Photosynthesis Research 13: 95–98 (1987)

Book reviews

D.O. Hall and K.K. Rao: **Photosynthesis**; 4th edition, 1987, Edward Arnold (Publishers) Ltd, 41 Bedford Square, London WC1B DQ, UK, ISBN: 0-7131-2945-X, 122 pages.

The fourth edition of Hall and Rao's Photosynthesis is a welcome and a refreshing addition to the growing library of photosynthesis books. Its major positive qualities are: it is short, to the point, up-to-date, balanced and easy to read. In 1987, it may be the first book that undergraduate and graduate students turn to to learn about photosynthesis. After reading the entire book, we found it relatively free of errors. Thus, we recommend it to all the undergraduates and graduates around the world who wish to obtain a basic knowledge about the important process of photosynthesis.

The book is divided into nine balanced chapters: (1) Importance and Role of Photosynthesis (8 pages); (2) History and Progress of Ideas (10 pages); (3) Photosynthetic Apparatus (19 pages); (4) Light Absorption and Two Photosystems (14 pages); (5) Photosynthetic Electron Transport and Phosphorylation (15 pages); (6) Carbon Dioxide Fixation (19 pages); (7) Bacterial Photosynthesis (11 pages); (8) Research in Photosynthesis (16 pages); and (9) Laboratory Experiments (contains only a list: 2 pages). We were pleased to see that the 4th edition includes a discussion of chloroplast genetics, evolution of photosynthesis, a comparison of plant and bacterial photosynthesis and the latest breakthrough in photosynthesis research: crystallization of a bacterial reaction center from *Rhodopseudeomonas viridis* and the determination of its structure by X-ray analysis. We also felt that the presentation of chloroplast structure in chapter 3 was particularly clear. Overall we found chapter 1 to be an interesting and useful introduction, but the inclusion of a brief discussion of the concept of redox potential would be a welcome addition here. The text is followed by a useful one-page appendix, a list of further reading (5 pages) and a short subject index (3 pages). As a member of the editorial board of *Photosynthesis Research*, one of us (G) was particularly pleased to see that several minireviews in our journal were cited in the list of further reading.

In view of our expectation that this book will be read by a vast number of students, we have taken pains to provide a page-by-page list of suggestions and notes for the benefit of the readers (the aim of this list is to aid the novice, rather than to criticize the book): **Page 2**: line 11 — the reader should remember that there is a continual increase in atmospheric CO_2, and this increase might lead to serious problems in the future (see e.g., a brief discussion on pp. 173–174 in A.P. Ingersoll "The Atmosphere", Scientific American, September, 1983) **Page 6**: Paragraph 2 beginning "It should . . ." to the end of the paragraph is misleading and should be skipped by the reader. **Page 13**: line 4 — the citation of $100\,W\,m^{-2}$ is confusing as the light saturation levels for curves B and C are at lower intensities than for curve A in Fig. 2.3; line 13 — it is incorrect to list 800 nm as red light especially, in the context of the text, because there is no photosynthesis at that wavelength. **Pages 16 and 17**: Emerson did not measure quantum yields of photosynthesis in saturating light flashes; quantum yields were always measured with low intensity continuous (monochromatic) light beams. **Pages 30 and 31** (Table 3.2): For "water oxidizing protein, M, a question mark should follow +0.82 V as this has not been measured for the 34 kDa protein; the description of function, etc., should be clearly marked as an "assumption" (there is no evidence yet); for P680, it is no longer certain if it is on the 47 kDa protein (also referred to as a 53 kDa protein in Figs. 5.2 and 8.1) or on the D_1–D_2 proteins; thus, you should read, "bound to the D_1–D_2 proteins, or to the 47 kDa protein"; for cytochrome b_{559}, the molecular weight of its two polypeptides are 9.16 kDa and 4.27 kDa (Cramer et al. *Photosynth. Res. 10*, 393–403, 1986); you should omit its function as "between M and RC protein" (this has not yet been shown). You might want to add for cytochrome b_{563} that it might be involved in the so-called "Q cycle". **Page 38**: The legend for Fig. 4.2(b) is missing; it should read "Energy level diagram". **Page 44**: Perhaps, you should add to the legend of

