

# What is biogeochemical cycle

*“Biogeochemical cycles mainly refer to the movement of nutrients and other elements between biotic and abiotic factors.”*

The term biogeochemical is derived from “bio” meaning biosphere, “geo” meaning the geological components and “chemical” meaning the elements that move through a cycle.

The matter on Earth is conserved and present in the form of atoms. Since matter can neither be created nor destroyed, it is recycled in the earth’s system in various forms.

The earth obtains energy from the sun which is radiated back as heat, rest all other elements are present in a closed system. The major elements include:

- Carbon
- Hydrogen
- Nitrogen
- Oxygen
- Phosphorus
- Sulphur

These elements are recycled through the biotic and abiotic components of the [ecosystem](#). The atmosphere, hydrosphere and lithosphere are the abiotic components of the ecosystem.

## Types of Biogeochemical Cycles

Biogeochemical cycles are basically divided into two types:

- **Gaseous cycles** – Includes Carbon, Oxygen, Nitrogen, and the Water cycle.
- **Sedimentary cycles** – Includes Sulphur, Phosphorus, Rock cycle, etc.

# Water Cycle

## Water Cycle

The water from the different water bodies evaporates, cools, condenses and falls back to the earth as rain.

This biogeochemical cycle is responsible for maintaining weather conditions. The water in its various forms interacts with the surroundings and changes the temperature and pressure of the atmosphere.

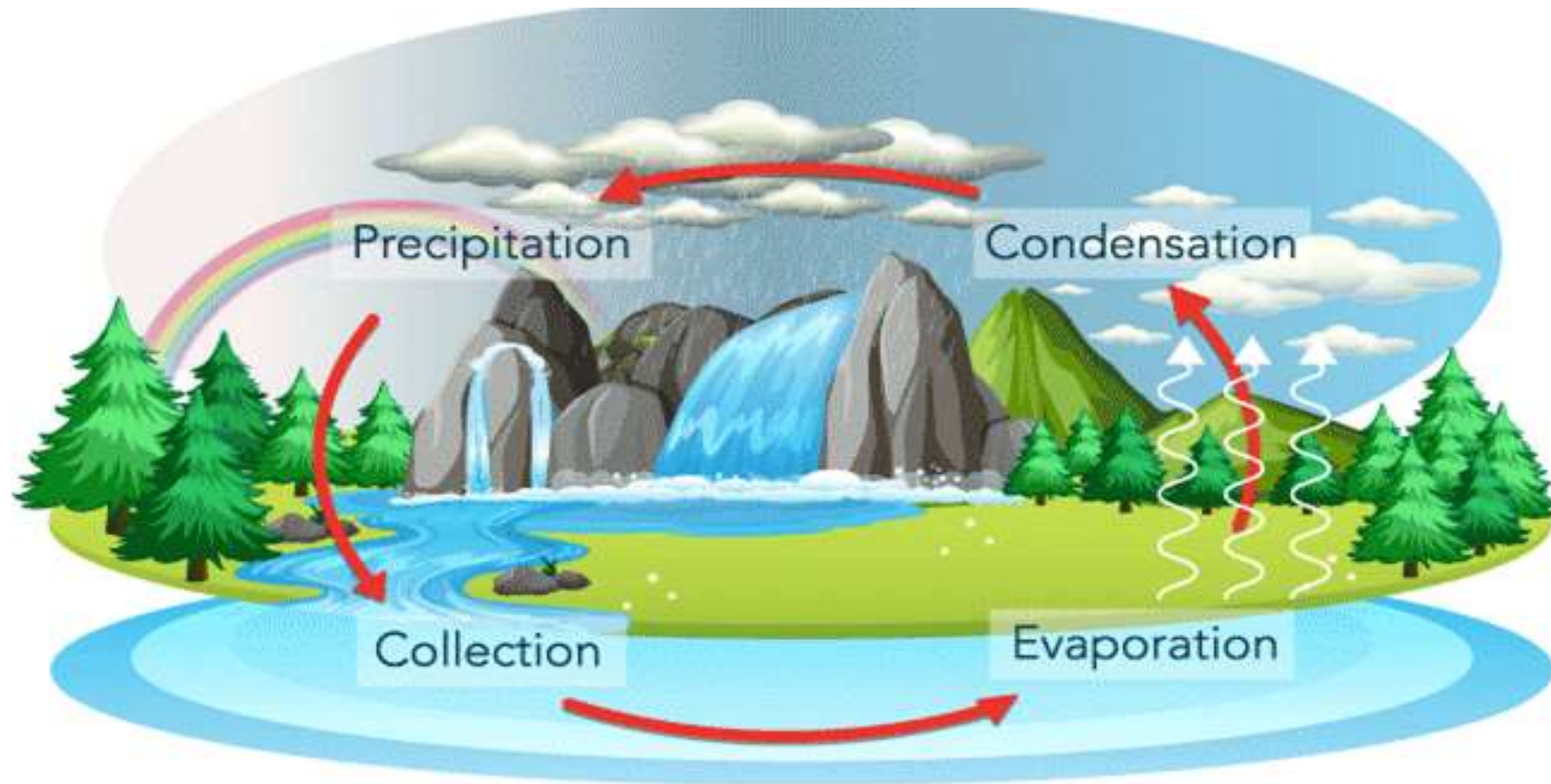
There's another process called Evapotranspiration (i.e. vapour produced from leaves) which aids this process. It is the evaporation of water from the leaves, soil and water bodies to the atmosphere which again condenses and falls as rain.

