

Nitrogen Cycle

“Nitrogen Cycle is a biogeochemical process which transforms the inert nitrogen present in the atmosphere to a more usable form for living organisms.”

Furthermore, nitrogen is a key nutrient element for plants. However, the abundant nitrogen in the atmosphere cannot be used directly by plants or animals.

Nitrogen Cycle is a biogeochemical process through which nitrogen is converted into many forms, consecutively passing from the atmosphere to the soil to organism and back into the atmosphere.

It involves several processes such as nitrogen fixation, nitrification, denitrification, decay and putrefaction.

The nitrogen gas exists in both organic and inorganic forms. Organic nitrogen exists in living organisms, and they get passed through the food chain by the consumption of other living organisms.

Inorganic forms of nitrogen are found in abundance in the atmosphere. This nitrogen is made available to plants by symbiotic bacteria which can convert the inert nitrogen into a usable form – such as nitrites and nitrates.

Nitrogen undergoes various types of transformation to maintain a balance in the ecosystem. Furthermore, this process extends to various biomes, with the marine nitrogen cycle being one of the most complicated biogeochemical cycles.

Stages of Nitrogen Cycle

Process of Nitrogen Cycle consists of the following steps – Nitrogen fixation, Nitrification, Assimilation, Ammonification and Denitrification. These processes take place in several stages and are explained below:

Nitrogen fixation

It is the initial step of the nitrogen cycle. Here, Atmospheric nitrogen (N_2) which is primarily available in an inert form, is converted into the usable form - ammonia (NH_3).

During the process of Nitrogen fixation, the inert form of nitrogen gas is deposited into soils from the atmosphere and surface waters, mainly through

precipitation. Later, the nitrogen undergoes a set of changes, in which two nitrogen atoms get separated and combine with hydrogen to form ammonia (NH₄⁺).

The entire process of Nitrogen fixation is completed by symbiotic bacteria which are known as Diazotrophs. Azotobacter and Rhizobium also have a major role in this process. These bacteria consist of a nitrogenase enzyme which has the capability to combine gaseous nitrogen with hydrogen to form ammonia.

Nitrogen fixation can occur either by the atmospheric fixation- which involves lightening or industrial fixation by manufacturing ammonia under high temperature and pressure condition. This can also be fixed through man-made processes, primarily industrial processes that create ammonia and nitrogen-rich fertilisers.

Types of Nitrogen Fixation

1. **Atmospheric fixation:** A natural phenomenon where the energy of lightning breaks the nitrogen into nitrogen oxides and is then used by plants.
2. **Industrial nitrogen fixation:** Is a man-made alternative that aids in nitrogen fixation by the use of ammonia. Ammonia is produced by the direct combination of nitrogen and hydrogen and later, it is converted into various fertilisers such as urea.
3. **Biological nitrogen fixation:** We already know that nitrogen is not usable directly from the air for plants and animals. Bacteria like Rhizobium and blue-green algae transform the unusable form of nitrogen into other compounds that are more readily usable. These nitrogen compounds get fixed in the soil by these microbes.

Nitrification

In this process, the ammonia is converted into nitrate by the presence of bacteria in the soil. Nitrites are formed by the oxidation of Ammonia with the help of Nitrosomonas bacterium species. Later, the produced nitrites are converted into nitrates by Nitrobacter. This conversion is very important as ammonia gas is toxic for plants.

The reaction involved in the process of Nitrification is as follows:



Assimilation

Primary producers – plants take in the nitrogen compounds from the soil with the help of their roots, which are available in the form of ammonia, nitrite ions, nitrate ions or ammonium ions and are used in the formation of the plant and animal proteins. This way, it enters the [food web](#) when the primary consumers eat the plants.

Ammonification

When plants or animals die, the nitrogen present in the organic matter is released back into the soil. The decomposers, namely bacteria or fungi present in the soil, convert the organic matter back into ammonium. This process of decomposition produces ammonia, which is further used for other biological processes.

Denitrification

Denitrification is the process in which the nitrogen compounds makes its way back into the atmosphere by converting nitrate (NO_3^-) into gaseous nitrogen (N). This process of the nitrogen cycle is the final stage and occurs in the absence of oxygen. Denitrification is carried out by the denitrifying bacterial species- Clostridium and Pseudomonas, which will process nitrate to gain oxygen and gives out free nitrogen gas as a byproduct.

Nitrogen Cycle in Marine Ecosystem

The process of the nitrogen cycle occurs in the same manner in the marine ecosystem as in the terrestrial ecosystem. The only difference is that it is carried out by marine bacteria.

The nitrogen-containing compounds that fall into the ocean as sediments get compressed over long periods and form sedimentary rock. Due to the geological uplift, these sedimentary rocks move to land. Initially, it was not known that these nitrogen-containing sedimentary rocks are an essential source of nitrogen. But, recent researches have proved that the nitrogen from these rocks is released into the plants due to the weathering of rocks.

Importance of Nitrogen Cycle

Importance of the nitrogen cycle are as follows:

1. Helps plants to synthesise chlorophyll from the nitrogen compounds.

2. Helps in converting inert nitrogen gas into a usable form for the plants through the biochemical process.
3. In the process of ammonification, the bacteria help in decomposing the animal and plant matter, which indirectly helps to clean up the environment.
4. Nitrates and nitrites are released into the soil, which helps in enriching the soil with necessary nutrients required for cultivation.
5. Nitrogen is an integral component of the cell and it forms many crucial compounds and important biomolecules.