Fig. 4.7: "however, no evidence exists for Cyt b_6 to be involved in the linear electron transport as shown in the figure". **Page 51**: Paragraph 2, line 3 — 10^{-1} is too slow, change it to 10^{-2}. **Page 53**: (1) It should be mentioned (here and on p. 61) that no *firm* evidence exists yet for cyclic photophosphorylation to occur in vivo; (2) it is misleading to talk about "low energy electrons" (line 1 under section 5.3); (3) chlorophyll *b* is not a carrier (line 8 under section 5.3); (4) it may be misleading to state that it is the water protons that are transferred to $NADP^+$. **Pages 54 and 55**: You need a picture to understand EFs, ESs, PFs, PFu, etc. (perhaps you can see p.32 of chapter 1 by L.A. Staehlin in Encyclopedia of Plant Physiology New Series, volume 19, Springer Verlag, Berlin, 1986). Note that the orientation of electron carriers shown in Fig. 5.2(b) is schematic; also that P680 may not be on the 53 kDa (or 47 kDa) polypeptide; and that the molecular weight of cytb_{559} is not 110 kDa (9.16 and 4.27 kDa). We don't know what the photograph below the diagram is all about. **Page 56**: paragraph 1 — since the authors are talking about photosystem I and photosystem II, not pigments in solution, you should change 660 nm to 680 nm for chlorophyll *a*, and 643 nm to 650 nm for chlorophyll *b*; also note that algae are plants, and thus we should not talk about plants *and* algae (also see p. 93, line 3, under section 7.6; and p. 104, line 13). Paragraph 2 — You should add "later in 1957", between "showed" and "that" (line 3). However at the end of this paragraph, you could add: "It was soon shown by others that the second light, absorbed by a short wavelength form of chlorophyll *a*, also gave enhancement in the yield — this solved the dilemma of energy absorbed in chlorophyll *b* always ending up in chlorophyll *a* (see chapter 4, and a discussion on pp. 175–176 in E. Rabinowitch and Govindjee, Photosynthesis, John Wiley & Sons, N.Y., 1969). Paragraph 4 — It is not true that "similar experiments have recently been done to show the reduction and oxidation of cytochrome *b* in the chloroplast"; cytochrome *b* has not been shown to participate in the linear electron transport (obviously, R. Hill was not right about this prediction). **Page 57**: last paragraph — we would add Levine, who worked extensively with *Chlamydomonas* mutants; *Scenedesmus* was used by Bishop; lines 5–6 — (see Fig. 5.2(a)) correct it by changing cytochrome *b* to *f*, plastocyanin to plastoquinone and cytochrome f to P700 (note: there is no intermediate between plastocyanin and cytochrome f). **Page 58**: paragraph 1 — although the net effect of DCMU is inhibition of O_2 evolution, the specific block occurs between Q_A and PQ (see Fig. 5.2(a)); it is suggested that this occurs because DCMU "competes" with Q_B for binding on the Q_B-protein (32 kDa or D1); see Fig. 5.2(b). **Page 64**: paragraph 1 — Fig. 5.2(a) shows that photosystem II reduces pheophytin (redox potential of pheophytin/pheophytin$^-$ is ~ -600 mV); thus, in principal, this system should be able to reduce any molecule with E_m more positive than -600 mV! **Page 74**: The overall ΔG for electron transfer from H_2O to $NADP^+$ should be positive, rather than negative. Otherwise, photosynthesis should not require light energy: this transfer is uphill and occurs because light provides the necessary energy. **Page 83**: The reader should be reminded that on line 4 of Table 6.1, one should distinguish between CO_2 and HCO_3^-: The RUBISCO enzyme utilizes CO_2 and PEPC'ase utilizes HCO_3^- and this difference is very important for the differences between C_3 and C_4 plants. **Page 87**: A schematic illustration of chromatophore formation, as given for inside-out membrane vesicles in Fig. 4.10, would be a useful addition. **Page 90**: It would be nice to mention that reaction centers of photosystem II of plants might be quite similar to that of the purple bacterium *R. viridis*, and that Photosystem I reaction center complex might be quite similar to that of green bacterium *Chlorobium*. Note also that the scheme provided in Fig. 7.4, *per se*, does not have too much to do with the X-ray structure analysis (mentioned in the preface of the book). It would be instructive to see diagrams by Deisenhofer and Michel (see *e.g.*, Figs. 2 and 3 in chapter 8.4 (pages 375 and 378) in Encyclopedia of Plant Physiology New Series, Volume 19, Springer Verlag, 1986). **Page 93**: Paragraph 2, lines 5–8 — the sentence beginning with "The relatively . . . complex" is misleading and makes no sense to us; it could be omitted from your reading. Last line: please note that one is talking about the green bacterium *Chlorobium*, and not *Chloroflexus*; the latter have electron carriers similar to those in purple bacteria, not photosystem I. **Page102**: What is discussed in the last paragraph is the mechanism of "energy redistribution between the two photosystems", not "energy transfer", and certainly not "spillover". It is more a "separate package" model in which the absorption cross section of the two photosystems change, rather than only a change in the spillover of energy transfer from the Photosystem II region to Photosystem I. Thus the title of section 8.5 is misleading, we think. **Page 103**: It is not true that F720 belongs only to algae and F735