***The water cycle, also known as the hydrologic cycle or the hydrological cycle, describes the continuous movement of water on, above and below the surface of the Earth.***

## **Water Cycle Diagram**

During this process, water changes its state from one phase to another, but the total number of water particles remains the same. In other words, if it were possible to collect and boil 100 gms of water, it will still retain a mass of 100 gms as steam. Likewise, if 100 gms of steam is collected and condensed, the resultant water would still weight 100 gms.

# Water cycle



# Carbon Cycle

It is one of the biogeochemical cycles in which carbon is exchanged among the biosphere, geosphere, hydrosphere, atmosphere and pedosphere.

All green plants use carbon dioxide and sunlight for **photosynthesis**. Carbon is thus stored in the plant. The green plants, when dead, are buried into the soil that gets converted into fossil fuels made from carbon. These fossil fuels when burnt, release carbon dioxide into the atmosphere.

Also, the animals that consume plants, obtain the carbon stored in the plants. This carbon is returned to the atmosphere when these animals decompose after death. The carbon also returns to the environment through cellular respiration by animals.

Huge carbon content in the form of carbon dioxide is produced that is stored in the form of fossil fuel (coal & oil) and can be extracted for various commercial and non-commercial purposes. When factories use these fuels, the carbon is again released back in the atmosphere during combustion.

# Carbon Cycle Steps

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

Carbon present in the atmosphere is absorbed by plants for photosynthesis.

