

# **BIOLOGICAL NITROGEN FIXATION**

---

Edited by  
**Gary Stacey, Robert H. Burris  
and Harold J. Evans**

John Wiley & Sons, Inc.  
**Chapman & Hall**

**New York**

**London**

# Contents

Contributors	vii
Preface	xi
Introduction Highlights in Biological Nitrogen Fixation during the Last 50 Years <i>Harold J. Evans and Robert H. Burris</i>	1
1. Phylogenetic Classification of Nitrogen-Fixing Organisms <i>J. P. W. Young</i>	43
2. Physiology of Nitrogen Fixation in Free-Living Heterotrophs <i>Susan Hill</i>	87
3. Nitrogen Fixation by Photosynthetic Bacteria <i>Gary P. Roberts and Paul W. Ludden</i>	135
4. Nitrogen Fixation in Cyanobacteria <i>Robert Haselkorn and William J. Buikema</i>	166
5. Nitrogen Fixation by Methanogenic Bacteria <i>A. L. Lobo and S. H. Zinder</i>	191
6. Associative Nitrogen-Fixing Bacteria <i>Claudine Elmerich, Wolfgang Zimmer, and Claire Vieille</i>	212
7. Actinorhizal Symbioses <i>Dwight D. Baker and Beth C. Mullin</i>	259
8. Ecology of <i>Bradyrhizobium</i> and <i>Rhizobium</i> <i>Peter J. Bottomley</i>	293
9. The Rhizobium Infection Process <i>Jan W. Kijne</i>	349

10.	Physiology of Nitrogen-Fixing Legume Nodules: Compartments, and Functions <i>Dietrich Werner</i>	399
11.	Hydrogen Cycling in Symbiotic Bacteria <i>Daniel J. Arp</i>	432
12.	Evolution of Nitrogen-Fixing Symbioses <i>Janet I. Sprent and John A. Raven</i>	461
13.	The <i>Rhizobium</i> Symbiosis of the Nonlegume <i>Parasponia</i> <i>Jan-Hendrik Becking</i>	497
14.	Genetic Analysis of <i>Rhizobium</i> Nodulation <i>Sharon R. Long</i>	560
15.	Nodulins in Root Nodule Development <i>Henk J. Franssen, Jan-Peter Nap, and Ton Bisseling</i>	598
16.	Plant Genetics of Symbiotic Nitrogen Fixation <i>Donald A. Phillips and Larry R. Teuber</i>	625
17.	Molecular Genetics of <i>Bradyrhizobium</i> Symbioses <i>W. Mark Barbour, Shui-Ping Wang, and Gary Stacey</i>	648
18.	The Enzymology of Molybdenum-Dependent Nitrogen Fixation <i>M. G. Yates</i>	685
19.	Alternative Nitrogen Fixation Systems <i>Paul E. Bishop and R. Premakumar</i>	736
20.	Biochemical Genetics of Nitrogenase <i>Dennis R. Dean and Marty R. Jacobson</i>	763
21.	Regulation of Nitrogen Fixation Genes in Free-Living and Symbiotic Bacteria <i>M. J. Merrick</i>	835
22.	Isolated Iron-Molybdenum Cofactor of Nitrogenase <i>William E. Newton</i>	877
	<i>Index</i>	931