olfactory and vomeronasal systems in mammals modulate behavioural responses.

Genetics of adaptation in bacteria, mechanism of cyclin-di-GMP signalling in bacteria and host genetic factors that determine susceptibility to infectious diseases are also featured in this volume.

As it has always been, this volume of the *Annual Review of Genetics* too is a compendium of latest information on topics of interests to both researchers and students of genetics.

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There are many welcome changes in this volume of *Annual Review of the Plant Biology* (*ARPB*), though these extend to several other *Annual Reviews* series too. Many illustrations in colour (long overdue), key references in boldface and critical notes in the margin, all greatly enhance the readability and value of the reviews.

One also notices that the *ARPB* is getting weightier each year (this volume comprises > 900 pages); natural perhaps to accommodate the greatly expanded research activity. Also, the editors cover not only the more conceptual advances such as relating to the photosynthetic apparatus or phytochrome action, but provide space and thus encourage somewhat less glamorous or more mundane topics such as chlorophyll degradation or vitamin synthesis, which is perhaps necessary since ultimately the idea is to understand a plant in its entirety – and many future biotechnological exploits may involve manipulating genes which, even as they may seem quite ordinary biochemically, could have important implications in agriculture or human welfare. The added weight of the *ARPB* also derives from the survey of many technical advances such as DNA microarrays. As always, each chapter is written by a world expert, though often involving younger collaborators as 'senior' authors.

The *ARPB* continues the fine tradition of the Prefatory chapters (these should be read by all young and aspiring researchers). This time an admirable and highly readable chapter has been written by Sarah Gibbs on 'Looking at life: from binoculars to the electron microscope'. Gibbs started research with the late Kenneth Thimann, a doyen of American Plant Physiology and Biochemistry, and a grand-guru of many of us. But as luck would have it, Thimann then had to leave for India on a visit sponsored by the US Government. He spent much time in Delhi, where my father, the late Panchanan Maheshwari (who had known Thimann since his own Harvard visit in the 1940s), organized the first national symposium in Plant Physiology at Delhi University and in which Thimann was a key guest speaker and a close advisor. But the visit became longer as Thimann' wife contracted jaundice, necessitating admission in a local hospital. And it is probably this unexpected long stay in India, which altered Sarah Gibb's career. Not having much success with the slow-growing *Acetabularia*, she was a bit distraught and on Thimann's suggestion (on his return), she sought another advisor and changed her research area to electron microscopy investigating the pyrenoid of *Chlamydomonas*. Eventually, she moved to McGill (Montreal), where she became a distinguished member of the faculty. Her autobiographical sketch is one among the most inspiring and frank ones that I have ever read and shows how despite the difficulties that a woman faces in pursuing a career (despite a debilitating affliction of multiple sclerosis); by sheer hard work, determination and grit, she became an outstanding specialist of chloroplast ultrastructure.

Turning now to the various reviews, a timely one is on the 'Structure and function of photosystems I and II' (several titles have been abbreviated by me to conserve space) by Nelson and Yocum, who have themselves done pioneering work on these systems. They bring together the work of many other key laboratories, such as of Barber, Fromme, Saenger, Witt and others (it is a particular pleasure to note here that among the world leaders in this research are Yachandra and Chitnis who have past links with India). Although the general organization of the two photosystems is now fairly clear, the most fundamental question – of how exactly molecules of water split to release electrons, protons and oxygen – is still a mystery.

Addressing now the other core chapters, as a student of developmental plant biology, I find among those most interesting, the first one is on 'Micro RNAs' by Jones-Rhodes in collaboration with David and Bonnie Bartel, with pioneers in this area. The new RNAs in recent years have emerged as powerful regulators of development. It is clear now that the removal of old mRNAs is as important as synthesis of new ones, which is accomplished by various micro RNAs, appearing at critical points (by cleavage of larger precursors while these primary transcripts are still in the nucleus), then moving out into the cytoplasm and getting incorporated in a silencing complex which has ribonuclease activity. Typically, pairing of the micro RNA with a mRNA having a complementary sequence targets the latter for cleavage and total destruction. Research in several laboratories has shown that many of the target mRNAs code for transcription factors and their degradation is obviously as important as the synthesis of new ones for the onset of a new developmental programme.

From the viewpoint of growth and morphogenesis, a chapter of great interest is by Hussey *et al.*, which touches an area of great mystery, i.e. how cell shape is determined and how, for example, root hairs or trichomes arise. It appears that the actin skeleton is fundamental, whose overall size is itself dependent on ARP (AR for Actin Related) and a number of other proteins, among them formins, gelsolins and prolifins. Another review of related interest is by Eherhardt and Shaw on 'Microtubule dynamics and organization in plant cortical arrays', which too is a topic central to growth and morphogenesis. Microtubule organization undergoes dynamic changes with growth. Although there is considerable progress in understanding the various components of the cytoskeleton, little is yet understood as to how decisions such as directional growth or orientation of the spindle during cell division are made. The relative role of actin and ARP vs microtubule proteins is yet to be delineated since microtubules appear to be involved in a variety of other roles such as cell-wall biosynthesis (cellulose microfibril alignment), spiral cell growth or stomatal movement. The great benefit deriving from use of *Arabidopsis* is in generation

of mutants with altered fate, which is fully made use of in this study.