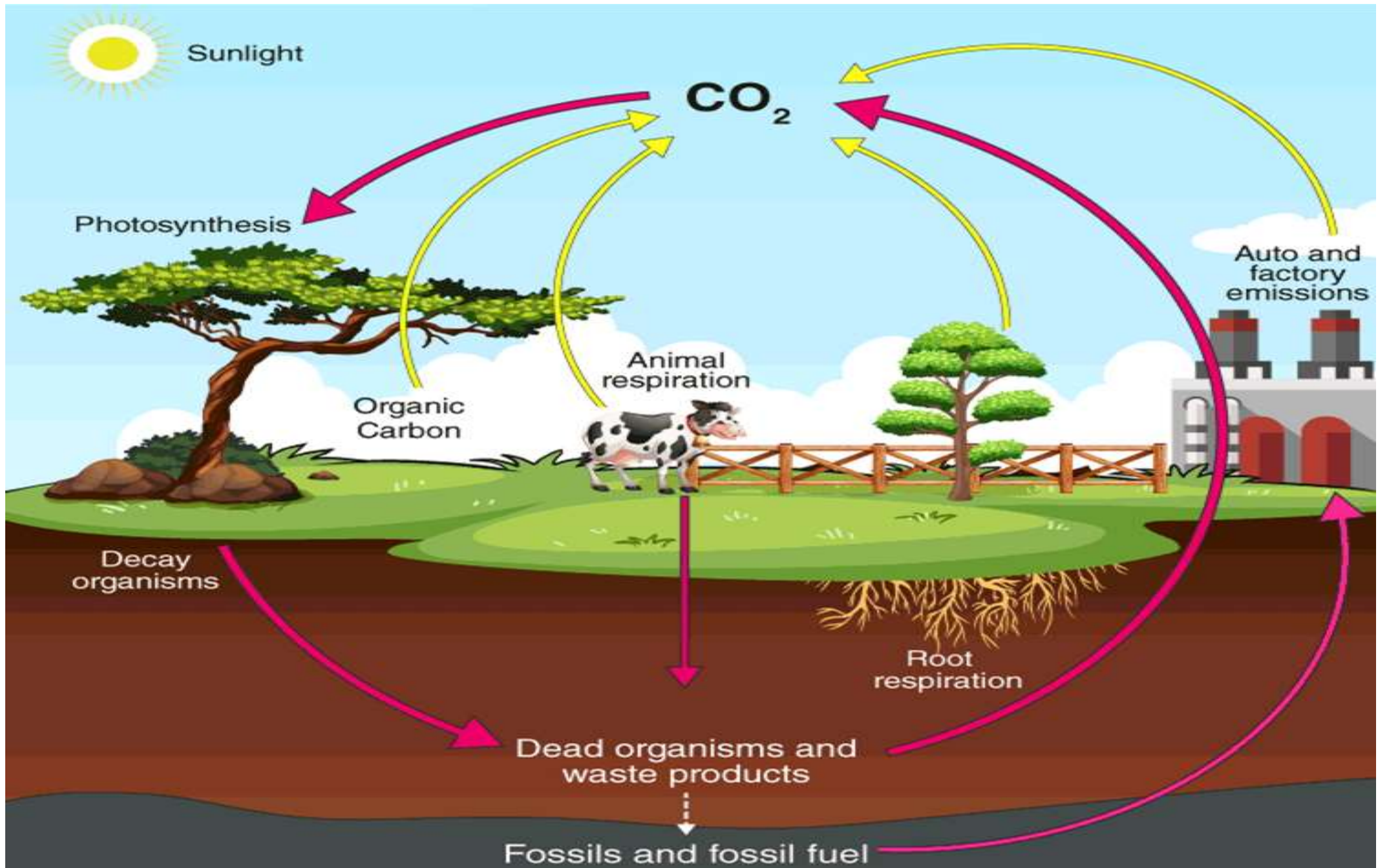
These plants are then consumed by animals and carbon gets bioaccumulated into their bodies.

These animals and plants eventually die, and upon decomposing, carbon is released back into the atmosphere.

Some of the carbon that is not released back into the atmosphere eventually become fossil fuels.

These fossil fuels are then used for man-made activities, which pump more carbon back into the atmosphere.





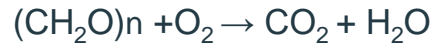


## Carbon Cycle on Land

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 CO<sub>2</sub> 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.

