

# Contents

Foreword.....	v
<b>PART I. General</b> .....	<b>1</b>
<b>Chapter 1. Glycoproteins: structure and biosynthesis</b> <i>by Jean Montreuil (Villeneuve d'Ascq)</i> .....	<b>3</b>
1. Introduction.....	3
2. Types of glycan-protein linkages, classification of glycoproteins.....	4
3. Primary structure of glycoprotein glycans.....	4
3.1. Concepts and rules, 5 — 3.2. Description of glycan primary structures, 6 —	
4. Spatial conformation of glycans.....	9
4.1. Glycosaminoglycans and proteoglycans, 11 — 4.2. Mucin-like glycans and glycoproteins, 11 — 4.3. Glycans of <i>N</i> -glycosylproteins, 12 — 4.4. Conformational changes of glycans. Mobility of the antennae, 13 —	
5. Glycoprotein biosynthesis.....	14
5.1. The reaction and its partners, 14 — 5.2. Biosynthesis of <i>O</i> -glycosylproteins, 15 — 5.3. Biosynthesis of <i>N</i> -glycosylproteins, 16 — 5.4. Control of the biosynthesis of glycoproteins, 18	
6. Conclusions.....	21
Acknowledgements.....	21
References.....	22
<b>Chapter 2. Cell surface asymmetry is a prerequisite for the function of transporting and secreting epithelia</b> <i>by Daniel Louvard, Hubert Reggio and Evelyne Coudrier (Paris and Marseille)</i> .....	<b>25</b>
1. Introduction.....	25
2. Structural and functional polarity of epithelia.....	26
2.1. The extracellular matrix as a source of asymmetry in epithelia, 26 — 2.2. The asymmetric distribution of plasma-membrane proteins is superimposed onto an asymmetrical distribution of the cytoskeletal networks, 27 — 2.3. The junctional complexes play an essential role in transporting epithelia but their structure is still poorly understood at a molecular level, 29 —	
3. The organisation of the brush border of enterocytes.....	32
3.1. Brush-border enzymes, 33 — 3.2. Organization of the microvillar microfilaments, 33 —	

3.3. Microfilaments–membrane interactions in microvilli, 36 — 3.4. The terminal web of the brush border, 37 —	
4. Biogenesis of cell polarity: a goal for future studies .....	38
References .....	40
<b>Chapter 3. Early biochemical events in the biogenesis and topogenesis of secretory and membrane proteins</b>	
<i>by George Scheele (New York) .....</i>	<b>43</b>
1. Protein translocation across the RER membrane .....	43
2. Translocation receptors .....	49
3. Start-transport and stop-transport signal sequences.....	51
4. Insertion and orientation of secretory and membrane proteins.....	52
5. Cotranslational and posttranslational processing of secretory and membrane proteins.....	54
References .....	59
<b>Chapter 4. Intracellular transport of newly synthesized secretory and membrane proteins</b>	
<i>by H. Sjöström, O. Norén, E.M. Danielsen and S.-U. Gorr (Copenhagen) .....</i>	<b>61</b>
1. Introduction .....	61
2. Types and number of pathways towards the plasma membrane .....	63
2.1. Transport from rough endoplasmic reticulum to the Golgi apparatus, 63 — 2.2. Post-Golgi exocytic pathways, 63 — 2.3. Membrane recycling, 65 — 2.4. Crinophagic pathway, 65 — 2.5. Overlap between different pathways, 66 —	
3. Isolation and characterization of transport vesicles .....	66
3.1. Secretory granules, 66 — 3.2. Purification of vesicles of the constitutive pathway, 67 — 3.3. Purification of endocytic vesicles, 67 — 3.4. Coated vesicles, 68 —	
4. Sorting .....	71
4.1. Sorting in the membrane, 71 — 4.2. Sorting of vesicles, 74 — 4.3. Sorting after fusion, 74 — 4.4. Sorting sequences, 75 —	
Acknowledgement .....	76
References .....	76
<b>Chapter 5. Hormonal regulation of digestive secretions</b>	
<i>by Jens Juul Holst (Copenhagen) .....</i>	<b>79</b>
1. Introduction .....	79
2. Chemistry of the gastrointestinal regulatory peptides .....	80
2.1. Identification of regulatory transmitters (peptides), 80 — 2.2. Biosynthesis of regulatory peptides, 87 — 2.3. Tissue-specific differential processing, 88 — 2.4. Peptide families, 89 —	
3. Secretion of regulatory peptides .....	90
3.1. Endocrine secretion, 90 — 3.2. Paracrine secretion, 92 — 3.3. Criteria for paracrine control, 92 — 3.4. Peptidergic nerves, 95 — 3.5. Stimulus for release of regulatory peptides, 99 — 3.6. Stimulus-secretion coupling, 100 —	
4. Mode of action.....	100
5. Peptidergic control of gastric and pancreatic secretions.....	103
5.1. Gastric secretion, 103 — 5.2 Pancreatic secretion, 105 —	
References .....	107

