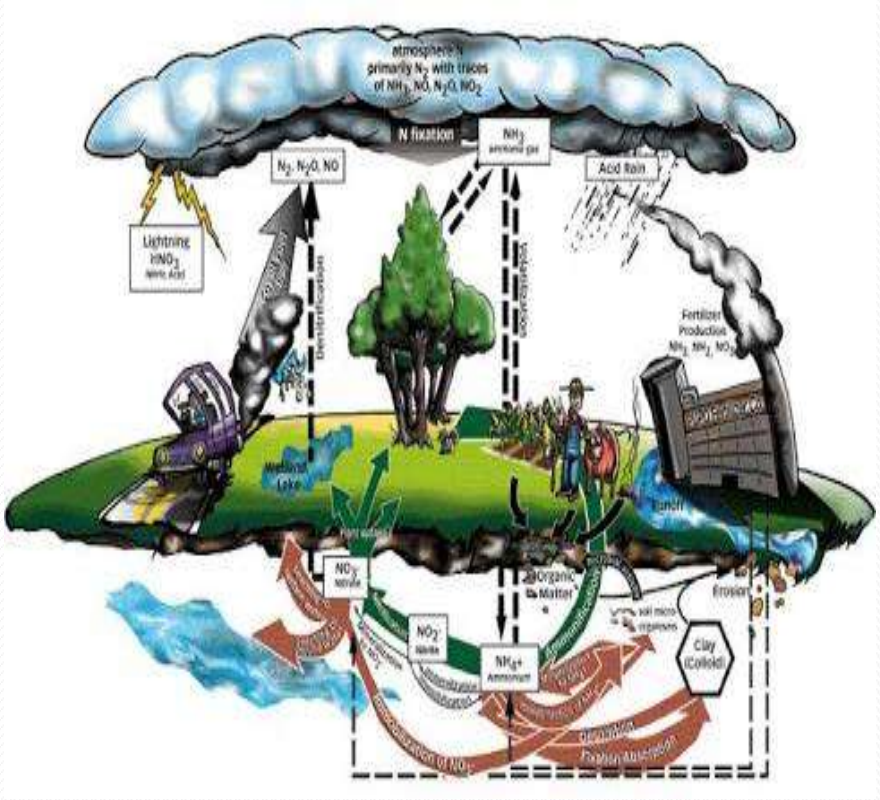
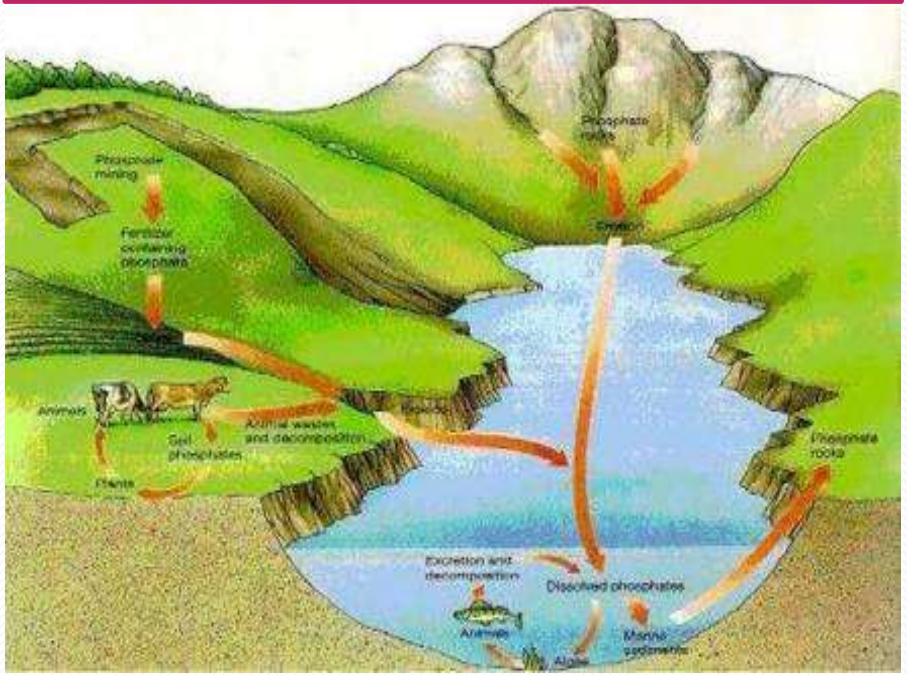
Biogeochemical cycle

NITROGEN CYCLE



PHOSPHORUS CYCLE



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INTRODUCTION

- The term biogeochemical tells us that **Biological**, **Geological** & **Chemical** factors are involved.
- In earth science, a biogeochemical cycle is a pathway by which a chemical substances moves through both Biotic(Biosphere) & Abiotic(Lithosphere, Atmosphere & Hydrosphere) compartments of earth.
- A cycle is a series of change which comes back to the starting point & which can be repeated.

