Biological Nitrogen fixation

Nitrogen is the greatest limiting factor after water for plant growth. In nature nitrogen is present in organic form as proteins and in many inorganic form as NH_3, NO_3^-. In atmosphere there is abundance molecular nitrogen.

The molecular nitrogen can not be directly used by the plant. It is either fixed industrially or biologically by micro-organism. About 95% of the natural fixation of nitrogen occurs through certain micro-organism i.e Biological nitrogen fixation. The process of nitrogen transformation is nitrogen fixation. The micro-organism remains in free living state or in Symbiotic association.

Non-Symbiotic bacteria :-

These bacteria live freely in the soil and fix atmospheric nitrogen from the air. The nitrogen combines with other element forming nitrogenous compounds. The common non-symbiotic bacteria are Azotobacter (Aerobic form) and closteridium (non-aerobic form).

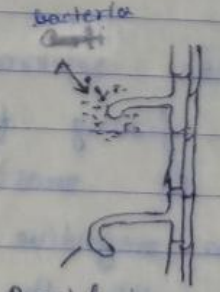
Symbiotic nitrogen fixing bacteria :-

There are several genera of symbiotic nitrogen fixing bacteria of which Rhizobium is most common. Rhizobium is a gram negative bacteria which forms association with the members of Fabaceae eg. Pea, Bean, Medicago etc. Recently, rhizobium has been reported is

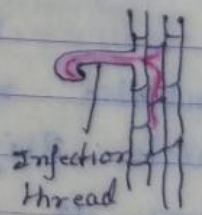
the nodules of Tarema aspera.

The nodules or the tubercles the home of million of bacteria have the ability to take up free nitrogen of the air and convert it into nitrogenous compounds. A part of the fixed nitrogen passes into the tissues of legume plants and a part diffuses into the surrounding soil.

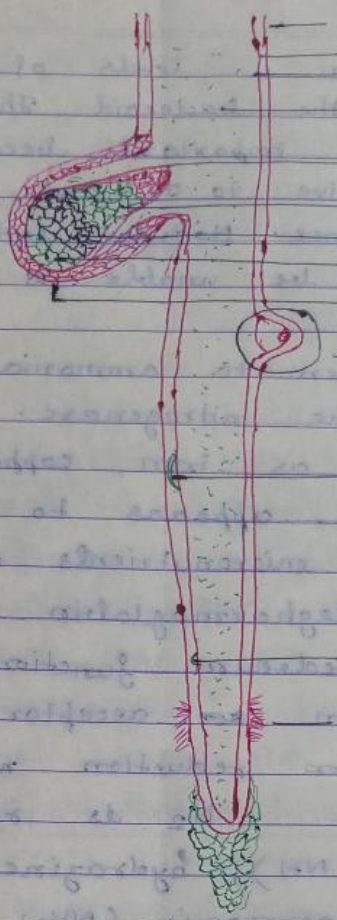
During infection of a root free living Rhizobium aggregate around root hairs. They penetrate by means of infection thread. Coincident with the passage of the thread, cortical cell division is stimulated of form the bulk of the eventual nodule tissue of polyploid cells. The infection thread usually terminales in a polyploid host cell. Many small groups bacteroids are also formed in the nodule cells. The bacteria utilize the carbohydrate and other food of leguminous plants. The bacteria utilize atmospheric nitrogen to synthesize Organic, nitrogenous compounds. Some of these nitrogenous compounds become available to the leguminous plant in which the bacteria is growing.



Root hair
Enterance of bacteria through root hair



Infection thread formed by bacteria.



Peneteration of rhizobia and formation of nodules.

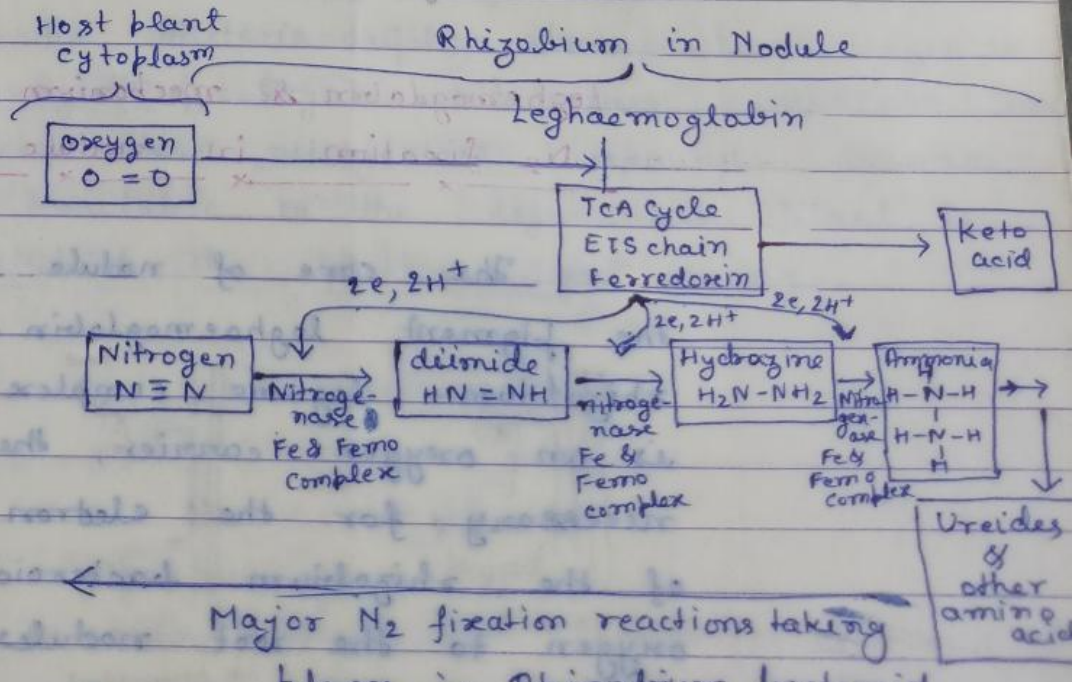
Leghemoglobin & mechanism of Symbiotic N_2 fixation in nodule.