<b>Chapter 6. Adaptation of pancreatic and intestinal hydrolases to dietary changes</b> <i>by Antoine Puigserver, Catherine Wicker and Christine Gaucher (Marseille)</i> .....	<b>113</b>
1. Introduction .....	113
2. Influence of diet composition on the level and biosynthesis rate of some digestive enzymes ...	114
2.1. Secretory pancreatic hydrolases, 114 — 2.2. Membrane-bound intestinal hydrolases, 116	
3. Possible role of hormones in the dietary regulation of digestive enzymes.....	119
3.1. Control of pancreatic amylase biosynthesis by insulin, 119 — 3.2. Control of intestinal lactase by thyroxine, 120 —	
4. Molecular mechanisms mediating enzyme adaptation to diet.....	121
5. Concluding comments .....	123
References .....	123
 <b>Chapter 7. Structure and function of gastrointestinal mucus</b> <i>by G.G. Forstner and J.F. Forstner (Toronto)</i> .....	<b>125</b>
1. Introduction .....	125
2. Composition of intestinal mucin.....	125
2.1. Native mucin, 125 — 2.2. Peptide domains, 127 — 2.3. Oligosaccharides: general features, 129 — 2.4. Acidic and neutral species, 129 —	
3. Physical properties of intestinal mucins .....	129
3.1. Gel formation, 129 — 3.2. Molecular size and shape, 130 — 3.3. Models, 130 —	
4. Secretion of mucin, .....	131
4.1. Mechanisms of secretion, 131 — 4.2. Intracellular distribution of secretory granules, 132 — 4.3. Measurement of secreted mucin, 132 — 4.4. Stimulants of secretion, 133 — 4.5. Mucin and fluid/electrolyte secretion, 135 — 4.6. Fate of secreted mucin, 135 —	
5. Functional aspects.....	136
5.1. Lubrication, 136 — 5.2. Trapping of bacteria and parasites, 137 — 5.3. Permeability barrier, 137 — 5.4. Digestive zone, 138 —	
6. Mucus and disease.....	138
6.1. Neoplastic disease, 138 — 6.2. Transitional epithelium, 139 — 6.3. Inflammatory bowel disease, 140 — 6.4. Peptic ulcer disease, 140 — 6.5. Cystic fibrosis, 141 —	
References .....	141
 <b>PART II. The Bile</b> .....	<b>145</b>
 <b>Chapter 8. A quantitative dynamic concept on the role of bile in fat digestion</b> <i>by Jacques C. Hauton (Marseille)</i> .....	<b>147</b>
1. General introduction .....	147
2. A dynamic concept on the behaviour of lipids.....	148
2.1. Introduction and proposal of a new unit, 148 — 2.2. A 'quantitative' classification of lipids based on interphase partition coefficients, 149 — 2.3. Mathematical relations resulting from the quantitative classification of lipids, 150 — 2.4. Application to class 5 bile salts and class 4 phosphatidylcholines, 151 — 2.5. Genesis and physico-chemical parameters of mixed micelles, 152 — 2.6. Presence of two different lipid-water interfaces in mixed micelles. A new triangular co-ordinate model, 153 — 2.7. Possible co-existence of a stable interfacial phase and a micellar phase, 156 — 2.8. Mixed premicelles comprising classes 3:5 or 4:5 lipids, 157 — 2.9. Effect of partial blocking of the $S_A$ and/or the $S_D$ lipid-water interfaces, 157 —	