DEFINITION – " **More or less circular pathways, through which the chemical elements, including all the essential elements of the protoplasm, circulate in the biosphere from environment to organisms and back to the environment, are known as the Biogeochemical cycle".**

- Biogeochemical cycles always involve Hot equilibrium states: A balance in the cycling of the elements between compartments.
- As biogeochemical cycles describe the movements of substances on the entire globe, the study of these is inherently multidisciplinary.

CYCLING ELEMENTS

- **Macronutrients** : required in relatively large amounts
  "Big six": **Carbon** , **Hydrogen** , **Oxygen** , **Nitrogen**, **Phosphorous.**

other **Macronutrients**:
Sulfur, **Potassium** , **Calcium** , **Iron** , **Magnesium**

- **Micronutrients** : required in very small amounts, (but still necessary)
  Boron
  Copper
  Molybdenum

TYPES OF BIOGEOCHEMICAL CYCLE

- Biogeochemical cycles can be classed as;

❖ **GASEOUS CYCLE** – The term gaseous cycle refers to the transformation of gases between various biogeochemical reservoirs; **Hydrosphere**, **Atmosphere** & **Biosphere** Important gaseous cycles are;

a) **NITROGEN CYCLE**

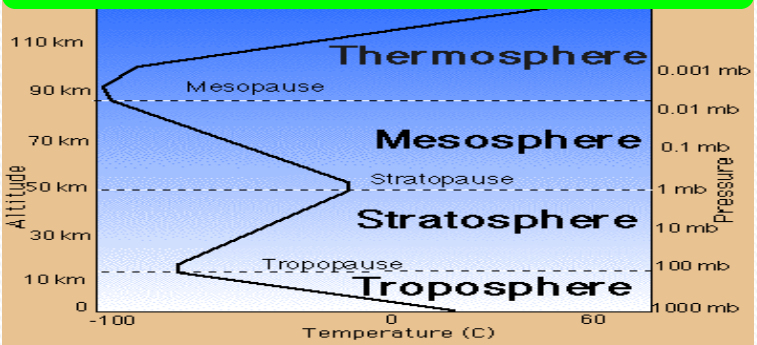
b) **OXYGEN CYCLE**

c) **CARBON CYCLE**

d) **WATER CYCLE**

HYDROSPHERE

ATMOSPHERE



- **SEDIMENTARY CYCLE** – Sedimentary cycles include the leaching of minerals & salt's from the earth's crust, which the settle as sediment or rock before the cycle repeats. Sedimentary cycle includes;

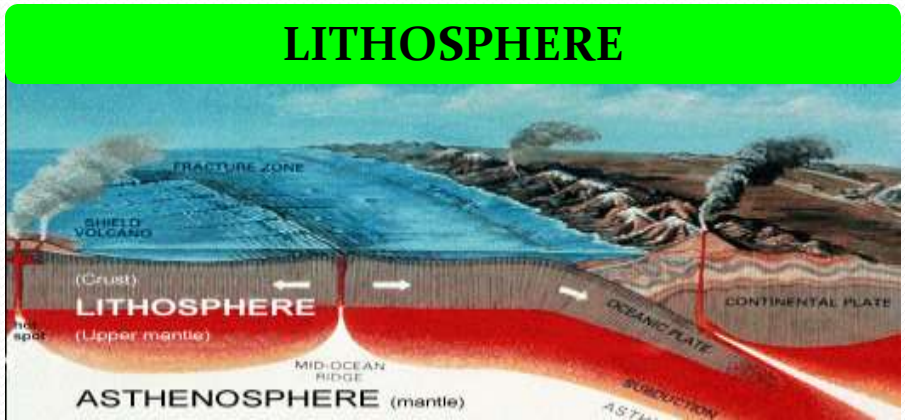
a) **PHOSPHORUS CYCLE**

b) **SULFUR CYCLE**

c) **IRON CYCLE**

d) **CALCIUM CYCLE**

- Sedimentary cycles vary from one elements to another, but each cycle consist fundamentally of a solution phase & a sediment phase.



