Photosynthesis and the Environment

Edited by

Neil R. Baker

Department of Biological and Chemical Sciences, University of Essex, Colchester, United Kingdom



KLUWER ACADEMIC PUBLISHERS
DORDRECHT / BOSTON / LONDON

Contents

Pre	eface	Χİ
1	Processing of Excitation Energy by Antenna Pigments Thomas G. Owens	1–23
	Summary I. Introduction II. Structure and Composition of Photosynthetic Antennae III. Role of the Antenna in Photosynthesis IV. Light-Harvesting Function of Antenna Pigments V. Non-Photochemical Quenching and Regulation of Light Energy Utilization VI. Concluding Remarks Acknowledgments References	1 2 4 5 9 12 21 21
2	Control and Measurement of Photosynthetic Electron	
	Transport in Vivo David Mark Kramer and Antony Richard Crofts	25–66
	Summary I. Introduction II. Control of the Photosynthetic Electron Transfer Chain III. What Reactions Can We Measure? IV. Instrumentation and Measurement V. The Future of Instrumentation for Intact Plants Acknowledgments References	26 27 28 31 32 58 59 60
3	Regulation of Light Utilization for Photosynthetic Electron	
	Transport B. Genty and J. Harbinson	67–99
	Summary I. Introduction II. Operation of Light-driven Energy Transduction in Leaves III. Significance of Structural Acclimation on the Operation of Light-driven	68 68 69
	Energy Transduction. A Case Study: Acclimation to Growth Irradiance IV. Conclusions V. Appendix: The Use of Light-Induced Absorbance Changes Around 820 nm	86 90
	to Measure P700 Oxidation Acknowledgments References	91 92 92
4	Mechanisms of Photodamage and Protein Degradation During Photoinhibition of Photosystem II B. Andersson and J. Barber 10	1–121
	Summary I. Introduction II. Photosystem II: Structure and Function III. Photochemical Processes Giving Rise to Damage	101 102 104 106

5	Change? V. Degradation of Reaction Center Subunits in Photosystem II VI. Repair of Photodamaged Photosystem II Requires Co-ordination Betwoeld Degradation and Biosynthesis Acknowledgments References Radical Production and Scavenging in the Chloroplasts Kozi Asado	110 11
	Summary I. Introduction III. Radicals and Dioxygen IIII. The Primary Target Molecules and Sites IV. Production of Reactive Oxygens and Radicals and their Scavenging E V. Microcompartmentation of the Scavenging Systems of Superoxide and Hydrogen Peroxide in Chloroplasts VI. Dioxygen Protects from Photoinhibition VII. Concluding Remarks Acknowledgments References	
6	Metabolic Regulation of Photosynthesis Mark Stitt Summary I. Introduction II. Pathways and Metabolite Measurements: Evidence for Highly Coordin Regulation of Many Reactions III. Regulatory Properties of Calvin Cycle Enzymes IV. Coarse Regulatability V. How can the Regulatory Capacity of a Protein be Evaluated? VI. Distribution of Control in Photosynthetic Carbon Metabolism Acknowledgments References	151—190 152 153 lated 154 155 166 167 173 183 183
7	Carbon Metabolism and Photorespiration: Temperature Dependence in Relation to Other Environmental Factors Richard C. Leegood and Gerald E. Edwards Summary I. General Philosophy II. Stomatal Versus Biochemical/Photochemical Limitations III. Changes in Biochemical Versus Photochemical Efficiency IV. Effects of Temperature on Metabolism V. Effects of Temperature on Photosynthesis in C ₃ Plants VI. Effects of Temperature on C ₄ Photosynthesis VII. Effects of Temperature on Crassulacean Acid Metabolism VIII. Temperature Compensation in Photosynthetic Metabolism IX. Effects of Temperature on Carbon Partitioning to Starch and Sucrose X. Acclimation of Photosynthesis to Temperature Shifts References	191-221 192 193 193 193 194 200 205 206 207 211 215

8	Gas Exchange: Models and Measurements John M. Cheeseman and Matej Lexa	223–240
	Summary I. Introduction II. The Biochemical Model III. Beyond the Biochemical Model IV. The Feedback Loop: Consequences for Field Studies V. Conclusion Acknowledgments References	223 224 226 228 235 237 237
9	Stomata: Biophysical and Biochemical Aspects William H. Outlaw Jr., Shuqiu Zhang, Daniel R. C. Hite and Anne B. Thistle	241–259
	Summary I. Introduction II. Plasmalemma Guard Cell Proton Pump III. Plasmalemma Potassium Channels IV. Plasmalemma Anion Channels V. Tonoplast Transport Processes VI. Abscisic Acid, Calcium, and the Phosphoinositide Messenger Systems VII. Integrating Role of Abscisic Acid in the Plant's Physiology VIII. Carbon Metabolism IX. Concluding Remarks References	241 242 244 245 246 247 249 249 253 253
10	Source-Sink Relations: The Role of Sucrose C. J. Pollock and J. F. Farrar	261–279
	Summary I. Introduction II. Sucrose As a Regulator III. Changes in Source Leaf Metabolism IV. Sinks V. Potential Mechanisms of Gene Regulation by Sugars VI. Conclusion References	262 262 263 266 271 274 275 276
11	Developmental Constraints on Photosynthesis: Effects of Light and Nutrition John Richard Evans	281–304
	Summary I. Introduction II. Effects of Light III. Effects of Nutrition IV. Conclusions Acknowledgments References	281 282 283 295 299 300 300

