Photomorphogenesis in Plants and Bacteria. Function and Signal Transduction Mechanisms. 3rd edn. Eberhard Schafer and Ferenc Nagy (eds). Springer, Dordrecht, The Netherlands. 2006. 662 pp. Price: £125.00.

The book under review edited by Eberhard Schafer and Ferenc Nagy, two experts in the field of plant photomorphogenesis, has 29 chapters appropriately grouped in five parts. Although the title of the book refers to photomorphogenesis both in plants and bacteria, most of the chapters focus on plants. The chapters are contributed by internationally reputed scientists from Europe, Japan, South America and USA. The editors have dedicated the book to Hans Mohr with whom this reviewer had an opportunity to work at the University of Freiburg, Germany. The book rightly honours a person, who is one of the top plant photobiologists of the world.

Plants have evolved extensive sensory mechanisms that make them capable of sensing the light signal that they receive in terms of its intensity, quality, duration and direction. They have developed adaptational mechanisms for specific light conditions, controlling several complex events associated with their growth. Perception of light signal by different photoreceptors is the first and most important event of the light sensory mechanism. The chapters of the book deal with both biochemical and biophysical characterization as well as the function of major photoreceptors such as phytochrome, cryptochrome and phototropins. The book focuses on the biology of photoreceptors, signalling systems associated with them and the recent techniques used in the study of these fascinating receptors.

Part 1 of the book consists of four chapters contributed by both the editors with a historical presentation of photomorphogenesis research, emphasizing the development of our knowledge in the area of structure and physiology of the phytochrome. The authors describe phytochrome induction responses, use of classical action spectra and *in vivo* spectroscopic measurements of physiological responses of the photoreceptor in the first two chapters. The next two chapters cover the structure, cellular location, physiology, distribution and evolution of the phytochrome; there is also a brief description of the different molecular biology tools used in the study of the receptors and mechanism of signal transduction, specifically identification of signal transduction pathways through the analysis of photomorphogenic mutants.

Part 2 contains five chapters covering the complete story of the phytochrome. The contributors of the chapters are well-known experts in the field of this well-studied photoreceptor. The first two chapters deal with the general structure of the phytochrome, its biochemical and biophysical characteristics, biosynthesis and holoassembly, and its distribution and evolution both in plants and bacteria. The next three chapters discuss the phytochrome gene structure, sequence analysis and expression, and its distribution and evolution in seed plants. Stability of the phytochrome in light/dark conditions, the intracellular localization of different phytochromes are also summarized.

Blue light and UV receptors are covered in six chapters in Part 3. The first three chapters deal with the early history of classical physiological responses of the receptors such as phototropism, stomatal opening, leaf expansion and chloroplast movement. These chapters also describe the discovery, structure, distribution and mode of action of cryptochromes and phototropins with emphasis on the molecular structure and mechanism of action of both types of receptors in the background of recent knowledge in the field. The role of cryptochromes in the wide spectrum of organisms like bacteria, algae, mosses, higher plants, *Drosophila* and mammals has been critically summarized, with special reference to its role in the regulation of circadian rhythms in *Drosophila* and mammals. The remaining three chapters primarily summarize recent developments in the mechanism of perception of light by blue light/UV receptors and various signal transduction pathways operating in the blue-light mediated photomorphogenesis.

The focus of Part 4 shifts to the molecular mechanism of photosignal transduction pathways, biochemical analysis of signal transduction components, dissecting and identifying the pathways through mutational analysis, crosstalk in the signalling network, and interaction between different photoreceptors. The photobiologist Peter Quail, reviews the contributions made by the pioneers in the field of intracellular signalling systems and also critically summarizes all the chapters of the book, with a focus on photosignal transduction.

Part 5 of the book does not specify any theme; however it includes interesting review chapters like the role of phytochrome in shade condition, and photoreceptors in ferns and mosses and their function with specific reference to spore germination and chloroplast movement. This concluding part also includes chapters on circadian regulation of photomorphogenic events, role of chlorophyll precursors as the communicating system in plastid–nucleus signalling, and molecular mechanism of photoperiodic responses with an up-to-date knowledge in these areas of research. The chapter on commercial application of photomorphogenesis research is unique because the authors draw our attention to the application of photomorphogenesis research in biotechnology, specifically in the area of light-based plant biological engineering. The last article by the photobiologist H. Smith summarizes the progress made so far in the area of photomorphogenesis research. The advancement made in this area, according to Smith, is the result of the use of precise light sources, analysis of action spectra, gene cloning, reverse genetics, intracellular imaging and micro-array analysis.