NITROGEN CYCLE

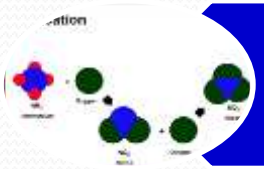
- The majority of earth's atmosphere is **Nitrogen(78%).** However, Atmospheric N_2 has limited availability for biological use, and this form is relatively nonreactive and unusable by plants.
- Nitrogen availability can affect the rate of key ecosystem processes including primary production and decomposition
- The Nitrogen(N_2) cycle is the process by which N_2 is converted between its various chemical forms.
- This transformation can be carried out through both biological & physical processes.

PROCESS OF NITROGEN CYCLE

- 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**.
- Organic nitrogen may be in the form of a living organism, humus or in the intermediate products of organic matter decomposition.
- The process of N2-cycle transform nitrogen from one form to another. Many of those processes are carried by microbes.

STEPS OF NITROGEN CYCLE

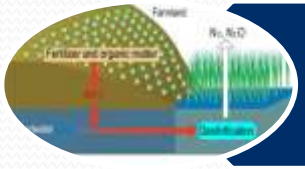
Nitrogen Fixation(N2 to NH_3/$NH4^+$ or No_3^-)



Nitrification (NH_3 to No_3^-)

Assimilation (Incorporation of NH_3 & No_3^- into biological tissues)

Ammonification (organic N2 compounds to NH_3)



Denitrification(No_3^- to N2)

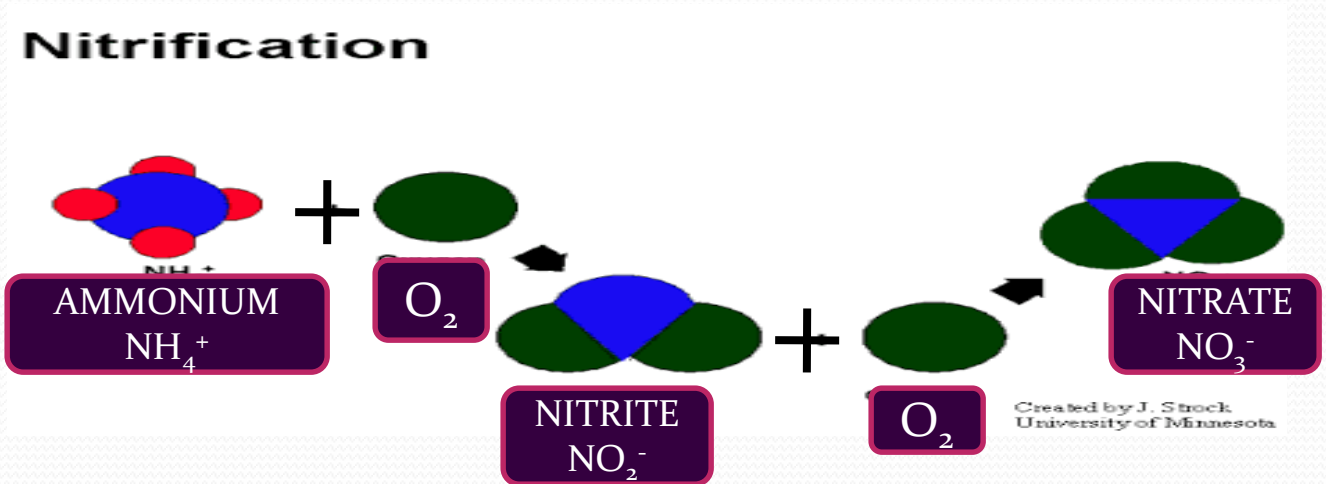
NITROGEN FIXATION

- Atmospheric nitrogen must be fixed in a usable form to be taken up by plants, mostly fixation is done by free living (eg. *Azotobacter* & *Closteridium* or symbiotic (*Rhizobium*) known as Diazotrophs.
- Symbiotic nitrogen- fixing bacteria such as *Rhizobium* usually live in the roots- nodules of legumes. Here they form a mutualistic relationship with the plant, producing ammonia in exchange for carbohydrates.
- Today about 30% of the total fixed N2 is produced industrially using the **Haber – Bosh process** which uses high temperature & pressure to convert nitrogen gas & a hydrogen source into ammonia.
- Biological nitrogen fixation can be represented by following equation;

