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# Book Reviews

**Altman A, Waisel Y, eds. 1997.** *Biology of root formation and development*. Basic Life Sciences volume 65. 376 pp. New York: Plenum Press. $125 (hardback).

Although noted more for his radical contributions to rhythm and blues than to developmental biology, the late Willie Dixon had it about right when he said, 'You know, you can't have the fruits without first you have the roots!' How we might manipulate roots to deliver those 'fruits'—in whatever form—is just one reason for wanting to know more about root development. We would also like to know how root development is controlled and regulated by internal and external factors, how it varies taxonomically, and how it impinges—if at all—on fitness. We are closer to answering some of these questions than we have ever been. This is thanks largely to the surge of the interest in root development over the past decade and the excitement within the subject that this has generated. The publication of a book entitled *Biology of root formation and development* is certainly timely.

It contains the proceedings of the Second International Symposium on the Biology of Root Formation and Development, held in Jerusalem in June 1996. The editors say in their Preface that the book covers a wide range of topics. It sure does. There are 78 contributions under the following section headings: Diversity of roots; Induction of root formation and root development; Hormonal control of root induction and development; Ecological aspects of root development; Applied aspects of root formation and development; Root products; and Models and methods for root studies. The book mixes reviews with specific pieces of research which would not be out of place in a journal such as the *Annals of Botany*. About 30 of the contributions are 'short papers', some of which are very short indeed ($< 1$ page). In many respects, *Biology of root formation and development* is a companion to *Plant roots: the hidden half* (Waisel, Eshel and Kafkafi, 1996). It amplifies or updates some of the developmental themes of its weightier predecessor. Although these books share an editor and a few contributors, there is little overlap between them.

*Biology of root formation and development* has some notable highlights, starting with a scholarly chapter by Peter Barlow and Beatriz Palma. They discuss how different kinds of root form in the places they do. They use algorithms relating root formation to positions in various kinds of phytomer ('an autonomous modular unit of plant construction'). The algorithms form a precise and concise syntax for the developmental transitions involved in root formation, reminiscent (to me, anyway) of the 'universal grammar' devised by linguists to explore how language develops in humans. As well as sharing an algebraic similarity, both grammars reduce complex patterns to simple rules despite their having few well-defined molecular mechanisms. It will be interesting to see how universal and useful this grammar of roots turns out to be.

Some of the most (literally) dazzling recent research on root development has come from Ben Scheres' group in Utrecht. Their use of lasers to destroy single cells in apices of *Arabidopsis* roots, coupled with studies of root mutants, has revealed how cell fate is determined by positional information rather than by cell lineage. This work is summarized beautifully in a chapter by van den Berg *et al*. Although the use of monochrome photographs and diagrams gets the message across effectively, multi-coloured images would have been much clearer and more striking.

Armed with a plant biochemistry textbook in one hand and a stiff drink in the other, we come to the middle 50% of the book which is devoted to various hormonal and biochemical aspects of root development. There is a lot of information here about adventitious rooting in cuttings. This is, of course, enormously important to horticulture and forestry, the 'fruits' of which often depend on the early establishment of a vigorous, healthy root system. Some of these contributions seem to have stepped from the pages of classical plant hormone textbooks, with dose–response relationships and time-courses of metabolite concentrations much in evidence. But we soon see the appearance of molecular techniques, mutants, *Agrobacterium rhizogenes*, quantitative genetics and other 'performance indicators' which suggest that the subject is far from dormant.

I was surprised, though, to see so little mention of ethylene, a molecule whose morphogenetic effects on roots are (relatively) well-known and (relatively) well-characterized biochemically and genetically. Only one chapter (by Glick *et al*., on growth promotion by the rhizobacterium *Pseudomonas putida* GR12-2) specifically considers ethylene. Other hormones—auxins, gibberellins, jasmonic acid, $\gamma$-amino-butyric acid, abscisic acid, etc.—are covered rather more fully. Among these chapters, that by Wolfram Hartung and Neil Turner is particularly good. They review what ABA does in, and for, stressed roots. This information comes in handy three chapters later, when the regulation of *leaf* development by ABA is described. This is an unexpected inclusion which seems to have escaped from another symposium altogether. (There is another startling contribution towards the end of the book: 'Mosses as Petri dish models for underground foraging.') Interesting stuff, to be sure, but it scores few points for immediate relevance.

