

Contents

Preface	1
1 Introduction	3
2 The Outer Membrane of the Gram-Negative Bacteria and their Components	9
2.1 Lipids	9
2.1.1 Classification, Significance	9
2.1.2 Isolation and Analysis	10
2.1.3 Chemical Structure	10
2.1.3.1 Fatty Acids	10
2.1.3.2 Waxes and Glycerides	12
2.1.3.3 Phospholipids and Glycolipids	14
2.1.3.3.1 Glycerolphospholipids	15
2.1.3.3.2 Glycolipids	16
2.1.3.3.3 Sphingolipids	17
2.1.3.3.4 Hopanoids	17
2.1.4 Spatial Structure and Physical Properties	18
2.1.5 Biosynthesis of the Lipids	22
2.1.5.1 Biosynthesis of Fatty Acids	22
2.1.5.2 Biosynthesis of Waxes and Glycerides	23
2.1.5.3 Biosynthesis of Phospholipids and Glycolipids ..	24
2.1.5.3.1 Biosynthesis of Glycerolphospholipids ..	24
2.1.5.3.2 Biosynthesis of Glycolipids	24
2.1.5.3.3 Biosynthesis of Sphingolipids	24
2.1.5.3.4 Biosynthesis of ACL	25
2.1.5.3.5 Biosynthesis of Hopanoids	29
2.1.5.4 Incorporation into the Outer Membrane	29
2.2 Lipopolysaccharides	31
2.2.1 General Remarks	31
2.2.2 General Structure	33
2.2.3 Isolation and Analysis	34
2.2.3.1 Isolation	34
2.2.3.2 Analysis	37
2.2.4 Composition and Structure	40
2.2.4.1 The O-Specific Polysaccharide	40

2.2.4.2	The Core Region	42
2.2.4.3	The Lipid A	45
2.2.4.4	Physical Properties and Spatial Structure	48
2.2.5	Biosynthesis	50
2.2.5.1	Biosynthesis of the Precursors	50
2.2.5.2	Biosynthesis of Lipid A and the Core Region	52
2.2.5.3	Biosynthesis of O-Specific Polysaccharides	57
2.2.5.4	Genetic Determination of the LPS Biosynthesis	61
2.2.6	The Enterobacterial Common Antigen (ECA)	65
2.3	Proteins of the Outer Membrane of Gram-Negative Bacteria	67
2.3.1	General Remarks	67
2.3.1.1	Composition and Structure	67
2.3.1.2	Isolation and Analysis	73
2.3.2	Proteins of the Outer Membrane	74
2.3.2.1	Classification	74
2.3.2.2	Detection and Isolation	75
2.3.2.3	The Channel-Forming Proteins	75
2.3.2.3.1	Porin Proteins	76
2.3.2.3.2	Proteins Forming Specific Channels	78
2.3.2.3.3	High-Affinity Receptor Proteins	79
2.3.2.4	The Structure Proteins	81
2.3.2.4.1	Braun's Lipoprotein	81
2.3.2.4.2	OmpA-Protein	83
2.3.2.5	Further Proteins	84
2.3.2.6	Biosynthesis of the Outer Membrane Proteins	84
2.3.3	Organisation and Function of the Outer Membrane Proteins	86
2.4	The Total Membrane	91
2.4.1	General Structure of Biological Membranes	91
2.4.1.1	Composition, Structure, Function	91
2.4.1.2	The Asymmetry of Membranes	92
2.4.2	Composition of the Outer Membrane	94
2.4.3	Structure of the Outer Membrane	95
2.4.4	The Fluidity of the Outer Membrane	98
2.4.5	Assembly of the Outer Membrane	100
3	Periplasmic Space and Rigid Layer	103
3.1	The Periplasmic Space	103
3.2	The Rigid Layer of Gram-Positive and Gram-Negative Bacteria	105
3.2.1	Significance, Isolation, Composition, Structure	105
3.2.1.1	Isolation of the Peptidoglycan	105
3.2.1.2	Chemical Structure of Peptidoglycan	106
3.2.1.2.1	Chemical Structure of the Polysaccharide Moiety	107
3.2.1.2.2	Chemical Structure of the Peptide Moiety	109