$$N_2 + 8H + 8e^- + 16ATP = 2NH_3 + H_2 + 16\ ADP$$

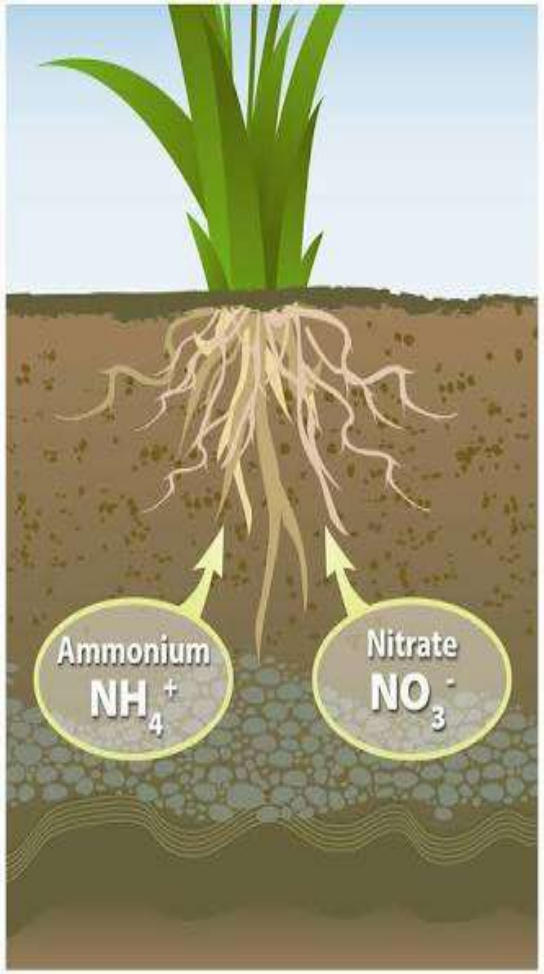
nitrification

- The conversion of ammonia to nitrate is performed primarily by soil living bacteria & other nitrifying bacteria.
- In the primary stage of nitrification the oxidation of ammonium is performed by bacteria such as the *Nitrosomonas* species, which convert ammonia to nitrites.
- Other bacterial species such as *Nitrobacter* are responsible for the **oxidation of the nitrite into nitrates**.
- It is important for the ammonia to be converted to nitrates or nitrites because ammonia gas is toxic to plants.



ASSIMILATION

- Plant take nitrogen from soil by absorption through their roots as **Amino acids**, **Nitrate ions**, **Nitrite ions**, or **Ammonium ions**.
- Plants can absorb nitrate or ammonium from the soil via their root hairs. If nitrate is absorbed, it is first reduced to nitrite ions and then ammonium ions for incorporated into amino acids, nucleic acids & chlorophylls.
- In plants that have a symbiotic relationship with Rhizobia, some N2 is assimilated in the form of ammonium ions directly from the nodules.