Nitrogen is also cycled by human activities such as combustion of fuels and the use of nitrogen fertilisers. These processes, increase the levels of nitrogen-containing compounds in the atmosphere. The fertilisers containing nitrogen are washed away in lakes and rivers and results in eutrophication.

Conclusion

- Nitrogen is abundant in the atmosphere, but it is unusable to plants or animals unless it is converted into nitrogen compounds.
- Nitrogen-fixing bacteria play a crucial role in fixing the atmospheric nitrogen into nitrogen compounds that can be used by the plants.
- The plants absorb the usable nitrogen compounds from the soil through their roots. Then, these nitrogen compounds are used for the production of proteins and other compounds in the cell.
- Animals assimilate nitrogen by consuming these plants or other animals that contain nitrogen. Humans consume proteins from these plants and animals and then, the nitrogen assimilates into our system.
- During the final stages of the nitrogen cycle, bacteria and fungi help decompose organic matter, where the nitrogenous compounds get dissolved into the soil which is again used by the plants.
- Some bacteria then convert these nitrogenous compounds in the soil and turn it into nitrogen gas. Eventually, it goes back to the atmosphere.
- These sets of processes repeat continuously and thus maintain the percentage of nitrogen in the atmosphere.

Topic- Ecological succession

ecological Succession Definition

Ecological succession is a term developed by botanists to describe the change in structure of a [community](#) of different [species](#), or [ecosystem](#). The concept of ecological succession arose from a desire to understand how large and complex ecosystems like forests can exist in places known to be recently formed, such as volcanic islands. The different types of ecological succession exists during different phases of an ecosystem, and depend on how developed that ecosystem is. In the concept of ecological succession, ecosystems advance until they reach a *climax community*. In the climax community, all of the resources are efficiently used and the total mass of vegetation maxes out. Many forests that have not been disturbed in many years are examples of a climax community.

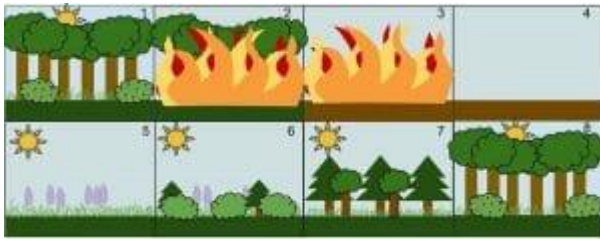
Types of Ecological Succession

Primary Succession

When the planet first formed, there was no soil. Hot magma and cold water make hard rocks, as seen by newly formed islands. Primary ecological succession is the process of small organisms and erosion breaking down these rocks into soil. Soil is then the foundation for higher forms of [plant](#) life. These higher forms can produce food for animals, which can then populate the area as well. Eventually, a barren landscape of rocks will progress through primary ecological

succession to become a climax community. After years and years, the soil layer increases in thickness and harbors many nutrients and beneficial [bacteria](#) that are required to support advanced plant life. If this primary ecosystem is disturbed and wiped out, [secondary succession](#) can take place.

Secondary Succession



The above graphic is an example of secondary ecological succession. The first picture displays a climax community. As the frames progress, the community is destroyed by a fire. As long as the fire does not burn hot enough to destroy the soil and the organisms it harbors, secondary ecological succession will take place. As seen in frame 5, small plants will come back first. After they create a solid layer of vegetation, larger plants will be able to take root and become established. At first, small shrubs and trees will dominate. As the trees grow, they will begin to block the light from most of the ground, which will change the structure of the species below the canopy. Eventually (frame 8), the ecosystem will arrive at a climax community, which may or may not be the similar to the original community. It all depends on which species colonize the area, and which seeds are able to germinate and thrive.

3. Autogenic succession:

After the succession has begun, in most of the cases, it is the community itself which, as a result of its reactions with the environment, modifies its own environment and thus causing its own replacement by new communities. This course of succession is known as autogenic succession.

4. Allogenic succession:

In some cases, the replacement of the existing community is caused largely by any other external condition and not by the existing organism. Such a course is referred to as allogenic succession.

5. Autotrophic succession:

It is characterised by early and continued dominance of autotrophic organisms like green plants. It begins in a predominantly inorganic environment and the energy flow is maintained indefinitely. There is gradual increase in the organic matter content supported by energy flow.

6. Heterotrophic succession:

It is characterised by early dominance of heterotrophs, such as bacteria, actinomycetes, fungi and animals. It begins in a predominantly organic environment, and there is a progressive decline in the energy content.

General Process of Succession:

The whole process of a primary autotrophic succession is actually completed through a number of sequential steps, which follow one another. These steps in sequence are as follows:

I. Nudation:

The development of bare area is the initial prerequisite. The cause of nudation may be topographic (soil erosion, landslide, volcanic activity, etc), climatic and biotic (human beings and pathogens).

II. Invasion:

This is the successful establishment of a species in a bare area. The species actually reaches this new site from any other area. This whole process is completed in the following three successive stages.

