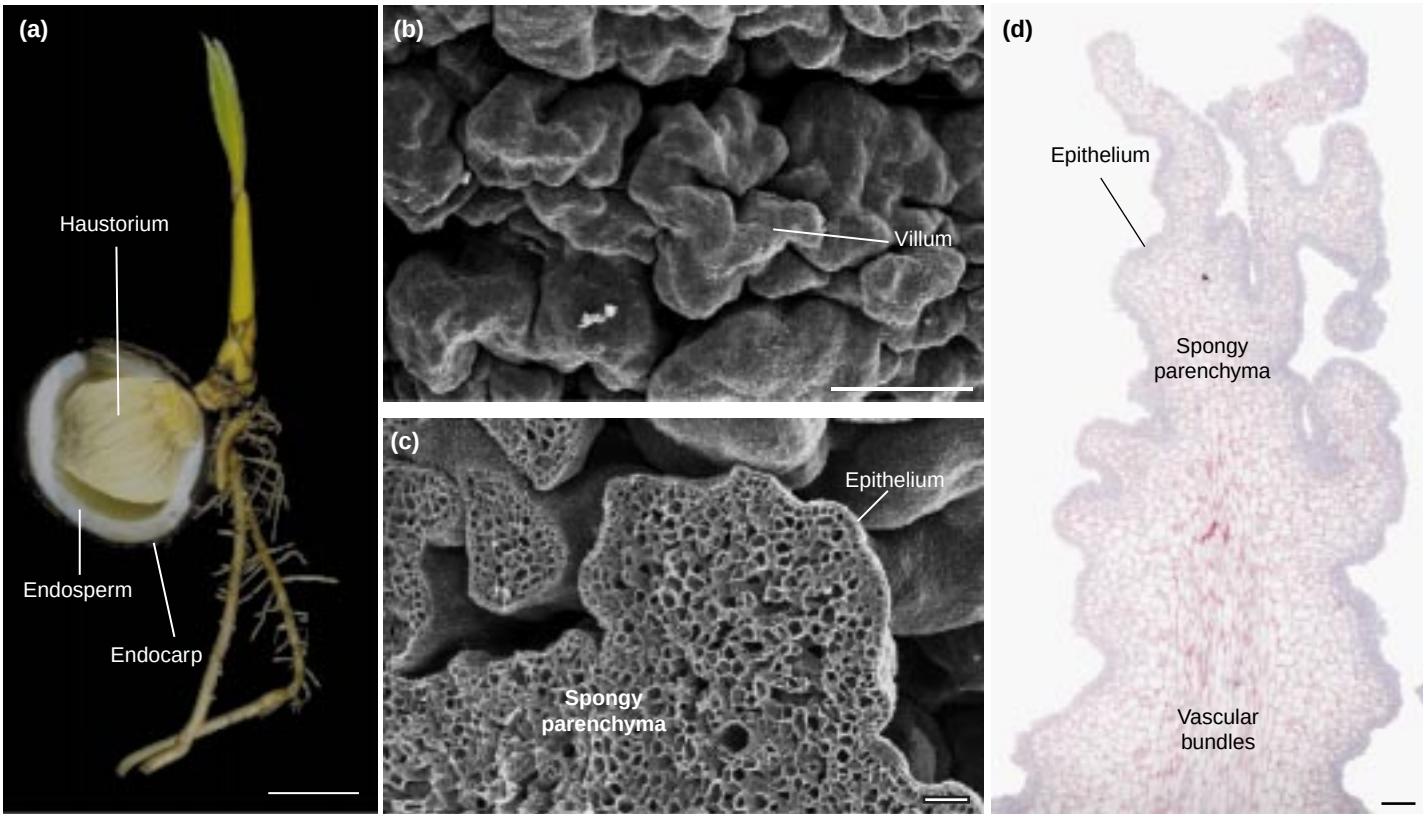

Fig. 1. Haustorium in coconut. (a) Four-month-old germinated coconut (*Cocos nucifera*) with the haustorium developing inside the nut cavity. Scale bar = 5 cm. (b) Scanning electron micrograph of the haustorium rough surface (~0.5 cm^2) showing a group of villi. Scale bar = 1 mm. (c) Scanning electron micrograph of the haustorium cut transversely. Scale bar = 100 μm. (d) Longitudinal section of a haustorial villum. Scale bar = 100 μm.

marked ingrowths on their external cell wall, thus increasing the plasmalemma surface:cell volume ratio as seen in the microvilli of digestive epithelium cells in the animal stomach [4].

Thanks to its structure, the haustorium is particularly well adapted to its role in the digestion of seed reserves and in the provision of nutrients to the embryo during germination. This organ is typical of palm embryos and has numerous structural analogies with animal stomachs, which are of great interest to comparative anatomy and physiology studies, as well as in the analysis of structure–function relationships.

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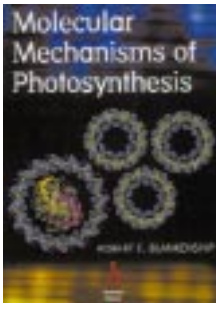
Book Review

Photosynthesis – telling it like it is



Molecular Mechanisms of Photosynthesis
By Robert E. Blankenship.

Blackwell Science, 2002. £29.95 (pbk) (vii + 321 pages). ISBN 0 632 04321 0

This is a terrific book. Read it if you have even the slightest interest in photosynthesis – what it is, what it does, how it works and how it evolved. You will also learn how we know what we think we know about the single most important process for life on our planet.