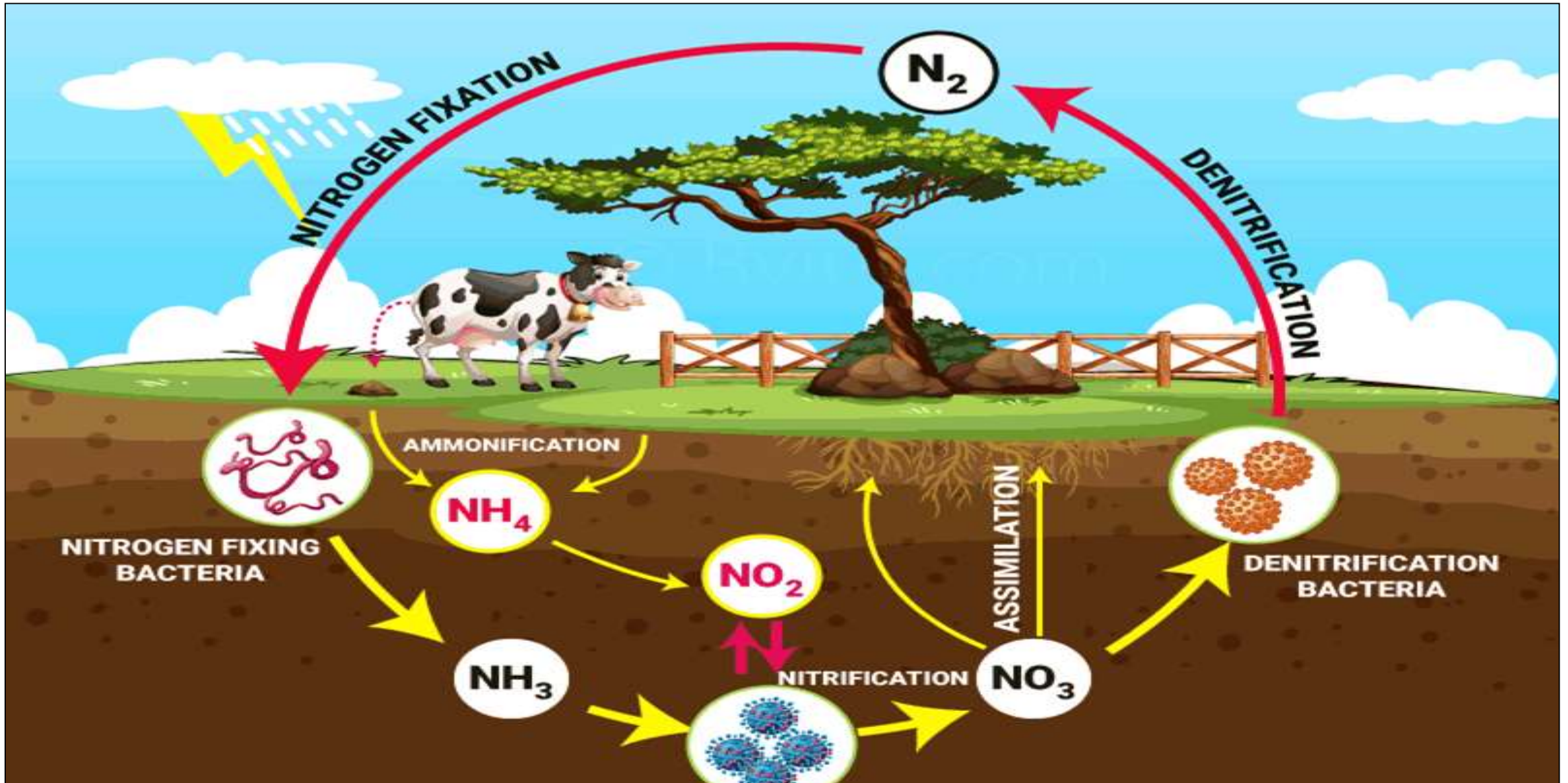
# Nitrogen Cycle

It is the biogeochemical cycle by which nitrogen is converted into several forms and it gets circulated through the atmosphere and various ecosystems such as terrestrial and marine ecosystems.

Nitrogen is an essential element of life. The nitrogen in the atmosphere is fixed by the nitrogen-fixing bacteria present in the root nodules of the leguminous plants and made available to the soil and plants.

The bacteria present in the roots of the plants convert this nitrogen gas into a usable compound called ammonia. Ammonia is also supplied to plants in the form of fertilizers. This ammonia is converted into nitrites and nitrates. The denitrifying bacteria reduce the nitrates into nitrogen and return it into the atmosphere.

# Nitrogen cycle



## Stages of Nitrogen Cycle

Process of the 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 Process

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.

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 atmospheric fixation- which involves lightening, or industrial fixation by manufacturing ammonia under high temperature and pressure conditions. 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, which are then used by plants.
- 2. Industrial nitrogen fixation:** It 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. Later, it is converted into various fertilisers such as urea.
- 3. Biological nitrogen fixation:** We already know that nitrogen is not used directly from the air by 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* bacteria 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 make their way back into the atmosphere by converting nitrate ( $\text{NO}_3^-$ ) into gaseous nitrogen ( $\text{N}$ ). 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 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

The 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 the 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 the 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, rivers and result in eutrophication.



# Oxygen Cycle

This biogeochemical cycle moves through the atmosphere, the lithosphere and the biosphere. Oxygen is an abundant element on our Earth. It is found in the elemental form in the atmosphere to the extent of 21%.