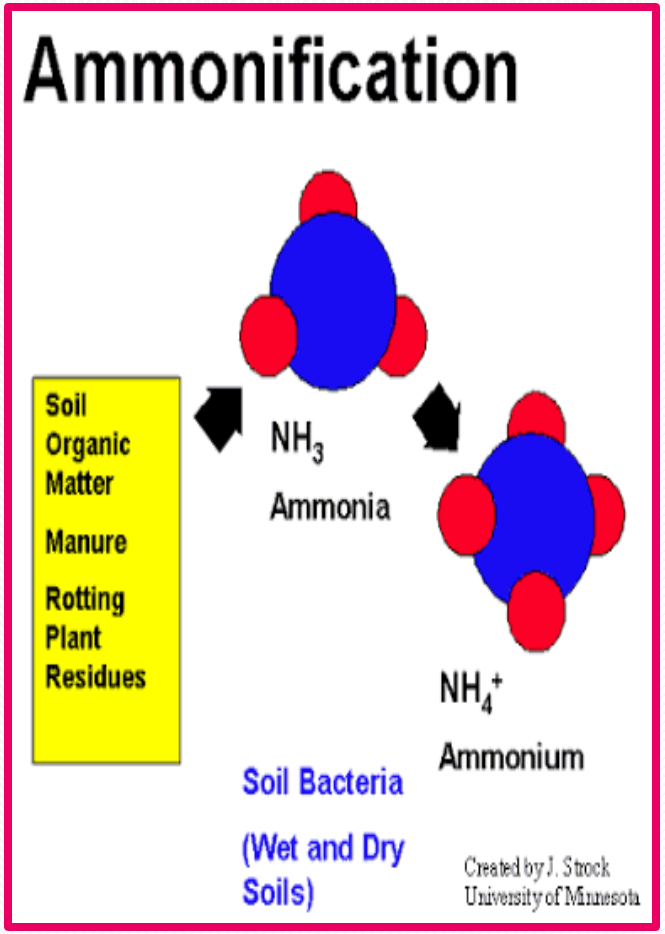
AMMONICATION

- When a plant or animal dies or an animal expels waste, the initial forms of N2 is organic.
- Bacteria or fungi convert the organic N2 within the remains back into ammonium, a process is called **Ammonification** or **Mineralization**
- Enzymes are involved are;

  GS : Gln synthetase

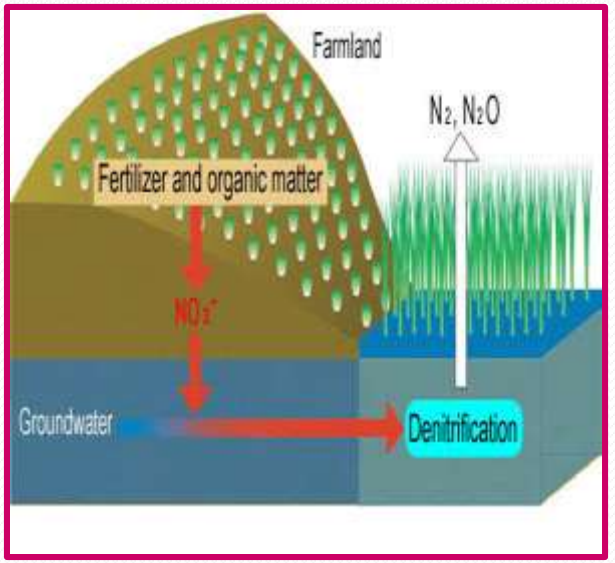
  GOGAT : Glu-2- oxoglutarate

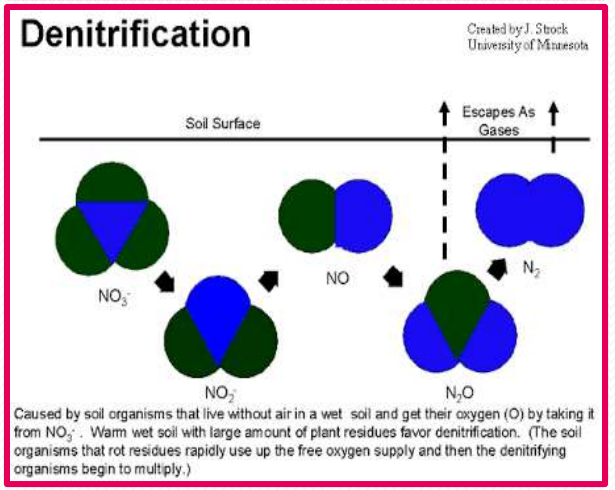
  GDH : Glu-dehydrogenase



DENITRIFICATION

- **Denitrification** is the reduction of nitrates back into the largely inert N2 gas, completing the **N2-cycle**.
- This process is performed by bacterial species such as *Pseudomonas* & *Clostridium* in **anaerobic conditions.**
- They use the nitrate as an electron accepter in the place of oxygen during respiration.
- **Denitrification** happens in anaerobic conditions eg. Waterlogged soils.



