

Microbiology

- Azolla
- Rhizobium
- Blue green algae
- Mycorrhiza



AZOLLA

INTRODUCTION

- Azolla like many species of legumes, harbors a symbiotic micro-organism capable of reducing atmospheric nitrogen and supplying this fixed nitrogen to higher plants .
- **KINGDOM – Plantae**
- **CLASS - Polypodiopsida**
- **ORDER - Salviniiales**
- **FAMILY - Salviniaceae**

- Azolla is a genus of aquatic ferns in the family Salviniaceae .
- They are extremely reduced in form and specialized , looking nothing like other typical ferns but more resembling duckweed or some mosses .
- It is also called as Mosquito fern , Dairy fern , and Water fern .
- The prokaryote associated with azolla is blue green algae (Anabaena)

Nitrogen Fixation In Azolla

- The water fern azolla harbors nitrogen fixing cyanobacterium (Anabaena azolla) as symbiont in its dorsal leaves and is known as a potent N_2 fixer .
- Azolla fixes N_2 mainly in the paddy fields .





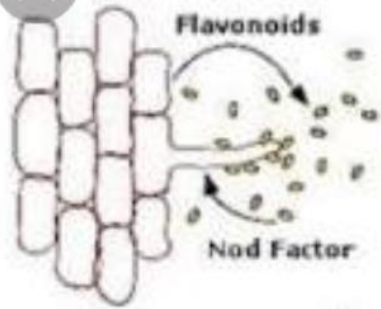
RHIZOBIUM

Rhizobium is a genus of Gram-negative soil bacteria that fix nitrogen. Rhizobium species form an endosymbiotic nitrogen-fixing association with roots of legumes and Parasponia.

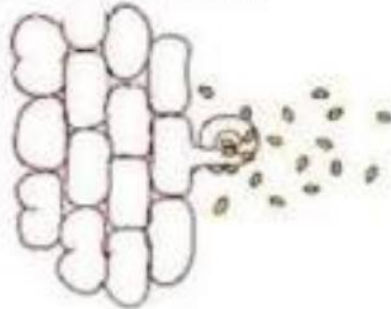


- ▶ The bacteria colonize plant cells within root nodules, where they convert **atmospheric nitrogen** into **ammonia** using the enzyme **nitrogenase** and then provide organic nitrogenous compounds such as glutamine to the plant.
- ▶ The plant, in turn, provides the bacteria with organic compounds made by photosynthesis. This mutually beneficial relationship is true of all of the rhizobia, of which the genus *Rhizobium* is a typical example.
- ▶ Biological N₂ fixation represents the major source of N input in agricultural soils including those in arid regions. The major N₂-fixing systems are the symbiotic systems, which can play a significant role in improving the fertility and productivity of low-N soils.

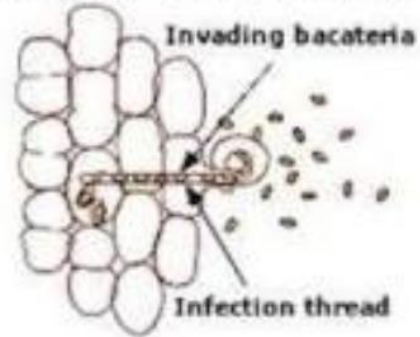
Chemical recognition.



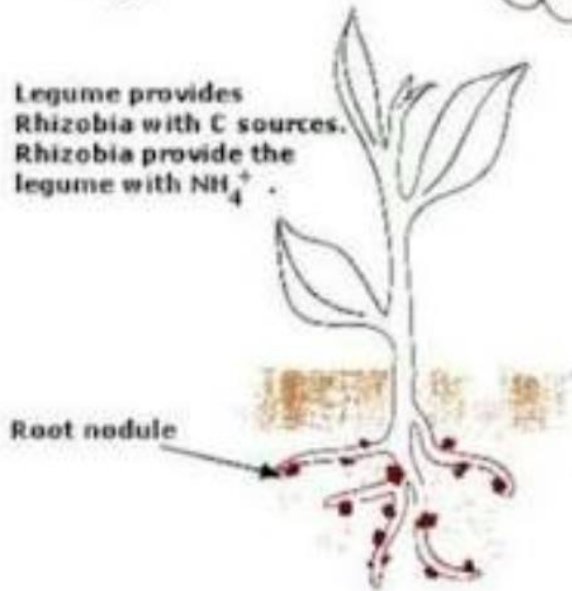
Deformation of root hair and root cell division.



