## 1-3: Biogeochemical cycles
## and Ecosystem homeostasis:……………………………Week 4

For a full understanding of ecosystem functions , we need some knowledge of the quantitative and energetic pathways within an ecosystem . A brief consideration of the cyclic passage of the key elements ( such as carbon , hydrogen , oxygen , nitrogen , phosphorus, and sulfur ) between the living and nonliving components of the ecosystem , is a logical starting point toward this understanding .

### Carbon cycle :

Carbon is a key element in all organic material . Carbon exists in the atmosphere as carbon dioxide , which is the form required in the photosynthesis ( Fig .4 ) . From plants , organic carbon may go into animals , and from either plants or animals it may re-enter the atmosphere as $CO_2$ through respiration and decomposition . Carbon tied up in hard parts of some animals , such as shells , will remain for a long time as marine deposits of animal inorganic carbonates . Limestone can result from marine deposits of animal inorganic carbonates as well as from inorganic precipitation of carbonates in water . These carbonates in limestone can then return to the carbon cycle only very slowly through a process of erosion and dissolution . Carbon may also in the form of organic deposits in coal and petroleum until released in burning .

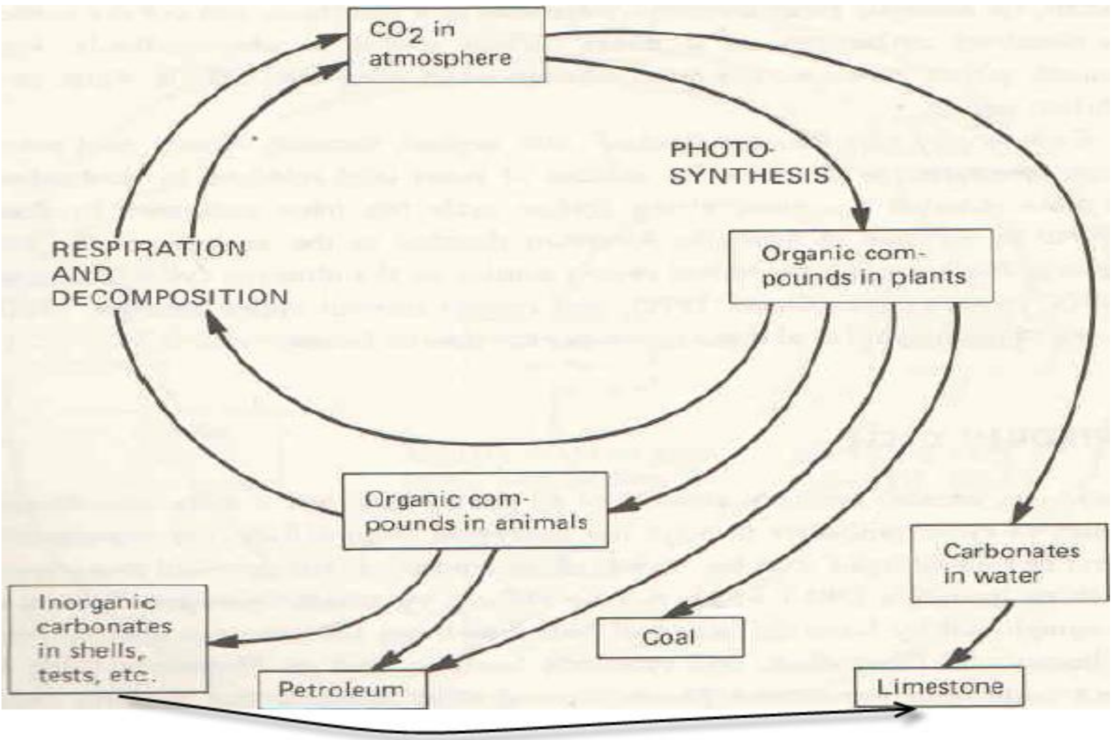


**Fig . 4 : Carbon cycle**

## Nitrogen cycle :

Nitrogen is an essential element of all protoplasm , particularly proteins . The atmospheric form of the free nitrogen must be fixed to $NH_3$ or $NO_3$ which can be utilized by plants(Fig.5). Nitrogen fixation is accomplished by bacterial action of both free – living *soil* bacteria such as *Azotobacter* and *Clostridium* and symbiotic bacteria such as *Rhizobium* living in root nodules of leguminous plants . Some blue – green algae such as *Nostoc* and *Anabaena* can also perform this process . Nitrogen fixation is also achieved as a physical process in the atmosphere by the ionizing effect of lightning and cosmic radiation , and it can be achieved industrially through the Haber and Bosch method . Plants incorporate fixed nitrogen into protoplasm by amino acid and protein synthesis . Organic nitrogen compounds of plants may incorporated then into animal protein through consumption and assimilation by animals .