(i) Migration:

When the area becomes bare, some plants from the nearby localities move into it in the form of propagules. Several agencies help in the migration.

(ii) Ecesis:

It is a process of establishment of immigrants. It is not necessary that all the migrated propagules must stabilize. The stabilization process depends greatly on the conditions prevailing in that area.

(iii) Aggregation:

After ecesis, as a result of reproduction, the individual of the species increase in number, and they come close to each other. This process is known as aggregation.

III. Competition and coactions:

After aggregation of a large number of individuals of the species at the limited place, there develops competition mainly for space and nutrition. Individuals of a species affect each other's life in various ways and this is called coactions. The species, if unable to compete with other species, if present, would be discarded.

IV. Reaction:

This is the most important stage in succession. The mechanism of the modification of the environment through the influence of living organisms on it, is known as reaction. As a result of reaction, changes takes place in soil, water, light conditions, temperature etc. of the environment. Due to all these the environment is modified, becoming unsuitable for the existing community which sooner or later is replaced by another community (seral community). The whole sequence of communities that replaces one another in the given area is called a sere, and various communities constituting the sere as seral communities.

V. Stabilization (climax):

This is the final stage of development. Climax community is nearly stable and will not change so long as the climate and physiographic remain the same. However, the environment as well as the community are in a dynamic state.

Some ecologists (Gleason, 1929) have talked of retrogressive succession in which continuous biotic influences have some degenerating influence on the process. Due to destructive effects on organisms, sometimes the development of disturbed communities does not occur and the process of succession instead of progressive becomes retrogressive. As for example, forest may change to shrubby or grassland community. This is called retrogressive succession.

Sometimes due to changes in local conditions as soil characteristics or microclimate, the process of succession becomes deflected in a different direction than that presumed under climatic condition of the area. Thus the climax communities are likely to be different from the presumed climatic climax community. This type of succession is called deflected succession

Ecological Succession in Hydrosere :

It is succession occurring in the aquatic environment. Such a type of succession does not necessarily lead the aquatic communities toward the development of land communities.

Succession is recognizable only if the colonization of plant communities takes place in artificial small and shallow ponds, lakes, etc. where wave action speeds up the process by allowing the erosion of soil towards edge regions. In this way, the filling process also speeds up quickly and consequently the body of water disappears within few years .

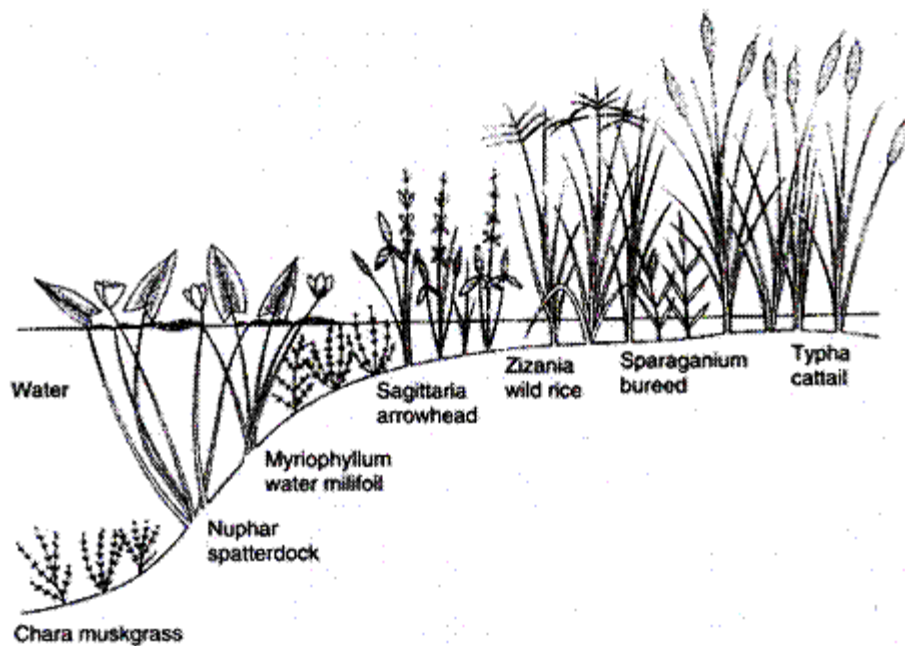


Fig. 7.1. Zonation of aquatic vegetation (hydrophytes) along a pond and along river banks. Note the changes in vegetation with water depth.

In a new pond hydrosere starts with the colonisation of phytoplankton and finally terminates into a forest (the climax community).

The process of aquatic succession :

1. Phytoplankton stage:

In the initial stage of succession algal spores are brought in the body of water. The simple forms of life like bacteria, algae and many other aquatic plants (phytoplankton) and animals (zooplankton) floating in water are the pioneer colonizers. All these organisms add large amount of organic matter and nutrients due to their various life activities and after their death, they settle at the bottom of pond to form a layer of muck.

2. Rooted Submerged stage:

The phytoplankton stage is followed by submerged plant stage. When a loose layer of mud is formed on the bottom of the pond, some rooted submerged hydrophytes begin to appear on the new substratum. The submerged aquatic vegetation develops in the regions of ponds or lakes where water depth is about 10 feet or more. The pioneers are hydrila, Potamogeton,, Utricularia, Ceratophyllum, Vallisneria, Chara, etc.

