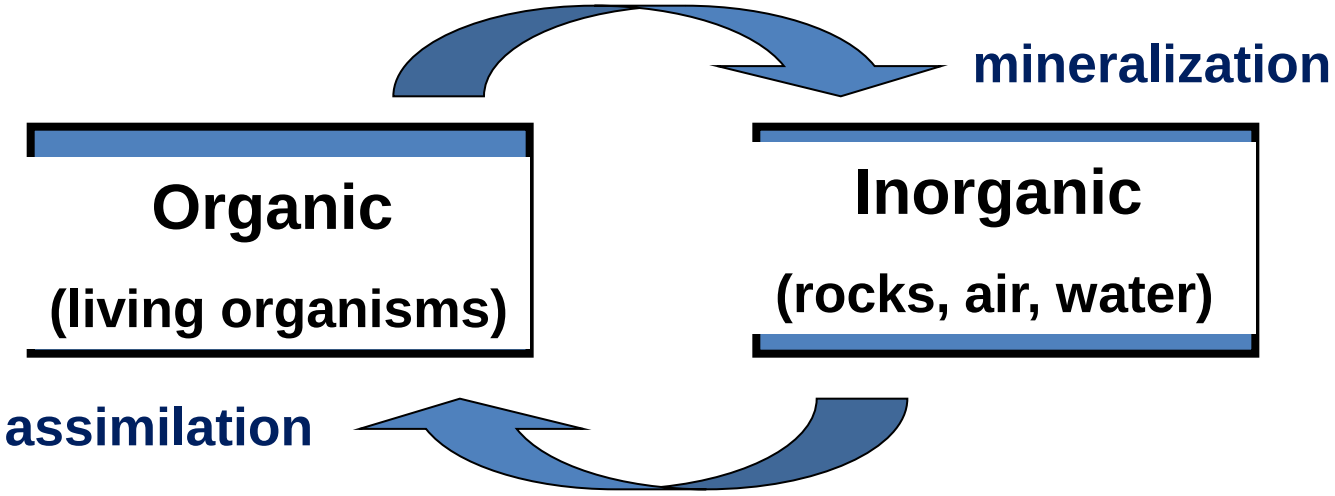
Role of microorganisms in the cycling of elements