In the 'ecological' section, I particularly liked the chapter by A. Stokes and D. Guitard on the responses of tree roots to mechanical stress. They describe how changes in root development (particularly radial asymmetry) help to brace a tree against, for example, strong winds. Their coverage is admirably broad, including root system architecture, the development of buttress roots in rainforest trees, the histology of woody roots, and thigmomorphogenic genes of

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non-woody roots (i.e. of *Arabidopsis*). A liberal definition of 'ecological' applies in this section, as it embraces cotton and canola in growth chambers, sunflowers in pots, micropropagated *Eucalyptus* species planted into the field, and hydroponically grown *Phaseolus vulgaris*. A liberal definition of 'root development' also applies. It is analysed only crudely in many of these chapters, in terms of total dry weight, length, or distribution with depth, etc. Disappointing, but predictable, I suppose.

The book has good subject and taxonomic indices, although I was alarmed to see, in the latter, *Agrobacterium* and *Pseudomonas* listed as *plant* genera. In most chapters, the graphics are sharp and clear, but, in some, their quality is surprisingly poor. Some photographs (e.g. those on p. 108—which also lack any scale or magnification—and on p. 219) are so indistinct in my copy that they might as well have been omitted. Even by normal gel standards, that on p. 293 is fuzzy, as is the amino acid chromatogram on p. 323. Some graphs lack legends (e.g. pp. 272–273, 285–286). Another inconsistency is that some chapters have abstracts or summaries while others do not. Subsections are numbered in some chapters but not in others, Latin binomials are italicized in some chapters, not in others. Some chapters have been proof-read meticulously, others have not and contain, for example, cited references which are not listed, and various typographical errors. Infelicitous phraseology mars certain contributions. Individually, none of these things necessarily detracts from the science, but cumulatively they irritate, and suggest a hurried production—which indeed it is, the book appearing only a year after the symposium. On balance, rapid publication in a fast-moving field is preferable to aesthetic detail but, for $125, one should expect both.

Our knowledge of root development has changed dramatically over the past decade. Some of the contributions to *Biology of root formation and development* are worthy additions to that growing body of knowledge. But the subject, as a whole, seems ripe for an authoritatively written and lavishly produced *magnum opus* to synthesize the information now proliferating in journals and symposia. That *would* be a genuinely fruitful development.

**David Robinson**

## LITERATURE CITED

**Waisel Y, Eshel A, Kafkafi U, eds. 1996.** *Plant roots: the hidden half*. 2nd edn. New York: Marcel Dekker.

**Baker NR. 1996.** *Photosynthesis and the environment*. *Advances in photosynthesis volume 5*. 508 pp. Dordrecht: Kluwer Academic Publishers. £198 (hardback).

*Photosynthesis and the environment* edited by Professor Neil Baker, as the title suggests, places photosynthesis into an environmental context. However, the book not only relates photosynthesis to the external environment as implied in the title, but also the internal environment of the plant as a whole. This gives the book great strength; for in biological systems, it is essential to be able to relate reductionism—required to give precise explanations for phenomena—to the wider context of the whole organism and its environment in order to facilitate a comprehensive understanding of biological processes and their significance.

Emphasis in the book is given to light reactions; this is inevitable given Baker's pedigree in this area. The book begins in this light, starting with excitation energy processing, followed by electron transport, mechanisms of photodamage and radical production. There are then two chapters that deal with carbon, in terms of metabolic regulation and impact of environment. Chapters on gas exchange and stomata are followed by one on source/sink interactions. Source/sink interactions really are the ultimate in holisticism and deal with the essence of the problem of the plant and its environment: dealing with fluctuating supply of, and demand for, assimilate. Understanding these mechanisms will get to the heart of understanding the book's theme. The interaction of the effect of light and nutrition on the photosynthetic system as a whole is dealt with next, preceding a chapter on molecular biological approaches to environmental effects on photosynthesis. Responses and acclimation of photosynthesis to fluctuating light, drought, temperature, $CO_2$, $O_3$ and ultraviolet-B radiation then form the rest of the book apart from a penultimate chapter on the evaluation and integration of environmental stress using stable isotopes, with a final summing up chapter by the editor himself.