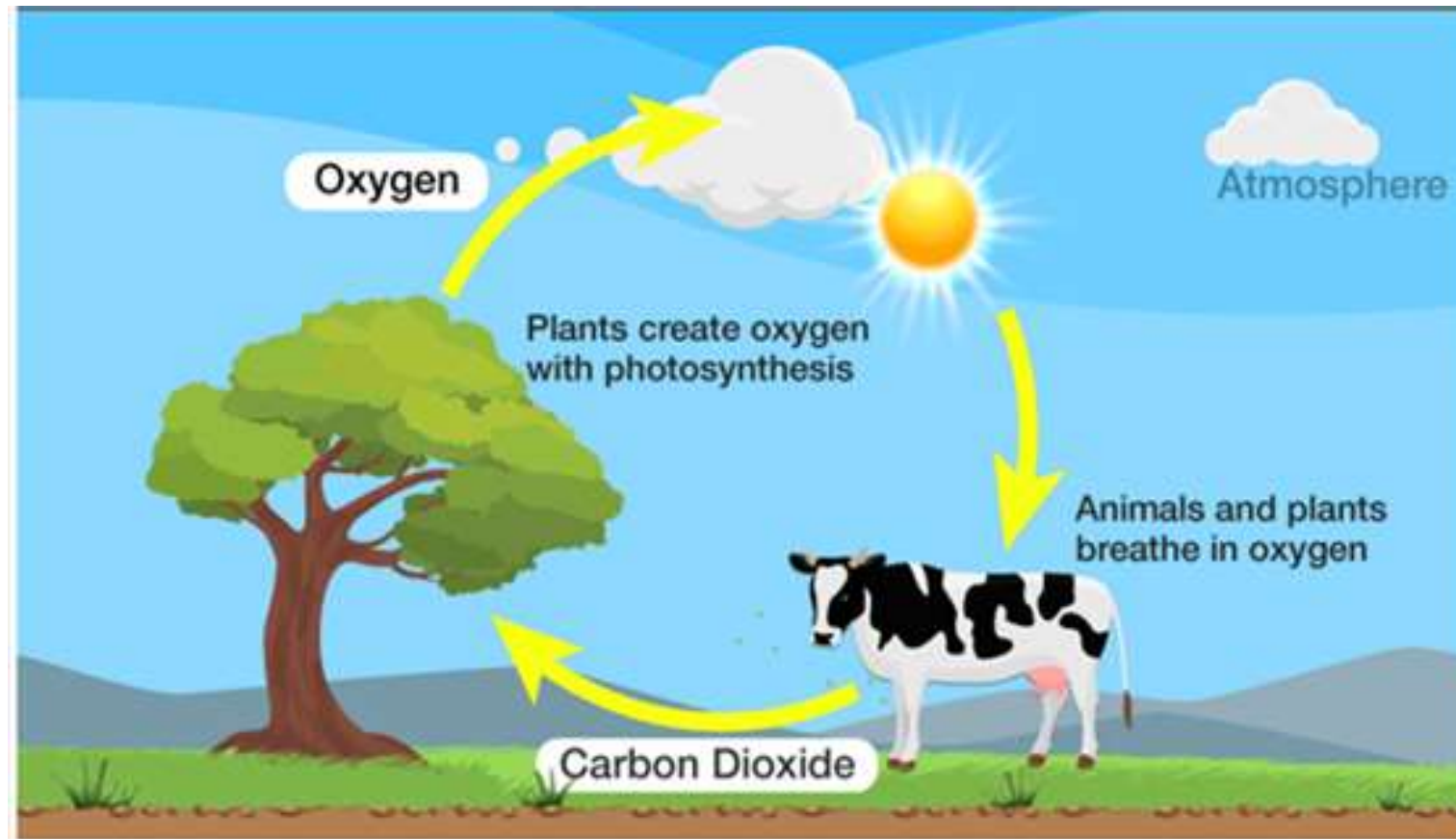
Oxygen is released by the plants during photosynthesis. Humans and other animals inhale the oxygen exhale carbon dioxide which is again taken up by the plants. They utilise this carbon dioxide in photosynthesis to produce oxygen, and the cycle continues.

As we all know, the air is a mixture of gases. The air in the atmosphere is composed of different gases, namely nitrogen (78%), oxygen (21%), argon and other trace gases (1%).

According to the earth's history, oxygen gas was first introduced by cyanobacteria through the process of photosynthesis. Earlier, around 4.6 billion years ago, there was no life on planet earth because the atmosphere was devoid of oxygen. Later, there was a gradual increase in the oxygen levels and by the Carboniferous Period- 299 million years ago, oxygen reached the levels that were similar to today's estimates.

Today, oxygen is freely available in the air and also dissolved in water. It is the second most abundant gas present in the atmosphere and also the most common element of the human body. It plays an essential role in most life forms on earth and also serves as an essential element in biomolecules like proteins and nucleic acids.

# OXYGEN CYCLE



Oxygen cycle, along with the carbon cycle and [nitrogen cycle](#) plays an essential role in the existence of life on the earth. The oxygen cycle is a biological process which helps in maintaining the oxygen level by moving through three main spheres of the earth which are:

Atmosphere

Lithosphere

Biosphere

This biogeochemical cycle explains the movement of oxygen gas within the atmosphere, the ecosystem, biosphere and the lithosphere. The oxygen cycle is interconnected with the carbon cycle.