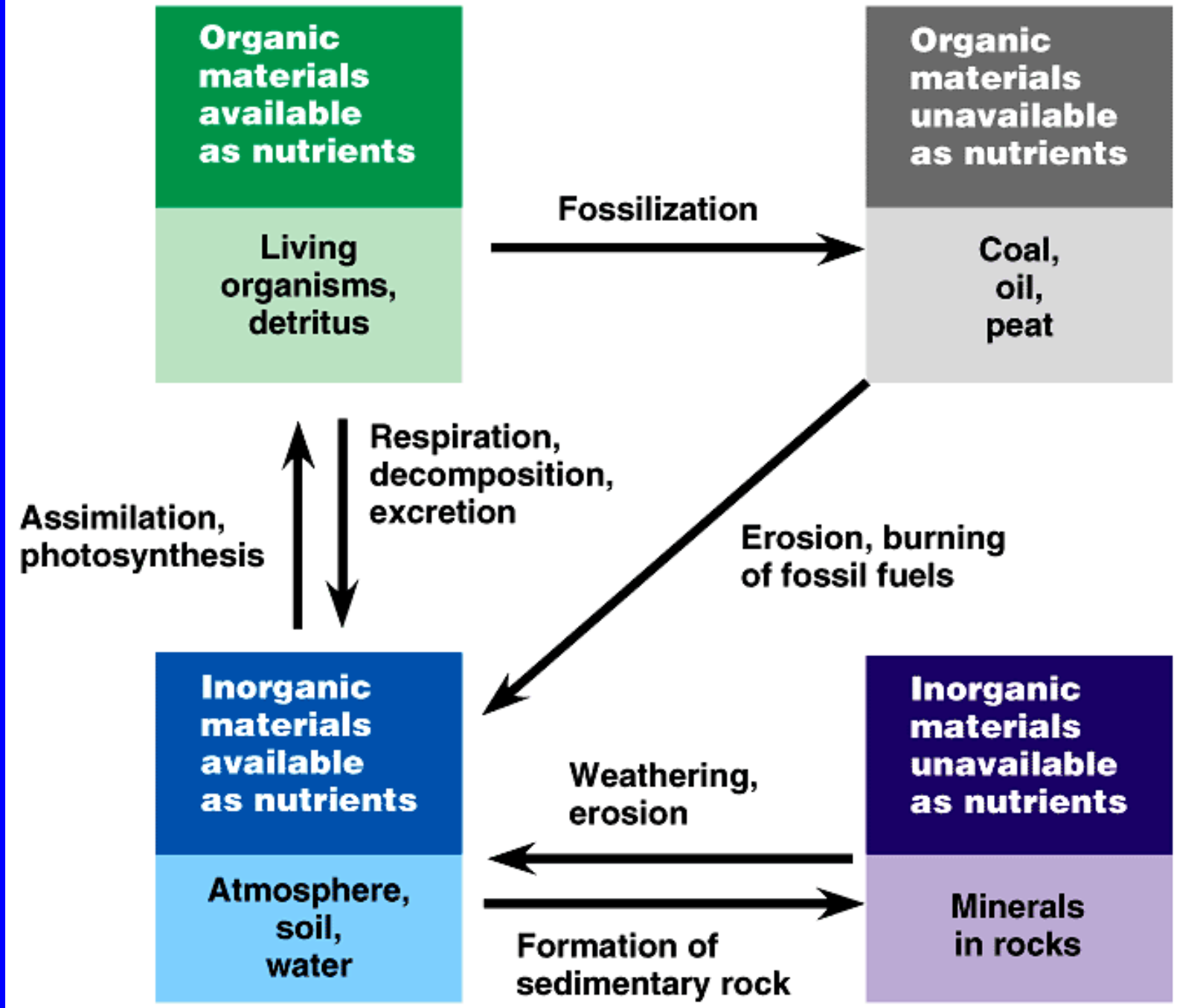
NUTRIENT CYCLING

- **Energy – 1-way flow**

  - eventually gets “lost”

