Nitrogen-Fixing

The nitrogen-fixing mutualism (a symbiotic relationship that benefits both organisms) in legumes includes a modification of the plant to provide a location for the bacteria to colonize, grow, and most importantly to provide the special conditions to conduct the reactions involved in nitrogen fixation. The modified tissues, called nodules, occur on the roots and are large enough to be visible to the naked eye.

Manylegumes(alfalfa, clover, peas, beans, lentils, soybeans, peanut and others) contain symbiotic bacteria called *Rhizobia* within root nodules of their root systems. These bacteria have the special ability of fixing nitrogen from atmospheric, molecular nitrogen (N_2) into ammonia (NH_3). The chemical reaction is:

$$N_2 + 8H^+ + 8e^- \rightarrow 2NH_3 + H_2$$

Ammonia is then converted to another form, ammonium (NH_4^+), usable by (some) plants by the following reaction:

$$NH_3 + H^+ \rightarrow NH_4^+$$

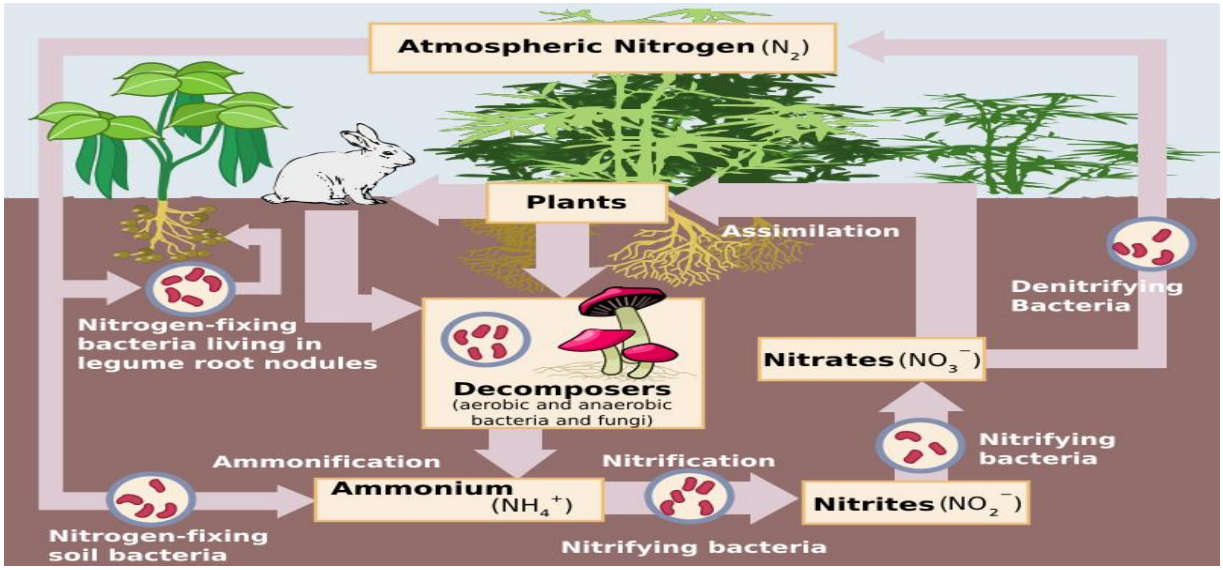
This arrangement means that the root nodules are sources of nitrogen for legumes, making them relatively rich in plant proteins. All proteins contain nitrogenous amino acids. Nitrogen is therefore a necessary ingredient in the production of proteins. Hence, legumes are among the best sources of plant protein.

