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Nitrogen fixation

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Nitrogen fixation

is a process by which molecular nitrogen in the air is converted into ammonia (NH_3) or related nitrogenous compounds in soil. Atmospheric nitrogen is molecular nitrogen , a relatively nonreactive molecule that is metabolically useless to all but a few microorganisms. Biological nitrogen fixation converts N_2 into ammonia , which is metabolized by most organisms.

Nitrogen fixation is essential to life because fixed inorganic nitrogen compounds are required for the biosynthesis of all nitrogen-containing organic compounds , such as amino acids and proteins, nucleoside triphosphates and nucleic acids. As part of the nitrogen cycle, it is essential for agriculture and the manufacture of fertilizer . It is also , indirectly, relevant to the manufacture of all nitrogen chemical compounds, which includes some explosives, pharmaceuticals and dyes.

Nitrogen fixation is carried out naturally in soil by microorganisms termed diazotrophs that include bacteria such as *Azotobacter* and archaea . Some nitrogen-fixing bacteria have symbiotic relationships with plant groups , especially legumes. Looser non-symbiotic relationships between diazotrophs and plants are often referred to as associative , as seen in nitrogen fixation on rice roots. Nitrogen fixation occurs between some termites and fungi . It occurs naturally in the air by means of NOx production by lightning.

All biological nitrogen fixation is effected by enzymes called **nitrogenases**, which actually an enzyme complex consisting of dinitrogenase reductase and dinitrogenase , which are highly conserved, O_2-sensitive enzymes working in tandem to reduce N_2. Nitrogenase is somewhat nonspecific with respect to substrate, so it will also reduce H^+ to H_2, N_2O to N_2, and C_2H_2 to C_2H_4

All nitrogenases have an iron – and sulfur-containing cofactor that includes a heterometal complex in the active site . In most species, this heterometal complex has a central molybdenum atom. However, in some species it is replaced by a vanadium or iron atom. Enzymes responsible for nitrogenase action are very susceptible to destruction by oxygen. Many bacteria cease production of the enzyme in the presence of oxygen.

'he nitrogen-fixing organisms: All the nitrogen-fixing organisms are prokaryotes (bacteria). Some of them live independently of other organisms - the so-called free-living nitrogen-fixing bacteria. Others live in intimate symbiotic associations with plants or with other organisms (e.g. protozoa). Examples are shown in the table below.

Examples of nitrogen-fixing bacteria			
ree living		ymbiotic with plants	
Aerobic	**Anaerobic**	**egumes**	**'ther plants**
zotobacter ***Beijerinckia*** ***Klebsiella* (some)** **Cyanobacteria (som e)**	*'lostridium* (some) *Desulfovibrio* Purple sulphur bacteria* Purple non-sulphur bacteria*	*hizobium*	*rankia* *Azospirillum*

	Green sulphur bacteria*		

Nitrification and Denitrification

Nitrification is the biological oxidation of ammonia to nitrite followed by the oxidation of the nitrite to nitrate. The transformation of ammonia to nitrite is usually the rate limiting step of nitrification. Nitrification is an important step in the nitrogen cycle in soil. Nitrification is an aerobic process performed by small groups of autotrophic bacteria and archaea Nitrogen occurs in waste water usually as ammonium (NH_4^+) or bonded in organic compounds. Organically bonded nitrogen is transformed into ammonium when these compounds are depleted by microorganisms.

In the first step of nitrification, ammonia-oxidizing bacteria oxidize ammonia to nitrite according to equation .

NH3 + O2 → NO2 + 3H + 2e-

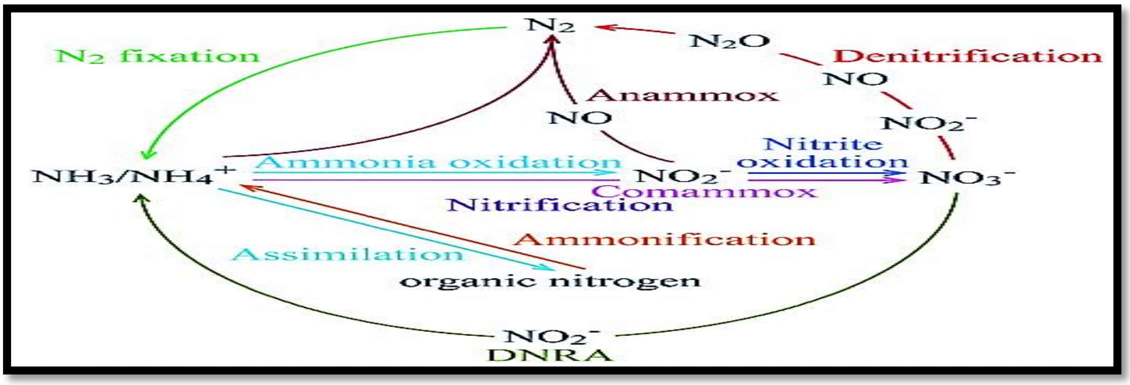
Nitrosomonas is the most frequently identified genus associated with this step, although other genera, including *Nitrosococcus*, and *Nitrosospira*. Some subgenera, *Nitrosolobus* and *Nitrosovibrio*, can also autotrophically oxidize ammonia . In the second step of the process, nitrite-oxidizing bacteria oxidize nitrite to nitrate according to equation .

NO2 + H2O → NO3 + 2H+2e-

Denitrification is a microbially facilitated process where nitrate (NO_3^-) is reduced and ultimately produces molecular nitrogen (N_2) through a series of intermediate gaseous nitrogen oxide products. Facultative anaerobic bacteria perform denitrification as a type of respiration that reduces oxidized forms of nitrogen in response to the oxidation of an electron donor such as organic matter. Denitrifying microbes require a very low oxygen concentration of less than 10%, as well as organic C for energy

Denitrification generally proceeds through some combination of the following half reactions, with the enzyme catalyzing the reaction in parentheses:

- $NO_3^- + 2\ H^+ + 2\ e^- \rightarrow NO_2^- + H_2O$ (Nitrate reductase)
- $NO_2^- + 2\ H^+ + e^- \rightarrow NO + H_2O$ (Nitrite reductase)
- $2\ NO + 2\ H^+ + 2\ e^- \rightarrow N_2O + H_2O$ (Nitric oxide reductase)
- $N_2O + 2\ H^+ + 2\ e^- \rightarrow N_2 + H_2O$ (Nitrous oxide reductase)



Ammonia assimilation : Ammonia is assimilated as glutamate by different reactions:

$$2\text{-ketoglutarate} + NH_3 + NADPH + H^+ \xrightarrow{\text{glutamate dehydrogenase}} \text{glutamate} + NADP + H_2O$$

glutamine synthetase

glutamate + NH_3 + ATP → glutamine + ADP + Pi

glutamate synthase

glutamine + NADPH + H^+ → 2-ketoglutarate + 2 glutamate + $NADP^+$

At a high ammonia concentration, glutamate dehydrogenase can assimilate ammonia without consuming ATP since this enzyme has a low affinity for the substrate . ATP is consumed in the assimilation of ammonia at low concentrations by the action of glutamine synthetase which has a high substrate affinity . In *Escherichia coli*, about 85% of organic nitrogen originates from glutamate and the remaining 15% arises from glutamine.