- **Nutrients – cycle**





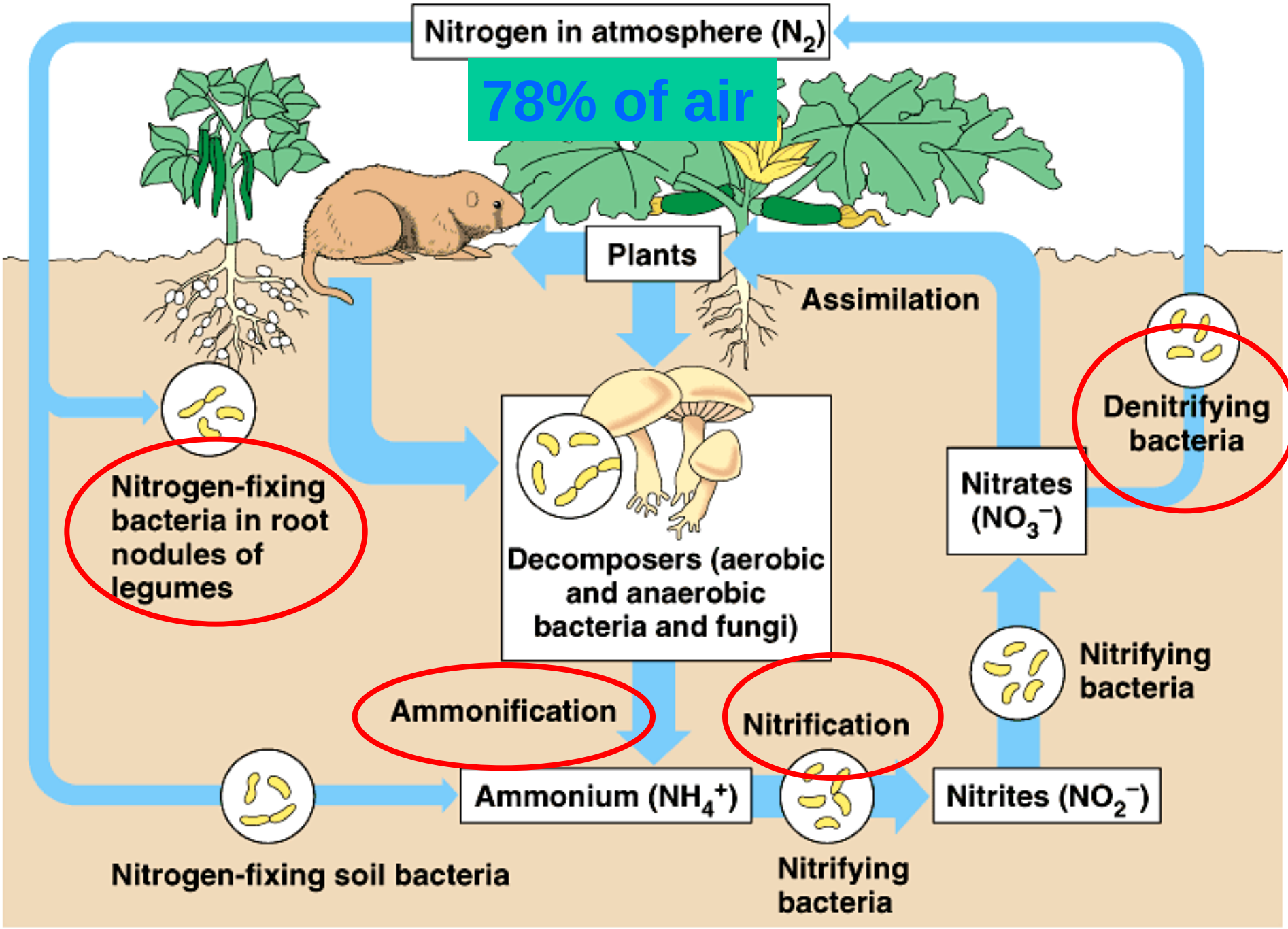
- **Decomposition , Photosynthesis are the two important process of an ecosystem**.
- Microorganisms depending on substrate specificity colonize the organic matter and decompose it.
- Organic matter serves in two ways - Provides energy for growth & carbon source (other products such as organic acids, carbon dioxide, methane, etc.)
- The process of conversion of substrate to protoplasmic carbon is known as **assimilation**.
- Accumulation of inorganic substance by the micro - organisms and making the plants, nutrient-deficient is known as **immobilization**.
- **Microbial succession occurs on the decomposing material till it fully disappears in elemental forms.**
- Events of sequential appearance of microorganisms on a substrate with respect to time is called succession.

