Photosynthesis Research (2005) 85: 251–253

Book review

Molecular to Global Photosynthesis. Edited by Mary D. Archer and James Barber. Imperial College Press, London, UK, 2004, 764 pp (hard-copy, USD 158).

This book is volume 2 in the Series titled '*Photoconversion of Solar Energy*' (Series Editor, Mary D. Archer); Volume 1 dealt with '*Clean Electricity from Photovoltaics*' and was edited by Mary D. Archer and Robert Hill. Volumes such as those in the present series are much needed since they present information relating basic photosynthetic processes to energy-crop and bio-fuel production. Given that fossil fuels are finite and are hence expected to run out, the human race needs to have in place innovative effective strategies for converting solar energy to fuel and other energy sources. This book presents a 'classic', view of photosynthesis, with a heavy slant on light reactions, productivity and fuel production. The reader should therefore not look to this work for information on the genetics or molecular biology of photosynthesis; it is rather a concentrated, comprehensive account of the structure and function of the photosynthetic apparatus in relation to environment and product and biomass production.

Beginning with a charming *Preface*, using a quotation from Nicholas Copernicus that pays homage to the Sun "*In the midst of all this dwells the Sun... Sitting upon the royal throne, he rules all the family of planets which turn around him...we find in this arrangement an admirable and world harmony*", this book elegantly summarizes photosynthesis, the process that converts solar energy into chemical energy, from molecular to global level. Moreover, this work is appropriately dedicated to a fine man and a great scientist, Sir George Porter (1920–2002). Sir George made a significant contribution to the field, particularly in promoting the importance of water splitting as a unique model for energy production, which once understood could be used to design new, efficient and clean bio-reactors for energy production. The use of quotations at the beginning of each chapter, together with brief biographies of the authors provides added value to this excellent volume.

The volume holds a useful and interesting mix of subject areas, although not all chapters are of necessity presented with the same level of detail. While this is often the case with multi-authored books, the wide-ranging and general nature of some of the chapters requires a more descriptive overview. The book is truly international in perspective, comprising of chapters written by 24 authors from 9 countries (Belgium, Denmark, France, Germany, Israel, Russia, Spain, UK and USA). While focusing mainly on oxygenic photosynthesis, anoxygenic photosynthesis is discussed wherever it is relevant. Chapters 1–5 deal with the basics of the photosynthetic processes whereas chapters 6–13 deal with wider aspects and applications. Chapter 6 successfully bridges these topics in a valuable consideration of the *evolution of photosynthetic organisms*. The reader will recognize, as they read our review, that we have added our own personal and historical perspective of the volume in relation to the literature in the field. Our comments may therefore be colored slightly by our own perspectives of the enormous scientific heritage and wealth of literature that has long characterized the field of photosynthesis research when we recommend further reading in relation to chapters 1–5.

Chapter 1 provides a wonderful introduction to photosynthesis for the non-specialist reader beginning with the foundations of true research in the field by including the welcome quotation from Robert Mayer (in 1845) on the storage of light energy. This chapter traces the relationships between photosynthesis and respiration, discussing concepts from energy requirements to biomass production, while encompassing basic ideas regarding pigments, light harvesting, electron transport and the original early concepts of 'light' and 'dark' reactions of photosynthesis. If we were to suggest a second work for the reader to complement and extend the insights given in this comprehensive chapter, it would be Bacon Ke's superb book on "Photosynthesis: Photobiochemistry and

Photobiophysics (2001; volume 10: Advances in Photosynthesis and Respiration, Kluwer Academic Publishers, now Springer). Moreover, the reader could consider the role of chlorophyll *d* in *Acaryochloris marina* and Andrew Benson's contributions with regard to photosynthetic carbon fixation. Similarly, the Emerson enhancement effect in connection with the two-light reaction two-pigment system scheme; and the structure of cytochrome b_6f complex are important topics for further reading (see Govindjee and Krogmann (2004) Photosynth Res 80: 15–57 for a time-line and references). *Chapter 2* contains a thorough and useful description of the light absorption and harvesting processes. Moreover, it is beautifully illustrated with 15 exceptional colored plates that enhance the enjoyment of reading this authoritative overview. This chapter provides a thorough description of pigment energy levels, the mechanism of energy transfer and primary photochemistry. However, this topic is not trivial and if one is not alert, it is easy to confuse effective rate of charge separation intrinsic rate of charge separation and overall charge separation time. If we were to suggest anything to add to this solid and keynote chapter, it would be: the new structures of higher plant Photosystem I (Ben-Shem et al. (2003) Nature 426: 630–635) and of the higher plant light-harvesting complex II (Liu et al. (2004) Nature 428: 287–292); and the charge separation work in Photosystem II (Greenfield et al. (1997) J Phys Chem B 101: 2251–2255). *Chapter 3* contains an excellent discussion of mechanisms of electron transport in photosynthesis including a detailed consideration of primary reactions in both oxygenic and anoxygenic photosynthesis. If we were to suggest anything to add, it would be a recognition of the early work done in the laboratories of one of us (G); Jack van Rensen; and Alan Stemler on the role of bicarbonate in Photosystem II (see e.g., van Rensen et al. (1999) Physiol Plant 105: 585–592; Stemler (2004) Photosynth Res 73: 177–183; and van Rensen (2004) Photosynth Res 73: 185–192). *Chapter 4* is provides a sound and thorough summary of photosynthetic carbon assimilation written by two pioneers in the field who give their own unique perspectives of the subject from C-3 and C-4 photosynthesis through to photorespiration and CAM together with the history of research on the chloroplast envelope phosphate translocator. Non-specialist readers and students will find this chapter useful and easy to follow. Readers of this chapter may also wish to consult the historical perspectives given by Benson (2002, Photosynth Res 73: 29–49) and Bassham (2003, Photosynth Res 76: 35–53) for the C-3 cycle; Portis and Salvucci (2002, Photosynth Res 73: 257–264) for Rubisco activase; Ogren (2003, Photosynth Res 76: 53–63) for photorespiration; and Black and Osmond (2003, Photosynth Res 76: 329–341) for CAM. *Chapter 5* deals with the all-important process of regulation of photosynthesis in higher plants in a simplistic but useful analysis. Since this is a very large area to cover, we congratulate the authors of *Chapter 5* in bringing together a discussion of some of the many and varied strategies that plants use to adapt to high light, carbohydrate overload by feedback regulation and factors that limit growth under different abiotic stress conditions. For further reading, we suggest that the reader also consults the chapters in Eva-Mari Aro and Bertil Andersson (eds) (2001, Regulation of Photosynthesis, Kluwer Academic Publishers, now Springer), and in Christine Foyer and Graham Noctor (eds) (2002, Photosynthetic Nitrogen Assimilation and Associated Carbon and Respiratory Metabolism. Kluwer Academic Publishers, now Springer).