The atmosphere is the layer of gases presents above the earth's surface. The sum of Earth's ecosystems makes a biosphere. Lithosphere is the solid outer section along with the earth's crust and it is the largest reservoir of oxygen.

# Stages of the Oxygen Cycle

The steps involved in the oxygen cycle are:

**Stage-1:** All green plants during the process of photosynthesis, release oxygen back into the atmosphere as a by-product.

**Stage-2:** All aerobic organisms use free oxygen for respiration.

**Stage-3:** Animals exhale Carbon dioxide back into the atmosphere which is again used by the plants during photosynthesis. Now oxygen is balanced within the atmosphere.

# Production of Oxygen

**Plants:** The leading creators of oxygen are plants by the process of [photosynthesis](#). Photosynthesis is a biological process by which all green plants synthesize their food in the presence of sunlight. During photosynthesis, plants use sunlight, water, carbon dioxide to create energy and oxygen gas is liberated as a by-product of this process.

**Sunlight:** Sunlight also produces oxygen. Some oxygen gas is produced when the sunlight reacts with water vapour in the atmosphere.

## Phosphorous Cycle

In this biogeochemical cycle, phosphorus moves through the hydrosphere, lithosphere and biosphere. Phosphorus is extracted by the weathering of rocks. Due to rains and erosion phosphorus is washed away in the soil and water bodies. Plants and animals obtain this phosphorus through the soil and water and grow. Microorganisms also require phosphorus for their growth. When the plants and animals die they decompose, and the stored phosphorus is returned to the soil and water bodies which is again consumed by plants and animals and the cycle continues.



# Steps of Phosphorus Cycle

Following are the important steps of phosphorus cycle:

- Weathering
- Absorption by Plants
- Absorption by Animals
- Return to the Environment through Decomposition

## Weathering

Phosphorus is found in the rocks in abundance. That is why the phosphorus cycle starts in the earth's crust. The phosphate salts are broken down from the rocks. These salts are washed away into the ground where they mix in the soil.

## Absorption by Plants

The phosphate salts dissolved in water are absorbed by the plants. However, the amount of phosphorus present in the soil is very less. That is why the farmers apply phosphate fertilizers on agricultural land.

The aquatic plants absorb inorganic phosphorus from lower layers of water bodies. Since phosphate salts do not dissolve in water properly, they affect plant growth in [aquatic ecosystems](#).

