Chapter 15

Biological N Inputs

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TABLE S15.1 **Examples of genera of diazotrophic bacteria arranged by mode of energy generation and the oxygen sensitivity of their diazotrophy**

Energy source	Sensitivity of N_2 fixation to oxygen	Examples (Genera)
Heterotrophic	Aerobic diazotrophs	*Azotobacter,*
		Gluconacetobacter
	Microaerophilic diazotrophs	*Azospirillum, Herbaspirillum, Methylococcus*
	Facultatively aerobic diazotrophs	*Klebsiella, Paenibacillus Enterobacter*
	Obligately anaerobic diazotrophs	*Clostridium, Desulfovibrio, Methanosarcina*
Phototrophic	Aerobic diazotrophs	*Anabaena, Nostoc*
	(primarily filamentous heterocyst-forming cyanobacteria)	
	Microaerophilic diazotrophs (filamentous nonheterocystous cyanobacteria)	*Lyngbya, Oscillatoria*
	Facultatively aerobic diazotrophs (purple nonsulfur bacteria)	*Rhodobacter*
	Obligately anaerobic diazotrophs (purple sulfur bacteria)	*Chromatium*

Adapted from Young, 1992. With kind permission of Springer Science + Business Media B.V. From Soil Microbiology, Ecology, and Biochemistry, 3rd Edition, Paul, E.A, Biological N inputs (2007). pp. 365–387.

TABLE S15.2 Examples of Nitrogen fixing (*nif*) genes, their products and functions

Gene	Product and function
*nif*H	Nitrogenase reductase subunit; binds two molecules of MgATP and reduces nitrogenase by single electron transfers
*nif*D	Nitrogenase protein alpha subunit of dinitrogenase
*nif*K	MoFe protein beta subunit of dinitrogenase
*nif*F	Flavodoxin, reductant of nitrogenase reductase
*nif*J	Pyruvate-flavodoxin oxidoreductase; couples oxidation of pyruvate to reduction of flavodoxin
*nif*S	Pyridoxal-dependent cysteine desulfurase: required for synthesis of nifB-FeMo cofactor intermediate
*nif*U	Complements nifS. Required for assembly of nifB-FeMo cofactor intermediate-mobilization of Fe and S for metallocluster assembly and synthesis of active enzyme.
*nif*V	Homocitrate synthase; organic component of FeMo cofactor
*nif*N	Subunit of $nifN_2E_2$ which provides a transient site for the assembly of FeMo cofactor.
*nif*E	Subunit of $nifN_2E_2$
*nif*B	FeMo cofactor precursor biosynthesis
*nif*Q	Early step in FeMo cofactor biosynthesis
*nif*X	Intermediate carrier in FeMo cofactor biosynthesis
*nif*Y	Intermediate carrier in FeMo cofactor biosynthesis
*nif*W	Required for synthesis of fully active dinitrogenase
*nif*Z	Required for synthesis of fully active dinitrogenase
*nif*A	Positive regulatory protein
*nif*L	Negative regulatory protein
*nif*T	Unknown function
nafY clpX rnf ABCDEGH	Probably an intermediate carrier in FeMo cofactor biosynthesis Involved in controlling proteolytic cleavage of FeMoCo cofactor biosynthesis proteins NifE NifN NifB Required for maturation of an active nitrogenase reductase

Data from Dean and Jacobsen (1992); Setubal et al. (2009); Dos Santos and Dean, (2011).

TABLE S15.3 Examples of genera and species of the root nodule bacteria of legumes and their hosts

Genera and representative species
Azorhizobium (2 species) *A. caulinodans* (*Sesbania*)
Bradyrhizobium (~13 species) *B. arachidis* (peanut) *B. canariense* (genistoid legumes) *B. cytisus* (*Cytisus*, broom) *B. elkanii* (soybean) *B. japonicum* (soybean) *B. liaoningense* (soybean) *B.* sp. (*Vigna*, *Lupinus*, etc.)[a]
Mesorhizobium (~20 species) *M. amorphae* (*Amorpha*) *M. chacoense* (*Prosopis*, mesquite) *M. ciceri* (*Cicer*, chickpea) *M. huakii* (*Astragalus*, milkvetch) *M. loti* (*Lotus*, trefoil) *M. mediterraneum* (*Cicer*, chickpea) *M. plurifarium* (tropical trees)
Rhizobium (~30 species) *R. etli* (*Phaseolus*, bean) *R. galegae* (*Galega*) *R. gallicum* (*Phaseolus*, bean) *R. giardinii* (bean) *R. huakuii* (*Astragalus*) *R. huautlense* (*Sesbania*) *R. indigofera* (*Indigofera*) *R. leguminosarum* (three biovars nodulate: (i) clovers, (ii) peas, lentils, and vetch, (iii) bean) *R. mongolense* (*Medicago*) *R. phaseoli* (beans) *R. tropici* (*Phaseolus*, *Leucaena*, bean)
Ensifer, formerly ***Sinorhizobium*** (~10 species) *E. americanum* (*Acacia*) *E. arboris* (tree legumes) *E. fredii* (soybean) *E. kostiense* (tree legumes) *E. kummerowiae* (*Kummerowia*) *E. medicae* (annual medics) *E. meliloti* (alfalfa) *E. morelense* (*Leucaena*) *E. saheli* (*Sesbania*) *E. teranga* (*Sesbania*)

TABLE S15.3 Examples of genera and species of the root nodule bacteria of legumes and their hosts—Cont'd

Burkholderia (~10 species)
B. phymatum (nodulates *Mimosa* spp.)
B. tuberum (nodulates *Cyclopia, Macroptilium* and *P. vulgaris*, not *Mimosa* spp.)

[a]*Although many legumes are nodulated by bacteria of the* Bradyrhizobium *genus, the latter have not received official species designation. They are referred to by the name of the legume host from which they were isolated, (e.g., Bradyrhizobium* [Lupinus*]).*
There are several other genera of alpha-proteobacteria with legume-nodulating properties including *Devosia, Cupravidus, Ochrobactrum, Methylobacterium,* and *Phyllobacterium.*
Taken from the website of the ICSP subcommittee on the taxonomy of *Rhizobium* and *Agrobacterium,* http://edzna.ccg.unam.mx/rhizobial-taxonomy/