The book provides basic knowledge in photomorphogenesis and is therefore suitable as a textbook for graduate-level studies in plant development, physiology, biochemistry and molecular biology. At the same time, some chapters provide update information in the field with novel ideas and technical know-how for post-graduate students and researchers in photobiology.

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Perhaps it is the sign of the times. I did an exercise of trying to classify the various review articles in the *Annual Review of Entomology* from 2000 onwards, and found that as I approached 2007, it was becoming increasingly harder to place articles into categories such as insect behaviour, insect physiology or insect ecology. This is because all articles seemed to be so inter-disciplinary in nature that they could easily fit into several categories simultaneously. This is probably true of all good review articles in the present age; they should attempt to represent a synthesis of the synergism that is occurring in science, wherein there is abundant crosstalk between disciplines. My examination of the volumes over the last eight years also revealed a new trend. There appears to be more emphasis on taxon biology, i.e. more specific reviews of particular taxa that are not necessarily related to their importance as insect pests, e.g. separate reviews of the evolutionary biology of centipedes, bed bugs as well as of millipedes, in the present volume. An innovation that is specific to this year is a complete change in publishing format; the new colour format has a glossary, text-box summaries, and reference highlighting (in which 'key' references are in bold font with explanatory notes in the margin providing reasons for choosing this reference as is done in the *Current Opinion* series of journals). This new format has, in my opinion, not added value to the text. There is also no uniformity in the application of the format. For example, the review by van Asch and Visser on the importance of synchrony between forest caterpillars and their host trees, or the one by Reinhardt and Siva-Jothy on the biology of bed bugs does not follow the format of highlighting certain references and explaining why they are important. Why have a new format, if all authors do not follow it? I personally do not like this system of reference highlighting because it can contribute to citation and reader biases in this age of information overload, when everyone is trying their best to keep up with the current literature. I was also not impressed by the quality of the glossary in the margins. A glossary can be an important addendum and can add value to a review article. However, if it is used to explain words such as 'pollinator', 'diapause' and 'typical host' vs 'atypical host', it serves little purpose, especially when many other terms in these articles which should have been explained, were ignored. Perhaps the editors need to take a closer look at how the use of this new publishing format can be improved, so that value is added to articles instead of taken away.

There are valuable articles in this compilation, several of which are topical. An example is the one by Hance *et al.* ('Impact of extreme temperatures on parasitoids in a climate change perspective'). The most negative effect of climate change is not only its impact on individual species, but its potential disruption of species interactions due to an asymmetrical response of the members of a species pair to the change. Resultant mismatches between the phenologies of the interacting pairs could make potentially beneficial interactions no longer tenable. Such mismatches could contribute to serious insect pest outbreaks, since parasitoids may be unavailable when the insect pests are present. An interesting focus of this article was also the potential impact of extreme temperatures on insect endosymbionts such as *Wolbachia*, now known to be an important agent responsible for female-biased sex ratios in insects. Can temperature changes cure insects of *Wolbachia* infections? In the face of climate change, the article convincingly shows that there is an urgent need for research which emphasizes the impact of both the stochasticity as well as the extremes of variables such as temperature and rainfall on species interactions.