12	Molecular Biological Approaches to Environmental Effects on Photosynthesis	305–319
	Christine A. Raines and Julie C. Lloyd	
	Summary I. Introduction II. Genetics and Biogenesis of the Photosynthetic Apparatus III. Molecular Approaches to Environmental Stress IV. Environmental Stress in Photosynthetic Systems V. Conclusions References	305 306 307 308 315 317
13	Photosynthesis in Fluctuating Light Environments Robert W. Pearcy, John P. Krall and Gretchen F. Sassenrath-C	321–346 Cole
	 Summary Introduction The Nature of Sunfleck Light Regimes Factors Regulating the Photosynthetic Utilization of Sunflecks Regulation of the Transient Responses to Individual Lightflecks Are There Specific Adaptations in Shade Leaves for the Utilization of Sunflecks? Sunfleck Utilization in Natural Light Regimes Acknowledgments References 	321 322 323 324 334 340 341 343 343
14	Leaf Photosynthesis Under Drought Stress Gabriel Cornic and Angelo Massacci	347–366
	Summary I. Introduction II. The Resistance of Photosynthetic Mechanisms to Drought III. CO ₂ Concentration Inside the Chloroplast During Drought is Low IV. Changes in Metabolic and Whole Leaf Photosynthetic Responses Induced by Water Deficits V. Maintenance of Plant Water Content During Soil Drying VI. Light Utilization by Plants Under Drought VII. Conclusions Acknowledgments References	347 348 351 354 356 358 359 362 363
15	Photosynthetic Adjustment to Temperature Stefan Falk, Denis P. Maxwell, David E. Laudenbach and Norman P. A. Huner	367385
	Summary I. Introduction II. Short-Term Temperature Response of Photosynthesis III. Long-Term Temperature Response of Photosynthesis IV. Thylakoid Membrane Lipids V. Temperature and Chloroplast Development VI. Interaction of Light and Temperature VII. Photosynthetic Adaptation, Acclimation and Stress Acknowledgments References	367 368 369 372 375 377 378 380 380

16	Photosynthetic Responses to Changing Atmospheric Carbon Dioxide Concentration George Bowes	387–407
	Summary I. Rising CO ₂ in Perspective II. Sites of Action of CO ₂ in Plants III. Adaptation to Changes in Atmospheric CO ₂ IV. Diversity in Photosynthetic Responses to CO ₂ Enrichment V. Concluding Comments Acknowledgments References	387 388 389 390 393 402 402
17	The Modification of Photosynthetic Capacity Induced by Ozone Exposure Robert L. Heath	409–433
	Summary I. Introduction and Background II. Model Studies III. Whole Plant Studies IV. Photosynthesis or Stomates? V. Conclusions References	409 410 414 418 420 429
18	Ultraviolet-B Radiation and Photosynthesis Alan H. Teramura and Lewis H. Ziska	435–450
	Summary I. Introduction II. Penetration of UV-B Radiation III. Direct Effects of UV-B Radiation on the Light Reaction of Photosynthes IV. Direct Effects of UV-B Radiation on Carbon Reduction V. Direct Effects of UV-B Radiation on Carbon Oxidation VI. UV-B Induced Changes in Leaf Development VII. Changes in Plant Growth and Development with UV-B Radiation VIII. Protection and Repair of Photosynthesis IX. Future Research Priorities Acknowledgments References	435 436 437 sis 437 440 441 442 443 444 446 446
19	Evaluation and Integration of Environmental Stress Using Stable Isotopes H. Griffiths	451–468
	Summary I. Introduction II. Background to Stable Isotope Studies III. Applications of Stable Isotope Techniques IV. Future Potential Acknowledgments References Summary	451 452 453 459 464 465 465 469

20	Environmental Constraints on Photosynthesis: An Overview	
	of Some Future Prospects Neil R. Baker	469–476
	I. Introduction	469
	 Light Energy Transduction by Thylakoids 	470
	III. Carbon Metabolism	472
	IV. Leaf Gas Exchange	472
	 V. Scaling from the Chloroplast and Leaf to the Canopy 	475
	Acknowledgments	475
	References	475
Ind	ex	477