3.2.1.3	The Spatial Structure of the Peptidoglycan	111
3.2.1.4	Peptidoglycan as a Transport Barrier	117
3.2.2	Biosynthesis of Peptidoglycan	118
3.2.2.1	Biosynthesis of UDP- <i>N</i> -Acetylmuramyl Pentapeptide	119
3.2.2.2	Biosynthesis of the Complete Subunit and of the Bridge Peptide	120
3.2.2.3	Transfer to the Growing Terminus of the Polysaccharide Chain	123
3.2.2.4	Cross-Linking	123
3.2.2.5	Regulation of Peptidoglycan Biosynthesis	125
3.2.2.6	Possibilities to Influence the Biosynthesis of Peptidoglycan	128
4	Further Cell Wall Components of Gram-Positive Bacteria	133
4.1	Polysaccharides (Except Capsular Polysaccharides)	133
4.1.1	The Teichoic Acid Family	133
4.1.1.1	Teichoic Acids	134
4.1.1.1.1	Poly-(Polyolphosphate)-Teichoic Acids	134
4.1.1.1.2	Poly-(Glycosylpolyolphosphate)-Teichoic Acids	135
4.1.1.1.3	Heterogeneity of Teichoic Acids	136
4.1.1.1.4	Linkage Units to Peptidoglycan	136
4.1.1.2	Teichuronic Acids	136
4.1.1.3	Lipoteichoic Acids	137
4.1.1.4	Functions of the Teichoic Acids	139
4.1.2	Acidic Polysaccharides	140
4.1.3	Biosynthesis	141
4.1.3.1	Biosynthesis of Teichoic Acids	141
4.1.3.2	Biosynthesis of Teichuronic Acids	142
4.1.3.3	Biosynthesis of Lipoteichoic Acids	142
4.1.3.4	Control of the Biosyntheses	142
4.2	Proteins	144
4.2.1	Isolation and General Structure	144
4.2.2	Streptococcal Cell Wall Proteins	146
4.2.3	Staphylococcal Protein A and Similar Proteins	147
4.2.4	Clumping Factor of Staphylococci	149
4.2.5	Further Proteins of the Gram-Positive Cell Wall	149
4.2.6	Biosynthesis	150
4.3	Cell Wall Components of Mycolata	151
4.3.1	The Mycoloyl Arabinogalactan Complex	152
4.3.1.1	The Mycolic Acid Moiety	152

4.3.1.1.1	Properties, Structure	152
4.3.1.1.2	Biosynthesis	154
4.3.1.2	The Arabinogalactan Moiety	155
4.3.1.3	The Complete Molecule	155
4.3.2	Lipoarabinomannan	157
4.3.3	Extractable Lipids	158
4.3.3.1	Lipooligosaccharides (LOS)	158
4.3.3.2	Phenolic Glycolipids (PGL)	159
4.3.3.3	Glycopeptidolipids (GPL)	160
4.3.4	Waxes and Sulfolipids	161
4.3.5	Proteins	161
5	Cell Wall Components of Archaea	162
5.1	Pseudomurein	163
5.2	Methanochondroitin	164
5.3	Heteropolysaccharides	166
5.4	Glutaminylglycan	166
5.5	Lipids	167
5.6	S-Layers and Sheaths	169
6	Components Outside the Cell Wall	171
6.1	Capsules and Slime Layers	171
6.1.1	General Characterisation	171
6.1.2	Detection of Capsules	172
6.1.3	Isolation and Chemical Analysis of the Capsule Material .	173
6.1.4	The Capsules of Gram-Negative Bacteria	174
6.1.4.1	<i>Escherichia coli</i>	174
6.1.4.2	The Capsules of other Gram-Negative Bacteria	178
6.1.4.2.1	Gram-Negative Rods	178
6.1.4.2.2	Gram-Negative Cocci	179
6.1.5	Capsules of Gram-Positive Bacteria	179
6.1.5.1	Streptococci and Staphylococci	179
6.1.5.2	Mycobacteria	180
6.1.6	Biosynthesis of CPS	180
6.1.7	Capsules in Immunogenicity and Virulence	182
6.2	S-Layers	183
6.2.1	General Remarks	183
6.2.2	Composition and Structure	183
6.2.2.1	Archaea	185
6.2.2.2	Bacteria	187
6.2.3	Biosynthesis	187
6.2.4	Fixation of S-Layers in the Cell Wall	190
6.2.5	Functions of S-Layers	190
6.3	Sheaths	193

6.4	Filamentous Proteins.....	194
6.4.1	Flagella.....	194
6.4.2	Fimbriae and Fibrils.....	198
6.4.3	Sex Pili.....	202
7	Cell Wall Models.....	204
7.1	Gram-Negative Bacteria	206
7.2	Gram-Positive Bacteria.....	211
7.2.1	"Typical" Gram-Positive Bacteria	211
7.2.2	"Atypical" Gram-Positive Bacteria.....	215
8	Cell Wall Functions.....	219
8.1	The Cell Wall as a Transport Organ	219
8.1.1	General Remarks.....	219
8.1.2	Transport Across the Bacterial Cell Wall.....	221
8.1.2.1	Transport from the Exterior to the Interior.....	221
8.1.2.2	Transport from the Interior to the Exterior.....	227
8.1.3	The Transport (Transduction) of Signals	231
8.2	Protective Function of the Bacterial Cell Wall	233
8.3	The Importance of the Cell Wall for Pathogenicity and Virulence	235
8.3.1	Adherence of Bacteria at Surfaces.....	238
8.3.2	Survival at Surfaces and Penetration Into or Across the Tissue.....	239
8.3.3	Growth in the Host.....	241
8.3.4	Undermining, Repulse or Elimination of the Defence Mechanisms of the Host.....	242
8.3.5	Damaging of the Host	244
8.3.6	The Roles of Particular Cell Wall Components.....	244
8.3.6.1	Polysaccharides and Related Compounds	245
8.3.6.2	Lipids (Including Lipid A)	247
8.3.6.3	Proteins.....	248
8.3.6.4	Peptidoglycan.....	250
8.4	Significance of the Cell Wall for the Maintenance of the Bacterial Shape.....	251
8.4.1	Rod-Shaped Bacteria.....	251
8.4.2	Spherical (Coccoid) Bacteria.....	253
8.5	Interactions between the Bacterial Cell Wall and Bacteriophages ..	257
8.6	Interactions between the Bacterial Cell Wall and Antibiotics	261
Uncommon Abbreviations	266
Index.	268