The book is excellent, not least because of the holistic way in which it treats photosynthesis, but also as a result of the high quality of the contributing chapters. Presentation is good: attractive, easy to read, with clear diagrams and wide margins for notes and rude comments. The summary at the start of each chapter is an excellent idea. From my own point of view, I would have given more emphasis to photosynthetic carbon metabolism and to photosynthesis as a sink-driven process, rather than as a light-driven one; but here too there would have to be balance. There would be no photosynthesis without light (and indeed no life on earth). The best chapters are the ones that quote my own papers (joking). There is some overlap in material, with temperature being covered in more than one chapter, but overall the amount of overlap is low for a volume where chapters are contributed by different authors and where some degree of disorder is usually inevitable.

The book is intended for advanced undergraduate and graduate students and beyond. The book is excellent, with everything going for it. The only deterrent to buying it being the near £200 hardback asking price.

**M.J. Paul**

**de Kroon H, van Groenendael J, eds. 1997.** *The ecology and evolution of clonal plants*. xii + 453 pp. Leiden: Backhuys Publishers. $67 (softback).

This a splendid book on fundamental botany. Clonal growth is a consequence of the main ecological difference between plants and the animal kingdom: imperative modular growth. The ceaseless and necessary renewal of modules of the photosynthetic apparatus and reinvestment of primary production imposes the ecological behaviour we see in vegetation. Plants cannot stand still, and all field interactions between species and individuals are a con-

sequence of the interplay of forces involved in growth and renewal.

Modular growth is almost necessarily clonal. A non-clonal plant would be a one-flowered, single-stemmed annual, and I do not know of a species which produces such populations. Unlike at least the higher animals, plants are indifferent to the number of cell divisions between gametes. Therefore any discussion of the significance of these phenomena addresses the very basis of plant life: for *The ecology and evolution of clonal plants*, de Kroon and van Groenendael have carefully compiled invited papers to do this very well. Yet the emphasis here is only on plants with what we used to call vegetative reproduction, while I believe that there is a continuum of plant form from the simplest annual to the rhizomatous immortal. I feel the word 'clone' has become debased, and wish there were a better one to encompass pithily the plant types that the authors have in mind.

It is fascinating that, just as I have had to carefully introduce my view of the subject, so the authors of every paper have written a similarly extensive introduction to create in the reader's mind their own paradigm of plant clonal growth and the questions they intend to discuss.

There has been a series of published proceedings of workshops on this topic, initiated by that great man of Darwinian botany, John Harper, but this book is outside any series: it is not based on conference proceedings, and consists of reviews of existing published work and ideas, using little new material. It is all better for this, because the authors have been able to step back and examine the material within the brief of their chosen topic. There are 18 articles, from authors rather evenly spread across the northern hemisphere, only Michael Hay being from New Zealand. The first papers are descriptive accounts of the occurrence, architecture and timing of vegetative reproduction. The implications of this organization are examined physiologically, genetically and in relation to competitive behaviour and community organization in the subsequent contributions. Sectoriality, integration, division of labour and foraging in patchy environments are the physiological topics discussed. Mutation rates, hierarchical selection and reactive variability are points of genetical interest. Finally resource dynamics, spatial patterns and environmental effects are dealt with in enquiries into the part vegetative reproduction plays in plant community structure.

Multi-authored collections of papers are very hard to review adequately. In this volume there are diverse styles and standards, yet I found something of value in every one. I think every member of the botanical community who is at all interested in the way plants grow in nature will find a stimulus here, not for factual information, but for help in conceptualizing the behaviour of vascular plants. The editors have usefully gathered into one slim volume many different enquiries about the consequences of vegetative plant dispersal.

**A. D. Q. Agnew**

**Karp A, Isaac PG, Ingram D, eds. 1998.** *Molecular tools for screening biodiversity*. 498 pp. London: Chapman & Hall. £75.00 (hardback).

This multi-author volume has over one hundred contributors who collaborated in an EU project on 'Molecular Genetic Screening Tools'. The contributor list in itself provides a useful resource of information on key European research workers in the field of biodiversity. The material is ordered into a number of parts: 1, DNA extraction; 2, basic screening methods; 3, sources of probes and primers; 4, data analysis; and 5, case studies. Each of the parts is subdivided into sections, and finally into individual chapters or boxes. There is also an appendix on 'safety in the molecular laboratory'. The idea of using a mixture of boxes, for some highly focused material (e.g. characteristics of microsatellites, VNTR probes, selected software packages for personal computers), and conventional chapters adds variety and accessibility. The fact that the chapters vary in length and style, rather than having one standard format, is so refreshing. The material is well compartmentalized and particular items so easily located that the book can be read in any order, even from back to front as I did; or one can just dip into odd bits and pieces at leisure. There is the tendency to enjoy browsing this book, and to get 'infected' with enthusiasm for this new and exciting field. Suddenly we can 'see' genotypes, whereas hitherto we have been confined to the phenotype with all the limitations and frustrations that this involves.