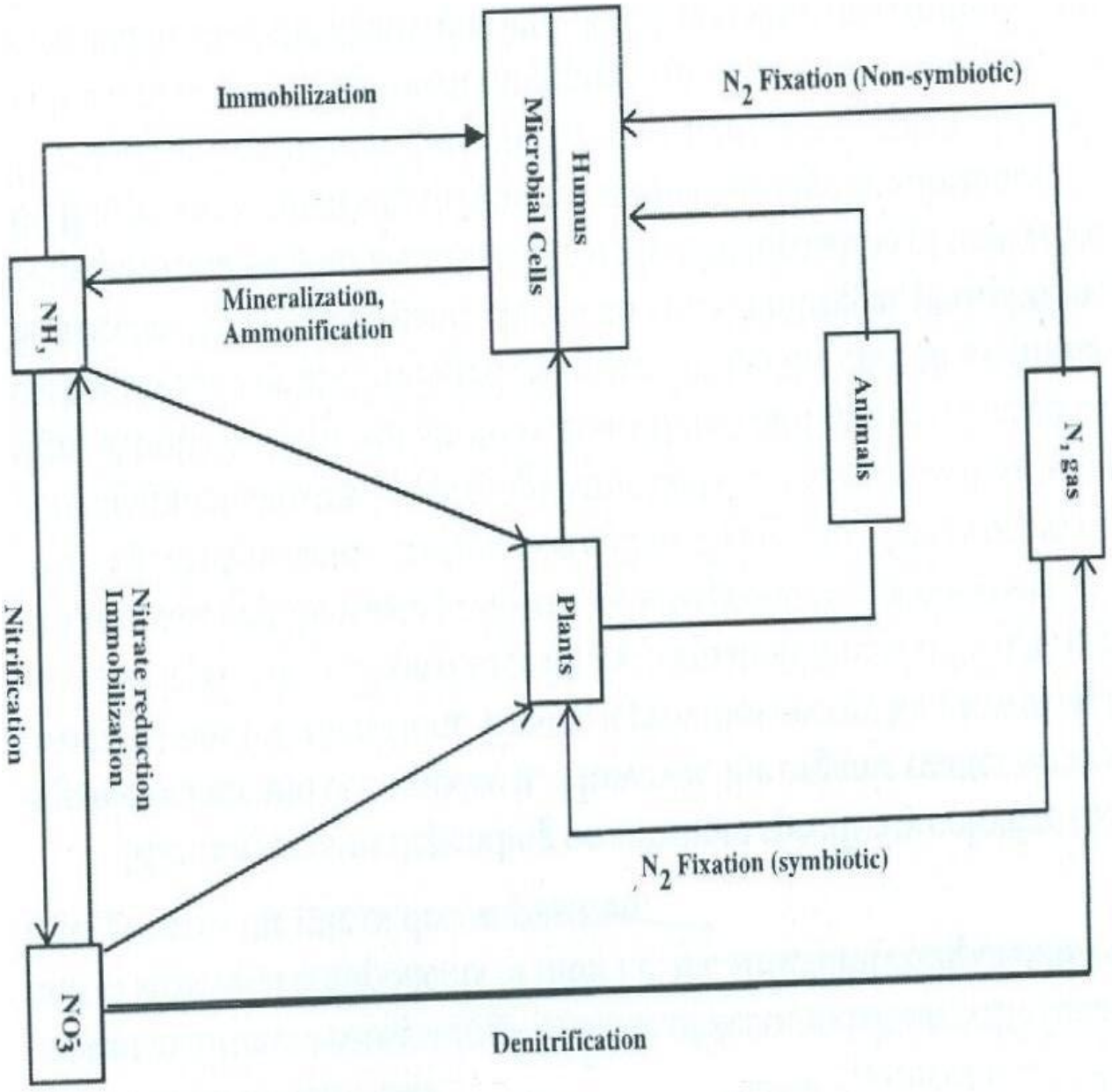
Biogeochemical cycle

- Biogeochemical cycling associated with microorganisms is very important for the maintenance of soil fertility.

Nitrogen cycle

- Nitrogen has the highest concentration in the atmosphere.
- Essential constituent of proteins and chlorophyll
- Key processes of cycling of nitrogen: nitrogen fixation, ammonification, nitrification and denitrification.




Immobilization
Microbial Cells
Humus
N_2 Fixation (Non-symbiotic)
NH_3
Mineralization,
Ammonification
Animals
N_2 gas
Plants
Nitrification
Nitrate reduction
Immobilization
N_2 Fixation (symbiotic)
NO_3^-
Denitrification

Nitrogen fixation

- Conversion of molecular nitrogen into a nitrogenous compound is known as nitrogen fixation.
- Nitrogen fixing microorganisms are called diazotrophs. Could be free living and symbiotic.

Ammonification

- Ammonification - organic nitrogen is converted to ammonia.
- Aerobic conditions: amino groups are removed from amino acids with the liberation of ammonia.