These plants form tangled mass and have marked effects upon the habitat. When these plants die their remains are deposited at the bottom of the ponds or lakes. The eroded soil particles and other transported materials are also deposited at the bottom. This gradually raises the bottom of the ponds and lakes up. As this process of stratification progresses the body of water becomes more and more shallow, consequently the habitat becomes less suited for the submerged vegetation but more favourable for other plants.

3. Rooted Floating stage:

When the depth of water reaches about 4 to 8 feet, the submerged vegetation starts disappearing from its original place and then the floating plants make their appearance gradually in that area. In the beginning the submerged and floating plants grow intermingled but in the course of time the submerged plants are replaced completely. The most tolerant species in the area are able to reproduce and perpetuate. Their broad leaves floating on the water surface check the penetration of light to deeper layer of water.

This may be one of the main causes responsible for the death of submerged plants. Due to continuous interaction between plant communities and aquatic environment, the habitat becomes changed chemically as well as physically. More water and air borne soil and dead remains of plants are deposited at the bottom. Thus, the substratum rises up in vertical direction. Important floating plants that replace the submerged vegetation are trapa, azolla, Pistia, Nymphaea, nelumbo etc.

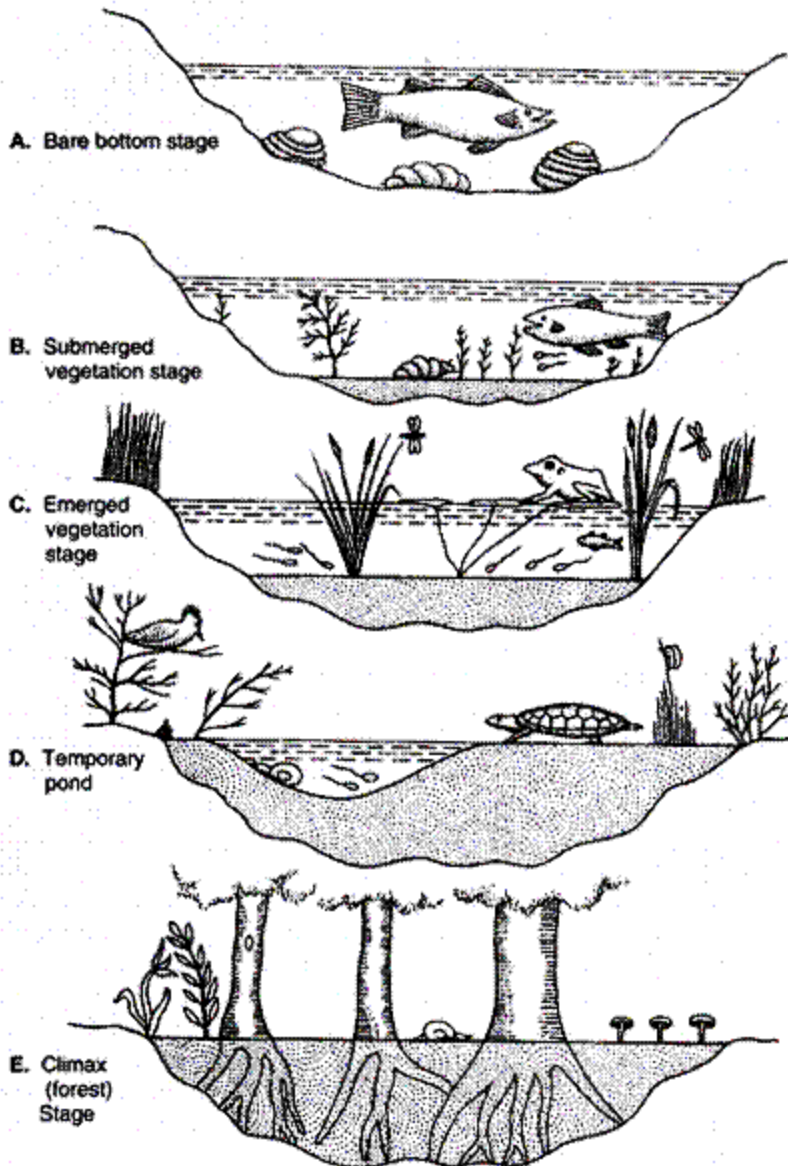


Fig. 7.2. Community succession in an open pond.

4. Reed-swamp stages:

When the ponds and lakes become too shallow (water depth one to three feet) and the habitat is changed so much that it becomes less suited to the floating plants some other plants which are well adapted to new environment will then come in .Under these conditions, the floating plants start disappearing gradually and their places are occupied by amphibious plants which can live successfully in aquatic as well as aerial environment Important examples are sagruttaria ,dragonflies, Typha, Phragmites (Reed), etc.

5. Sedge Marsh or Meadow stage:

The filling process finally results in a marshy soil which may be too dry for the plants of pre-existing community. Now the plants well adapted to new habitat begin to appear in the pre-existing community in mixed state. Important plants that are well suited to marshy habitat are the members of cyperaceae and grammeae. The species of sedge (*Carex*) and rushes (*Juncus*), species of *Themeda*, *Iris*, *Dichanthium*, *Cymbopogon*, *Campanula*, *Mentha*, *Caltha*, *Gallium*, etc. are the first invaders of marshy area.