In terms of information content the book is encyclopaedic, covering a broad spectrum of all the things one needs to know to become a practitioner, a teacher, or a student of biodiversity. The technical stuff is all here, written first-hand by the experts. One can look up how to extract DNA from difficult species/tissues, in plants and animals, understand all of the well known marker systems currently in use, isolate microsatellite markers, design primers, measure genetic distance and learn all of the things that one needs to know to study and to interpret biodiversity.

What else is good about this book? It is highly authoritative, inviting to read and really informs the reader by getting right to the bottom of every single issue that it touches. There is inevitably some repetition which comes from having so many authors, but the editors have done their job and achieved a high level of integration and direction over the compilation. One never gets the feeling that there is anything written here other than first-hand experiences. The more you read the more you begin to understand the proper applications, and the proper limitations, of the various marker techniques: which markers are dominant, which are codominant, which distinguish between alleles of a single locus and which do not. There is a real sense of selecting the right marker for the right job, be it genetic diversity, genetic distance, evolutionary relationships, or making high resolution maps. We are given to understand exactly what kind of information we can draw from each marker system, and the benefits of combining different systems to extend and to validate our investigations. The case histories pull all this essential knowledge together, and show us the resolving power of markers for the study

of genetics at the population and evolutionary level. It is reminiscent of the exciting times in the 60s which followed the discovery of intra-genic recombination and the way into the fine structure of the gene. Now we can find our way into the fine structure of the genome and the population, which is something that geneticists have been dreaming of doing for a long time. Of course all this stuff comes at an economic cost, and we are appraised of this as well. The fact that the book came out of a project linking many labs has given the editors, and the authors, the opportunity of making comparative studies on markers as tools. Reproducibility testing of RAPDs by a network of European labs, for example, has given us the confidence limits of the methods and shown the importance of carefully defining and of standardizing the 'conditions of use'. This book will meet a need for high quality information and serve the needs of researchers, teachers and undergraduates.

What is wrong with this book? Nothing.

**Neil Jones**

**Smith TM, Shugart HH, Woodward FI, eds. 1997.** *Plant functional types: their relevance to ecosystem properties and global change*. 369 pp. International Geosphere-Biosphere Programme Book series 1. Cambridge University Press. $80.00 (hardback), $44.95 (softback).

This volume comprises papers presented at a workshop on Plant Functional Types held in 1993. The book is divided into five different sections which are unhelpfully called Parts 1 to 5; descriptive section titles would help the reader orientate him/herself. There is a degree of overlap between the sections which may explain some of the problem.

According to the Preface, Part 1 is an introduction and historical background to classifying by function. Here the first paper by Gitay and Noble asks 'What are functional types and how should we seek them?'—a useful place to start—and the paper includes something on the history of various definitions and attempts to clear some of the confusion surrounding the various terms. Among their conclusions, the authors highlight the fact that classifying functional types or groups is context-dependent and that there is no universal functional classification—a point worth noting. Chapter 2 by Shugart focuses on species and ecosystem functional types through forest examples. The two types are distinguished by a different emphasis, on adaptation in the former and on ecosystem responses in the latter. It is a well written and readable chapter, if a little wordy, and it gives background on form and function.

Woodward and Kelly start the next section of the book which looks at theoretical and practical applications of functional types to global climate change. They, in part, summarize much of the work by Woodward that has been the basis for the recent rapid development in modelling vegetation responses to climate, and the subsequent application to global change questions. Some of this development is based on known mechanisms rather than correlations but, as Woodward and Kelly point out, there is still much to do in quantifying these mechanisms. Hobbs asks an important question: can plant functional types (PFTs) be used to predict and describe responses to environmental change? He concludes that groupings of plants can be used to capture the responses of different vegetation types to disturbances and changes in climate. He reaches these conclusions using south-western Australian sclerophyllous vegetation and annual grasslands in California where the clear influence of man compounds changes in climate. Walker examines further the role of large disturbances or events in switching vegetation types within a similar mean climate and how the idea of functional types can be used to predict the effect of global change in such communities that can have more than one state. The issue of species redundancy naturally arises and its valued role in unpredictable systems. He also attempts to classify function in two ways: via species and via environment. In the former, species responses are used while the latter uses a minimum set of environmental features—climate, soil and disturbance—to determine the kinds of vegetation that are possible, the 'PFT niches'. Westoby and Leishman, again using Australian examples, attempt to classify plant species into functional types using clustering techniques and 43 different attributes as variables. They specify the limitations to the methods, but are clearly optimistic that this approach will allow such methodologies to be used to answer more than one question and cover more than one continent. The final paper in this section moves to the northern hemisphere where Grime *et al.* draw on their well known research in Sheffield to assess the value of concept of functional types. The paper is one of the longest in the book, and tends to work at a different scale to most other presentations. It includes a section describing the search for functional types from nuclear DNA to seed size through the Integrated Screening Programme.