Nitrification

- Ammonia is oxidized to nitrate.
- First step, ammonia is oxidized to nitrite Nitrosofication.

$$2NH_3 + 3O_2 \rightarrow 2HNO_2 + 2H_2O$$

Nitrosomonas and *Nitrosococcus.*

- Second step: The nitrite is oxidized to nitrate

$$2HNO_2 + O_2 \rightarrow 2HNO_3 + 2H_2O$$

Nitrobacter.

Denitrification

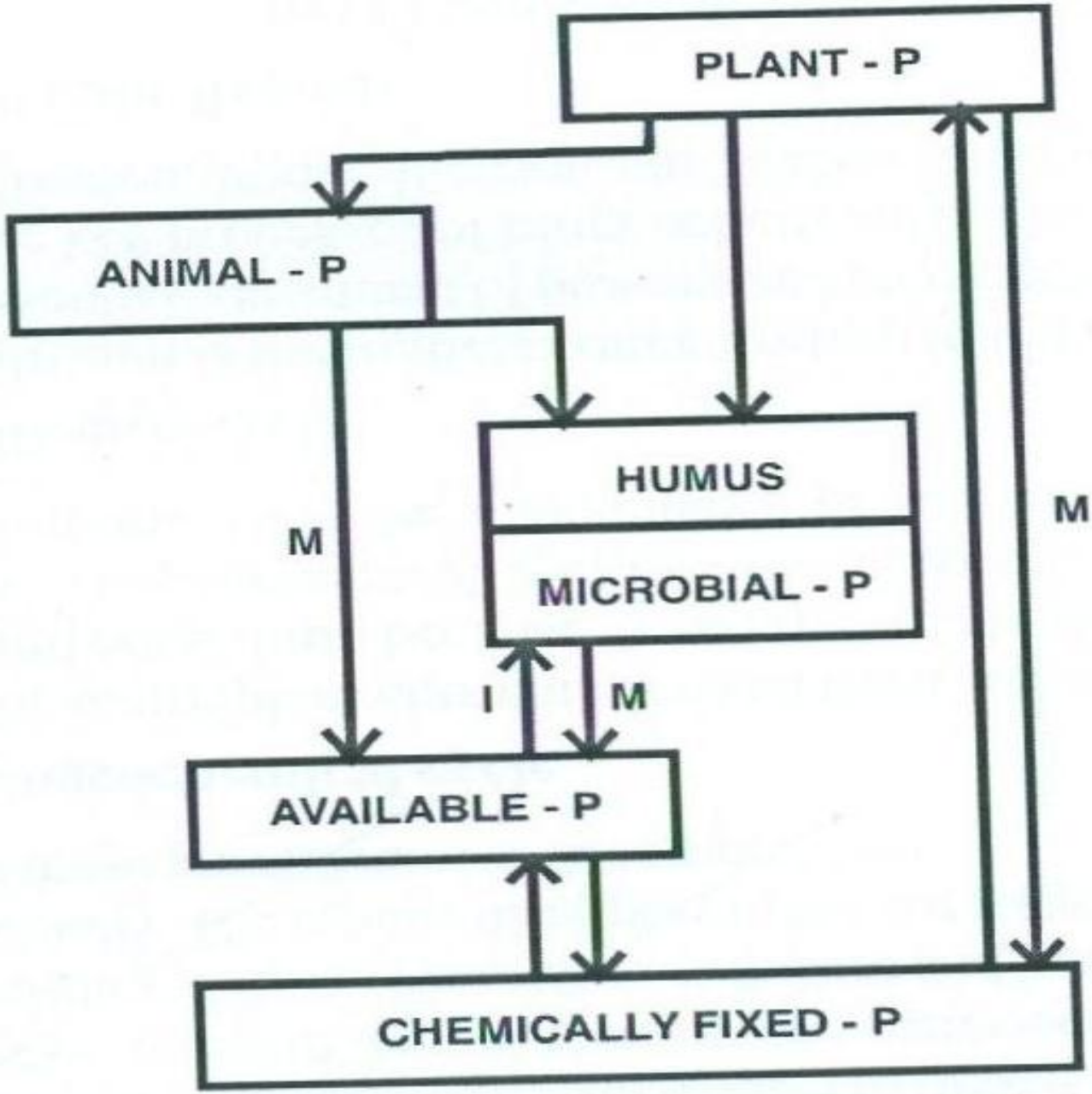
- Denitrification : Nitrates are reduced to nitrites to gaseous nitrogen