3. Interphase molecular exchanges in the absence of non-lipidic carrier.....	159
4. Structure of the bile-lipoprotein complex.....	159
4.1. Gel filtration without bile salt equilibration, 160 — 4.2. Gel filtration with bile salt equilibration, 160 — 4.3. Dynamic structure of the human bile-lipoprotein complex, 161 —	
5. Origin of the bile-lipoprotein complex.....	162
6. Role of bile in fat digestion.....	163
6.1. Site of action of the main pancreatic lipolytic enzymes, 163 — 6.2. Role of bile in the intestinal absorption of lipids, 164 — 6.3. Entero-hepatic circulation of bile salts, 166 —	
7. Conclusion.....	167
Acknowledgements .....	167
References .....	167
Addendum .....	170
<b>PART III. The Pancreas.....</b>	<b>171</b>
<b>Chapter 9. The exocrine pancreas</b>	
<i>by George Scheele and Horst Kern (New York and Marburg) .....</i>	<b>173</b>
1. Morphological structure of the acinar and ductal pancreas .....	173
2. Secretory proteins in the exocrine pancreas.....	176
3. Secretory pathway .....	180
4. Hormonal regulation of the exocrine pancreas .....	183
5. Coordinate and anticominate regulation of protein synthesis by hormonal stimulation.....	185
6. Alterations in the secretory pathway during secretagogue stimulation.....	188
7. Discharge of secretory proteins in the exocrine pancreas — parallel vs. nonparallel .....	190
References .....	192
<b>Chapter 10. Chemistry and enzymology of pancreatic endopeptidases</b>	
<i>by P. Desnuelle (Marseille) .....</i>	<b>195</b>
1. Introduction .....	195
2. Specificity .....	196
3. Molecular properties and activation of zymogens .....	197
4. The catalytic site .....	200
5. Reaction pathway .....	201
6. Mechanism of action .....	202
7. Multiplicity of forms .....	203
8. Naturally occurring inhibitors.....	204
9. Organization of messenger RNAs and genes.....	206
9.1. mRNAs, 206 — 9.2. Gene structure, 207 — 9.3. Chromosomal gene localization, 209	
—	
References .....	209
Addendum .....	211
<b>Chapter 11. Crystal structures of pancreatic serine endopeptidases</b>	
<i>by Wolfram Bode and Robert Huber (Martinsried).....</i>	<b>213</b>
1. Introduction .....	213
2. The general structure of serine proteinases.....	215

3. The zymogens and their mode of activation .....	222
4. Enzyme–ligand complexes and the catalytic mechanism .....	225
4.1. Pretransition state Michaelis complexes, 226 — 4.2. Tetrahedral intermediate analogs, 229 — 4.3. Acyl enzyme intermediates, 230 — 4.4. Enzyme–product complexes, 231 — 4.5. The reaction pathway, 231 —	
References .....	233
 <b>Chapter 12. Pancreatic exopeptidases</b>	
<i>by Antoine Puigserver, Catherine Chapus and Brigitte Kerfelec (Marseille)</i> .....	235
1. Introduction .....	235
2. Molecular characteristics of procarboxypeptidases A and B .....	236
3. Dissociation and reconstitution of the complex forms of procarboxypeptidase A .....	238
4. Intrinsic activity of procarboxypeptidases A and B .....	239
5. Activation of procarboxypeptidases .....	240
6. Catalysis by carboxypeptidase A .....	242
6.1. Chemical modification of active site residues, 242 — 6.2. X-Ray diffraction crystal anal- ysis, 243 —	
7. Multiple binding sites of carboxypeptidase B .....	245
8. Concluding remarks .....	245
References .....	246
 <b>Chapter 13. Pancreatic amylase: molecular genetics and evolution</b>	
<i>by Miriam H. Meisler and Deborah L. Gumucio (Ann Arbor)</i> .....	249
1. Introduction .....	249
2. Cloning the amylase mRNA .....	249
3. Gene structure .....	250
4. A clustered multigene family .....	251
5. Regulation of pancreatic amylase mRNA .....	253
6. Post-translational processing of amylase proteins .....	254
7. Amylase structure .....	256
8. Evolution of amylase sequences .....	256
9. Concluding remarks .....	261
Acknowledgements .....	261
References .....	261
Addendum .....	263
 <b>Chapter 14. Pancreatic ribonuclease and deoxyribonuclease</b>	
<i>by Pierre Desnuelle (Marseille)</i> .....	265
1. Pancreatic ribonuclease (ribonucleate 3'-pyridino-oligonucleotidohydrolase, E.C. 3.1.4.22) .	265
1.1. Introduction, 265 — 1.2. Purification, action on RNA and assay, 266 — 1.3. Structure, 267 — 1.4. Reduction and oxidation, 269 — 1.5. Chemical labeling, 270 — 1.6. Mechanism of action, 270 — 1.7. Macromolecular inhibitors, 271 —	
2. Pancreatic deoxyribonuclease (deoxyribonucleate 5'-oligonucleotide hydrolase, E.C. 3.1.4.5.) .....	272
2.1. Introduction, 272 — 2.2 Purification and structure, 272 — 2.3. Chemical labeling, 273 — 2.4. Role of divalent cations, 273 —	