Another indication of rapidly changing research requirements due to changing environments is the heightened realization of the need to revert to organically grown crops and thus also to examine the impact of pesticides on beneficial arthropods. How can insect pests be managed, however, in organic fields? This is the subject of a review by Zehnder *et al.* ('Arthropod pest management in organic crops'), who examine a hierarchical framework of defence strategies which begin with measures such as crop rotation or soil management and end with insecticides of biological and mineral origin. This article lacks a detailed discussion of the definition of 'organic'; the implications of an ambiguous definition of such a term are quite serious. For example, just as in India there appear to be few regulations on the composition and safety of so-called herbal medicines, similarly in the global market, there appear to be conflicting views on the definition of 'organic'. Can a formulation be considered 'safe' just because it is an extract of a plant and is thus regarded as a botanical? There are several highly toxic compounds in plants, resulting from millions of years of evolution against pests, and all these compounds are most certainly not safe for human consumption. What are the procedures for testing and ensuring that an organic formulation is safe not only for human consumption, but also for non-target beneficial insects such as pollinators and parasitoids of insect pests? Perhaps a future review article in the *Annual Review of Entomology* should focus on precisely such issues. A related article in this volume is one by Desneux *et al.* ('The sublethal effects of pesticides on beneficial arthropods'). The authors make a valid case for requiring an evaluation of these sublethal effects in pesticide registration procedures. Sublethal effects can impact on various aspects of the biology of beneficial arthropods from longevity to fecundity to sex ratios, through mobility, navigation and orientation, and also on feeding and oviposition behaviour. Surely these factors must be evaluated before declaring a pesticide appropriate for use? Regrettably, few such evaluations actually exist, since the primary focus of pesticide research is the target pest organism.

Every *Annual Review* volume has far too many articles to allow a critique or a commentary on all of them in a book review. However, every volume has a couple of articles that are truly gems. This year the two gems, in my opinion, are the following: 'Group decision making in nest-site selection among social insects' (P. K. Visscher). A quick browse through this article and my imagination was completely captured. Social insect colonies, e.g. those of honey bees, often divide or emigrate, and undergo a process of swarming. In all these cases, new nest sites need to be located and workers need to recruit to the new site. How are new nest sites found, what are the criteria for deciding on the suitability of a nest site, and more importantly, how does this collective action of mass migration to the new nest site occur, i.e. how is unanimity achieved? Is this action a masterpiece of hierarchical decision-making or is it self-organized? Using the available literature on two species, the honey bee *Apis mellifera* and *Temnothorax* ants, the authors explores the proximate features that make a nest site acceptable, how the scout ants or bees evaluate and recognize this suitability, how they convey this information to their nestmates and how a unanimous decision is finally effected. It is worth remembering that recruit bees also get information from scout forager bees about various pollen and nectar resources; however, in this case, recruit bees do not necessarily converge on the same food resource, as has to happen in decisions about new nest sites. On the contrary, the recruit bees respond to the various food locations indicated by the different scouts so that food resources are collected from a foraging zone around the nest. How then is unanimity achieved in the case of nest-site selection, i.e. how does an 'expiration of dissent'[1] take place? Apparently in honey bees, there is a progressive decline in the number of runs in the waggle dance in each successive trip made by nest-site scouts, and this decline helps achieve unanimity in nest-site selection. In the ant *Leptothorax*, quorum sensing of recruited ants by scout ants at the potential nest site causes a switch from tandem running behaviour in scout ants to transport behaviour, wherein scout ants physically carry ants to the nest site[2], resulting in nest-site switch. In tandem running, ants follow each other closely, so that the front end of one ant touches the rear end of the one ahead. Apparently quorum-sensing behaviour also occurs in swarming bees that ultimately choose a nest site[3]. I found this review particularly appealing because of the potential parallels in decision-making processes in societies that range from microbes to humans.

