## Respiration in Archaea and Bacteria

Diversity of Prokaryotic Electron Transport Carriers

Edited by

## **Davide Zannoni**

Department of Biology University of Bologna, Italy



## Contents

Lu	itoriai	V
Со	ntents	x
Pre	eface	xiv
Color Plates		
1	Evolution and Phylogenetic Analysis of Respiration  Jose Castresana	1–14
	Summary I. Introduction II. Chemical Composition of the Primitive Atmosphere and Oceans III. Heterotrophic vs. Autotrophic Origin of Energy Conversion IV. The Comparative Genomics Evidence on the Evolution of Respiration V. Ancient Respiratory Mechanisms VI. Respiratory Mechanisms Evolved in Archaea VII. The Last Universal Ancestor Was a Generalist Organism VIII. The Respiration-Early Hypothesis: Photosynthesis Came Later Acknowledgments References	1 2 2 3 3 5 8 8 9 10
2	NADH Dehydrogenase (NADH-Quinone Oxidoreductase)  Takao Yagi, Salvatore Di Bernardo, Eiko Nakamaru-Ogiso,  Mou-Chieh Kao, Byoung Boo Seo, and Akemi Matsuno-Yagi	15–40
	Summary I. Introduction II. Genes and Regulations of H*-Translocating NADH-Quinone (Q) Oxidoreductase (NDH-1) and NADH-Q Oxidoreductase (Non-Energy Transducing, NDH-2) III. NDH-1 IV. NDH-2 Acknowledgments References	15 16 17 20 31 33 33
3	Bacterial Hydroquinone:Cytochrome c Oxidoreductases. Physiology, Structure and Function  Jason W. Cooley, Elisabeth Darrouzet and Fevzi Daldal	41–55
	Summary I. Introduction II. Experimental Systems Used in the Study of the Cyt $bc_1$ III. Structure of the Cyt $bc_1$ IV. Function of the Cyt $bc_1$ : The Modified Q cycle	41 42 44 46 50

knowledgments ferences	53 53
and Function of Succinate:Quinone Oxidoreductases and f Quinol:Fumarate Reductases in Fumarate Respiration & D. Lancaster	57–85
The Site(s) of Menaquinol Oxidation and Quinone Reduction	58 58 61 s 62 68
Quinol:Fumarate Reductases (QFRs) Electron Transfer Inhibition of SQR and QFR	69 70 74
and Reconstitution of the Electron Transfer Chains Energetics of Fumarate Respiration and the Mechanism of $\Delta p$ Generation Conclusions knowledgments	74 77 80 81 81
ferences	01
	7–113
al and Molecular Features of Terminal Oxidases 87	
ral and Molecular Features of Terminal Oxidases  Sakamoto and Nobuhito Sone  mmary Introduction Diversity and Unity of Cytochrome Oxidases SoxM-Type Oxidases SoxB-Type Oxidases FixN-Type Oxidases Cytochrome bd Interaction with Cyt c and Quinol: Cytochrome c Oxidoreductase (QCR) I. Energy-Yielding Terminal Oxidases  ferences	7-113 88 88 89 91 96 98 100 102 104
	F Quinol:Fumarate Reductases in Fumarate Respiration  The D. Lancaster  mmary Introduction Organization of the sdh and frd Genes Structure and Function of the Quinol: Fumarate Reductase (QFR) Subunit The Site(s) of Menaquinol Oxidation and Quinone Reduction Catalytic Properties of Succinate:Quinone Reductases (SQRs) and Quinol:Fumarate Reductases (QFRs) Electron Transfer Inhibition of SQR and QFR I. The Function of Menaquinone in W. succinogenes Fumarate Respiration and Reconstitution of the Electron Transfer Chains Energetics of Fumarate Respiration and the Mechanism of Δp Generation Conclusions knowledgments

7	Functional Aspects of Heme-Copper Terminal Oxidases Peter Brzezinski, Gisela Larsson and Pia Ädelroth	129–153
	Summary I. Introduction II. Structures III. General Design of a Proton Pump IV. Intramolecular Electron and Proton Transfer V. Reaction of the Reduced Enzyme With Oxygen VI. Putative Specific Proton Pumping Mechanisms VII. Current Issues and Unresolved Questions Acknowledgments References	130 130 131 134 134 139 144 145 145
8	The Na+-Translocating NADH-Quinone Reductase of Marine and Moderately Halophilic Bacteria  Maki Hayashi and Tsutomu Unemoto	155–174
	Summary I. Introduction II. Redox-Driven Na+ Pump of Vibrio alginolyticus III. Other Components of the Respiratory Chain of <i>V. alginolyticus</i> IV. Catalytic Properties and Sub-Unit Structure of Na+-NQR V. Mechanism of Energy Coupling VI. Inhibitor Studies VII. Distribution of the Na+-NQR VIII. Bioenergetics of Marine Bacteria References	155 156 156 158 159 164 168 169 170
9	Microbial Molybdenum-Containing Enzymes in Respiration: Structural and Functional Aspects  Alastair G. McEwan, Ulrike Kappler and Christopher A. McDevitt	175–202
	Summary I. Introduction II. Phylogeny of Enzymes of the Dimethylsulfoxide (DMSO) Reductase III. Respiratory Processes Involving Molybdenum Enzymes IV. Organization of Electron Transport Pathways V. Structural Studies of Prokaryotic Respiratory Molybdenum Enzymes VI. Mechanism of Molybdenum-Containing Enzymes References	176 176 179 180 186 189 194
10	The Pyrroloquinoline Quinone (PQQ)-Containing Dehydrogenases Christopher Anthony	203–225
	Summary  I. Introduction  II. The Physiological Roles of the Quinoprotein Dehydrogenases and	203 204
	Their Electron Transport Chains  III. The Structures of the PQQ-Containing Quinoprotein Dehydrogenases	205 208

	IV. The Dehydrogenases Acknowledgments References	209 222 222
11	Biogenesis of Cytochrome c  Elisabeth Enggist and Linda Thöny-Meyer	227–250
	Summary I. Introduction II. Prokaryotic Genes for Cytochrome c Maturation III. Apo-Cytochrome c IV. Heme V. Heme Ligation VI. Open Questions Acknowledgment References	228 228 229 232 236 242 244 245 246
12	Bacterial Hemoglobins: Old Proteins with 'New' Functions? Roles in Respiratory and Nitric Oxide Metabolism Guanghui Wu, Laura M. Wainwright, Jorge Membrillo- Hernández and Robert K. Poole	251–286
	<ul> <li>Summary</li> <li>Introduction to Globins—Definition and the Classical View</li> <li>The Vitreoscilla Globin, Vgb, and other Single Domain Myoglobin-like Globins</li> <li>Truncated Globins</li> <li>Flavohemoglobins</li> <li>Evolution of Globins</li> <li>Concluding Remarks</li> <li>Acknowledgments</li> <li>References</li> </ul>	252 253 255 262 266 278 279 280 280
13	Oxidases as Redox Sensors in Pigment Synthesis , Jeong-II Oh and Samuel Kaplan	287–309
	Summary  I. Introduction  II. Overview of PS Gene Regulation  III. $cbb_3$ Cytochrome $c$ Oxidase  IV. $cbb_3$ -PrrBA Signal Transduction Pathway  V. Redox State of the Quinone Pool and PS Gene Expression  VI. Concluding Remarks  Addendum Added in Proof  Acknowledgments  References	287 288 292 295 299 302 305 305 305
Spe	pject Index ecies Index ne and Gene Product Index	311 321 325