In the decomposition through death and decay , ammonia ( $NH_3$ ) is produced from amino acids by the action of ammonifying bacteria such as *Pseudomonas* and *Proteus* . Under normal conditions, ammonia is quickly converted into nitrite form ( $NO_2$ ) by nitrite bacteria such as *Nitrosomonas* , and into nitrate form ( $NO_3$ ) by nitrate bacteria such as *Nitrobacter* . Nitrates are then absorbed directly by plants as basic nutrients . Nitrogen is returned to its atmospheric form by the action of denitrifying bacteria such as *Pseudomonas* and *thiobacillus*

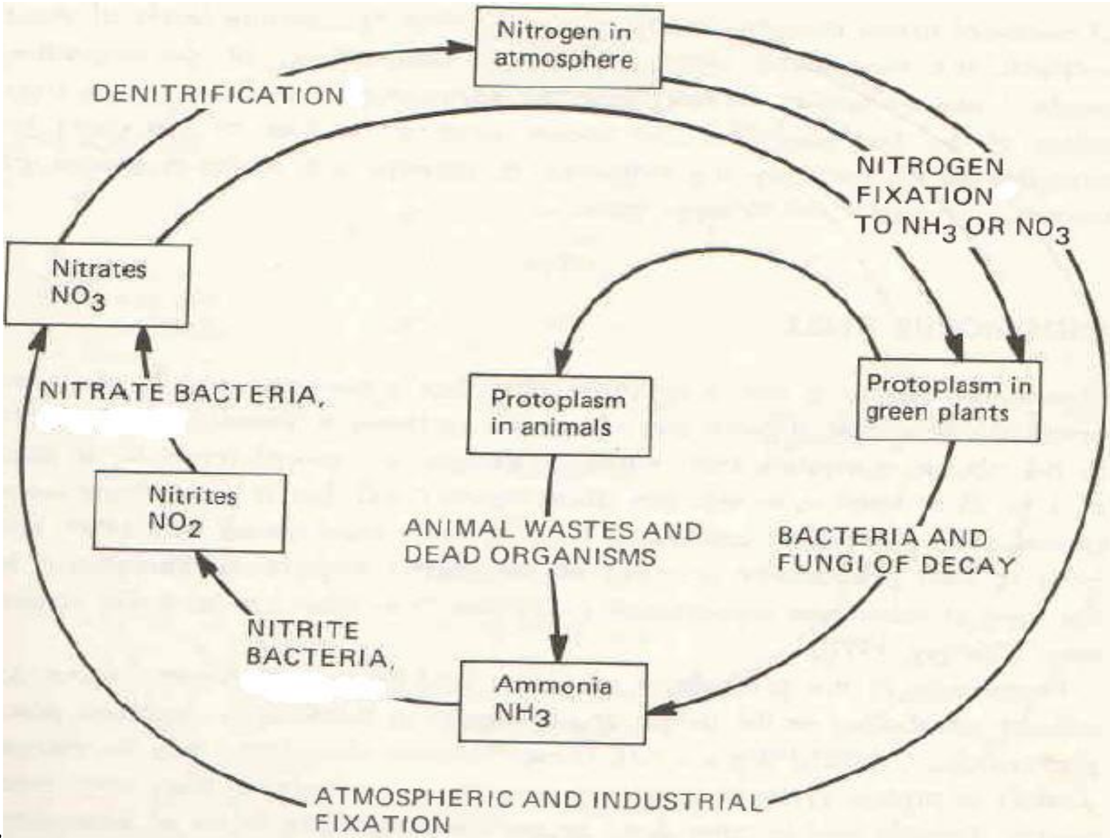


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**Fig . 5 : Nitrogen cycle**

## Phosphorus cycle :

Phosphorus plays an essential role in almost every step of organic synthesis , since it presents in ATP which is a universal fuel of living organisms . It is much less abundant in the abiotic component of the ecosystem than nitrogen ( 1 : 23 ) . It is more likely than almost any other element to limit productivity in many of the earth's ecosystems .

Phosphorus in the protoplasm of plants and animals is broken down by cellular metabolism or the action of phosphatizing bacteria to dissolved phosphates ( $CaHPO_4$ ) (Fig . 6 ) . These dissolved phosphates may be utilized directly by plants , or they may enter marine deposits and covert to relatively insoluble forms of phosphates rocks ( $Ca_3(PO_4)_2$ ) ,which is the greatest reservoir of phosphates in the world .In these insoluble forms , phosphorus may be released slowly to soluble forms by the action of dilute nitric acid formed during nitrification . In general , the loss of phosphorus to the ocean has been greater than the gain to land . A modern source of phosphorus is the common household detergents , which now enter waste water systems and are then released into aquatic ecosystems . The high phosphate content of these detergents can stimulate undesirable algal production , thus these detergents are usually a major components of pollution and eutrophication .

