

Contents

From the Series Editors	vii
Series Editors	xv
Preface	xxv
The Editors	xxvii
Contributors	xxxi
Author Index	xxxv

Part I: General and Molecular Aspects of Bio-Hydrogen Generation

1 Bioenergy from Microorganisms: An Overview	3–21
<i>Patrick C. Hallenbeck</i>	
Summary	3
I. Climate Change and Future Energy Challenges	4
II. A Wide Variety of Biofuels	6
III. The Microbial Production of Hydrogen	11
References	19
2 Structural Foundations for O₂ Sensitivity and O₂ Tolerance in [NiFe]-Hydrogenases	23–41
<i>Anne Volbeda and Juan C. Fontecilla-Camps</i>	
Summary	23
I. Introduction	24
II. [NiFe]-Hydrogenases	25
III. Structural Studies of O ₂ -Sensitive [NiFe]-Hydrogenases	27
IV. Structural Studies of O ₂ -Resistant [NiFeSe]-Hydrogenases	29
V. Structural Studies of O ₂ -Tolerant Membrane-Bound [NiFe]-Hydrogenases	30
VI. Regulation of Hydrogenase Expression and Activity: The Example of <i>Escherichia coli</i>	32
VII. [NiFe]-Hydrogenase Maturation	33
VIII. Biotechnological Applications	35
IX. Conclusions	37
References	37

3	Engineering Hydrogenases for H₂ Production: Bolts and Goals	43–77
	<i>Marc Rousset and Pierre-Pol Liebgott</i>	
	Summary	43
	I. Introduction	44
	II. Classification and Physiological Properties of Hydrogenases	46
	III. Maturation of Hydrogenases: Specific and Complex Process	56
	IV. Enzyme and Metabolic Engineering to Improve H ₂ Production	58
	V. Conclusion	70
	References	70
4	H₂ Production Using Cyanobacteria/Cyanobacterial Hydrogenases: From Classical to Synthetic Biology Approaches	79–99
	<i>Catarina C. Pacheco, Paulo Oliveira, and Paula Tamagnini</i>	
	Summary	79
	I. Introduction	80
	II. Transcriptional Regulation and Maturation of Cyanobacterial Hydrogenases	81
	III. Strategies to Improve Cyanobacterial H ₂ Production	83
	IV. Conclusions and Future Perspectives	93
	References	94
5	Hydrogen Production by Water Biophotolysis	101–135
	<i>Maria L. Ghirardi, Paul W. King, David W. Mulder, Carrie Eckert, Alexandra Dubini, Pin-Ching Maness, and Jianping Yu</i>	
	Summary	101
	I. Introduction	102
	II. Hydrogenases	109
	III. Ferredoxin Network in <i>Chlamydomonas reinhardtii</i>	117
	IV. Barriers to H ₂ Photoproduction	118
	References	121
6	Nitrogenase-Dependent Hydrogen Production by Cyanobacteria	137–153
	<i>Hermann Bothe and William E. Newton</i>	
	Summary	137
	I. Introduction	138
	II. Nitrogenases in Cyanobacteria	138
	III. Hydrogen Production by Nitrogenases	141
	IV. Hydrogen Formation in Heterocystous Cyanobacteria	142
	V. Hydrogen Formations by Unicellular Cyanobacteria	145
	VI. Conclusion	149
	References	149