We highly recommend *Chapter 6*, where the basics of aquatic photosynthesis, together with potential applications, are described in considerable and impressive detail. Here, the evolution of aquatic photosynthetic organisms is discussed in relation to function and environment. This enjoyable chapter captures the imagination regarding the effect of photosynthesis on the earth's oxygen concentration and its effects on the evolution of various organisms. In this regard, we recommend that the reader also consults Olson and Blankenship (2004, Photosynth Res 80: 373–386). *Chapter 7* follows appropriately from the preceding fundamental analysis of aquatic photosynthesis as it describes the vast potential that exists for exploitation of algae for product production. Examples are given regarding uses in animal feed and for production of bioactive molecules such as drugs for treating cancers and other serious diseases. A number of laboratories around the world are currently using molecular engineering technologies to produce novel and useful products from the green alga *Chlamydomonas* and from other algae.

Chapter 8 deals with the very important topic of photosynthetic hydrogen production. It begins

with the wonderful quotation from Jules Verne as follows: "*I believe that water will one day be used as a fuel, because the hydrogen and oxygen that constitute it, used separately, or together, will furnish an inexhaustible source of heat and light*." This chapter contains a wealth of useful information, presented in an informative and clear style. The authors stress the importance of molecular engineering of 'hydrogenase' so that new forms, that are insensitive to oxygen, are produced. This is a crucial goal for successful exploitation of this and other related developing biotechnologies. For further reading in this regard we recommend: Melis et al. (2004, Photosynth Res 82:277–288).

Chapter 9 returns from a consideration of the potential of the photosynthetic organisms in the earth's oceans to energy crops on land. The chapter provides a much appreciated practical approach to the topic. It is a valuable source of information particularly for non-specialists who might, however, find the subject quite hard-going, particularly with regard to the figures. It is surprising perhaps that data from two major countries (China and India), which house almost 50% of world's population are not presented or discussed. *Chapter 10* deals with technical issues related to the production of biofuels. The information provided in this chapter will be very useful not only to researchers already engaged in this area, but also other scientists interested in learning more about this developing field. The inclusion of a number of photographs of various plants in this chapter *is* visually appealing but appears to serve little particular value. *Chapter 11* presents the basics of the global carbon cycle. It is well-written and particularly timely and important, given the current upsurge of interest in energy-neutral crops in relation to global warming. It is perhaps because of the intense public and scientific interest in this topic, that we found this chapter a little brief. We were left with the feeling that there was much left unsaid and we wanted to have more information than that covered in the chapter. However, following on logically from this subject, *Chapter 12* discusses the management of terrestrial vegetation in order to mitigate global climate change. Finally, the book ends with a key chapter, (*Chapter 13*) on the future prospects and potential of '*Biotechnology*'. This chapter is highly informative and well-written including issues such as the essential development of new methods, the production of transgenic crops and trees, and population growth in relation to agriculture. It also describes global petroleum resources and the engineering of novel input and output traits as well as protein engineering for molecular *pharming* and the production of bioplastics even provides some information on key economic and political issues.

In conclusion, we recommend *Molecular to Global Photosynthesis* to the reader without reservation, as it is a timely book not only for research scientists but also for non-specialists such as the policy makers. This book will become a essential volume for all college and university libraries as it fits into a rather unique niche in terms of ramifications for all biosciences. While some chapters are very specialized in terms of the information that they hold, we consider that this attractive and unique book will appeal to a wide readership as it examines the key basic and applied aspects of photosynthesis in a straightforward and informative style. The recognition that photosynthesis sustains all life on earth, providing food, fuel and oxygen, is crucial to the survival of humanity, as politicians debate strategies for the future exploitation of agriculture and the exploitation of the earth's oceans. Moreover, the application of the knowledge gained from a better understanding of how this multi-faceted process works and can be gainfully exploited, is essential in order to sustain the environment of our planet while providing for the needs of its peoples. Through the use of solar energy in 'artificial photosynthesis' it will soon be possible to produce energy and hydrogen gas. Plant biotechnologies have much to offer in terms of improved biomass as well as exploitation in other areas such as biofuels, drugs; and chemicals. We congratulate Mary D. Archer and James Barber for producing this important, timely and thought-provoking book.

Govindjee
Department of Plant Biology
University of Illinois at Urabana Champaign
Urbana, IL 61801, USA
E-mail: govlife.uiuc.edu

Christine H. Foyer
Rothamsted Research
Harpenden, AL 52JQ, UK
E-mail: Christine.foyer@bbsrc.ac.uk