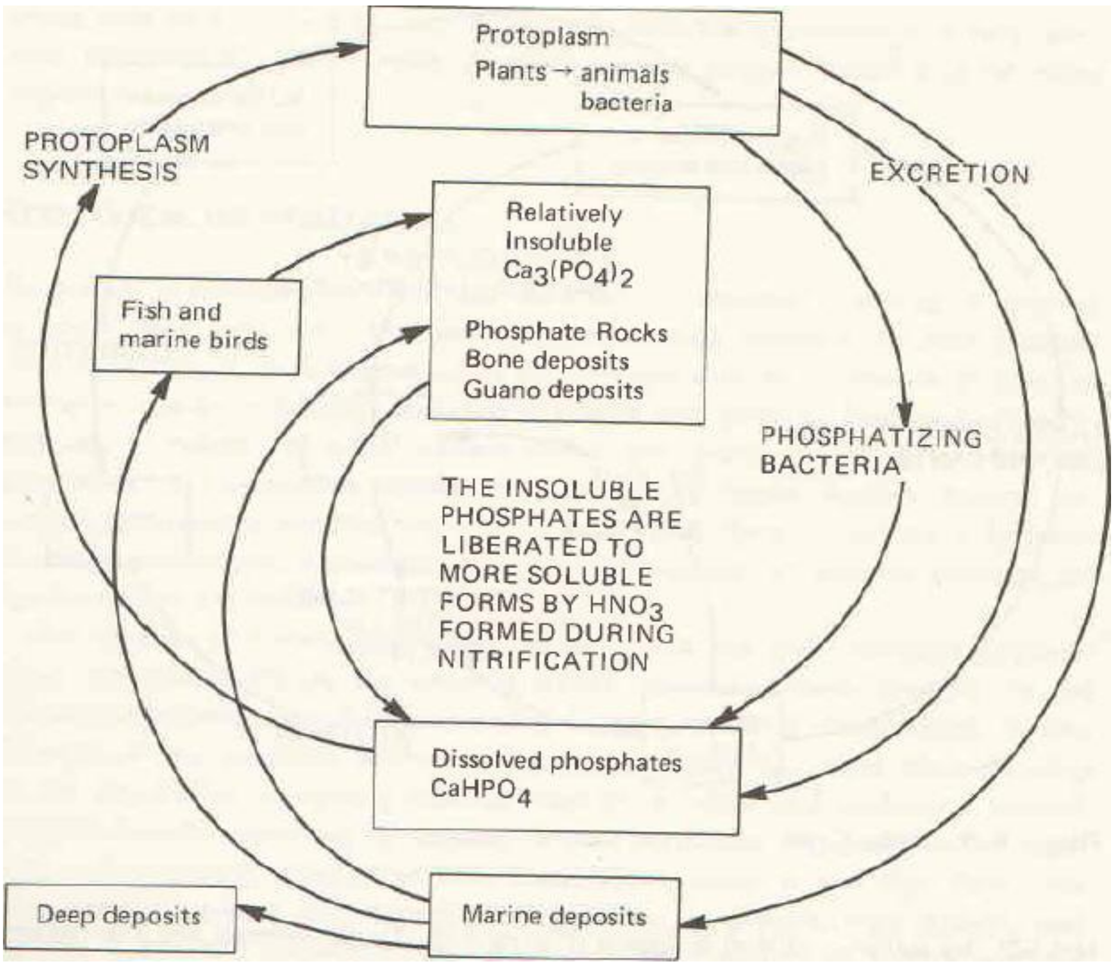


**Fig . 6 : Phosphorus cycle**

## Sulfur cycle :

Sulfur is an essential element in protein synthesis , since it provides a linkage between polypeptide chains in protein molecules . Life could not exist without sulfur . However **,** it is less likely to be limiting of ecosystem productivity than phosphorus .

Organic sulfur in plants and animals is decomposed to $H_2S$ by bacterial action , and the $H_2S$ is further oxidized to sulfates such as $NH_3SO_4$ by sulfur – oxidizing bacteria ( Fig . 7 ) . These sulfates are then taken up by plant as basic nutrients . Sulfur is also locked into coal and petroleum and is released as sulfur dioxide when these products are burned .