Light has long been recognized to play a key role in plant growth and development. Among the three articles in this volume, one by Kehoe and Gutu deals with the phenomenon of complementary chromatic adaptation. From the initial pioneering work by Fujita and Hattori on *Tolypothrix*, the reader is led to various advances at molecular level in recent years (many by the senior author with the alga *Fremyella*). Regulation by both light (through photoreceptors such as phytochrome) and the redox state (recognized more recently) are critical for such response. Another article, having certain common themes, is by Prat and colleagues (Rodriguez-Falcon *et al.*) on control of tuberization of potato where phytochrome and photoperiod have long been known to be critical. One significant finding is that the *CO* (*CONSTANS*) and *FT* genes, so crucial for flowering in *Arabidopsis*, rice and other plants, are critical also for tuber formation, which clearly illustrates that *CO* and *FT* control the broad photoperiodic response(s), whether for flowering or any other aspect of development. Finally, Lagarias and colleagues (see article by Rockwell *et al.*) discuss the latest advances in phytochrome research focusing on the structure of this photoreceptor (which in the past few years has been shown to exist in many bacteria as well as fungi like *Aspergillus*), as also its mechanism of action. In the past decade, several laboratories have focused on higher plants and have shown that Pr–Pfr transition of phytochrome molecule leads to its accumulation in the nucleus as also phosphorylation of certain serine residue(s), which perhaps sets up a cascade of altered biochemical reactions. However, the precise role of both of the kinase-like C-terminus or of phosphorylation remains mysterious. In the plants examined, phosphorylation occurs at the N-terminal or central region of the molecule rather than the C-terminal HKD (histidine kinase-like domain), and in this reaction the photoreceptor is now thought to get desensitized rather than activated.

Research in plant hormones has been central to the study of plant development. The article by Sakakibara deals with cytokinins, and another by Matsubayashi and Sokagami with the new emerging class of 'peptide' hormones, the first example of which was systemin. However, recent work has now led to the discovery of more peptide hormones, such as phytosulfokine, CLV3 and ENOD40, involved in various processes ranging from somatic embryogenesis to nodulation. With new developments in genome technology, more such hormones are likely to be discovered. Another area of current interest is that of 'Tolerance to dehydration and cold stress' and an article by Yamaguchi-Shinozaki and Shinozaki (a prominent husband–wife team) reviews the transcriptional controls. A significant advance is of finding key transcription factors and corresponding cis-acting elements in promoters of stress-induced gene activity, by these authors themselves in *Arabidopsis*.

Turning to reproductive development, Cande and colleagues (see review by Hamant *et al.*) discuss 'Genetics of meiotic prophase I'. Mechanisms that turn on meiosis are of interest not only from a fundamental viewpoint, but also perhaps in analysing the molecular basis of apomixis (where typically the meiotic programme is aborted) and the use of such knowledge in biotechnology.

A subject of increasing emphasis currently is the molecular basis of morphogenesis. After the pioneering work by Meyerowitz, Saedler and others on floral morphogenesis, researchers have taken two directions. There are those like Benfey and Schiefelbein, who are analysing the simplest systems such as growth of trichomes and root hairs, while others have begun analysis of development of other organs such as leaves and stem despite their complexity. Tsukaya reviews and analyses studies on 'Leaf shape determination' with emphasis on *Arabidopsis*.

Other reviews are on 'Sugar-sensing and signalling' by Sheen and her colleagues (Rolland *et al.*), 'Leaf hydraulics' (Sack and Holbook), 'Chlorophyll degradation during senescence' (Hörtensteiner), and 'Plastid-to-nucleus signalling' by Chory and her colleagues (Nott *et al.*), who characterize this as 'retrograde' signalling since it is the reverse of the normal mode. Here the redox state also plays a role no less important than metabolites.

About a dozen other reviews are devoted to such aspects as 'Flavonoids in seeds' (Lepiniec *et al.*, i.e. M. Caboche's group), 'Role of root exudates in rhizosphere interactions' (Bais *et al.*), 'Glucosinolates' (Halkier and Gerschenzon), 'Leaf hydraulics' (Sack and Holbrook), 'Plant uncoupling mitochondrial proteins' (Vercesi *et al.*), 'Glycosyltransferases of lipophilic small molecules' (Bowles *et al.*), 'Protein degradation in plastids' (Sakamoto), ofactor and enzymes' (Schwarz and Mendel), 'Vitamin synthesis in plants' (Della Penna and Pogson), 'Floral pigments' (Grotevold), and 'Pyrimidine and purine metabolism in plants' (Zrenner *et al.*).

Finally, this volume features five articles on techniques and model systems. Thicket *et al.* discuss 'Quantitative fluorescence microscopy'. Nelson *et al.* expand another revolutionary technique of 'Laser microdissection', which enables analysis of unique components of single cells. Rhee *et al.* discuss 'Bioinformatics', and Galbraith and Birnbaun review the 'Global studies of cell type-specific gene expression' of which DNA microarrays occupy the first few pages. An article by Cove and colleagues focuses on 'Mosses as model systems' (I am happy to see that the article cites work of several of my former colleagues at Delhi University). At one point of time (in the sixties and seventies), liverworts and mosses were considered the best bet for embarking on eukaryotic plant biology. Although subsequently (in the early eighties) *Arabidopsis* emerged as a model organism and where almost all molecular biology techniques have been applicable without too much difficulty, bryophytes represent an experimental system of great value, serving as a bridge between organisms such as *Synechocystis* and higher plants, which can enable us to address questions of evolutionary biology.

The *Annual Reviews* series (for plant biologists) started when I was admitted as a B Sc Honours student of Botany at the university. And I grew up all these years with it. Although *Trends in Plant Sciences* and *Current Opinion in Plant Biology* also cover much of the same broad area, the *Annual Reviews* will remain the most significant source for following the progress of science and this volume matches all its earlier incarnations in keeping up its high standard.

I recommend the volume to every department of plant science in India and elsewhere. It is simply indispensable for any advanced student or scholar.

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