The third section concentrates on functional types in different ecosystems. It is an interesting section with a range of examples of functional types and a range of ecosystems, though arid or semi-arid ecosystems again predominate. Shaver *et al.* examine arctic tundras and ecosystem-level implications, for carbon and nutrients for example, in using particular functional characteristics. Bond addresses the relationship between biodiversity and functional types within biomes. He examines the effects of climate change on the biodiversity of the fynbos biome in southern Africa, using a fire response functional classification. The role of a climate change is used as a basis for a model study by Reynolds *et al.* into desertification in New Mexico. They use the idea of ecosystem functional types (EFTs) at different scales, from patch to regional, to address their hypothesis that changes in ecosystem function in transition arid zones are best understood by the distribution of soil resources. Arid region functional types and their relationships are again addressed by Sala *et al.* using the Patagonian steppe as their field of study. They use functional types based on species morphology and phenology, and a model based on the partitioning of water among functional types. Lauenroth *et al.* contend that the usefulness of particular PFT classifications is limited to the particular context in which the classification is done. The importance of scale when using PFTs is discussed with reference to demography and ecosystem processes. Finally in this section, Scholes *et al.* propose a functional typology for African savannas and

grasslands and assess whether the functional and structural properties of savannas reflect present environmental conditions.

The penultimate section moves to a global perspective, and it is at such a scale that functional types have perhaps been most extensively (and successfully) applied. In fact, many of the global vegetation models using various climate change scenarios make predictions based entirely on a very limited number of PFTs (e.g. 14 in the original BIOME 1 model and 7 in BIOME 3). Cramer gives a clear appraisal of the value of PFTs in global vegetation modelling, not for forecasting changes in ecosystems, but rather as a tool in expanding our knowledge of how ecosystems function. Leemans takes the global approach beyond potential vegetation modelling and includes both ecological and agricultural plant functional types simulating changes in land cover and changes in the global carbon cycle. He highlights the importance of land use issues when discussing global change.

In the final section, the usefulness of functional types is addressed by Smith who examines their limitations using a modelling approach and cautions against their use in changing environmental conditions; he comments that model validation is a particular problem. Mooney then steps back from the use of PFTs in modelling to address the thorny issue of biodiversity and functional properties of ecosystems. He discusses this with particular regard to ecosystem stability and the role of keystone species in a changing global environment.

A brief summarizing chapter by the editors concludes the book, in which they point out that a fully developed set of functional types on a global scale is still a long way away.

This is a very useful compendium of ideas about, and uses of, plant functional types. The range of papers is wide which should give the book a wide audience in ecology, both for researchers and advanced students. A 4-year delay in publishing papers, some of which refer to the fast changing climate/global vegetation modelling field, is a pity. Most papers are naturally still relevant but some of the examples use both dated vegetation models and dated climate output.

The book is, in general, well presented, though the cover is less than inspiring. The paper quality makes it pleasant to hold. The figures are clear but the colour plates are all grouped together, and, as there are only few they are difficult to find. Finally the price, at least for the paperback, is what one might expect to pay for such a book nowadays, though one might not wish to! It may be that it is more likely to be a library book then a personal book.

**Martin T. Sykes**

**Van Gardingen PR, Foody GM, Curran PJ, eds.** *Scaling-up from cell to landscape*. 386 pp. Society for Experimental Biology, Seminar Series 63. Cambridge: Cambridge University Press. $120 (hardback).