7 Systems Biology of Photobiological Hydrogen Production by Purple Non-sulfur Bacteria	155–176
<i>James B. McKinlay</i>	
Summary	155
I. Introduction	156
II. Purple Non-sulfur Bacteria in the Light of Genomics and Systems Biology	158
III. Deciphering and Engineering the Metabolic and Regulatory Mechanisms Involved in H ₂ Production	162
IV. Future Directions for a System-Level Understanding of Photobiological H ₂ Production	169
References	172
8 The Extremely Thermophilic Genus <i>Caldicellulosiruptor</i>: Physiological and Genomic Characteristics for Complex Carbohydrate Conversion to Molecular Hydrogen	177–195
<i>Jeffrey V. Zurawski, Sara E. Blumer-Schuette, Jonathan M. Conway, and Robert M. Kelly,</i>	
Summary	177
I. Introduction	178
II. Extracellular Deconstruction of Lignocellulosic Biomass	179
III. Carbohydrate Transport	184
IV. Intermediary Metabolism	186
V. Metabolism of Fuel Production	188
References	192
9 Members of the Order Thermotogales: From Microbiology to Hydrogen Production	197–224
<i>Martina Cappelletti, Davide Zannoni, Anne Postec, and Bernard Ollivier</i>	
Summary	197
I. Introduction	198
II. Habitat	198
III. Metabolic Features	202
IV. Hydrogen Production by <i>Thermotogales</i> spp.	206
V. Future Perspectives	218
References	219
10 Bioelectrochemical Systems for Indirect Biohydrogen Production	225–233
<i>John M. Regan and Hengjing Yan</i>	
Summary	225
I. Principles of Microbial Electrolysis Cells	226
II. Microbial Catalysts at the Anode	229
III. Cathode Reaction	229
References	231

Part II: Applied Aspects in Biohydrogen Production

11 Applications of Photofermentative Hydrogen Production	237–267
<i>Inci Eroglu, Ebru Özgür, Ela Eroglu, Meral Yücel, and Ufuk Gündüz</i>	
Summary	238
I. Introduction	238
II. Guidelines for Effective Photofermentative Hydrogen Production	239
III. Utilization of Waste Materials for Photofermentative Hydrogen Production	242
IV. Photofermentative Hydrogen Production with Dark Fermenter Effluents	246
V. Optimization of Hydrogen Yield	254
VI. Efficiency Analysis	260
VII. Future Prospects	260
References	262
12 Photosynthesis and Hydrogen Production in Purple Non Sulfur Bacteria: Fundamental and Applied Aspects	269–290
<i>Alessandra Adessi and Roberto De Philippis</i>	
Summary	269
I. Introduction	270
II. The H ₂ Production Process in Purple Bacteria	270
III. Anoxygenic Photosynthesis	272
IV. Photosynthetic Efficiency (PE)	277
V. Substrate to Hydrogen Conversion (SC)	282
VI. Process Bottlenecks – Conclusions	283
References	285
13 Photobioreactors Design for Hydrogen Production	291–320
<i>José María Fernández-Sevilla, Francisco Gabriel Acién-Fernández, and Emilio Molina-Grima</i>	
Summary	291
I. Introduction	292
II. Major Routes for the Photobiological H ₂ Production	293
III. Major Factors Impacting on Photobioreactor Performance	295
IV. Principles for Photobioreactors Design and Scale Up	298
V. Concluding Remarks	316
References	317

14	Immobilization of Photosynthetic Microorganisms for Efficient Hydrogen Production	321–347
	<i>Anatoly Tsygankov and Sergey Kosourov</i>	
	Summary	321
	I. Introduction	322
	II. Methods of Immobilization	322
	III. Mechanical Support and Photobioreactors for Immobilized Photosynthetic Microorganisms	330
	IV. Hydrogen Production by Purple Bacteria	331
	V. Hydrogen Production by Immobilized Microalgae	332
	VI. Hydrogen Production by Immobilized Cyanobacteria	337
	VII. Concluding Remarks	341
	References	342
15	Hydrogen Production and Possible Impact on Global Energy Demand: Open Problems and Perspectives	349–356
	<i>Davide Zannoni, Giacomo Antonioni, Dario Frascari, and Roberto De Philippis</i>	
	Summary	349
	I. Introduction	350
	II. Hydrogen as Energy Carrier	350
	III. Hydrogen Storage: An Open Problem	351
	IV. Safety Issues in the Use of Hydrogen as a Fuel	354
	V. Economical and Political Issues	354
	VI. Conclusions	355
	References	355
	Subject Index	357–366