

Contents

| | |
|--|------|
| List of Contributors | xv |
| Preface | xvii |
| Bessel Kok (1918–1979): A Tribute, by George Cheniae and Jack Myers | xxi |

I Introduction

1

| | |
|---|---|
| Introduction to Photosynthesis: Energy Conversion by Plants and Bacteria | 1 |
| GOVINDJEE and JOHN WHITMARSH | |

| | |
|--------------------------------------|----|
| I. Introduction | 2 |
| II. Basic Concepts from Earlier Work | 5 |
| III. Concluding Remarks | 11 |
| IV. Literature | 11 |
| References | 12 |

2

| | |
|---|----|
| Current Attitudes in Photosynthesis Research | 17 |
| COLIN A. WRAIGHT | |

| | |
|---|----|
| I. Introduction | 19 |
| II. Reaction Centers | 21 |
| III. Electron Transfer Out of the Reaction Center | 28 |

| | |
|---|----|
| IV. The Electron Transport Chain | 33 |
| V. Energy Transduction | 44 |
| VI. Structure and Organization of the Photosynthetic Apparatus | 48 |
| VII. Phylogenetic and Metabolic Comparison in Photosynthesis | 51 |
| VIII. Concluding Remarks | 54 |
| References | 55 |

II Structure and Function

3

Photosynthetic Membrane Structure and Function

SAMUEL KAPLAN and CHARLES J. ARNTZEN

65

| | |
|-----------------------------|-----|
| I. Introduction | 67 |
| II. Photosynthetic Bacteria | 71 |
| III. Chloroplasts | 109 |
| IV. Conclusions | 140 |
| References | 140 |

4

Orientation of Photosynthetic Pigments *in Vivo*

JACQUES BRETON and ANDRÉ VERMEGLIO

153

| | |
|---|-----|
| I. Introduction | 155 |
| II. Methodology | 157 |
| III. Relative Orientation of Pigments within Isolated Photosynthetic Complexes | 166 |
| IV. Orientation of Pigments with Respect to the Membrane Plane | 178 |
| V. Local Order between Complexes in Photosynthetic Membranes | 187 |
| VI. Conclusions | 188 |
| References | 190 |

5**Reaction Centers**

195

MELVIN Y. OKAMURA, GEORGE FEHER, and NATHAN NELSON

| | |
|-------------------------------|-----|
| I. Introduction | 197 |
| II. Photosynthetic Bacteria | 203 |
| III. Green Plant Photosystems | 229 |
| IV. Concluding Remarks | 256 |
| V. Appendix | 262 |
| References | 264 |

III Primary Photochemistry**6****Electronic Structure and Function of Chlorophylls
and Their Pheophytins**

275

LESTER L. SHIPMAN

| | |
|---|-----|
| I. Introduction | 276 |
| II. Chemical Structures | 276 |
| III. Self-Consistent Field Calculations | 277 |
| IV. Canonical Molecular Orbitals | 278 |
| V. Configuration Interaction Calculations | 281 |
| VI. Singlet States | 282 |
| VII. Triplet States | 287 |
| VIII. Cation Radical States | 288 |
| References | 291 |

7**Chlorophyll Singlet Excitons**

293

ROBERT M. PEARLSTEIN

| | |
|--|-----|
| I. Introduction | 294 |
| II. Exciton Effects in Steady State Optical Spectra | 295 |
| III. Exciton States of Antenna Chlorophyll-Proteins | 302 |
| IV. Exciton Migration from Antenna to Reaction Center | 309 |

| | |
|---|-----|
| V. Exciton Effects in Picosecond Optical Spectra | 323 |
| VI. Exciton Effects within Reaction Center Complexes | 323 |
| References | 327 |

8**Primary Photochemical Reactions**

331

WILLIAM W. PARSON and BACON KE

| | |
|---|-----|
| I. Introduction: General Considerations | 332 |
| II. Photosynthetic Bacteria | 339 |
| III. Green Plants | 354 |
| References | 379 |

