ENV-103

Biogeochemical Cycles

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- All organisms are interconnected by vast global recycling systems known as nutrient cycles, or biogeochemical cycles
- A biogeochemical cycle is a complete path that a chemical substance takes through the four major components of earth's system: atmosphere, hydrosphere (ocean, rivers, lakes, groundwater and glaciers), lithosphere (rock and soil) and biosphere (plants and animals).

- Within these cycles, reservoirs or pools are where the particular nutrient is stored.

The Importance of studying biogeochemical cycles

- Quantifying the pools of the nutrient elements and gaining a better understanding of the biological, chemical and physical factors regulating them.
- Improve understanding of the interactions among the various biogeochemical cycles.
- Assessing anthropogenic disturbance of biogeochemical cycles and their impacts on ecosystem functioning, atmospheric chemistry, and human activities.
- Developing a scientific basis for decision making about managing these cycles.
- Exploring technical and institutional approaches to managing man's disturbance to the cycles.

Nutrients:

- Any element (chemical substance) that an organism needs to complete its lifecycle is called a nutrient.
- Macronutrients: Elements required by organisms in large amounts are called macronutrients.

  e.g. Carbon (C), Oxygen (O), Hydrogen (H), Nitrogen (N), Phosphorus (P), Sulfur (S), Calcium (Ca), Magnesium (Mg), and Potassium (K)

  - Include the "Big Six", which are the building blocks of life
    - Carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur
    - Each plays a special role in organisms
- Micronutrients: Elements required by organisms in small or trace amounts are called micronutrients.

  e.g. Iron (Fe), Copper (Cu), Zinc (Zn), Chlorine (Cl), and Iodine (I)

Life and Global Chemical Cycles

- For life to persist elements must be available at the right time, in the right amount, and in right concentrations relative to one another
  - Too much of some elements - can be toxic
  - Too little of some element - can limit growth and development
  - Neutral - some elements are neutral for life

Important bio elements for living beings

- **Carbon** is the basic building block for organic compound. Along with oxygen and hydrogen, carbon form carbohydrate.

- **Nitrogen** is the major component of protein.

- **Phosphorus** is essential to all living organisms and, together with nitrogen, it is one of the main nutrients for animal and plant growth.

- **Calcium** is important for bones of human being, and shells of different marine creatures.

Carbon cycle

- The carbon cycle is the biogeochemical cycle by which carbon is exchanged between the biosphere, lithosphere, hydrosphere, and atmosphere of the Earth.

Significance of the 'C' cycle

- If the carbon cycle removes too much CO_2 from the atmosphere, then the earth will cool; if the cycle generates too much, then the earth well get warmer.
- Thus, even slight changes in the carbon cycle can affect climate and ultimately the types of life that can exist on various parts of the planet.

Reservoirs of carbon (C)

- Atmosphere – mainly as carbon dioxide, also as methane
- Hydrosphere - in surface water and ground water as bicarbonate or carbonates
- Lithosphere - as minerals, e.g. magnesium and calcium carbonate, and as fossil fuels, e.g. gas, coal, petroleum
- Biosphere – as carbohydrate

IMPORTANCE OF STUDYING CARBON CYCLE

- Carbon is an essential element for all life, so understanding how it moves helps us to understand biological processes and factors that influence them.
- Increased levels of carbon dioxide insulate the Earth, causing temperatures to rise. Understanding how carbon dioxide is absorbed and released helps us understand the climate and predict global warming.
- Carbon is not in balance, so it's important to learn where it is being stored and released. The rate at which carbon is deposited into living organisms is not the same as the rate it is returned to the Earth. There is about 100x more carbon in living matter than in the Earth.

- Carbon enters the atmosphere through the **respiration of living things** and **burning of organic compounds**
- It is removed from the atmosphere by **photosynthesis** of green plants, algae and bacteria

- Photosynthesis is a series of chemical reactions by which living green plants, with sunlight as an energy source, convert carbon dioxide (CO_2) and water (H_2O) to sugar/ glucose ($C_6H_{12}O_6$) and oxygen (O_2).
  - The general chemical reaction for photosynthesis is