$$NO_3 \rightarrow N0_2 \rightarrow N_2O \rightarrow N_2$$

- Denitification occurs under anaerobic conditions
- *Thiiobacillus denitrificans, Micrococcus dentrificans* and *Clostridium* sp. etc are involved

Phosphorus cycle

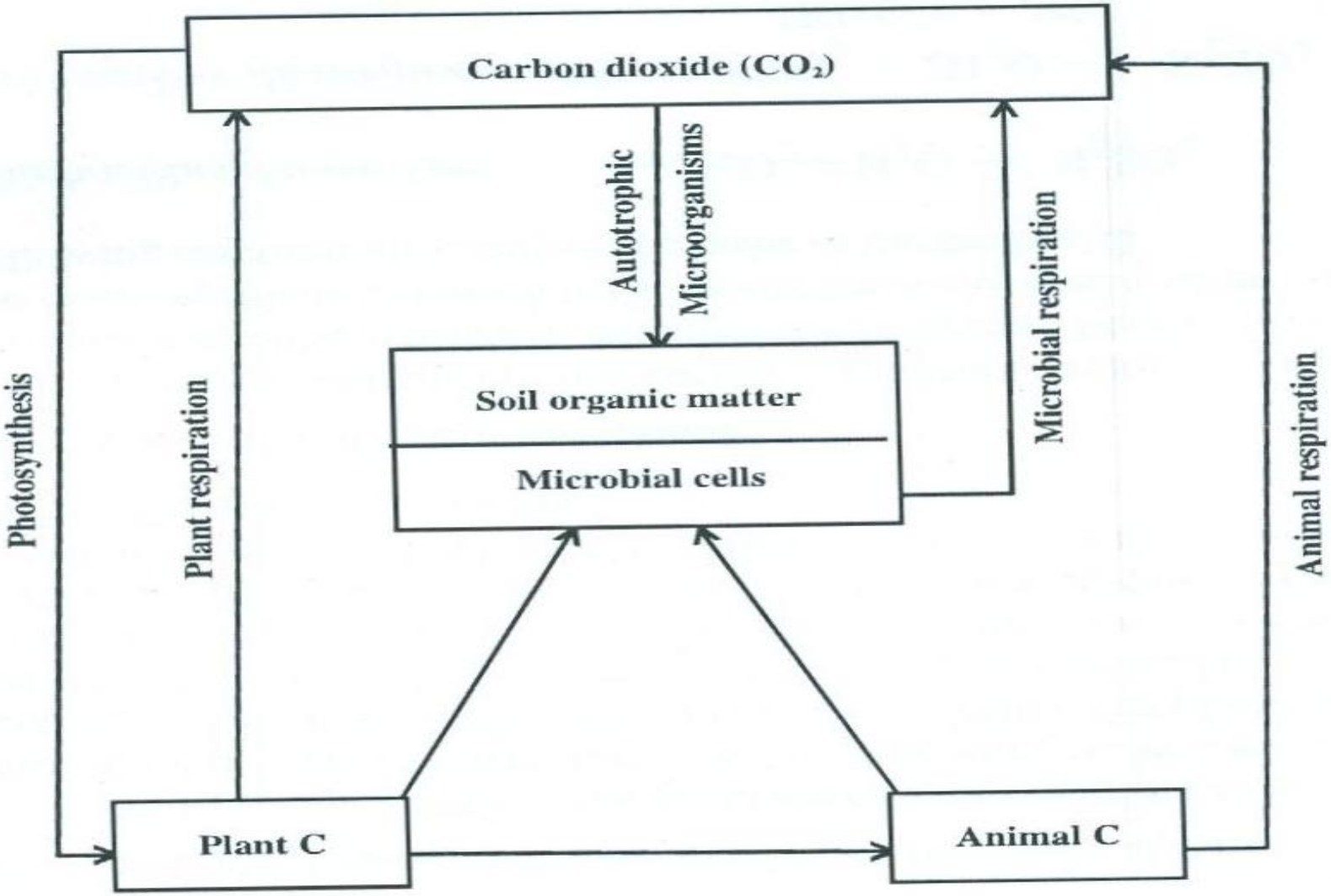
- Phosphorus : Mineral nutrient required for plants, animals and microorganisms.
- Microorganisms play a key role:
  (i) altering its solubility,
  ii) mineralization of organic phosphate into inorganic phosphate,
  (iii) oxidation and reduction of phosphorus compounds.
- Uptake of phosphate ions utilized for the synthesis of organic phosphates within the cell, thus a fraction immobilized.
- Upon death of plants , organic phosphate is rapidly released by enzymatic hydrolysis. Phosphate becomes limiting factor.
- **The availability of phosphates therefore depends on the degree of solubilization of insoluble phosphates by various organic and inorganic acids produced by microorganisms**.
- Soil microorganisms, fungi produce these acids and solubilize insoluble phosphates - available to the plants.
- *Bacillus, Pseudomonas, Micrococcus, Aspergillus, Penicillium* and *Fusarium.*