References .....	273
Addendum .....	274

### Chapter 15. Pancreatic lipase and phospholipase

<i>by Pierre Desnuelle (Marseille)</i> .....	275
1. Introduction .....	275
2. General properties of lipase and phospholipase .....	276
2.1. Michaelis curves for the hydrolysis of insoluble substrates by lipase, 276 — 2.2. Lipolysis is affected by the 'quality' of the interface, 277 — 2.3. Dynamics of enzyme binding to lipid interfaces, 278 — 2.4. Activation of lipolytic enzymes at interfaces, 279 — 2.5. Interfacial denaturation, 280 — 2.6. Postional specificity of lipolytic enzymes, 281 —	
3. Pancreatic phospholipase A <sub>2</sub> (phosphatido-2-acyl-hydrolase, EC 3.1.1.4) .....	281
3.1. Purification and assay, 281 — 3.2. Covalent and three-dimensional structure, 283 — 3.3. The catalytic site, 283 — 3.4. The substrate-binding sites, 284 — 3.5. The calcium-binding site, 286 — 3.6. Activation of pro-phospholipase, 286 —	
4. Pancreatic lipase (triacylglycerol lipase, EC 3.1.1.3) .....	286
4.1. Purification and assay, 286 — 4.2. Chemical structure, 287 — 4.3. Chemical specificity, 288 — 4.4. Mechanism of action, 288 —	
5. Pancreatic colipase .....	289
5.1. Inhibition of lipase activity by bile salts, 289 — 5.2. Existence of a pancreatic colipase, 290 — 5.3. Purification and chemical structure, 291 — 5.4. The colipase effect, 291 — 5.5. Mechanism of action, 293 —	
References .....	294
Addendum .....	296

### Chapter 16. Pancreatic carboxylic-ester hydrolase and non-enzymatic constituents of pancreatic juice

<i>by Charlotte Erlanson-Albertsson (Lund)</i> .....	297
1. Introduction .....	297
2. Carboxylic-ester hydrolase (E.C. 3.1.1.1) .....	298
2.1. Assay systems, 298 — 2.2. Purification, 298 — 2.3. Molecular properties, 299 — 2.4. Substrate specificity, 299 — 2.5. Activation by bile salt, 300 — 2.6. Mode of action, 302 — 2.7. Physiological function, 303 —	
3. Other constituents of pancreatic juice .....	304
3.1. Serum proteins, 304 — 3.2. Lysosomal enzymes, 304 — 3.3. Lactoferrin, 304 — 3.4. Carcinoembryonic antigen, 305 — 3.5. Pancreatic stone protein, 305 —	
4. Concluding remarks .....	305
Acknowledgements .....	306
References .....	306

## PART IV. The Intestine .....

### Chapter 17. Cytodifferentiation of the intestinal villus epithelium

<i>by K. Haffen, M. Kedinger and B. Lacroix (Strasbourg)</i> .....	311
1. Current views on the morphology of the intestinal mucosa .....	311
1.1. The intestinal epithelium, 311 — 1.2. Epithelial cell renewal, 315 —	