As Robert Blankenship states 'Photosynthesis is intrinsically interdisciplinary. Our discussion will span time scales from the cosmic to the unimaginably fast, from the origin of the Earth 4.5 billion years ago to molecular processes that take less than a picosecond. We will need a range of vocabularies and concepts that stretch from geology through physics and chemistry, to biochemistry, cell and molecular biology, and finally to evolutionary biology.'

At these brave words, a cynic might think 'superficiality'. Don't worry. Blankenship comes close to being a member of a species I thought was extinct – the polymath. Only the mistakes prevent one feeling the author is immortal. A sample is the units of irradiance in the first figure. Equation A85 has a careless P* instead of P, so you cannot derive the last equation,

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A86. For those hanging on in the roller-coaster ride of 'Light, Energy and Kinetics', there are a few undefined variables to scare you even more. Cross-referencing omits page numbers, so you have to be determined to find out what some symbols mean. Your conscientious reviewer had to give up the trail on some units, including 'mV vs. NHE', although E_m' (units mV) is clearly derived and defined. A list of abbreviations, please! The Appendix is great, but it needs some attention for any future edition or imprint. Transmission is defined as its reciprocal, a nonsense. What is, in concept, a great figure (A18) explaining the relationship between different spectra and kinetic traces contains a nest of mistakes in the legend and in the text, and yet another undefined variable, ΔOD (change in 'optical density', a synonym for ΔA). Then there are omissions. After the short course in quantum chemistry, why not tell the reader about EPR (electron paramagnetic resonance) [alias ESR (electron spin resonance)] spectroscopy, one of the key techniques of photosynthesis research today? And how about CD (circular dichroism), LD (linear dichroism) and FTIR (Fourier transform infra-red)? We were already nearly there with fluorescence polarization.

The balance is right, and I find only details with which to argue. Cyclic photophosphorylation is given short shrift, but the likely 14-fold symmetry of Cfo (chloroplast coupling factor ATPase, membrane-intrinsic complex) [1] puts in some structural support for needing extra ATP from cyclic photophosphorylation, as suggested by the agreed quantum requirement of 10+ (no, not 4, Dr Warburg – this history is told here as a ripping yarn). I am always uneasy about progressivist assumptions in evolution. Blankenship has fewer inhibitions. Repeatedly we are told that purple bacteria are primitive and higher plants advanced. I wonder what this actually means? This view seems phytocentric. We are not the pinnacle of evolution. Neither was spinach and neither, now, is *Arabidopsis thaliana* (a cress, by the way, not a mustard). On evolution, a curious omission is the reductive TCA cycle. However, on carbon assimilation, this is a great book too. C4 and CAM get a full and clear treatment, in addition to a genuine photograph of Andrew Benson's and Melvin Calvin's lollipops and the details of the cycle that emerged from them.

Top of the wish list for the next edition is colour. Blankenship has made some excellent molecular graphics but most will probably resemble grey fusilli pasta to those who do not already know their way around the wonderful structures of reaction centres and antennae we now have available at the click of a mouse [2]. The glossy full-colour plates (four) are bound towards the centre of the book, as if with special reverence. They are good, but the epoch-making *Rhodopseudomonas viridis* reaction centre is presented there as a space-fill model resembling a clump of lurid frogspawn (with a protruding ball-and stick isoprenoid tail of Qa, menaquinone) – too much colour, as if to compensate for too little elsewhere. Even two-colour prints on matt paper would reveal internal structure of proteins and cofactors in the many excellent ribbon-based diagrams.

Too much science is presented as a complete truth that assembled itself spontaneously, yesterday, and in the laboratory of whoever is writing. So let me particularly commend this book for its sense of place in history, and the lively anecdotes and personality profiles. Blankenship acknowledges the debt we all owe to brave and imaginative people of previous centuries and decades. He also has the grace to say 'We still don't know'. I personally regret the absence of Frederick Frost Blackman and his limiting factors, and Swedes claim Karl Wilhelm Scheele discovered oxygen. In 1794, the UK lost a genius, and the USA gained one, when Joseph Priestley fled westwards from bigotry and persecution. And the 20th century also had its share of colourful controversies. The many attributions of priority here are mostly right, I think, with one or two questions, for example the discovery of photophosphorylation (I stick with Bob Whatley and Dan Arnon for chloroplasts, and Al Frenkel for bacteria). But the integrity of this book is beyond question. People will rightly trust a book as good as this one. The style is clear, accessible and entertaining.

And history is still in the making [3]. 2001 was an *annus mirabilis* for photosynthesis, with crystal structures for the reaction centres [4] of the two photosystems that were Robin Hill's 'working hypothesis' 40 years ago. This book is completely up-to-date on this count and all others. I do not understand how it came out as early as February 2002. There is even a reference to a 2002 paper in the text, but it is boasting – the paper is actually cited as 2001 in the reference list. Perhaps this haste explains the glitches. *Photosynthesis* by David Hall and Krishna Rao [5] is still just right at a slightly lower energy level, and Bacon Ke [6] provides more for the specialist.

I once had a zoologist friend who worked on limpets. His opinion was 'Photosynthesis is fine – just as long as plants don't stop doing it.' If you really do not care about how life on Earth converts sunlight to sustain the biosphere, then you have no natural curiosity. And, probably, no soul. But try this book anyway. *Molecular Mechanisms of Photosynthesis* is an engaging story of some of the cutting edges of science over the past three centuries. You will learn how oxygen was discovered, why plants are green and the sky blue, and how a spectrophotometer works. There were Nobel prizes (total seven, I think) for discoveries described in almost every chapter of this book, and probably more to come. Away with academic disciplines. Science at this level is exhilarating, and something everyone should have an opportunity to know and to understand.

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