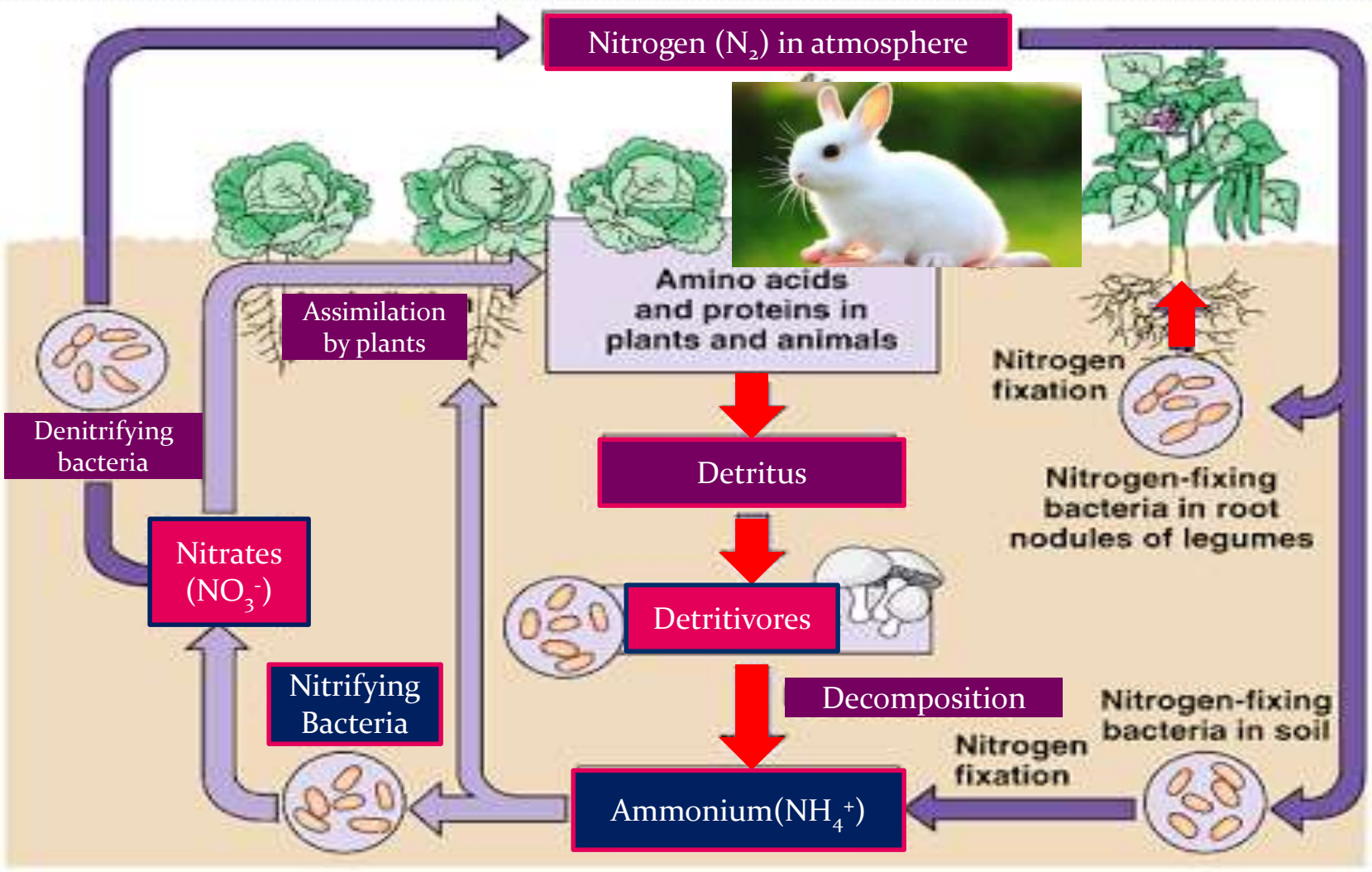


Denitrification Reaction Sequence

$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$

Nitrate — Nitrite — Nitric Oxide — Nitrous Oxide — Nitrogen Gas

NITROGEN CYCLE



ECOLOGICAL FUNCTION

- Nitrogen is necessary for all known forms of life on earth.
- It is a component in all amino acids as it is incorporated into proteins and is present in the bases that make up nucleic acids such as **RNA & DNA**.
- Chemical processing or natural fixation are necessary to convert gaseous nitrogen into compounds, such as nitrate or ammonia which can be used by plants.