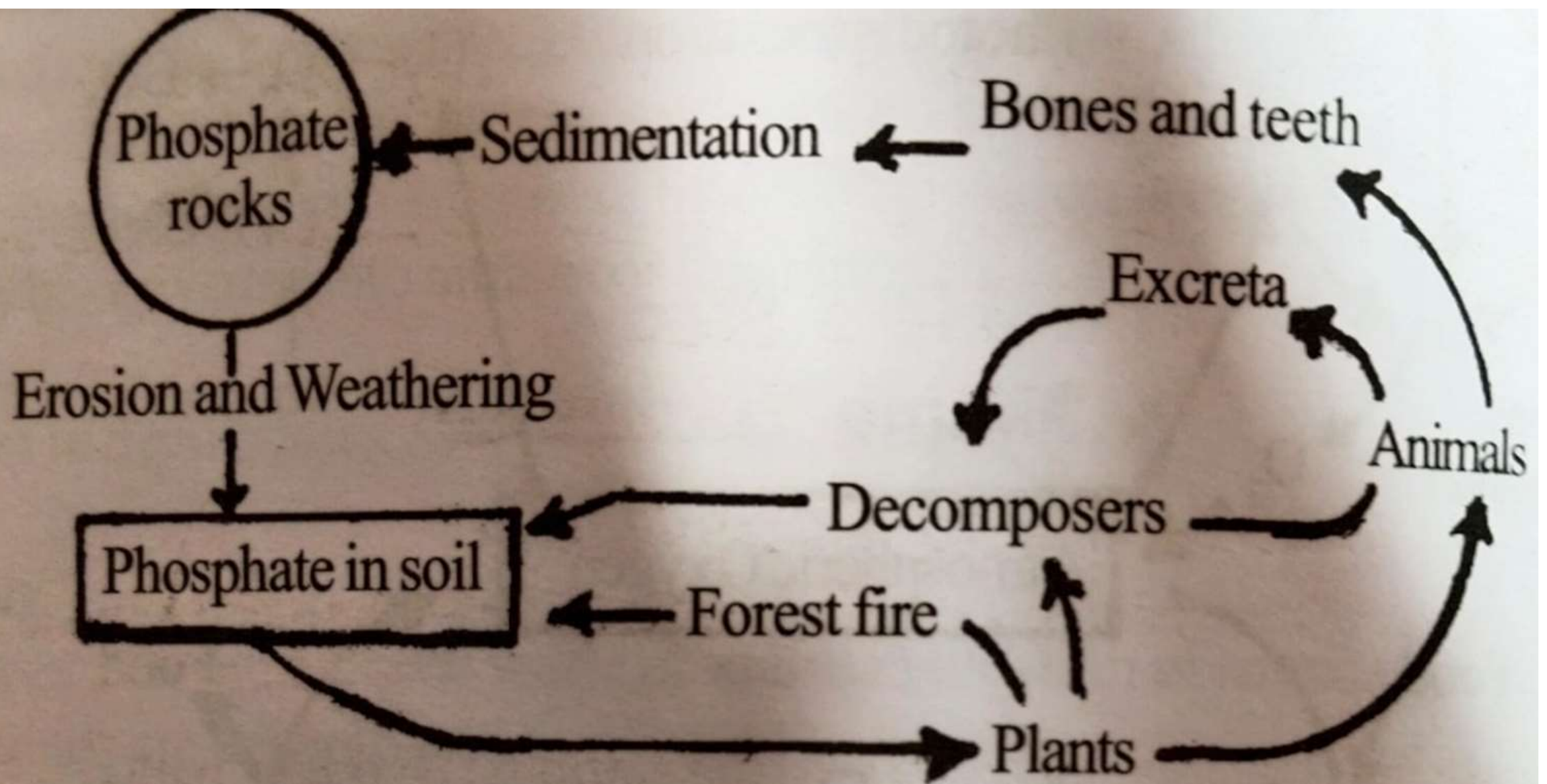
## Absorption by Animals

The animals absorb phosphorus from the plants or by consuming plant-eating animals. The rate of the phosphorus cycle is faster in plants and animals when compared to rocks.

## Return of Phosphorus Back to the Ecosystem

When the plants and animals die they are decomposed by microorganisms. During this process, the organic form of phosphorus is converted into the inorganic form, which is recycled to soil and water.

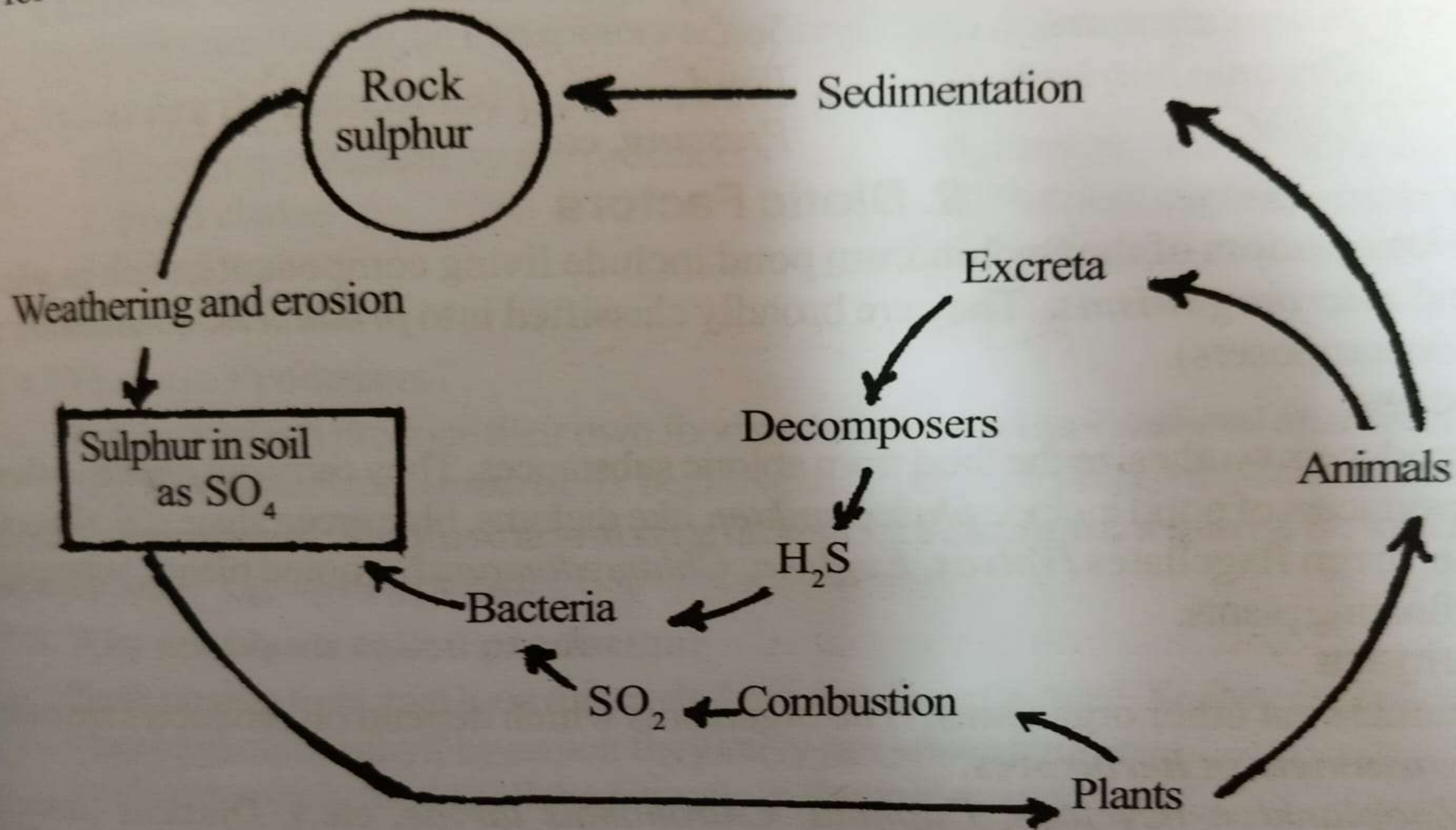
Soil and water will end up in sediments and rocks, which will again release phosphorus by weathering. Thus, the phosphorus cycle starts over.



