

~~SS~~

2739-029 8

The PHYSIOLOGY
and
BIOCHEMISTRY *of*
PROKARYOTES

David White
Indiana University

New York Oxford
OXFORD UNIVERSITY PRESS
1995

CONTENTS

Symbols	xv
Conversion factors, equations, and units of energy	xvii
Definitions	xix
Chapter 1. Structure and function	3
1.1 Phylogeny	3
1.2 Cell structure	7
1.3 Summary	29
Chapter 2. Growth	34
2.1 Measurement of growth	34
2.2 Growth physiology	36
2.3 Growth kinetics	43
2.4 Steady-state growth and continuous growth	44
2.5 Summary	46
Chapter 3. Membrane bioenergetics: The proton potential	49
3.1 The chemiosmotic theory	49
3.2 Proton electrochemical energy	50
3.3 The contributions of the $\Delta\Psi$ and the ΔpH to the overall Δp in neutrophiles, acidophiles, and alkaliphiles	55
3.4 Ionophores	55
3.5 Measurement of the Δp	57
3.6 Use of the Δp to do work	59
3.7 Exergonic reactions that generate a Δp	63
3.8 Other mechanisms for creating a $\Delta\Psi$ or a Δp	67
3.9 Halorhodopsin, a light-driven chloride pump	76
3.10 The Δp and ATP synthesis in alkaliphiles	76
3.11 Summary	77
Chapter 4. Electron transport	83
4.1 Aerobic and anaerobic respiration	83
4.2 The electron carriers	84
4.3 Organization of the electron carriers in mitochondria	88
4.4 Organization of the electron carriers in bacteria	89
4.5 Coupling sites	90

4.6	How a proton potential might be created at the coupling sites: Q loops, Q cycles, and proton pumps	93
4.7	Patterns of electron flow in individual bacterial species	97
4.8	Summary	104
Chapter 5.	Photosynthesis	109
5.1	The phototrophic prokaryotes	109
5.2	The purple photosynthetic bacteria	112
5.3	The green sulfur bacteria	117
5.4	Cyanobacteria and chloroplasts	119
5.5	Efficiency of photosynthesis	120
5.6	Photosynthetic pigments	121
5.7	The transfer of energy from the light-harvesting pigments to the reaction center	128
5.8	The structure of photosynthetic membranes in bacteria	129
5.9	Summary	129
Chapter 6.	The regulation of metabolic pathways	133
6.1	Patterns of regulation of metabolic pathways	133
6.2	Kinetics of regulatory and nonregulatory enzymes	135
6.3	Conformational changes in regulatory enzymes	138
6.4	Regulation by covalent modification	139
6.5	Summary	139
Chapter 7.	Bioenergetics in the cytosol	141
7.1	High-energy molecules and group transfer potential	141
7.2	The central role of group transfer reactions in biosynthesis	146
7.3	ATP synthesis by substrate-level phosphorylation	148
7.4	Summary	153
Chapter 8.	Central metabolic pathways	155
8.1	Glycolysis	157
8.2	The fate of NADH	161
8.3	Why write NAD^+ instead of NAD, and NADH instead of NADH_2 ?	162
8.4	The pentose phosphate pathway	162
8.5	The Entner–Doudoroff pathway	167
8.6	The oxidation of pyruvate to acetyl-CoA: The pyruvate dehydrogenase reaction	171
8.7	The citric acid cycle	173
8.8	Carboxylations that replenish oxaloacetate: The pyruvate and phosphoenolpyruvate carboxylases	175
8.9	Modification of the citric acid cycle into a reductive (incomplete) cycle during fermentative growth	176
8.10	Chemistry of some of the reactions in the citric acid cycle	177
8.11	The glyoxylate cycle	179
8.12	Formation of phosphoenolpyruvate	180
8.13	Summary of the relationships between the pathways	182
8.14	Summary	182
Chapter 9.	Metabolism of lipids, nucleotides, amino acids, and hydrocarbons	187
9.1	Lipids	187
9.2	Nucleotides	194
9.3	Amino acids	200
9.4	Aliphatic hydrocarbons	206
9.5	Summary	208

Chapter 10. Cell wall biosynthesis	212
10.1 Peptidoglycan	212
10.2 Lipopolysaccharide	217
10.3 Summary	221
Chapter 11. Inorganic metabolism	224
11.1 Assimilation of nitrate and sulfate	224
11.2 Dissimilation of nitrate and sulfate	226
11.3 Nitrogen fixation	228
11.4 Lithotrophy	233
11.5 Summary	242
Chapter 12. C₁ metabolism	246
12.1 Carbon dioxide fixation systems	246
12.2 Growth on C ₁ compounds other than CO ₂ : The methylotrophs	263
12.3 Summary	267
Chapter 13. Fermentations	272
13.1 Oxygen toxicity	272
13.2 Energy conservation by anaerobic bacteria	273
13.3 Electron sinks	274
13.4 The anaerobic food chain	274
13.5 How to balance a fermentation	276
13.6 Propionate fermentation using the acrylate pathway	277
13.7 Propionate fermentation using the succinate–propionate pathway	279
13.8 Acetate fermentation (acetogenesis)	281
13.9 Lactate fermentation	281
13.10 Mixed acid and butanediol fermentations	284
13.11 Butyrate fermentation	286
13.12 <i>Ruminococcus albus</i>	290
13.13 Summary	291
Chapter 14. Homeostasis	294
14.1 Maintaining a Δ pH	294
14.2 Osmotic potential	297
14.3 Summary	302
Chapter 15. Solute transport	306
15.1 Reconstitution into proteoliposomes	306
15.2 Kinetics of solute uptake	307
15.3 Energy-dependent transport	308
15.4 How to determine the source of energy for transport	319
15.5 A summary of bacterial transport systems	320
15.6 Summary	321
Chapter 16. Protein export and secretion	325
16.1 The Sec system	325
16.2 The translocation of membrane-bound proteins	329
16.3 Extracellular protein secretion	330
16.4 Summary	332
Chapter 17. Signaling and behavior	335
17.1 An introduction to two-component signaling systems	336
17.2 Adaptive responses by facultative anaerobes to anaerobiosis	339
17.3 The NarL/NarX/NarQ system	344
17.4 Chemotaxis	345

CONTENTS

17.5	Nitrogen assimilation: The Ntr regulon	352
17.6	The PHO regulon	356
17.7	Regulation of porin synthesis	358
17.8	Regulation of the <i>kdpABC</i> operon	358
17.9	Summary	360
Index		365