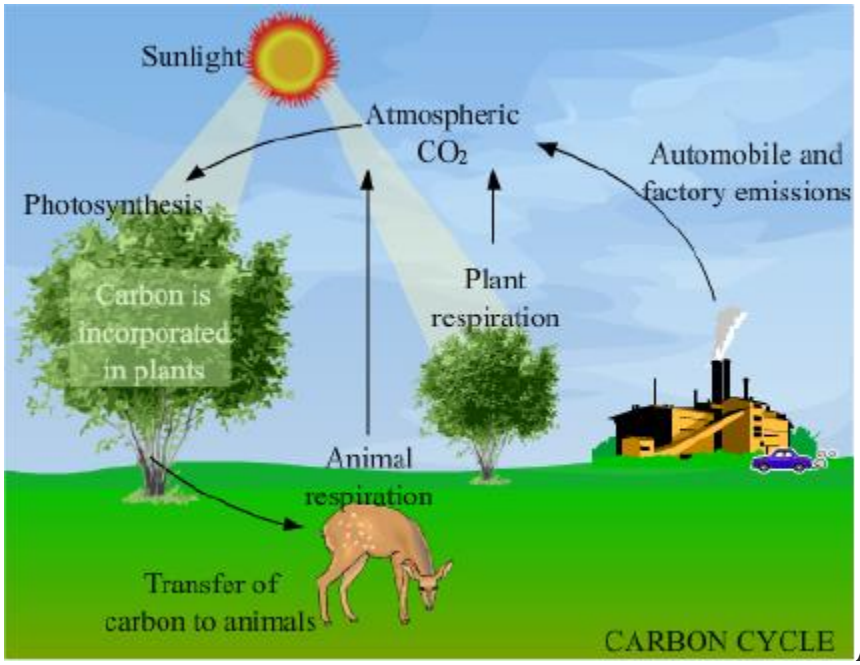
5. **Denitrification: $NO_3^- \longrightarrow N_2$**

   It is the process wherein the nitrates present in the soil are reduced to release nitrogen back into the atmosphere. This step is performed by denitrifying bacteria like *Psuedomonas*.

Alteration of the nitrogen cycle

Certain human activities alter the nitrogen cycle. For example, the application of nitrogen fertilizers to crops increases the leaching of nitrate into groundwater during rains. Excess nitrogen in water bodies can lead to eutrophication.

Carbon Cycle

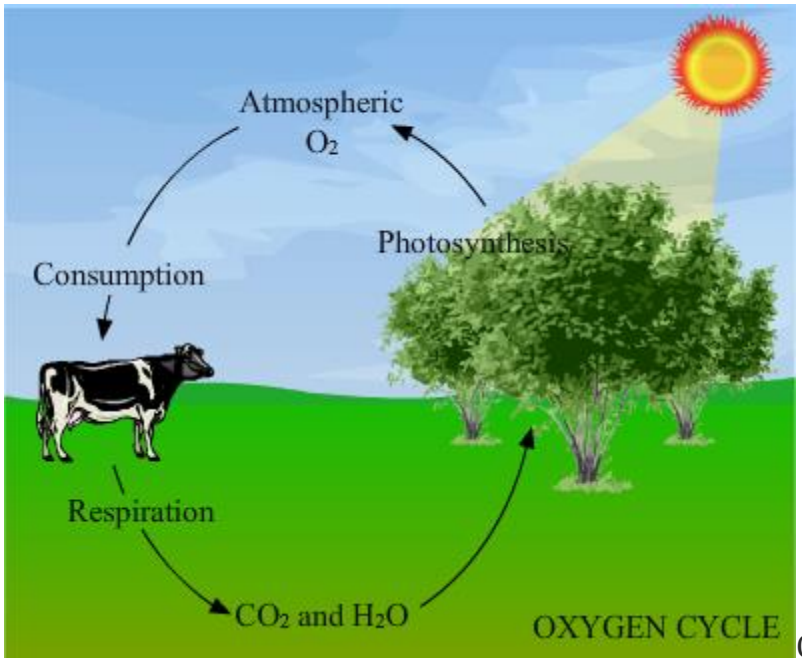


All organic substances are made up of carbon. Fats, vitamins, nucleic acids, carbohydrates and proteins contain carbon as a structural component. Carbonate salts form **endoskeletons** and **exoskeletons** of many animals.

- Carbon enters life forms through the process of photosynthesis. During photosynthesis, carbon dioxide and water combine to produce glucose and oxygen. This changes the atmospheric carbon into glucose molecules.
- Glucose, which is a source of food, is utilized by organisms to produce energy during respiration. During this process, glucose is broken down in the presence/absence of oxygen to produce carbon dioxide.
- Another process that releases carbon dioxide is combustion or burning. Many substances release carbon dioxide on burning. Vehicular emissions, industrial fumes and the gases released during the process of cooking are some instances of release of carbon dioxide through combustion.
- Thus, carbon is cycled repeatedly through different forms by the various physical and biological activities.

Carbon Cycle

Oxygen Cycle



Oxygen is an important component of life. We cannot survive without oxygen. It comprises about 21% of atmospheric air. It is also present in dissolved form in water bodies and helps in the survival of aquatic life. In combined form, it is found both in Earth's crust and in the air. In the air, it occurs as carbon dioxide. In the crust, it is present as oxides of most metals and silicon and also as carbonate, sulphate, nitrate and other minerals.

Oxygen is also a part of several essential biomolecules such as carbohydrates, proteins, nucleic acids and fats.

Oxygen cycle

There are processes that utilize atmospheric oxygen. At the same time, the balance of oxygen in the atmosphere is also maintained.

- Oxygen is utilized during respiration, combustion and formation of oxides of nitrogen.
- Oxygen is returned to the atmosphere in only one major way, and that is photosynthesis.

Did You Know?

Did you know that there are some life forms that do not require oxygen at all?

Such life forms which survive in the absence of oxygen are called anaerobic organisms. Certain bacteria fall in this category, for example, *Fusobacterium nucleatum.*

Biogeochemical Cycles(Sedimentary)

Phosphorus cycle is a sedimentary cycle.

Phosphorus Cycle

- Phosphorus is an important constituent of cell membranes, nucleic acids, and cellular energy transfer systems.
- Rocks contain phosphorus in the form of phosphate.
- When rocks are weathered, some of the phosphate gets dissolved in the soil solution and is absorbed by plants.
- The consumers get their phosphorus from the plants.
- Phosphorus returns back to the soil by the action of phosphate-solubilising bacteria on dead organisms.