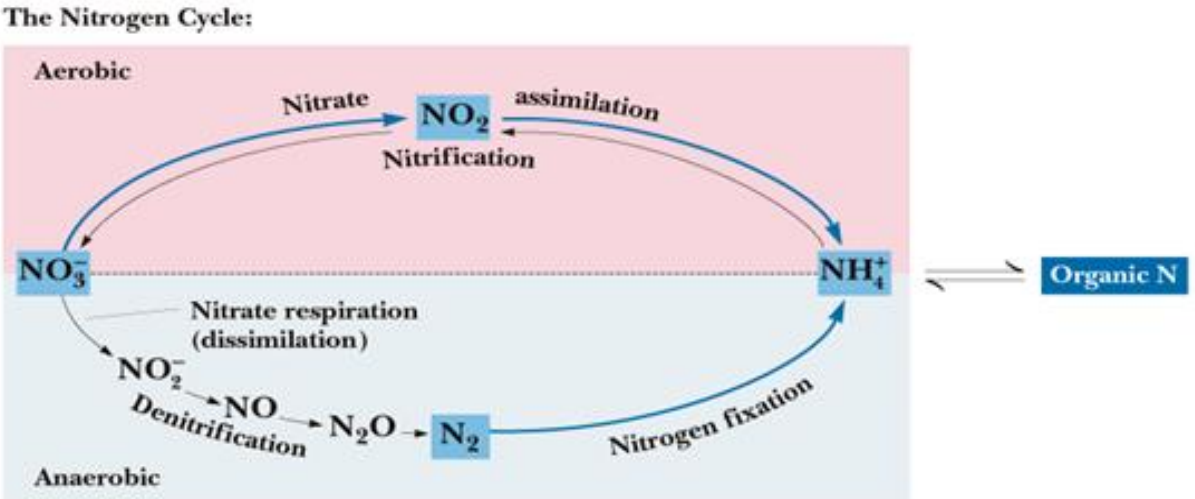
When a legume plant dies in the field, for example following the harvest, all of its remaining nitrogen, incorporated into amino acids inside the remaining plant parts, is released back into the soil. In the soil, the amino acids are converted to nitrate (NO_3^-), making the nitrogen available to other plants, thereby serving as fertilizer for future crops.

In many traditional and organic farming practices, crop rotation involving legumes is common. By alternating between legumes and non-legumes, sometimes planting non-legumes two times in a row and then a legume, the field usually receives a sufficient amount of nitrogenous compounds to produce a good result, even when the crop is non-leguminous. Legumes are sometimes referred to as "green manure".

Can we transfer N-fixation to other crops?

1. Morphological changes – development of nodule - critically important because need to exclude O_2
2. Host/symbiotic recognition
3. Chemical reactions to carry out N_2 fixation
4. Multiple genes, multiple chromosome locations, It has been a goal of researchers studying nitrogen fixation to create crops other than legumes that have the ability to carry out nitrogen fixation.
5. There are numerous morphological as well as chemical changes that must be made, and this will involve transferring multiple genes in such a fashion that they can continue to act together.





A review of the nitrogen cycle emphasizes the overall importance of nitrogen fixation that is associated with legume plants. Nitrogen fixation can be accomplished by **(1)** release of energy during lightning strikes; **(2)** bacteria, including those associated with legumes; **(3)** reactions carried out by people using energy from fossil fuels.

There are a number of strains of bacteria each of them regard to a particular crop or the number of legume crops; it can be divided into groups' as specialty Rhizobium type as in the Table below:

Group of legume crops	**Rhizobium type**	**Host type**
Broad bean and Vetch	*R. leguminosarum*	Broad bean, Lentil, Vetch, Peas
Alfalfa	*R. meliloti*	Alfalfa, Clover
Soybean	*R. japonicum*	Soybean, chickpea, Pea nut
Clover	*R. trifolii*	Different types of clover
Kidney bean	*R. phaseoli*	Kidney bean
Lupines	*R. lupini*	Different types of Lupines
Cow pea	*R. spp.*	Cow pea, Mung bean,

Factors affecting the nitrogen fixation

1. **Genetic factors:**

The process of nitrogen fixation occurs by the Nitrogenase enzyme which is controlled by nitrogen fixation gene (nif) to produce this enzyme.

2. **Environmental factors:**

a. C/N ratio: The increase of the proportion of nitrogen to carbon in the soil effect on the work of (nif) gene leading to reduce the effectiveness of the nitrogenase enzyme.
b. Mineral elements
c. Pesticides

3. **Temperature**. Optimum temperature for bacterial infection of the roots is 25 ° C, while optimum temperature for the process of nitrogen fixation is 25-28 ° C. When increasing the temperature to 30 ° C or fall to 15 ° C reduce nitrogen fixation speed to 20 and 40%, respectively.

4. **Drought or water stress**. The decrease in fresh weight of the bacterial nodes by 20% leads to stop the process of nitrogen fixation. If the plant over the stage of wilting, the bacterial nodes doesn't retrieved its activity even if watering the plant again, Due to the areas of separation in the channels connecting the cells of a single node.

   The reason for the decline in nitrogen fixation in plants exposed to a water stress is low carbohydrate processed for the bacterial nodes due to the decline of photosynthesis, decreased of respiration and the occurrence of some anatomical changes.

   The carbon dioxide: Usually atmosphere of nitrogen bacteria fixation contains the higher concentration of CO_2 and less concentration of oxygen compared with air. Rhizobium needs to the existence of concentration of CO_2 about 4% for the optimum growth.

5. **Availability of light and oxygen to plant**
6. **Inoculation**: It is necessary to treat legume seeds of bacterial vaccine in the case of it cultivate for the first time.