As these plants grow most luxuriantly in the marshes, they modify the habitats in several ways. They absorb and transpire a large quantity of water and also catch and accumulate plant debris and wind and water borne soil particles. Consequently a dry habitat results which may be totally unfit for the growth of normal hydrophytes. Gradually the mesophytes start appearing and after some time the sedge vegetation is totally replaced by them.

6. Woodland stage:

In the beginning some shrubs and later medium sized trees form open vegetation or woodland. These plants produce more shade and absorb and transpire large quantity of water. Thus, they render the habitat more dry. Shade loving herbs may also grow under the trees and shrubs. The prominent plants of woodland community are species of *Buteazon*, *Acacia*, *Cassia*, *Terminalia*, *Salix*, etc.

7. Climax forest:

After a very long time the hydrosere may lead to the development of climax vegetation. As the level of soil is raised much above the water level by progressive accumulation of humus and soil particles, the habitat becomes more dry and certainly well aerated. In such a habitat, well adapted self-maintaining and self-reproducing, nearly stable and uniform plant community consisting mostly of woody trees develops in the form of mesophytic forest.

In the climax forest, all types of plants are met with. Herbs, shrubs, mosses and shade loving plants represent their own communities. Trees are dominant and they have control over the entire vegetation. Bacteria, fungi, and other micro-organisms are more frequently found in the climax vegetation. They react upon the habitat and make the soil rich in the organic materials. At the climax stage, a complete harmony develops between plant community and habitat.

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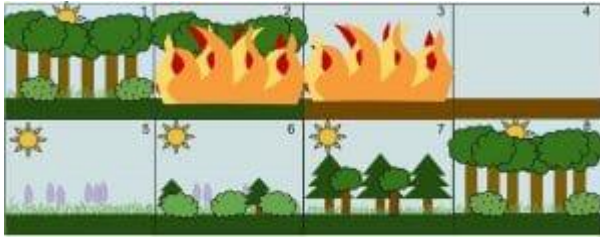
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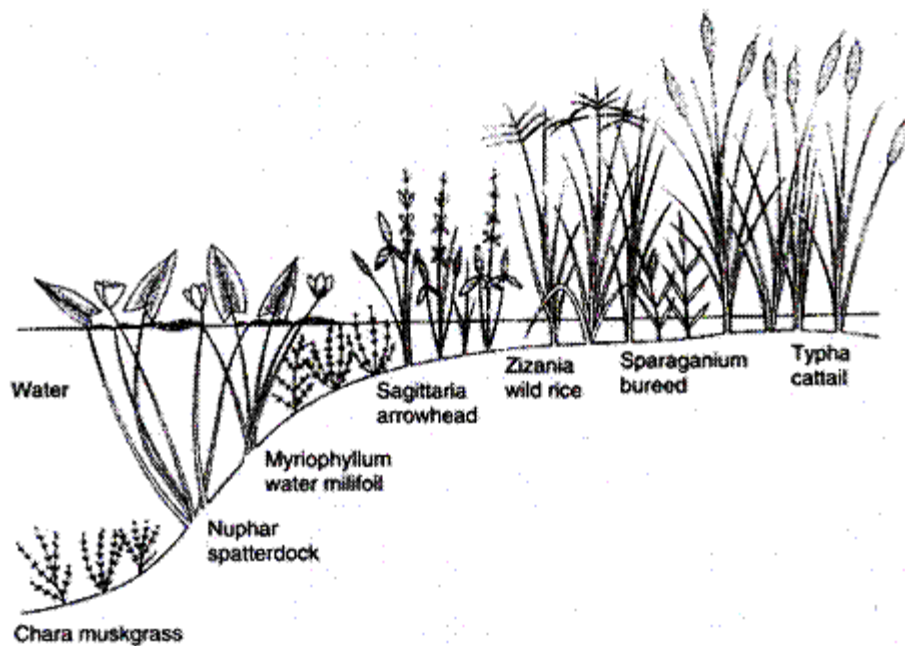


