

Contents

Chapter 1	THE NATURE OF ENERGETICS	1
1.1	Introduction	1
1.2	Equilibrium positions of reactions	2
1.3	The solvent capacity of cells	3
1.4	Coupled reactions	4
1.5	Phosphate as an intermediate	5
1.6	Adenosine triphosphate	6
1.7	The phosphate potential or energy charge	7
Chapter 2	OXIDATION-REDUCTION REACTIONS	9
2.1	Introduction	9
2.2	Redox potential	10
2.3	Electron carriers in cells	12
2.3.1	Introduction	12
2.3.2	Soluble electron carriers	12
2.3.3	Membrane-associated electron-transfer compounds	15
Chapter 3	MECHANISMS OF ENERGY TRANSDUCTION	19
3.1	Introduction	19
3.2	Substrate-level phosphorylation	20
3.3	The chemiosmotic coupling theory	22
3.4	Protonmotive potential	24
3.5	Stoichiometry of the process	25
3.6	The coupling of ATP synthesis to electron transport	25
3.7	Experimental evidence in favour of chemiosmosis	26
Chapter 4	THE ELECTRON-TRANSPORT CHAIN IN MITOCHONDRIA	27
4.1	Introduction	27
4.2	The number of components in the chain	27
4.3	The potential difference required for ATP synthesis	28
4.4	The composition of the chain	29
4.5	The mobile carriers	30
4.5.1	Ubiquinone	30
4.5.2	Cytochrome <i>c</i>	30
4.6	The complexes of the chain	31
4.6.1	The reactions of Complex I	31
4.6.2	The reactions of Complex II	31

4.6.3	The reactions of Complex III	32
4.6.4	The reactions of Complex IV	32
4.7	Other complexes in plant mitochondria	33
4.7.1	Introduction	33
4.7.2	The external NADH dehydrogenase	33
4.7.3	The alternative internal NADH dehydrogenase	34
4.7.4	The alternative oxidase	35
4.8	Inhibitors of the electron-transport chain	36
4.9	The mechanism of proton transport in the mitochondrion	37
4.9.1	Redox loops	37
4.9.2	The protonmotive Q cycle	38
4.9.3	Proton pumps	39
4.10	ATP synthesis in the mitochondrion	40
4.10.1	The structure of the ATP synthase	40
4.10.2	The formation of ATP	41
4.10.3	Reconstituting ATP synthesis	42
Chapter 5	ENERGY TRANSDUCTION IN THE CHLOROPLAST	43
5.1	Introduction	43
5.2	The primary reactions	45
5.3	The reactions of the photosystems	46
5.3.1	Introduction	46
5.3.2	Photosystem II	47
5.3.3	Photosystem I	49
5.4	The photosynthetic electron transport chain	50
5.4.1	The components of the chain	50
5.4.2	Non-cyclic electron transport	50
5.4.3	Cyclic electron transport	51
5.5	The establishment of a proton gradient in chloroplasts	52
5.6	The synthesis of ATP	53
5.6.1	The structure of the chloroplast ATP synthase	53
Chapter 6	THE GLYCOLYTIC AND PENTOSE PHOSPHATE PATHWAYS	55
6.1	The organization of plant metabolism	55
6.2	The hexose phosphate pool	57
6.3	Entry of metabolites into the hexose phosphate pool	59
6.3.1	The degradation of sucrose	59
6.3.2	The degradation of starch	60
6.3.3	The phosphorylation of free hexoses	63
6.4	Exit of metabolites from the hexose phosphate pool	64
6.4.1	The synthesis of sucrose	64
6.4.2	The synthesis of starch	65
6.4.3	Cell wall biosynthesis	66
6.5	The glycolytic and pentose phosphate pathways	66
6.5.1	Introduction	66
6.5.2	The conversion of fructose 6-phosphate to triose phosphate	66
6.5.3	The formation of pentoses by the oxidative reactions of the pentose phosphate pathway	69

6.5.4	The reversible reactions of the pentose phosphate pathway	71
6.6	The oxidative and ATP-generating reactions of glycolysis	72
6.7	The utilization of phosphoenolpyruvate (PEP) in plants	75
6.8	The utilization of pyruvate	75
6.8.1	Introduction	75
6.8.2	Anaerobic utilization of pyruvate	76
6.8.3	Pyruvate utilization by the mitochondrion	77
Chapter 7	THE TRICARBOXYLIC ACID CYCLE	80
7.1	Introduction	80
7.2	The reactions of the tricarboxylic acid cycle	80
7.3	The transport of metabolites into the mitochondrion	84
7.4	The interaction of the mitochondrion with the cytosol	85
Chapter 8	FATTY ACID SYNTHESIS AND BREAKDOWN	87
8.1	Fatty acid synthesis	87
8.1.1	Introduction	87
8.1.2	The source of acetyl CoA	87
8.1.3	The formation of malonyl CoA	88
8.1.4	The fatty acid synthetase complex	89
8.2	The degradation of fatty acids	92
8.2.1	Introduction	92
8.2.2	The degradation of storage lipids during seed germination	93
8.2.3	The degradation of triacylglycerols	93
8.2.4	Fatty acid degradation in the glyoxysome	94
8.2.5	β -Oxidation of fatty acids	94
8.2.6	The glyoxylate cycle	96
Chapter 9	THE CARBON REDUCTION CYCLE	99
9.1	Introduction	99
9.2	The fixing of carbon dioxide: ribulose biphosphate carboxylase (RuBPcase)	99
9.3	The reduction of 3-phosphoglycerate	102
9.4	The regeneration of the acceptor molecule: ribulose 1,5-biphosphate	103
9.5	The control of the reductive pentose phosphate cycle	105
Chapter 10	PHOTORESPIRATION	107
10.1	Introduction	107
10.2	The oxygenase activity of ribulose biphosphate carboxylase (RuBPcase)	107
10.3	The function of photorespiration	110
10.4	The requirement for three organelles in the pathway	111
10.5	The importance of nitrogen metabolism in photorespiration	112
Chapter 11	THE AVOIDANCE OF PHOTORESPIRATION: THE C₄ PLANTS	114
11.1	Introduction	114
11.2	The structure of C ₄ plants	114
11.3	The biochemistry of C ₄ plants	115

Chapter 12	AN ADAPTATION TO XEROPHYTIC CONDITIONS: THE CAM PLANTS	120
12.1	Introduction	120
12.2	The biochemistry of CAM plants	121
Chapter 13	THE INTERACTION OF THE CHLOROPLAST AND THE CYTOSOL	122
13.1	Introduction	122
13.2	The phosphate translocator	122
13.3	The integrated control of starch and sucrose biosynthesis	122
13.4	The coordination of sucrose synthesis with photosynthetic activity	124
Chapter 14	THE COMPARTMENTATION OF PLANT METABOLISM	126
14.1	Introduction	126
14.2	The source of plastids and activity of various plastids	126
14.3	The function of compartmentation in biosynthetic reactions	127
	REFERENCES AND FURTHER READING	132
	INDEX	141