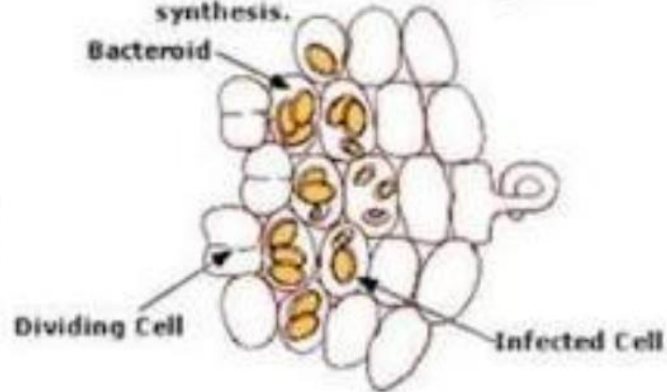
Formation of infection thread.



Legume provides Rhizobia with C sources. Rhizobia provide the legume with NH_4^+ .



Nodule tissue formation and bacteroid differentiation. Nitrogenase and leghemoglobin synthesis.

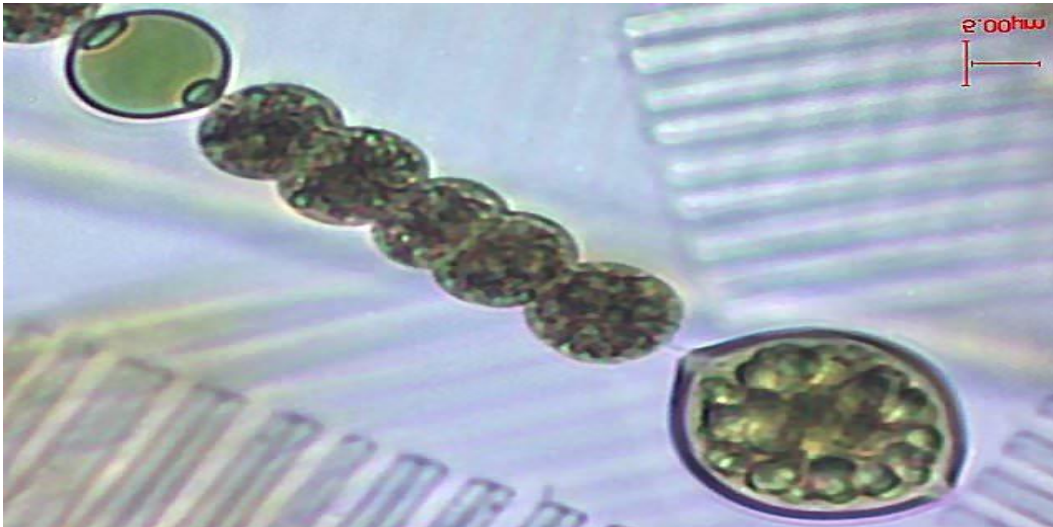




BLUE GREEN ALGAE

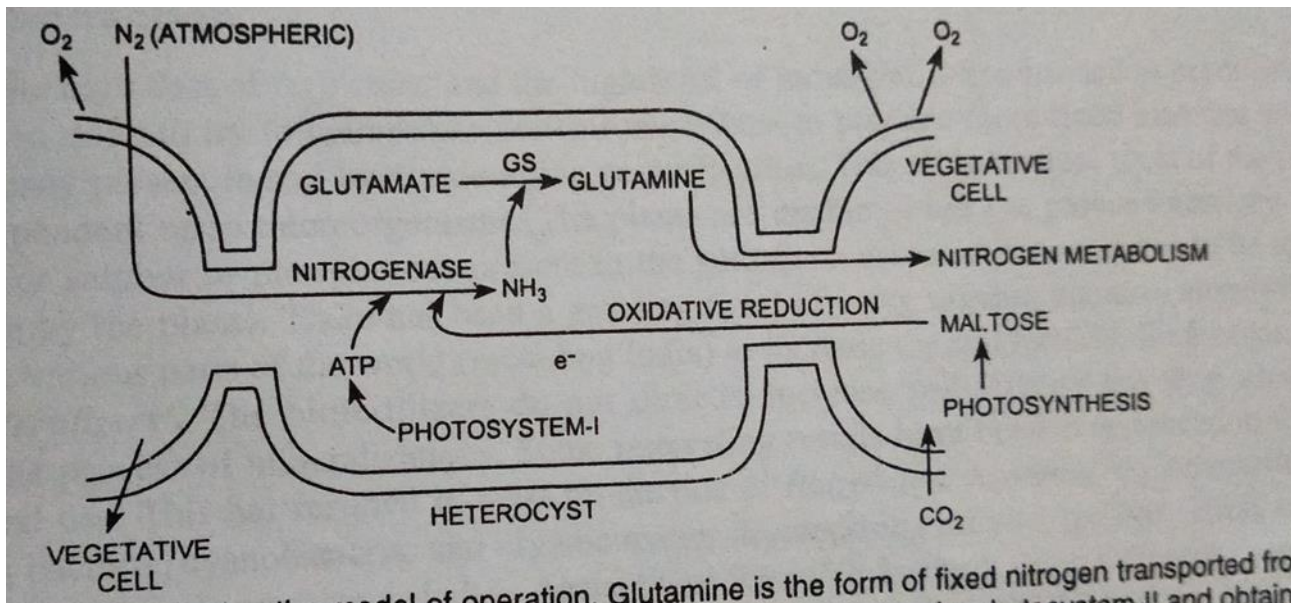
- ▶ The cyanobacteria are biochemically versatile organisms capable of using either autotrophically fixed or combined forms of C and N. This versatility is very useful for differentiation of symbiosis .
- ▶ In heterocysts of free-living cyanobacteria, glutamine synthetase (GS) is expressed along with nitrogenase and the product of primary assimilation of ammonium (glutamine) is exported to the vegetative cells
- ▶ When transferred into N-free medium, 5–10% of cells in the Nostoc or Anabaena filaments are differentiated into heterocysts that, like the rhizobial bacteroids, are devoid of reproductive ability.
- ▶ **Heterocysts** are enlarged and have thick walls blocking the oxygen diffusion inside the cells. Due to the arrest of photosynthesis, microaerobic conditions are reached inside the heterocysts permitting the nitrogenase synthesis.

- ▶ Some nitrogen-fixing cyanobacteria (Nostoc, Anabaena) form with various plants the symbioses that differ in many respects from the legume nodules. Many of these differences are caused by the ability of cyanobacteria to fix N_2 in free-living state and to support this fixation with products of their own photosynthesis



Heterocyst

- ▶ A range of differences between legume–rhizobia and plant–cyanobacteria symbioses were revealed with respect to structural and functional modifications of partners' cells .
- ▶ However, some general principles of their operation are evident too. In both, symbioses N₂ fixation is combined with photosynthesis resulting in integrated partners' C/N biochemical pathways.
- ▶ In both systems, energetic supply of the microbial N₂-fixing machinery as well as assimilation of its products are implemented mainly by the host plants.



Model of operation. Glutamine is the form of fixed nitrogen transported from the heterocyst to the vegetative cell and obtained