only to chloroplasts; it is a matter of relative proportions of the two emission bands: both are present in chloroplasts of higher plants and originate in different pigment protein complexes. In algae, however, F735 is extremely low. (Readers interested in fluorescence may wish to consult "Light Emission by Plants and Bacteria", edited by Govindjee, Amesz and Fork, Academic Press, 1986, for further reference.) Since the mechanism of ATP synthesis is a very important area, we would have preferred a little longer discussion of this topic in the chapter on "Research in Photosynthesis". Readers may, however, consult a rather detailed discussion on pages 179–188 by D.R. Ort in Encyclopedia of Plant Physiology New Series, Volume 19, Springer Verlag, 1986. Those who can afford the time are recommended to read the entire chapter by Ort (pp. 143–189) as additional reading. It is an excellent chapter and would broaden one's horizons.

In conclusion, we must mention that we enjoyed reading Hall and Rao's book. This book should be read by everyone who wants a balanced overview of the field of photosynthesis. (However, see the above long paragraph for corrections and suggestions.) We enthusiastically recommend it to all students of plant physiology, biochemistry, biophysics, biology, agronomy and botany. Our "crystal ball" says that this book will be one of the better "best sellers".

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Photosynthesis III. Photosynthetic Membranes and Light harvesting Systems.
L.A. Staehelin and C.J. Arntzen, editors, Springer-Verlag, Berlin 1986.

This volume is the third in the series *Encyclopedia of Plant Physiology* that considers the topic of photosynthesis. The previous volumes dealt with electron transport plus photophosphorylation and the photosynthetic carbon fixation processes. Both these volumes were characterized by a number of concise minireviews on particular subjects written by acknowledged experts in the respective field. This format yielded volumes which were up-to-date and well focused, and these turned out to be excellent sources for both research workers in the field and students who were seeking their first introduction to a particular subject.