This volume is one from a long list of diverse topics in biology, initially presented as lectures at meetings held by the Society of Experimental Biology and subsequently published in book form. The initiating meeting behind this volume was organized jointly by the Society for Experimental Biology and the British Ecological Society, and held at University College Swansea in 1994. The joint nature of the meeting opened the floor to a wide range of research interests and both spatial and temporal scales of attack on the fundamental problem, that of how to scale-up measurements or model simulations at one scale to a larger scale.

The volume includes 18 chapters covering a wide array of topics from satellite remote sensing, rural systems, through global, regional, catchment and canopy-scale modelling of vegetation, community-level studies of plants and soil to fine-scale heterogeneity of individual leaves. In all cases, the specific research objectives have generally led to the development of methods of scaling-up, although these methods are task specific.

Although all chapters make useful contributions to the issue of scaling-up, I found that three chapters made the greatest steps in addressing and advising on this issue. The chapter by Squire and Gibson used a rural farming system model to define the problems of scaling. They describe how the current scientific approach of reductionism, taking a system and analysing the dismembered parts, opposes the process of scaling-up because the inevitable heterogeneities and couplings of the full system are lost. Therefore Squire and Gibson define scaling-up as reversing reductionism, which can, in some cases, be achieved by a system modelling approach, integrating the sub-system components. This approach can also break down, particularly when sub-system behaviour changes within the full system.

Marshall, Crawford and Porter have produced a fascinating chapter which addresses the general question of approaches to scaling-up. Their clear conclusion is that there are no general recipes for scaling but the nature of the phenomenon under study largely dictates the scaling property of the system. For example, in soils, the controls of soil micro-organism diversity, gaseous diffusion and water movement all follow very different scaling laws which are not readily interchangeable between the different processes. As the authors also point out, experiments designed to investigate a particular scale, in terms of either space or time, can not lead to an understanding of system behaviour at any other scale. So the extrapolation of a process at one time scale, for example, requires knowledge of the underlying temporal correlations in the data.

The chapter by Harding, Blyth and Taylor gets right down to a specific problem where scaling-up is a necessary outcome. They discuss the problems of determining the regional-scale evapotranspiration of a heterogeneous landscape of vegetation patches. In this system it is possible to measure the rates of evapotranspiration from individual elements of the vegetation mosaic. How to integrate these is the problem to be addressed. Using a linear averaging scheme for clearly non-linear processes leads to errors and these errors occur at all spatial scales. The degree of error in an areal total of evapotranspiration, determined by linear averaging, depends on the magnitude of the controls such as stomatal resistance, or conductance but is large and falls in the range of approx. $< 10\%$ to $> 50\%$.

Other chapters also contribute lists of warnings and problems which are encountered when scaling-up. Given

that most natural systems are heterogeneous, variable and fractal, then some of these chapters are also giving the first sets of clues to methods of scaling and indicating that scaling-up is not just a multiplication of a point process by area. As a consequence, there is much in this volume of interest and which is important to consider as we attack large-scale issues.

**F. I. Woodward**

**Werker E. 1997.** *Seed anatomy. Handbuch der Pflanzenanatomie* (*Encyclopedia of Plant Anatomy*) vol. X3. 424 pp. Berlin: Gebrüder Borntraeger. DM 198 (hardback).

More than 70 years have passed since Netolitzky (1926) published his book *Angiospermen-Samen* (Seeds of Angiosperms) in this same series and more than 20 years since Corner's (1976) two volumes on dicotyledonous seeds, mainly of tropical plant families. In contrast to the taxonomic approach of these publications, Ella Werker's book on angiosperm seeds is written from a functional viewpoint with the emphasis on mature seeds. From the gross morphology of seeds to early germination stages, the reader is taken through every part of the seed in 17 chapters; not a single aspect seems to be missing. 'Seed' is taken *sensu stricto*; although seed-like structures such as nutlets and achenes may be mentioned as a brief comparison, the treatise is about seeds themselves. The book fills a large gap and has been long awaited by workers on the many different aspects of seeds.

A brief introductory chapter is followed by a chapter on morphological characteristics, such as shape, size, and colouring, and one on the seed surface. Variation in seed topography is discussed. The outer epidermis is mainly responsible for the surface morphology, but patterns caused by interior cell layers or the pericarp are demonstrated. The development and function of specialized structures—stomata and trichomes—are represented. Two short, but necessary chapters then explain the physiology of desiccation tolerance or intolerance (recalcitrant seeds) and longevity, and provide a physiological basis to which the anatomy can be related. In chapter 6 dealing with the funiculus and seed abscission, the book returns to structure. The funiculus (seed stalk) mediates the passage of nutrients and water from the fruit to the developing ovule and this chapter describes how, at maturity, it may be modified in several species, for instance to an aril serving in seed dispersal. Research on seed abscission is meagre; few studies have been performed in this area.