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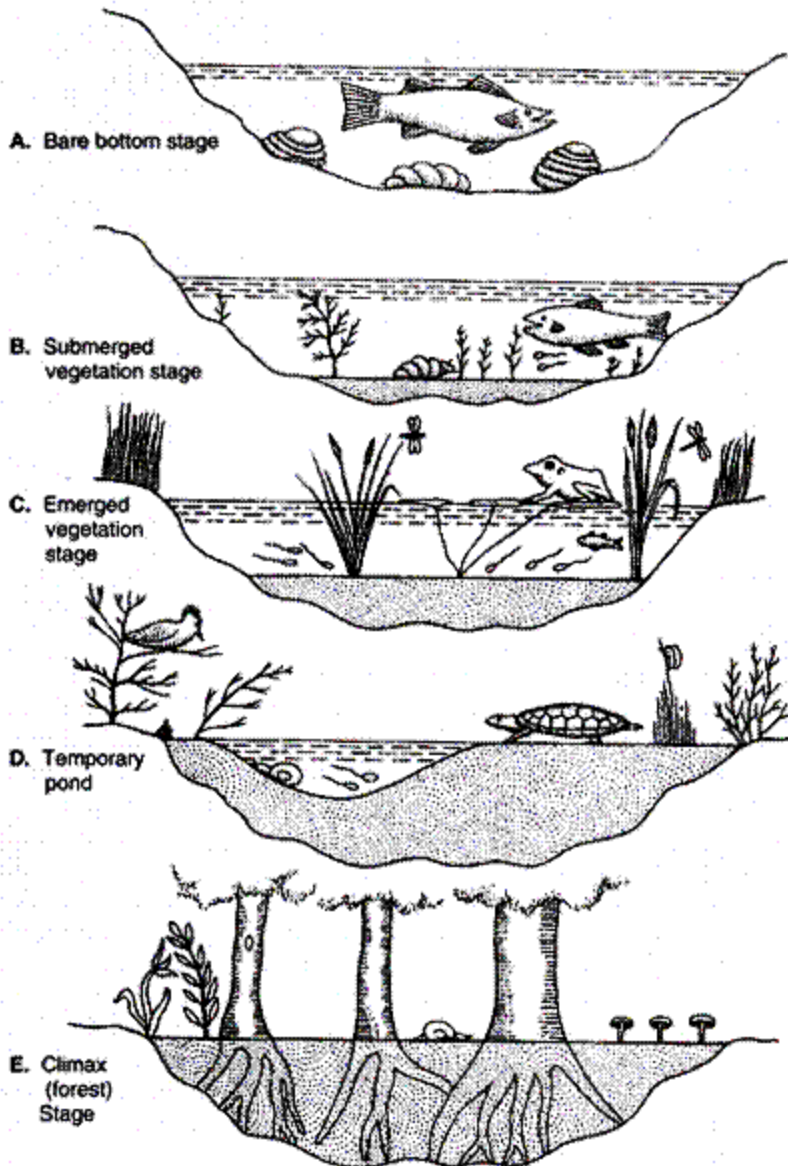


Fig. 7.2. Community succession in an open pond.

4. Reed-swamp stages:

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7. Climax forest:

After a very long time the hydrosere may lead to the development of climax vegetation. As the level of soil is raised much above the water level by progressive accumulation of humus and soil particles, the habitat becomes more dry and certainly well aerated. In such a habitat, well adapted self-maintaining and self-reproducing, nearly stable and uniform plant community consisting mostly of woody trees develops in the form of mesophytic forest.

In the climax forest, all types of plants are met with. Herbs, shrubs, mosses and shade loving plants represent their own communities. Trees are dominant and they have control over the entire vegetation. Bacteria, fungi, and other micro-organisms are more frequently found in the climax vegetation. They react upon the habitat and make the soil rich in the organic materials. At the climax stage, a complete harmony develops between plant community and habitat.

Carbon cycle

Carbon cycle shows the movement of carbon in elemental and combined states on earth. Diamond and graphite are the elemental forms of carbon. ***carbon cycle is the process where carbon compounds are interchanged among the biosphere, geosphere, pedosphere, hydrosphere, and atmosphere of the earth.***

Carbon cycle steps:

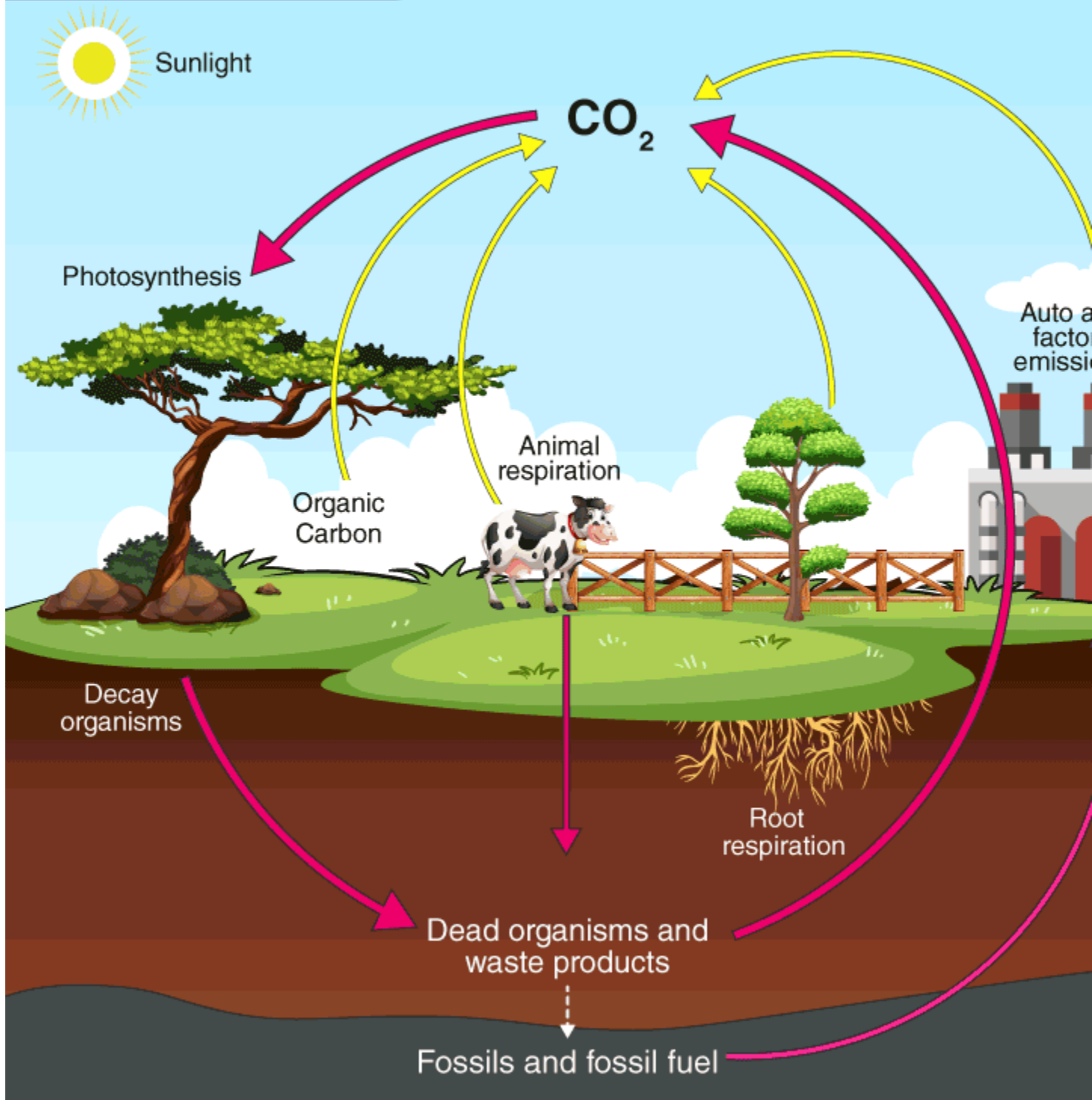
Following are the major steps involved in the process of the carbon cycle:

1. Carbon present in the atmosphere is absorbed by plants for photosynthesis.
2. These plants are then consumed by animals, and carbon gets bioaccumulated into their bodies.
3. These animals and plants eventually die, and upon decomposing, carbon is released back into the atmosphere.
4. Some of the carbon that is not released back into the atmosphere eventually become fossil fuels.
5. These fossil fuels are then used for man-made activities, which pumps more carbon back into the atmosphere.

Carbon cycle diagram:

The carbon cycle diagram below elaborates the flow of carbon along different paths.

CARBON CYCLE



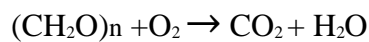
Carbon Cycle diagram showing the flow of carbon, its sources and paths.

Carbon Cycle on Land

Carbon in the atmosphere is present in the form of carbon dioxide. Carbon enters the atmosphere through natural processes such as respiration and industrial applications such as burning fossil fuels. The **process of photosynthesis** involves the absorption of CO₂ by plants to produce carbohydrates. The equation is as follows:



Carbon compounds are passed along the food chain from the producers to consumers. The majority of the carbon exists in the body in the form of carbon dioxide through respiration. The role of decomposers is to eat the dead organism and return the carbon from their body back into the atmosphere. The equation for this process is:



Oceanic Carbon Cycle

This is essentially a carbon cycle but in the sea. Ecologically, oceans take in more carbon than it gives out. Hence, it is called a “carbon sink.” Marine animals convert carbon to calcium carbonate and this forms the raw building materials require to create hard shells, similar to the ones found in clams and oysters.

When organisms with calcium carbonate shells die, their body decomposes, leaving behind their hard shells. These accumulate on the seafloor and are eventually broken down by the waves and compacted under enormous pressure, forming limestone.

When these limestone rocks are exposed to air, they get weathered and the carbon is released back into the atmosphere as carbon dioxide.

Importance of Carbon Cycle

Even though carbon dioxide is found in small traces in the atmosphere, it plays a vital role in balancing the energy and traps the long-wave radiations from the sun. Therefore, it acts like a blanket over the planet. If the carbon cycle is disturbed it will result in serious consequences such as climatic changes and **global warming**.

Carbon is an integral component of every life form on earth. From proteins and lipids to even our DNA. Furthermore, all known life on earth is based on carbon. Hence, the carbon cycle, along with the nitrogen cycle and oxygen cycle, plays a vital role in the existence of life on earth.

Key Points on Carbon Cycle

- Carbon cycle explains the movement of carbon between the earth’s biosphere, geosphere, hydrosphere and atmosphere.
- Carbon is an important element of life.

