Preface

Many textbooks treat the topic of photosynthesis as a branch of the biological sciences. The focus is usually on how the electron transport chain and the dark reactions work together to produce carbohydrates and oxygen from carbon dioxide and water. However, the earliest events in this process, including the absorption of light, the act of charge separation, the process of stabilizing the charge-separated state, the buildup of charge to catalyze the oxidation of water, and the movement of protons, are topics that fall more properly under the realm of biophysics and are often not given the attention they deserve. On one hand, the basic laws of physics govern the early events in photosynthesis and place important constraints on how the capture and storage of light energy can occur. On the other hand, living organisms have an enormous degree of flexibility, allowing basic biochemical processes to be optimized through the process of evolution. The result of the eons-long interplay between fundamental physical constraints and evolutionary adaptation is the process of oxygenic photosynthesis.

In this volume, we divide the topic of the biophysics of photosynthesis into five sections. Each of these sections covers a specific aspect of photosynthesis, ranging from light absorption through evolution of the reaction centers. The chapters describe the role that basic physical principles play and give a picture of current research in the area.

Part I deals with the absorption of a photon and the process of energy transfer among the antenna chlorophylls. In Chap. 1, Frank Müh and Thomas Renger use structural information provided by crystallography and spectroscopy to calculate couplings among pigment-protein and excitonic pigment-pigment assemblies. In Chap. 2, Jörg Pieper and Arvi Freiberg describe the technique of hole-burning spectroscopy and how it provides critical information on exciton-phonon coupling in antenna pigments. In Chap. 3, Tjaart Krüger, Vladimir Novoderezhkin, Elisabet Romero, and Rienk van Grondelle offer a fresh view of energy transfer among the pigment array and the initial act of photochemical charge separation.

Part II focuses on the underlying principles of electron transport relevant to photosynthetic reaction centers. In Chap. 4, Christopher Moser discusses how quantum mechanical tunneling among inorganic and organic cofactors governs electron

transport in proteins. In Chap. 5, Isaac F. Céspedes-Comacho and Jörg Matysik describe the often-neglected, but equally important, operation of spin in electron transport. In Chap. 6, David Mauzerall and Steve Mielke provide information on the thermodynamics of energy changes in photosynthesis through the use of pulsed photoacoustic spectroscopy.

Part III is devoted to the charge separation and its stabilization over periods of time that are relevant to physiology. In Chap. 7, Sergei Savikhin and Ryszard Jankowiak show how ultrafast optical spectroscopy and hole-burning spectroscopy provide information on the mechanism of primary charge separation in a variety of photosynthetic reaction centers. In Chap. 8, Stefano Santabarbara, Robert Jennings, and Giuseppe Zucchelli illustrate how the concept of quasi-equilibrium states provides a framework for understanding the kinetics of electron transfer and radical pair stabilization in photosystem I. In Chap. 9, James Allen and JoAnn Williams describe their work on protein cofactor interactions and how they are able to modulate the midpoint potentials of cofactors in the bacterial reaction center.

Part IV is concerned with the description of donor-side intermediates of photosystem II and the process of water splitting. In Chap. 10, K. V. Lakshmi, Christopher Coates, and Ruchira Chatterjee describe the discovery and properties of radical intermediates in photosystem II. In Chap. 11, Jian-Ren Shen outlines structure–function relationships gleaned from the high-resolution structure of the Mn_4CaO_5 water-splitting cluster. In Chap. 12, Serguei Vassiliev and Doug Bruce provide insight obtained from computational studies on water and oxygen diffusion pathways within photosystem II.

Part V attempts to provide a time course of how the flexibility of biology overcame the inflexibility of physics in the evolution of photosynthesis. In Chap. 13, Alexander Melkozernov provides a compelling narrative of how an attempt to protect against ionizing radiation provided the protein framework for what was to become the photosynthetic reaction centers. In Chap. 14, John Allen posits a novel mechanism to describe how anoxygenic type I and type II reaction centers cooperated in space and time to create the process of oxygenic photosynthesis.

We hope that the reader of this volume will come away with a deeper appreciation of the role of biophysics of the early events in photosynthesis and a more in-depth understanding of how light is converted into a stable charge-separated state and, ultimately, into chemical bond energy.

University Park, PA, USA — John H. Golbeck
St. Catharines, ON, Canada — Art van der Est

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