In the chapter on the seed coat, and throughout the book, Werker has adopted Corner's nomenclature: 'testa' and 'tegmen' for the outer and inner integument in bitegmic seeds, respectively. Most workers in seeds use 'testa' synonymously with the whole seed coat. After listing seed coat functions during development and at maturity, this chapter describes the developmental stages of the seed coat structure including cell types and tissues, micropyle, hilum, chalaza, raphe, lens and pleurograms. The vasculature of seeds is covered separately in the seed coat and the embryo. A variety of vasculature patterns in seed coats exist among species; nucellar vascularization is known in a few. The vasculature of the embryo is reported in the following chapter in which the location of the mature embryo and its morphology are the main topics. Embryo development is not however included since a forthcoming book in this series on plant embryology is in preparation.

Two chapters consider the nutritive tissues: the endosperm and the nucellus. The first chapter describes endosperm development and -types, and also the nucellus, which often disappears during seed development, but remains in some families as the perisperm. The second chapter concerns the reserve materials contained in both tissues: protein, lipids and carbohydrates, their formation and location in cells or cell walls.

Two short chapters describe seed heteromorphism and ruminate seeds, specializations associated with certain plant families. Secretory structures are of great importance in seeds, especially the formation of mucilage with its functions in seed dispersal, adherence to soil, and dormancy. Other secretions: phenolics, myrosinase, oils, and crystals, their location in seeds and possible function are described. Seed structures specifically adapted to dispersal by wind, water, animals or by self dispersal are also described and discussed in this chapter.

Seed dormancy may be due to water impermeability caused by seed coat characteristics, to oxygen impermeability by physical or biochemical barriers, to mechanical blocking by the tissues surrounding the embryo impeding radicle growth, to under-developed embryos, or to any combination of these. In particular, impermeability to water has been thoroughly investigated in many seeds to identify the cell layer(s) impervious to water. Natural openings (hilum, micropyle etc.) are also considered for water passage. The last chapter on germination discusses imbibition, cell reactivation in the embryo, penetration of the radicle through the enveloping tissues and the mobilization of the reserve materials. These processes are described in detail.

In her book, Ella Werker has collected an enormous amount of information, evidenced by 48 pages of references. The material is presented in a logical way and the book is easy reading. The many illustrations support the text well. They consist of line drawings and photographs of light-, scanning-, and transmission electron micrographs; in general of very high quality. Some legends, however, could provide more information about depicted structures especially where explanation is not found in the text. There are too many printing errors or similar, some disturbing such as 'exodermis' (root part) used instead of exotesta (fig. 11D), *Fagopyrum esculentum* (buckwheat, Polygonaceae) included among Gramineae (p. 221), or cross section of the *Triticum* caryopsis (fig. 98A) which is longitudinal. Many exotic plant species are exemplified in the book. Sometimes the family name is included with a species, but more often not. How many readers would know the position of *Sarawakodendron* or *Allanblackia* without identifying literature at hand? Although not a taxonomic book, such information would be welcome. Hilum and chalaza are separate structures, albeit not far from each other in leguminous seeds. However, the reviewer does not agree that the hilum should be included within the chalazal region

(pp. 81, 137, 313–314), and the hilar fissure should not be termed chalazal fissure (fig. 151).

This book ought naturally to be found in every university library and in departmental libraries of laboratories working on seeds, basically or applied. Many researchers will probably want to have their own copy. As already mentioned, a gap has been filled and I wish to not only congratulate the author, but also to commend this book to all interested in seeds.

**Ole B. Lyshede**

**Wild A, Ball R. 1997.** *Photosynthetic unit and photosystems—history of research and current views* (*relationship of structure and function*). 219 pp. Leiden: Backhuys Publishers. US$56 (softback).

The unusually long title (and subtitle) of this book sums up its very character, content and scope. The book traces the history and evolution of the concept of the photosynthetic unit, originating in the 1932 classical experiments of my dear Professor Robert Emerson and his student William Arnold (see Myers, 1932; Govindjee, Knox and Amesz, 1996).