IV Electron Transport**9****Electron and Proton Transport**

387

WILLIAM A. CRAMER and ANTONY R. CROFTS

| | |
|---|-----|
| I. Introduction | 389 |
| II. Mechanism of Electron Transfer | 391 |
| III. Properties of Quinones | 398 |
| IV. Primary and Secondary Quinone Acceptors | 404 |
| V. Cytochromes | 418 |
| VI. The Electron Donors to P700 and P870 | 431 |
| VII. Vectorial Electron Transport | 435 |
| VIII. Protolytic Reactions | 449 |
| References | 457 |

10**Oxygen Evolution in Photosynthesis**

469

THOMAS J. WYDRZYNSKI

| | |
|-----------------|-----|
| I. Introduction | 470 |
| II. Substrate | 470 |
| III. Energetics | 472 |

| | |
|--------------|-----|
| IV. Kinetics | 473 |
| V. Chemistry | 489 |
| References | 500 |

11**Thermoluminescence from
Photosynthetic Apparatus**

507

YORINAO INOUE and KAZUO SHIBATA

| | |
|----------------------------------|-----|
| I. Introduction | 508 |
| II. Glow Curves | 509 |
| III. Characteristics of Bands | 514 |
| IV. Origin of Charges | 521 |
| V. Temperature-Jump Luminescence | 531 |
| References | 531 |

V Photophosphorylation**12****Mechanism of ATP Synthesis**

537

DONALD R. ORT and BRUNO A. MELANDRI

| | |
|---|-----|
| I. Chemiosmotic Coupling | 539 |
| II. Structural Organization of Coupling Reactions and Components | 550 |
| III. The Transmembrane Electrochemical Hydrogen Ion Gradient | 555 |
| IV. Stoichiometries of Photosynthetic Energy Conversion | 571 |
| References | 583 |

13**The Development of Electrochemical Potential
Gradient across Photosynthetic Membranes**

589

WOLFGANG JUNGE and J. BAZ JACKSON

| | |
|------------------|-----|
| I. Introduction | 590 |
| II. The Membrane | 594 |

| | |
|--|-----|
| III. Measurement of Membrane Potential | 598 |
| IV. Electrogenic Reactions in Thylakoids and Chromatophores | 609 |
| V. Protolytic Reactions in Thylakoids and Chromatophores | 626 |
| VI. Concluding Remarks | 634 |
| References | 639 |

14**Proton Translocating ATPases of
Photosynthetic Membranes**

647

RICHARD E. McCARTY and CHANOCH CARMELI

| | |
|--|-----|
| I. Introduction | 648 |
| II. Function of ATPase Complexes | 650 |
| III. Structure of ATPase Complexes | 657 |
| IV. ATPase Activity of Coupling Factors | 670 |
| V. Nucleotide Binding and Conformational Changes | 681 |
| VI. Postulated Mechanisms | 688 |
| References | 690 |

VI Biosynthesis of Pigments**15****Biosynthesis of Pigments in Plants and Bacteria**

699

CONSTANTIN A. REBEIZ and JUNE LASCELLES

| | |
|---|-----|
| I. Introduction | 702 |
| II. Detection, Putative Structure, and Distribution of Different Chlorophyll <i>a</i> and <i>b</i> in Green Plants | 703 |
| III. Structure, Distribution, and Function of Bacterial Tetrapyrroles | 721 |
| IV. Formation of the Chlorophyll <i>a</i> Pool in Green Plants | 725 |
| V. Formation of the Chlorophyll <i>b</i> Pool in Green Plants | 756 |
| VI. Regulation of the Chlorophyll Biosynthetic Pathway | 757 |

| | |
|---|---------|
| VII. Synthesis of Hemes and Bacteriochlorophyll in Photosynthetic Bacteria | 759 |
| VIII. Regulation of Bacteriochlorophyll Synthesis | 767 |
| IX. Synthesis of Phycobilins | 770 |
| X. Formation of Prenyllipids (Including Carotenoids) | 771 |
| References | 772 |
| Index | 781 |