USE OF NITROGEN

- Nitrogen is important to the chemical industry, It is used to make **Fertilizers**, **Nitric acid**, **Nylon**, **Dyes** & **Explosives**.
- Nitrogen is present in virtually all pharmacological drugs & In the form of nitrous oxide it is used as anesthetic.
- The CPUs in computers use the N2-gas to keep them from heating up. **X-ray detectors** also rely on this element.
- **Cryopreservation** also uses N2-gas to conserve blood & other biological specimen.
- The element is used in controlling pollution, many industries use it to destroy toxic liquids and vapors in industrial tools.

PHOSPHORUS CYCLE

- The phosphorus cycle is the **slowest Biogeochemical cycle** that describes the movements of phosphorus(**P**) through the **Lithosphere**, **Hydrosphere** & **Biosphere**.
- Unlike many other biogeochemical cycles, the atmosphere dose not play a significant role in the movement of **P** because phosphorus and **P** based compounds are usually solids at the typical ranges of temperature & pressure found on earth.
- Low conc. of **P** in soils reduces plant growth & slows soil microbial growth.
- Unlike other cycles P cannot be found in the air as a gas, it only occurs under highly reducing conditions as the gas **Phosphine.**

PROCESS OF PHOSPHORUS CYCLE

- Initially , phosphate weathers from rocks and minerals, the most common mineral being **Apatite** .
- Overall small losses occurs in terrestrial environment by leaching erosion, through the action of rain.
- Weathering of rocks & minerals release phosphorus in a soluble form , where it is taken up by plants & it is transformed into organic compounds.
- The plants may then be consumed by herbivores and the phosphorus is either incorporated into their tissues or excreted.
- After death of animal or plant decays then phosphorus is returned to the soil where a large part of the P is transformed into insoluble compounds.
- Runoff may carry a small part of the P back to the ocean.

STEPS OF PHOSPHORUS CYCLE

Phosphate is released by the erosion of rocks.

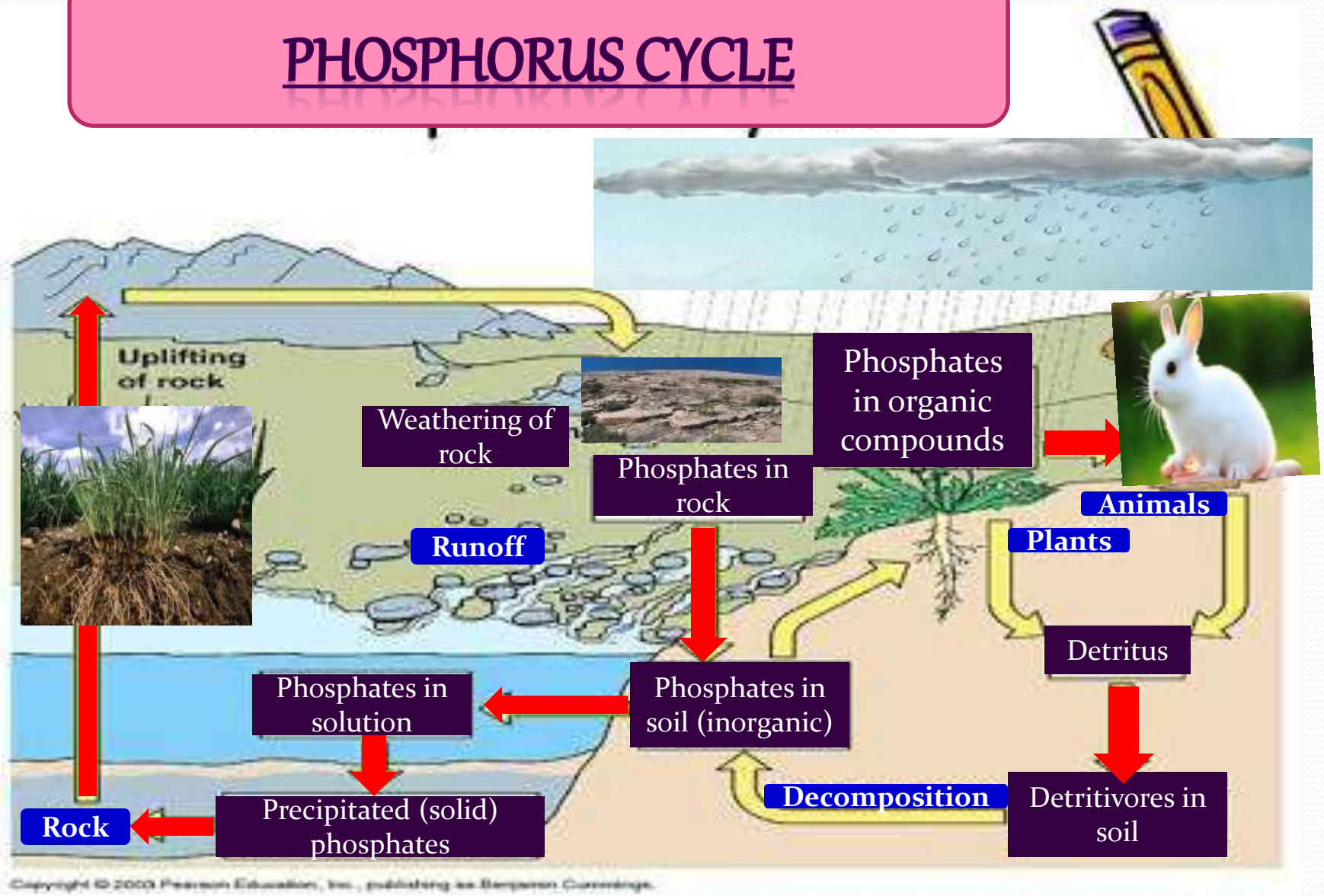
Plants and fungi take up the phosphate with their roots.