This book is divided into three: Part A deals with the early concepts of photosynthesis in three chapters (56 pages): 'Assimilation theories: photosynthetic function and mechanism'; 'Structure of chloroplasts and grana'; and 'An attempt to relate structure and function: the quantasome hypothesis and the background of a nearly forgotten term'. Part B, two chapters, deals with the discovery of what the authors call 'new results' (70 pages): 'The discovery of the photosystems in the 1960s before a background of various photosynthesis theories'; and 'The resurgence of the photosynthetic unit and its modern revision'. Part C, one chapter entitled 'Understanding the photosystems', deals with the current view of the photosynthetic apparatus (86 pages). It is followed by an index of authors cited in the book (7 pages), but, strangely, not of the subject at all.

Wild and Ball's book is refreshing and unusual in the sense that, unlike most other books, it first deals, at length, with historical aspects of photosynthesis, and, only then, provides a current and quite good, up-to-date understanding of photosynthesis. It makes excellent reading and is historically quite correct although incomplete in places. I liked the idea of references being given as footnotes on the same page as the text; in addition, some footnotes are quite interesting, e.g. #54, p. 15, gives personal information on Robert Emerson, and #20, p. 45 the exchange of ideas on the now-defunct term 'quantasomes' between Rod Park and Hans Gaffron. I also liked the discussions on pp. 110–113.

In spite of my enthusiasm for this book, I note several negative points: (1) although the title of chapter 1.1 is enboldened, those of 1.2 and 1.3 are not; (2) the tradition of writing all last names of authors in the text in capitals seems unnecessary (and even a burden) to me; (3) it is hard to separate individual entries when there are several citations in a single footnote; (4) many quotations are in German, thus, the non-German readers (most of the readers of a book published in English) must constantly jump down to the footnote and then back up to the text—this breaks the smoothness with which the book can be read.

Although I am not free from making proof-reading errors, I am bothered by those in published books, especially those of scientific importance, e.g. p. 59, energy transfer is from Chlorophyll *b* to *a*, not the other way around; p. 192: the term 'overexcitation' does not make sense to me. There are many spelling mistakes and incorrect or wayward uses of English, e.g. p. 71, connected is correct not connectet; p. 72, here instead of her; p. 92, 'of growth' or 'to grow' instead of 'to growth'; p. 107, longwave or longwavelength instead of longwaved; p. 127, crystallography instead of cristallography; p. 144, extent instead of extend; p. 163, lumenal instead of luminal; p. 172, rise instead of rize.

The citations are quite extensive and fair but there are omissions which are surprising: (1) Huzisige and Ke (1993), for its overview; (2) Malkin and Fork (1996), for the assessment of W. Arnold's 1936–1937 measurements of the maximum quantum yield of photosynthesis, the first to challenge Otto Warburg's values; (3) Thunberg (1923), shows the early ideas, later developed by van Niel; (4) Kautsky, Appel and Amann (1960); Govindjee *et al.* (1960) show the very important concepts (my bias, of course!) in development of the two light and pigment systems; (5) Rabinowitch (1945) shows the earliest 'Z'-scheme in its bare bones; (6) Rabinowitch (1956) developed the idea that one light reaction may oxidize a cytochrome which is then reduced by another light reaction.

Some scientific points that I think should not be ignored as they show lack of critical discussion are: (1) Morita's ideas on three light reactions; (2) recent ideas of E. Greenbaum on Photosystem I-less photosynthesis because of the lack of convincing evidence that Photosystem I is absent in the mutants used; (3) the term 'spill-over' used on p. 107 should have been more fully explained and challenged; (4) that the Chl/Cyt *f* ratio is correlated with photosynthetic capacity at high light, a major point of this book, should have been further discussed and clarified; (5) Babcock's model on p. 151 is not the only one for oxygen evolution—that of G. Renger is also important; (6) the statement that photosystem II is three times slower than photosystem I (p. 183) should have been either explained or challenged.

I believe this book should be purchased by all libraries. I recommend that it be read by everyone who teaches photosynthesis at any level as it is full of interesting historical and conceptual developments, and the current summary of photosynthesis is quite up-to-date. I agree with the authors that retracing historical developments and comprehending the overview of the history of the ideas are essential in grasping the nature of scientific enquiry in the field. Thus, I also recommend this book to undergraduates and graduates in botany, plant physiology, agriculture and related fields so that they may gain a perspective of the field which differs from those found in other books.

**Govindjee**

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