I - Immobilization; M - Mineralization

Carbon cycle

- Carbon exists in inorganic and complex organic compounds. In atmosphere of CO_2 is only 0.032 per cent .
- CO_2 returns back into the atmosphere through the process of respiration.
- Carbon degradation of organic matter by micro organisms.



The carbon cycle

Sulfur cycle

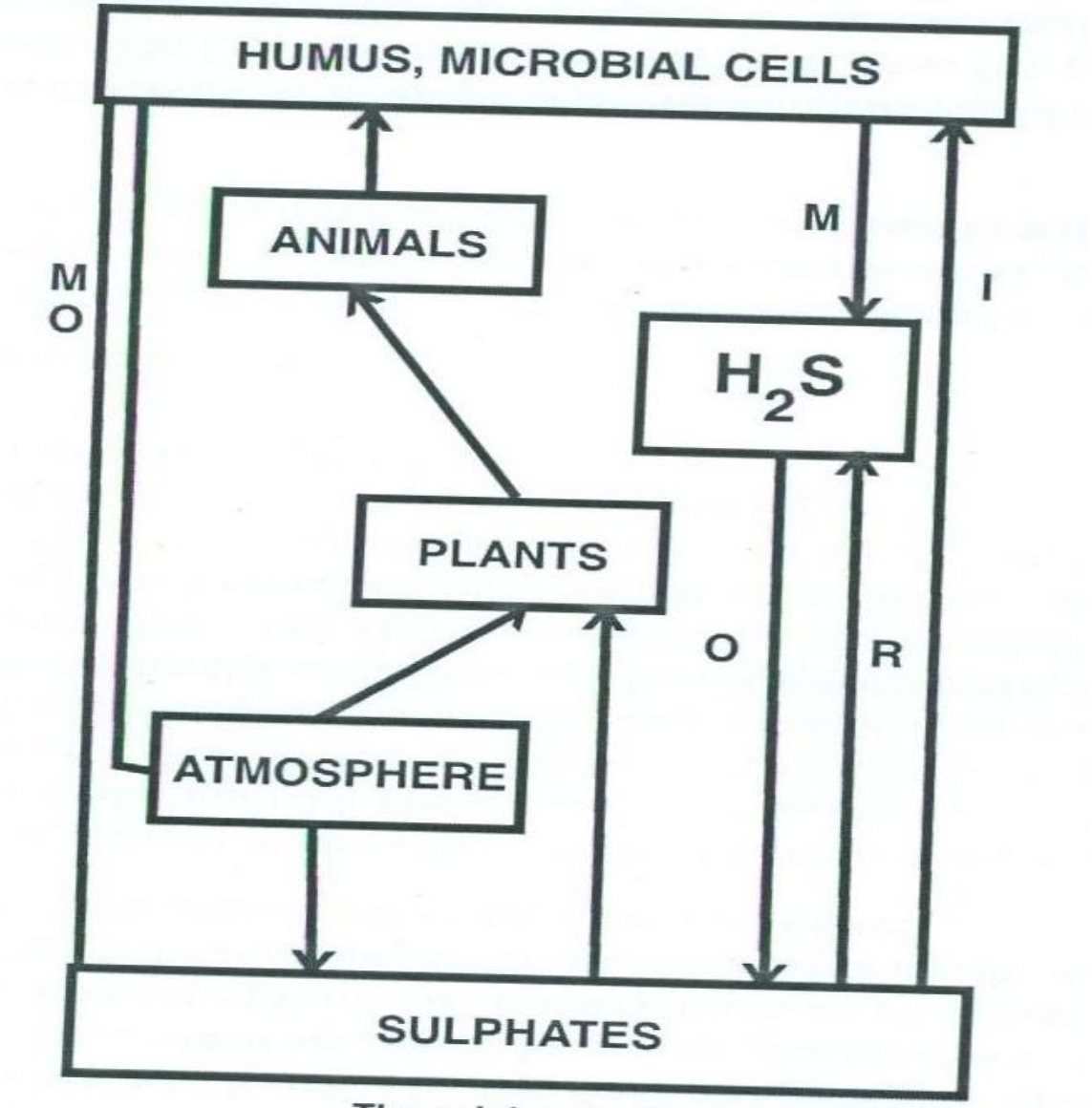
- Cyclic movements of sulfur between the living organisms and the environment sulfur cycle.
- Sulfur is an essential for all organisms
- Microbial proteins, aminoacids – cystine and methionine contain sulphur. In soil, it occurs both in inorganic and organic form
- Four distinct transformations are recognised;