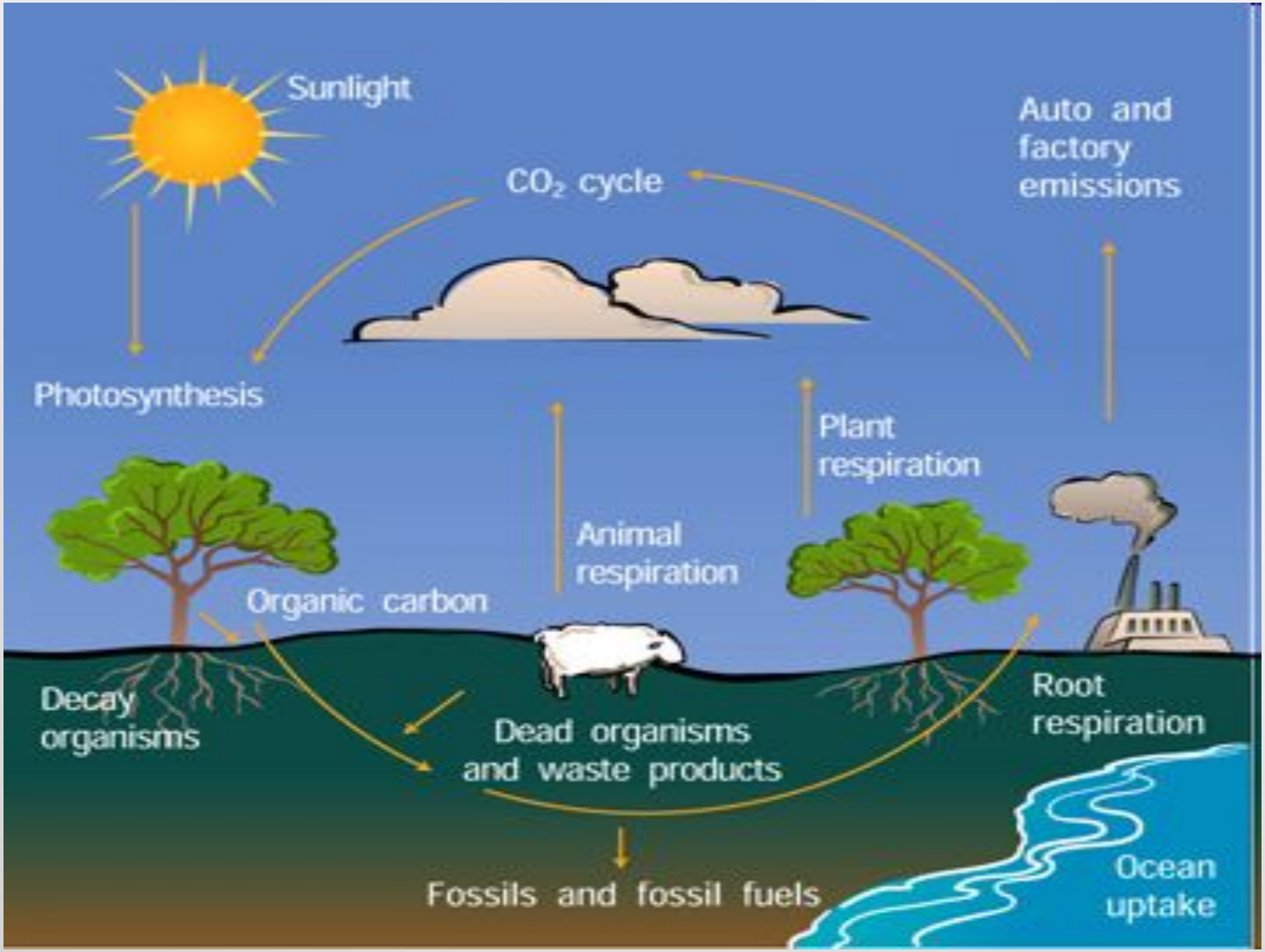
$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

- Photosynthesis produces oxygen as a by-product, and that is why we have free oxygen in our atmosphere.

- Burning carbon-containing fossil fuels and burning wood faster than it is re grown
- Removal of forests and other vegetation without sufficient replanting

Effects:

- Add excess carbon dioxide to the atmosphere
- Enhance earth's natural greenhouse effect
- Increase the earth's average temperature, resulting in global warming
- Alter climate patterns
- Disrupt global food production and wildlife