This new volume in this series emphasizes photosynthetic membrane structure and function. The format of this work is similar to that in the previous volumes in that a number of short articles by acknowledged experts are presented that consider light-harvesting systems, trapping events, the charge separation process, the photochemical reaction centers of photosynthetic bacteria as well as Photosystem I and II in plants, energy transfer, energy coupling and membrane topography and assembly. In addition to these topics, the editors have included five introductory chapters that present overviews of broader subjects that are considered in greater detail. The opening chapter by Staehelin is particularly comprehensive in describing structural aspects of photosynthetic membranes while the chapters of Thornber, Ort and Dutton detail more biochemical aspects of pigment-proteins and the energy transduction mechanisms of plants and bacteria. The latter two chapters serve to introduce the reader to the linkage between photo-induced charge separation in the reaction center and the process of charge recombination via secondary electron transport that ultimately produces ATP. These overview chapters serve as an introduction to the structure and function of the photosynthetic membrane for the non-specialist who is attempting to become familiar with this area without going into detailed analysis of the later chapters.

Many of the presentations in this volume are influenced by the major development in the field of photosynthetic membranes. This is the elucidation of the structure of the bacterial reaction center as determined by X-ray cyrstallographic methods, and these results are described in the chapter of Michel and Deisenhofer as well as being referred to in several other chapters that also discuss this structural work. Some duplication of topics is unavoidable in this coverage but the importance of these results to the entire field minimizes these effects. The strong analogies that have recently been found between the bacterial reaction center and the plant Photosystem II reaction center are referred to as well, although the rapid developments in this area did not allow for a complete description of these advances. The chapters of Hearst, Michel and Deisenhofer and Arntzen and Pakrasi serve to set the stage for these comparative discussions.

While the overall focus of this volume is on the photosynthetic membrane, a large number of the detailed individual chapters deal with pigment-protein complexes, their organization into reaction center or antenna complexes, and electron transfer events in these reaction centers. Coverage of these topics is extremely current, as exemplified by the discussion by Parson and Holten on the early acceptors in the bacterial complex and the nature of the early PSI electron acceptors considered by Setif and Mathis. Both these subjects are receiving much renewed interest and these presentations offer a detailed analysis. However, other elements of the photosynthetic membrane do not receive such detailed coverage, and this is particularly true of energy-coupling processes, particularly proton-pumping mechanisms and ATP synthesis. While Whitmarsh considers the general area of mobile electron carriers, which is also under widespread consideration in relation to the lateral heterogeneity of thylakoid complexes, only two chapters by Prince and Joliot consider the function of cytochrome *b–c* complexes. The large amount of data accumulated on the bacterial cytochrome complex is briefly discussed by Prince and the mechanistic problems of these complexes seems to receive rather brief coverage considering the extensive studies of several major laboratories in the photosynthesis field as well as in the mitochondrial area.

The problem of ATP synthesis also receives minor coverage, but in this case, the extent of progress over the last several years is slower. After consideration of this subject in the chapters of Melandri and Venturoli, Dilley, McCarty and Nalin and Strotman, one concludes that a breakthrough comparable to that of Michel and Deisenhofer in elucidating the structure of the bacterial reaction center may be required, and that further progress will be greatly facilitated by such structural advances. However, the concept and nature of the "energized state" remains an experimentally elusive area.

The final section of the volume returns to the overall membrane and considers problems of membrane organization, architecture, and synthesis. The inclusion of several chapters on membrane lipids by Siegenthaler and Rawyler, Keegstra and Murphy is particularly welcome as these components are often overlooked in treatments of the photosynthetic membrane and the role of lipids in photosynthetic systems has received recent attention. There is, however, little coverage in the general area of the molecular biology of photosynthetic membranes, and, in particular the amino acid sequences of photosynthetic membrane proteins as derived from DNA sequences of genes. Several major laboratories have been involved in this area and contributions from these groups would have allowed for this structural information to be included.

Photosynthesis III is a successful compilation of recent work on photosynthetic membranes. It is extremely current and well presented. I have personally used the two preceding volumes as a reference source for a graduate level photosynthesis course and it is clear this volume will be equally useful. The volume will also serve as a primary source for the research worker in the field who is seeking a concise presentation concerning the structure and function of the components of the photosynthetic membrane.

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