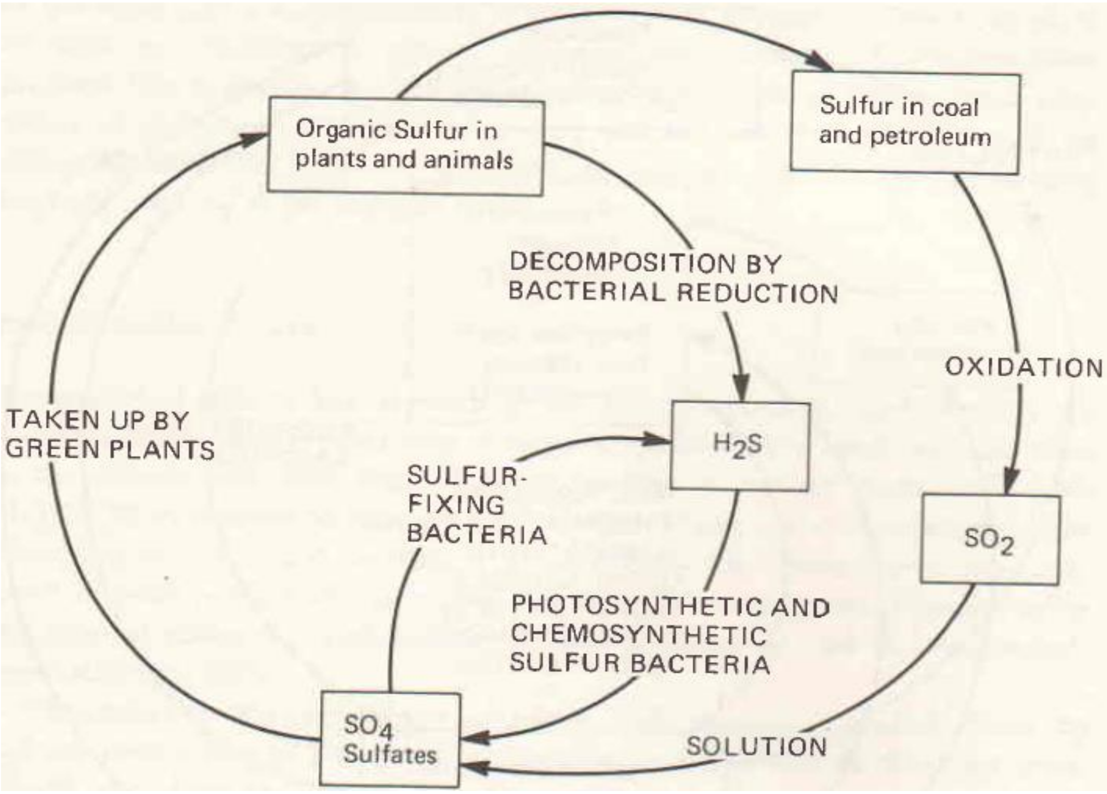


**Fig . 7 : Sulfur cycle**

## Ecosystem homeostasis :

**Ecosystem homeostasis is a technical term for the balance of nature .** It refers not only to a balance of species , as for example , a balance between predator and prey or host and parasite , but also a balance of basic nutrient cycles and energetic pathways within an ecosystem . **A homeostatic condition within an ecosystem indicates that all ecosystem functions are in balance . Thus , there would be a balance between production , consumption and decomposition , as well as between all species within the system .** The concept of ecosystem homeostasis helps us to understand processes of regulations within plant and animal communities and to clarify control mechanisms and ways of interaction between components of ecosystems .

**Many of the world's ecologic difficulties arise from upsets in natural homeostatic mechanisms in ecosystems . ecosystems have a certain amount of self-regulation within limits , but if these limits are exceeded , they may no longer be able to function and may undergo various patterns of change or breakdown . F**or example , in aquatic ecosystems a simple imbalance of production may cause great damage to the entire system . excessive nutrients received from sewage may cause excessive production of algae . If this production largely exceeds consumption by herbivores , it leads to harmful plankton blooms in which excessive decomposition becomes dominant . This decomposition may produce toxic products or it may consume available oxygen , so that fish and other aquatic animals die .

**As an example of ecosystem homeostasis** , there is a homeostasis involving carbon dioxide and oxygen in a balanced aquatic ecosystem , as follows ; an increase in water temperature in the springtime , which increases metabolic rate and respiration in aquatic plants and animals , results in an increase in carbon dioxide and a decrease of oxygen . The higher levels of free $CO_2$ and water temperatures stimulate more rapid photosynthesis and plant growth which utilizes the $CO_2$ and produce oxygen . Thus both $O_2$ and $CO_2$ tend to return to normal limits . If the temperature and metabolic rate declines , and all available free $CO_2$ is utilized in the water , then plant growth is limited until decomposition adds more $CO_2$ to the water .

**Man does not always desire a homeostatic ecosystem ,** since all agriculture practices , for example , are based on systems with more production than consumption . This can be considered either a nonhomeostatic system or an artificial homeostasis , which is highly unstable and needs protection . Thus , only by constant attention and control can the agricultural ecosystem be maintained in a productive state .