Carbon Cycle

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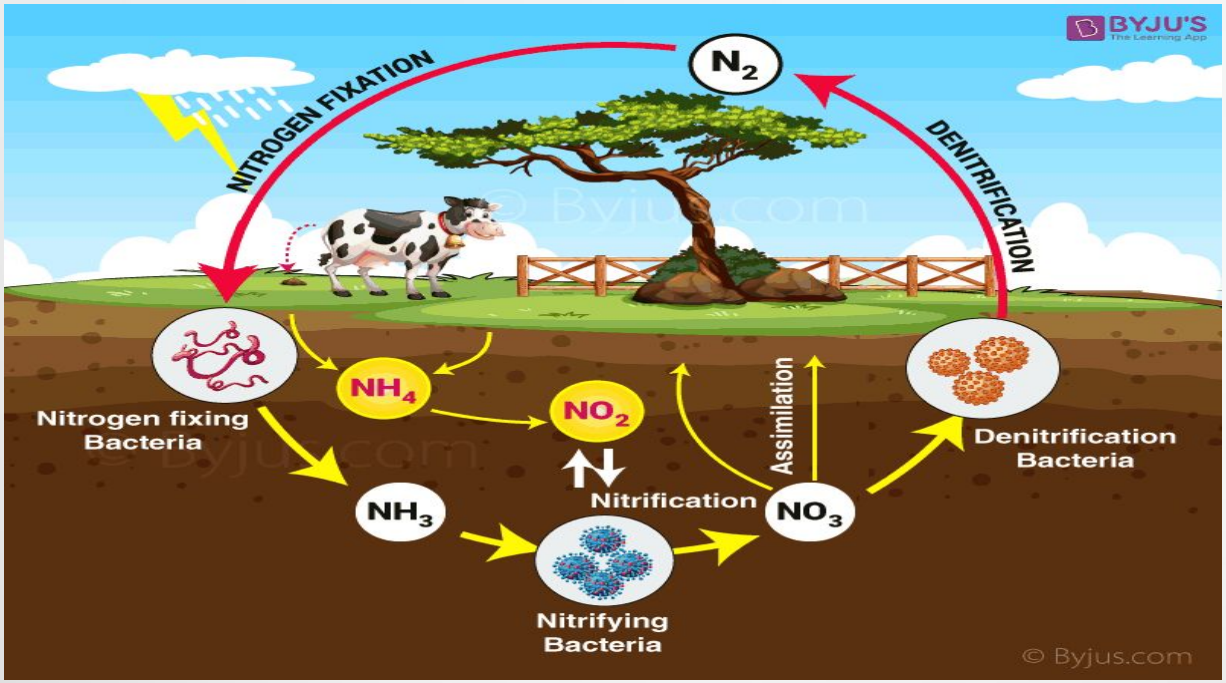
Nitrogen cycle

- The nitrogen (N) cycle is the process by which N is converted between its various chemical forms.
- This transformation can be carried out by both biological and non-biological processes.
- **Reservoirs of nitrogen** (N)

  - Atmosphere (as nitrogen, nitrous oxide and other nitrogen gases)
  - Biosphere (as protein)
  - Hydrosphere and lithosphere (as dissolved nitrates and ammonium)

Nitrogen is present in the environment in a wide variety of chemical forms including organic nitrogen, ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-), nitrous oxide (N_2O), nitric oxide (NO) or inorganic nitrogen gas (N_2).

STEPS OF NITROGEN CYCLE



- **Nitrogen Fixation** - Fixation is the first step in the process of making nitrogen usable by plants. Here bacteria change nitrogen into ammonium.
- **Nitrification** - This is the process by which ammonium gets changed into nitrates by bacteria. Nitrates are what the plants can then absorb.

- **Ammonification** - This is part of the decaying process. When a plant or animal dies, decomposers like fungi and bacteria turn the nitrogen back into ammonium so it can reenter the nitrogen cycle.
- **Denitrification** - Extra nitrogen in the soil gets put back out into the air. There are special bacteria that perform this task as well.

Effects of human activities on the Nitrogen cycle

- Human activities such as fossil fuel combustion, use of artificial nitrogen fertilizers, and release of nitrogen in wastewater have dramatically altered the global nitrogen cycle.
- Adding large amount of nitric oxide (NO) by burning fossil fuel at high temperature, which help to create acid rain.
- Inorganic fertilizers can leach through soil and contaminate ground water.
- Adding nitrogen compounds to aquatic ecosystems from agricultural runoff and discharge of municipal sewage which may be harmful to that ecosystem.
- Destruction of forest, grass land and wetlands increase nitrogen at troposphere
- Removing nitrogen from topsoil by harvesting nitrogen-rich crops.
- Livestock waste and commercial inorganic fertilizers applied to the soil warm the atmosphere and deplete ozone in the atmosphere.