  (i) decomposition of larger organic sulfur compounds to smaller units

  (ii) microbial immobilization

  (iii) oxidation of organic sulphides, thiosulphates and sulfur

  (iv) reduction of sulphates to sulphides.



The sulphur cycle
Mineralization I - Immobilization, O - Oxidation, R - Reduction

Decomposition of sulfur compounds

- Plants obtain their sulfur from sulfur compounds, animals feeding on plant materials sulfur is found mostly as a component of sulfur containing amino acids such as – cystine and methionine
- Dead organic matter contains large molecules.
- Decomposers excrete digestive enzymes.
- Enzymes convert large molecules into small ones.
- Sulfur to inorganic compounds H_2S and NH_3

Microbial associated assimilation or immobilization

- Sulfur in soluble form, mostly as SO_4, is absorbed through plant roots.
- Incorporated into amino acids and then to proteins.

Oxidation of sulfur compounds

- Some microorganisms oxidize reduced sulfur compounds.
- Sulfur oxidizers
- *Thiobacillus* catalysed by some of the thiobacilli.

Thiobacillus thiooxidans $S+1\frac{1}{2}O_2 + H_2O \rightarrow H_2SO_4$

Thiobacillus denitrificans $5S + 6KNO_3 + 2H_2O \rightarrow K_2SO_4 + 4KHSO_4 + 3N_2$

- Heterotrophic bacteria, actinomycetes, and fungi are also able to oxidize sulphur compounds.

Reduction of sulfur compounds

- Anaerobic conditions Sulphite is reduced to H_2S by sulfate reducing bacteria.
- *Desulfovibrio desulfuricans* seems to be the most important.
- Mechanism involves conversion of sulphate to sulphite, needs ATP.
- Sulphite is reduced to H_2S.
- $SO_4 \rightarrow S0_3 \rightarrow S_2O_3 \rightarrow S$