2. Functional relationship between stromal and epithelial cells in the small intestine .....	316
3. Enterocytic features in colonic cancer cells: foetal resurgence .....	319
References .....	321
<b>Chapter 18. Control mechanisms in the ontogenesis of villus cells</b>	
<i>by M. Kedinger, K. Haffen and P. Simon-Assmann (Strasbourg)</i> .....	<b>323</b>
1. Developmental pattern of brush-border enzymes in correlation with some morphogenetic events .....	323
2. Regulation of enzyme maturation .....	325
2.1. Epithelial-mesenchymal interactions, 325 — 2.2. Hormonal control of brush-border enzymes, 329 —	
3. Conclusions .....	332
References .....	332
<b>Chapter 19. The enzymes of the enterocyte plasma membrane</b>	
<i>by O. Norén, H. Sjöström, E.M. Danielsen, G.M. Cowell and H. Skovbjerg (Copenhagen)</i> .....	<b>335</b>
1. Introduction .....	335
2. The intestinal microvillus .....	336
3. The intestinal basolateral membrane .....	339
3.1. Introduction, 339 — 3.2. The Na <sup>+</sup> ,K <sup>+</sup> -ATPase, 340 —	
4. Properties of the microvillar enzymes .....	342
4.1. Introduction, 342 — 4.2. Distribution of the microvillar enzymes, 343 — 4.3. Structure of the microvillar enzymes, 345 — 4.4. Enzymatic properties, 351 — 4.5. Role in digestion, 353 —	
5. Biosynthesis of microvillar enzymes .....	355
5.1. Introduction, 355 — 5.2. Site of synthesis, 356 — 5.3. Passage through the Golgi complex, 357 — 5.4. Pathway from the Golgi to microvillus, 359 — 5.5. Proteolytic processing, 359 —	
6. Catabolism of microvillar enzymes .....	360
Acknowledgements .....	361
References .....	361
<b>Chapter 20. Cytosolic peptidases of the small intestine</b>	
<i>by H. Sjöström and O. Norén (Copenhagen)</i> .....	<b>367</b>
1. Introduction .....	367
2. Distinct enzymes and their characteristics .....	368
2.1. Leucine aminopeptidase, 368 — 2.2. Tripeptide aminopeptidase, 369 — 2.3. Arginine aminopeptidase, 370 — 2.4. Pyroglutamyl aminopeptidase, 370 — 2.5. Aminoacyl-histidine dipeptidase, 370 — 2.6. Prolyl dipeptidase, 371 — 2.7. Proline dipeptidase, 371 — 2.8. Glycyl-leucine dipeptidase, 372 — 2.9. Other cytosol peptidases, 373 —	
3. Distribution .....	374
3.1. Various tissues, 374 — 3.2. In the intestine, 374 —	
4. Development .....	375
4.1 Phylogensis, 375 — 4.2. Ontogenesis, 375 —	
5. Genetics .....	375
5.1. Chromosomal localisation, 375 — 5.2. Enzyme deficiencies, 376 —	
6. Function .....	376

Acknowledgement .....	378
References .....	378
<b>Chapter 21. The absorption of sugars and amino acids across the small intestine</b>	
<i>by Giorgio Semenza and Angela Corcelli (Zürich and Bari)</i> .....	<b>381</b>
1. General.....	381
1.1. The biochemistry and molecular biology of the small intestinal transport system, 382 — 1.2. Interference among substrates, 384 — 1.3. A few words about vesicles, 384 — 1.4. On the so-called 'diffusion', 386 —	
2. Intestinal absorption of sugars and derivatives .....	387
2.1. The absorption of D-fructose, 387 — 2.2. The absorption of sugars and of sugar derivatives of the D-glucose/D-galactose type, 388 — 2.3. The hydrolase-related transport of sugars, 400 — 2.4. L-Ascorbate, 400 — 2.5. Myo-inositol, 401 —	
3. Intestinal absorption of amino acids and derivatives, .....	401
3.1. Transport of amino acids across the BBM, 404 — 3.2. Transport of amino acids across the BLM, 407 —	
Acknowledgements .....	408
References .....	408
<b>Chapter 22. The intestinal glycocalyx</b>	
<i>by A.M. Ugolev and V.A. Tsvetkova (Leningrad)</i> .....	<b>413</b>
1. Introduction .....	413
2. Distribution and structure .....	413
3. Turnover rate.....	414
4. Functions .....	415
References .....	419
<b>Chapter 23. The brush-border membrane of the rat colonic columnar epithelial cell</b>	
<i>by Hans-Peter Hauri, Bruno Stieger and Adrian Marxer (Basel)</i> .....	<b>421</b>
1. Structure and functions of the colonic mucosa.....	421
2. Problems encountered with the isolation of the brush-border membranes from colonocytes ..	422
3. Development of a method for the isolation of brush-border membranes from rat colonocytes.	424
4. Protein composition of the brush-border membranes from rat distal colon .....	428
5. Conclusion and perspectives .....	430
Acknowledgements .....	431
References .....	431
<b>PART V. The Salivary Glands .....</b>	<b>433</b>
<b>Chapter 24. Morphology and secretory mechanisms of salivary glands</b>	
<i>by E.W. Van Lennep, D.I. Cook and J.A. Young (Sydney)</i> .....	<b>435</b>
1. Introduction .....	435
2. Morphology of the secretory endpieces.....	436
2.1. Ultrastructure of secretory endpiece cells, 436 — 2.2. Ultrastructure of secretory granules, 437 — 2.3. Contents of secretion granules in endpiece cells, 438 — 2.4. Myoepithelium, 438 —	