The other gem of an article was 'Nectar and pollen feeding by insect herbivores and implications for multitrophic interactions' (Wäckers *et al.*). As I have mentioned in the beginning of this review, all of entomology is becoming inter-disciplinary; I should also have added that all of insect–plant interactions is coming together into a comprehensive whole, as this particular review amply demonstrates. From this review, it becomes obvious that it is important to consider interactions at many levels within the same system in order to understand seemingly anomalous results. For example, in a system in which the larval stage of an insect feeds on plant tissue while the adult feeds on nectar and/or pollen resources, it has most often been assumed that the adults select oviposition sites based on optimal larval development. However, given the fact that females may select oviposition sites that are based on their own immediate survival and fecundity (e.g. proximity to suitable nectar/pollen sources), oviposition sites may appear to be maladaptive in sole accordance with optimal oviposition theory. The review therefore recommends an integration of optimal oviposition theory (maximizing offspring survival) and optimal foraging theory (maximizing female survival and fecundity). To cite another example: nectar and extrafloral nectar may help not only to attract adult herbivores which are often pollinators in the adult stage, but could also attract parasitoids of larval herbivores that often feed on nectar (especially extrafloral nectar). By attracting pollinators with floral nectar, the plant may also actually have to pay the cost of increased herbivory, since these pollinators may be induced to oviposit on plants to which they were attracted for nectar[4]. Thus, a plant may have to pay diverse costs in order to reap net reproductive benefits. Only multitrophic approaches and appropriate investigations via path analyses will allow us to ask and answer relevant questions in such systems. The use of heterospecific floral resources has often also been mooted in otherwise monoculture agricultural systems, to enhance survival and reproduction of parasitoids and predators of insect pests. However, this may actually have negative impacts if the plant pest, such as the thrips *Frankliniella occidentalis*, undergoes an increase in r_m (intrinsic rate of population increase) when pollen resources are added to the system. It has been calculated that the population of *F. occidentalis* on susceptible varieties of cotton increases a million-fold (after two months) when additional pollen is available compared to a 16,000-fold increase in the absence of pollen. Thus generalizations are no longer tenable, and great attention must be paid to the specifics of systems. Another important take-home message from this review was the impact of spacing between larval and/or adult food plants, and how this may affect foraging and oviposition decisions by herbivores as well as parasitoids. Since plant spacing is in turn affected by both pollination and dispersal strategies in natural systems, the multiplicity of levels at which investigations need to be conducted increases before meaningful answers can be obtained.

Other signs of the changing times were two review articles on internet-based resources facilitating insect systematics ('Keys and the crisis in taxonomy: Extinction or reinvention' by Walter and Winterton, and 'Biodiversity informatics' by Johnson). Both these reviews provide information on types of resources available as well as those that need to be made available in order to harness current information technology successfully for insect systematics. I found that the discussion on the merits and demerits of dichotomous keys versus pathway keys and interactive matrix-based keys could be useful, especially for professional systematists who can guide the development of such resources. Perhaps the quotation by Lobanov[5] cited in this review was indeed warranted: 'Keys are compiled by those who do not need them for those who cannot use them'.

Finally, a review on yellow fever and its vector in humans, the mosquito *Aedes aegyptii*, posed many interesting questions ('Yellow fever: A disease that has yet to be conquered' by Barrett and Higgs). Why, for example, is yellow fever absent in Asia and the Pacific when *A. aegyptii* occurs in these areas where, especially in Asia, it is involved in the transmission of dengue viruses? Is there a difference between the rate of evolution of the yellow fever and dengue viruses and their rates of co-evolution with *A. aegyptii*? The authors also point out that the yellow fever virus is believed to have originated in Africa and subsequently to have moved to South America. Furthermore, the disease causes deaths of its primary primate hosts in South America, but not in Africa. However, the authors do not explain this pattern. I wonder whether one reason for this difference could be the amount of evolutionary time that the host and virus have been in contact with each other on the different continents. Many host–parasite interactions evolve less virulence over evolutionary time, especially when they require vectors for their transmission between hosts. Therefore, in Africa the relationship may have reached a relatively non-virulent form owing to the antiquity of the interaction, while in South America the interaction may still be at an earlier stage. It would be interesting to compare the virulence of viral strains taken from these different areas on the same test organism. A minor quibble I have with this review is to point out that the galago (*Galago senegalensis*, the only primate in Africa to succumb fatally to yellow fever) is not a lemur but a bushbaby, although both lemurs and galagos are prosimians.

This year's *Annual Review* volume begins with an autobiographical essay by Charles D. Michener ('The professional development of an entomologist'). Although Michener is the world's foremost authority on bees, he writes in a characteristically gentle and unassuming style: 'I greatly doubt if I have written anything here that would help young or aspiring professional entomologists make their life decisions. I think important qualities to develop, especially for those in academic life are: (a) the ability to return seamlessly to what you were doing or thinking after being interrupted by someone with an entirely different problem, and (b) the resolve to keep doing and publishing the research that you enjoy when most of your time has to be devoted to something else'. This volume is certainly a celebration of the collective enjoyment and passion of its many contributors.

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