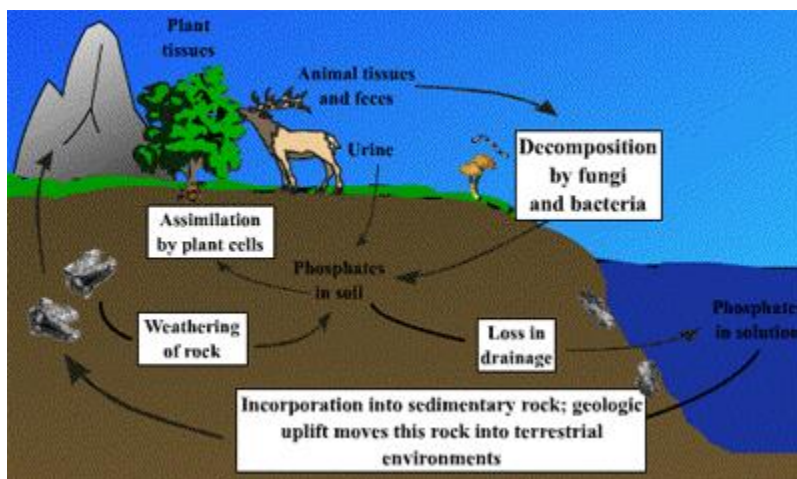
- Carbon dioxide in the atmosphere is taken up by the green plants and other photosynthetic organisms and is converted into organic molecules that travel through the food chain. Carbon atoms are then released as carbon dioxide when organisms respire.
- The formation of fossil fuels and sedimentary rocks contribute to the carbon cycle for very long periods.
- The carbon cycle is associated with the availability of other compounds as well.

Phosphorus Cycle

Phosphorus is an important element for all forms of life. As phosphate (PO_4), it makes up an important part of the structural framework that holds [DNA](#) and [RNA](#) together. Phosphates are also a critical component of ATP—the cellular energy carrier—as they serve as an energy 'release' for organisms to use in building proteins or contracting muscles. Like calcium, phosphorus is important to vertebrates; in the human body, 80% of phosphorus is found in teeth and bones.

The phosphorus cycle differs from the other major biogeochemical cycles in that it does not include a gas phase; although small amounts of phosphoric acid (H_3PO_4) may make their way into the atmosphere, contributing—in some cases—to acid rain. The water, carbon, nitrogen and sulfur cycles all include at least one phase in which the element is in its gaseous state. Very little phosphorus circulates in the atmosphere because at Earth's normal temperatures and pressures, phosphorus and its various compounds are not gases. The largest reservoir of phosphorus is in sedimentary rock.

It is in these rocks where the phosphorus cycle begins. When it rains, phosphates are removed from the rocks (via [weathering](#)) and are distributed throughout both soils and water. Plants take up the phosphate ions from the soil. The phosphates then move from plants to animals when [herbivores](#) eat plants and [carnivores](#) eat plants or herbivores. The phosphates absorbed by animal tissue through consumption eventually return to the soil through the excretion of urine and feces, as well as from the final decomposition of plants and animals after death.



The same process occurs within the aquatic ecosystem. Phosphorus is not highly soluble, binding tightly to molecules in soil, therefore it mostly reaches waters by traveling with runoff soil particles. Phosphates also enter waterways through fertilizer runoff, sewage seepage, natural mineral deposits, and wastes from other industrial processes. These phosphates tend to settle on ocean floors and lake bottoms. As sediments are stirred up, phosphates may re-enter the phosphorus cycle, but they are more commonly made available to aquatic organisms by being exposed through erosion. Water plants take up the waterborne phosphate which then travels up through successive stages of the aquatic food chain.

While obviously beneficial for many biological processes, in surface waters an excessive concentration of phosphorus is considered a pollutant. Phosphate stimulates the growth of plankton and plants, favoring weedy species over others. Excess growth of these plants tend to consume large amounts of dissolved oxygen, potentially suffocating fish and other marine animals, while also blocking available sunlight to bottom dwelling species. This is known as eutrophication.

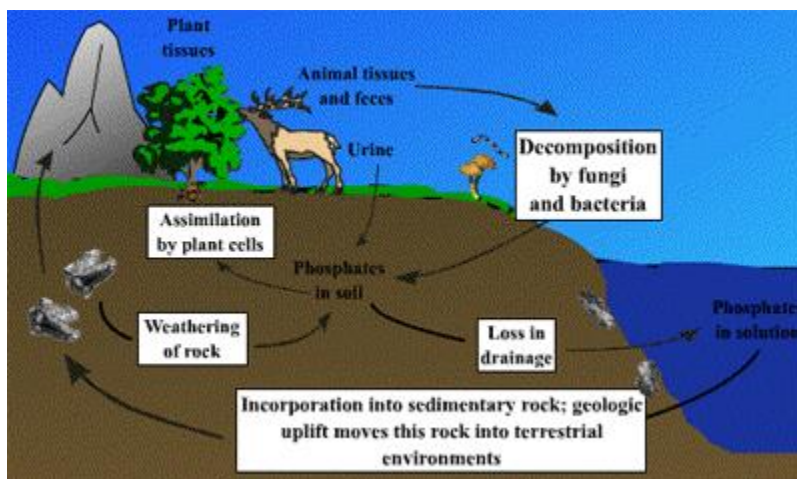
Humans can alter the phosphorus cycle in many ways, including in the cutting of tropical rain forests and through the use of agricultural fertilizers. Rainforest ecosystems are supported primarily through the recycling of nutrients, with little or no nutrient reserves in their soils. As the forest is cut and/or burned, nutrients originally stored in plants and rocks are quickly washed away by heavy rains, causing the land to become unproductive. Agricultural runoff provides much of the phosphate found in waterways. Crops often cannot absorb all of the fertilizer in the soils, causing excess fertilizer runoff and increasing phosphate levels in rivers and other bodies of water. At one time the use of laundry detergents contributed to significant concentrations of phosphates in rivers, lakes, and streams, but most detergents no longer include phosphorus as an ingredient.

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