3. Stimulus–secretion coupling in salivary glands .....	439
3.1. Receptor types, 439 — 3.2. Stimulus–protein secretion coupling, 440 — 3.3. Membrane retrieval after exocytosis, 443 — 3.4. Stimulation of secretory protein synthesis, 443 —	
4. Secretion of salt and water .....	444
4.1. The sodium pump, 445 — 4.2. The basolateral membrane and the anion symport, 445 — 4.3. The apical membrane and the hypothetical chloride channel, 446 — 4.4. The cytosol and the intracellular activity of inorganic ions, 447 — 4.5. The paracellular pathway, 448 — 4.6. Stimulation of secretion, an overview, 448 —	
5. The ducts .....	449
5.1. Morphology of the duct system, 449 — 5.2. Protein secretion by duct epithelial cells, 450 —	
References .....	453
<b>Chapter 25. Salivary amylase: evolution and tissue-specific expression</b>	
<i>by Miriam H. Meisler and Deborah L. Gumucio (Ann Arbor) .....</i>	<b>457</b>
1. Introduction .....	457
2. Cloning of salivary amylase mRNA .....	457
3. Gene structure and relationship to pancreatic amylase .....	458
4. Distance between salivary amylase ( <i>Amy-1</i> ) and pancreatic amylase ( <i>Amy-2</i> ) loci .....	458
5. Gene copy number .....	460
6. Expression in liver .....	460
7. Ectopic expression .....	462
8. Amylase evolution in the vertebrates .....	462
Acknowledgements .....	465
References .....	465
Addendum .....	466
<b>Chapter 26. Lingual lipase</b>	
<i>by Pierre Desnuelle (Marseille) .....</i>	<b>467</b>
1. Introduction .....	467
2. Location and purification .....	467
3. Molecular properties and action on triacylglycerol substrates .....	469
4. Biological role .....	470
References .....	470
Addendum .....	471
<b>PART VI. The Stomach .....</b>	<b>473</b>
<b>Chapter 27. The stomach. Cellular Aspects</b>	
<i>by Herbert F. Helander (Umeå) .....</i>	<b>475</b>
1. Introduction .....	475
2. Oxyntic gland area .....	476
2.1. The surface mucous cells, 476 — 2.2. The mucous neck cells, 478 — 2.3. The zymogen cells, 481 — 2.4. The parietal cells, 483 —	
3. Cardiac glands .....	488
4. Pyloric glands .....	488
5. Morphological aspects of stimulation .....	488

References .....	489
<b>Chapter 28. Pepsin, chymosin and their zymogens</b>	
<i>by Bent Foltmann (Copenhagen)</i> .....	<b>491</b>
1. Introduction .....	491
2. Structure .....	492
2.1. Primary structure, 492 — 2.2. Three-dimensional structure, 494 —	
3. Activity .....	496
4. Activation .....	497
5. Development .....	501
6. Genetics .....	503
7. Evolutionary overview .....	503
References .....	504
<b>Chapter 29. Molecular mechanisms of gastric HCl secretion</b>	
<i>by Miguel J.M. Lewin (Paris)</i> .....	<b>507</b>
1. Ion transport by gastric vesicles .....	507
1.1. H <sup>+</sup> transport, 508 — 1.2. K <sup>+</sup> and Cl <sup>-</sup> transport, 511 — 1.3. HCl transport, 513 —	
2. (H <sup>+</sup> ,K <sup>+</sup> )-ATPase .....	515
2.1. Subcellular localization, 515 — 2.2. Biochemical features, 516 — 2.3. Catalytic cycle,	
516 — 2.4. H <sup>+</sup> /ATP stoichiometry, 520 — 2.5. Molecular structure, 521 —	
Acknowledgements .....	523
References .....	524
Addendum .....	526
<b>PART VII. Subject Index</b> .....	<b>527</b>
<b>Subject Index</b> .....	<b>529</b>