Phosphorus moves from producers to consumers via food chain.

Phosphorus may seep into groundwater from soil over time forming into rock.

When these rock erode, the cycle begins again.

PHOSPHORUS CYCLE



ECOLOGICAL FUNCTION

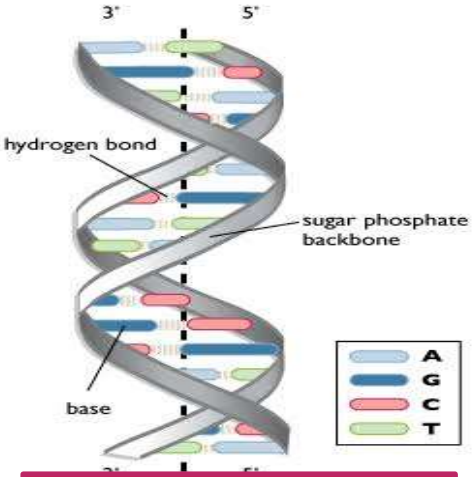
- **P** is an important nutrient for plants and animals, **P** is also limiting nutrient for aquatic organisms.
- **P** does not enter the atmosphere, remaining mostly on land, in rock & soil minerals.
- 80% of the mined **P** is used to make fertilizers. **P** from fertilizers, sewage can cause pollution in lakes & streams.
- **P** normally occurs in nature as part of a phosphate ion $(PO_4)_3^-$, The most abundant forms is **Orthophosphate**

FERTILIZER

IMPORTANCE OF PHOSPHORUS

BIOLOGICAL FUNCTION-

- The primary biological importance of Phosphates is as a component of nucleotides, which serves as energy storage within cells (ATP) or when linked together form the nucleic acids DNA & RNA.
- The double helix of two strands of DNA is only possible because of phosphate ester bridge that binds the helix.
- Besides making biomoleculs, P is also found in bone & enamel of mammalian teeth, whose strength is derived from calcium phosphate in the form of Hydroxyl apatite.
- It is also found in the exoskeloton of insects & phospholipids.



DNA STRANDS

BONES

OTHER USES

- Phosphorus catches fire readily, Red phosphorus is used in all matches.
- White phosphorus and zinc phosphate are mainly used as a poison for rats.
- It is used in making incendiary (fire causing) bombs, tracer bullets and for producing smoke screen.
- Many soluble phosphates are used to remove unwanted metal salts from the water.

TRACER BULLETS

CONCLUSION

- Biogeochemical cycles are important because they regulate the elements necessary for life on earth by cycling them through the biological & physical aspects of world.
- Biogeochemical cycles are a form of natural recycling that allows the continuous survival of ecosystem.

REFERENCES

- Ecology and Environment – P. D. SHARMA
- Biogeochemical cycle – Wikipedia, the free encyclopedia.
- E.P. Odum - Basic ecology

THANK YOU