The core of nodule is red due to the pigment, leghaemoglobin - a product of rhizobium - legume complex. Leghaemoglobin is an oxygen carrier, the oxygen is necessary for the electron transport chain of the rhizobium bacteroid. It provides oxygen to the root nodules bacteria quickly, even at very low levels of free oxygen. It is believed that the leghaemo-

globin levels of molecular oxygen low in the bacteroid. This function is particularly important because nitrogenase is sensitive to O_2 and loses activity in its presence. Nodules lacking leghaemoglobin may be unable to fix nitrogen.

The reduction of nitrogen to ammonia is catalyzed by the enzyme nitrogenase. Certain micronutrients such as iron, copper, cobalt and molybdenum appears to be essential. The first three micronutrients are required or contained in leghaemoglobin syntheris where as molybdenum functions atternately as an electron aeceptor and doner in the reduction nitrogen to ammonia.

N_2 is reduced to diimide ($HN=NH$), hydrazine (H_2N-NH_2) and then ammonia (NH_3) which may be outlined as follows —



Major N_2 fixation reactions taking places in Rhizobium bacteroid.

OR

Nogglo & Britz

$$N_2 \xrightarrow[+2H^+]{\text{Nitrogenase}} (NH=NH) \xrightarrow[\text{Diimide}]{+2H^+} (NH_2=NH_2) \xrightarrow[\text{Hydrazin}]{+2H^+} 2NH_3$$

Nitrogenase, Nitrogenase, Nitrogenase

Diimide, Hydrazin, Ammonia

The reduction of nitrogen into ammonia by the enzyme nitrogenase in bacteroids depend upon availability of ATP and reduced substrate. Capable of donating hydrogen atoms to nitrogen. ATP is generated in bacteroid respiratory chain system and reduced substrate is obtained from host-cells. Glucose 6 phosphate is considered to be the reduced substrate for the process and reduced NADP together with ferredoxin function as electron carriers.

Animals and plant proteins are decomposed by bacteria and amino acids are released which gives amonia by ammonifying bacteria.

Nitrogen convers in Soil

Oxidation of ammonia to nitrates in the soil may occur through autotrophic bacteria Nitrosomonas and Nitrobacter as follows —

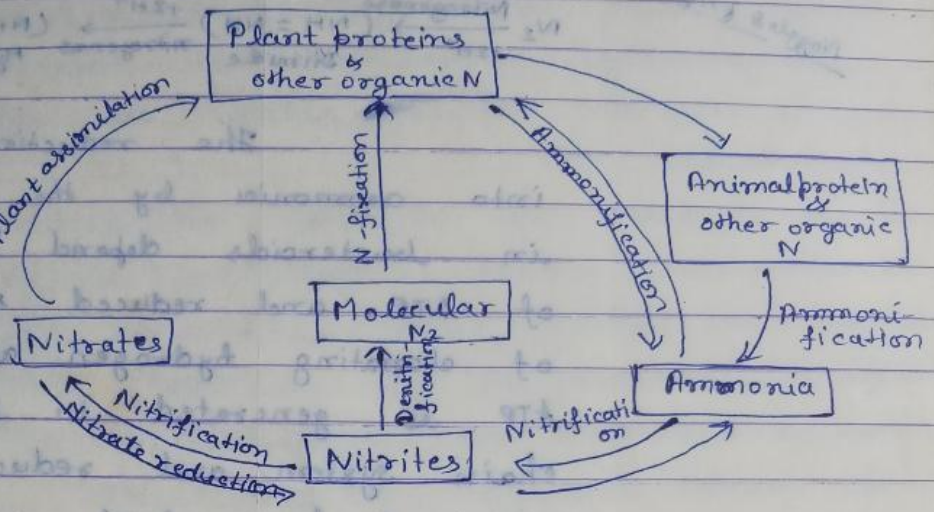
$$2NH_3 + 3O_2 \xrightarrow{\text{Nitrosomonas}} 2HNO_2 + 2H_2O$$

$$2HNO_2 + O_2 \xrightarrow{\text{Nitrobacter}} 2HNO_3.$$

The conversion of ammonia to nitrite and then to nitrate is called nitrification.

In denitrification, nitrate

is converted to nitrous oxide and then to N_2 gas. The cycle can be shown as follows —



The blue green algae are also nitrogen fixer. Perhaps, in not to distent future, cropping systems will be made up of culture of nitrogen-fixing algae and one crop plants.

Scientists are busy to transfer the nitrogen fixing gene (nif-gene) — unique inherent property of nitrogen fixation in certain microbes to the cereals, vegetables, fruit plants in order to enable the latter, to meet their assimiliable N requirement by their own.