Contents

Deaf	ace			ix	
	Preface Acknowledgements				
ACKI	ut the A	uthors		xiii xv	
Abo	ut the A	Lumors			
Cha	pter 1:	Introduc	tion	1	
1.1	Why S	Study Pho	otosynthesis?	1	
1.2	History				
	1.2.1		covery of photosynthesis	2	
	1.2.2	The concept of energy			
	1.2.3 Early research on photosynthesis				
			What absorbs the light for photosynthesis?	7	
		1.2.3.2	What goes in, and what comes out?	8	
		1.2.3.3	Which atoms go where? Is it possible		
			to answer this question?	10	
		1.2.3.4	How much light is required to drive		
			photosynthesis?	13	
Refe	erences			14	
Cha	pter 2:	The Phot	osynthetic Apparatus	17	
2.1	Introd	luction		17	
2.2		oplasts		17	
2.3			nbrane and Photosynthetic		
2.0		in Compl		20	
2.4		_		23	
2.5	Pigments Lipids and Proteins				
2.6	Evolu			23 26	
	rences			26	
Cha	pter 3:	Basics of	Photosynthesis: Light-Dependent Reactions	29	
3.1			vesting Sunlight to Drive		
Value.		Chemist		29 29	
3.2	Capturing the Energy of Light				
3.3	Conversion of Light Energy into Chemical Energy				

	3.3.1	Primary	photochemistry	36
	3.3.2			41
		3.3.2.1	The "Z-scheme" of photosynthesis	41
			Photosynthetic water oxidation	
			(oxygen evolution)	43
		3.3.2.3	Unique role of bicarbonate in light-induced	
			reactions of PSII	44
		3.3.2.4	Formation of reducing power	45
	3.3.3		transfer pathways and formation	
		of ATP (photophosphorylation)	46
Refe	rences			51
Cha	pter 4:	Basics of	Photosynthesis: The Carbon Reactions	59
4.1	C3 Ph	otosynthe	esis: The Calvin-Benson Cycle	59
4.2		*	esis: The Hatch-Slack Pathway	63
4.3			cid Metabolism	69
4.4			nd Biomass Production	71
4.5			vays and Evolution	74
	rences	*****		75
Cha	pter 5:	Regulatio	on of Photosynthesis	81
5.1	Backs	round		81
		Transition	is	82
			issipation of Electronic Energy	
	7	at ("Quen		86
5.4		ophyll Cy		87
5.5		* *	ers as Sinks for Excess	
		ation Ener		90
5.6			Chlorophyll Triplets	93
5.7		ation of R		94
5.8	-		on of Certain Calvin-Benson	
			by Thioredoxin	95
5.9			ory Mechanisms Related	
		otosynthe		96

Contents

5.10	0 Leaf Movement	97						
5.11	1 Concluding Remarks							
	ferences							
Cha	apter 6: Photosynthesis and Our Planet	107						
6.1	Oxygenation of the Earth's Atmosphere	107						
6.2	Protection: Ozone Was Formed From Oxygen							
	and It Protects Us From the UV Radiation	108						
6.3	Earth Temperature Over Time and the Effect							
	of the Biosphere on It	110						
	6.3.1 Influence of the Sun	110						
	6.3.2 Influence of the Earth's atmosphere	111						
6.4	Conclusion	115						
Refe	erences	117						
Cha	apter 7: Anoxygenic Photosynthesis	123						
7.1	Introduction	123						
7.2	Anoxygenic Photosynthetic Organisms:							
	Their Reaction Centers and Pathways							
	for Carbon Assimilation	125						
7.3	Relation between the RCs of Anoxygenic							
	and Oxygenic Photosynthetic Organisms	127						
7.4	Photosynthetic N ₂ Assimilation	128						
7.5	Rhodopsin-Based Phototrophy	131						
Refe	erences	132						
Cha	pter 8: The Past, Present and the Future	135						
8.1	Spread of Photosynthesis by Successive Endosymbiosis	135						
8.2	Adapting Photosynthesis that has Evolved Underwater	100						
	for Life on Land							
	8.2.1 Grana	140 141						
	8.2.2 Hormones	142						
	8.2.3 Stomata	143						
	8.2.4 Reaching for light	145						
	0							

		8.2.4.1	Evolution of trees	145	
		8.2.4.2	Cheating: Lianas (Climbers) and Epiphytes	145	
8.3	The R	Role of Fungi			
8.4	Makir	ng More F	Photosynthesis More Biomass,		
	More	Bioenerg	y, New Chemicals and Hydrogen	146	
	8.4.1	.770	: Classical breeding and genetic engineering	146	
	8.4.2	Convers	sion from C3 to C4 metabolism by genetic		
		enginee	ring	146	
	8.4.3	Cyanob	acterial genes in higher plants	147	
	8.4.4		ement of RuBisCO	148	
	8.4.5	Photore	spiratory bypass	149	
	8.4.6	Photosy	rnthetic H ₂ production	149	
	8.4.7	Biofuels	and other chemicals	152	
	8.4.8	Other in	mprovements	152	
Refe	erences			153	
Cha	pter 9:	The Ultir	nate: Artificial Photosynthesis	165	
9.1	Objec	tives and	Approaches	165	
9.2	Water Oxidation Coupled to Hydrogen Production:				
	in Pri	nciple Sin	nple, in Practice Not So Easy	166	
9.3	Reduction of Carbon Dioxide			172	
9.4	Conc	usions		176	
Refe	erences			177	
Inde	ex			183	