*Fig.3.32 : Phosphorus cycle.*

# Sulphur Cycle

This biogeochemical cycle moves through the rocks, water bodies and living systems. Sulphur is released into the atmosphere by the weathering of rocks and is converted into sulphates. These sulphates are taken up by the microorganisms and plants and converted into organic forms. Organic sulphur is consumed by animals through food. When the animals die and decompose, sulphur is returned to the soil, which is again obtained by the plants and microbes, and the cycle continues.



*Fig.3.33: Sulphur Cycle.*

Sulphur is one of the most abundant elements on the earth. It is a yellow, brittle, tasteless, odourless non-metal. Sulphur is present in all kinds of proteins. Plants directly absorb sulphur-containing amino acids such as methionine, cystine, and cysteine.

Sulphur is released into the atmosphere by the burning of [fossil fuels](#), volcanic activities, and decomposition of organic molecules.

On land, sulphur is stored in underground rocks and minerals. It is released by precipitation, weathering of rocks and geothermal vents.

## **Sulphur Cycle**

The process of sulphur cycle is explained below:

The sulphur is released by the weathering of rocks.

Sulphur comes in contact with air and is converted into sulphates.

Sulphates are taken up by plants and microbes and are converted into organic forms.

The organic form of sulphur is then consumed by the animals through their food and thus sulphur moves in the food chain.

When the animals die, some of the sulphur is released by decomposition while some enter the tissues of microbes.

There are several natural sources such as volcanic eruptions, evaporation of water, and breakdown of organic matter in swamps, that release sulphur directly into the atmosphere. This sulphur falls on earth with rainfall.



# Steps of Sulphur Cycle

Following are the important steps of the sulphur cycle:

## Decomposition of Organic Compounds

Protein degradation releases amino acids that contain sulphur. Sulphates are reduced to  $H_2S$  by the action of Desulfotomaculum bacteria.

## Oxidation of Hydrogen Sulphide to Elemental Sulphur

Hydrogen sulphide oxidises to produce elemental sulphur. Certain photosynthetic bacteria from the families Chlorobiaceae and Chromatiaceae initiate the oxidation process.

## Oxidation of Elemental Sulphur

Elemental sulphur present in the soil cannot be utilized directly by the plants. Therefore, it is converted into sulphates by chemolithotrophic bacteria.

## Reduction of Sulphates

Sulphates are reduced to hydrogen sulphide by *Desulfovibrio desulfuricans*. This occurs in two steps:

Firstly, the sulphates are converted to sulphites utilizing ATP.

Secondly, the reduction of sulphite to hydrogen sulphide.