

designers are currently involved in creating want instead of creating freedom from want, which he argues is the real freedom. According to Balaram, designers of the future should be not merely skilled in designing, but a 'broad-based, socially well-integrated, humane designer with a global vision'.

Perhaps the most insightful of the chapters is the one on the 'The power of representation'. The chapter broadly focuses on how powerful the symbolic value of a product is, and illustrates this beautifully through the artefacts that Mahatma Gandhi used to convey, both to himself and to others, the message of being part of the common masses of India and working towards its political and economic independence. Balaram uses the Gandhi-cap as an artefact to demonstrate how powerful the meaning of a product can be, and how this meaning changes with who uses it and the way in which it is used, and the coherence these have with the other messages that are associated with its user.

To support the rural population of India, Balaram proposes the creation of the 'barefoot designer', who will take design to the villages of India and make it useful to its people. How can the knowledge and skills of the modern designer be married to the context of the rural poor to create better shelters, better sickles, better roads and better drinking water? Balaram proposes formation of a large number of design institutions, many of which will be located in small towns in India, with their curriculum attuned to rural needs. Each village would nominate one person to be trained at one of these institutions, while being guided to design and deliver within his own cultural milieu. The intent is to create designers that would remain part of the rural community, and bring knowledge of the problem and solution together in an ethnographically situated manner to improve rural living.

A particularly interesting part of this book are its case studies, which span from design of a toothbrush-cum-tongue cleaner, through design of a family planner, to design of a Devanagari script; most of these are designed by the author or his students. I personally find the design of a weighing machine for postal letters interesting. The novelty in thinking in this design lies in the fact that a machine for weighing letters is not really about measuring the exact weight of a

letter, but about assessing the postage necessary for dispatching the letter by post. The design needs to ensure that the machine finds the appropriate postage-sensitive weight range for a letter.

To me this is a book of the author's reflections and insights, in particular about the practice, learning and teaching of industrial design for India's rural poor. The language is fluid, and the style informal. The book is thought-provoking, as any good book should be. It would serve its purpose well if it inspires greater interest in, and debate on industrial design in India.

One final comment. While books on the views on design are important for creating public interest in, and encouraging debate on design and its place in the society, the design community needs to reach out beyond views, and work towards developing a validated understanding of design – a science of design – that can be utilized for continuous improvement of current ways of designing. This requires sustained research into design. The good news is that there is a substantial research community around the world, and a growing body of scientific knowledge about design. This includes a growing community of Indian researchers and a growing body of knowledge about design within India, spearheaded by the Indian Institute of Science, several IITs, and others. It would have been really interesting to have a chapter in this book on research into design in India and how this could be used to improve the act of designing, especially for India's rural poor.

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The *Annual Review of Plant Biology* provides a picture of current trends in plant science. The leading plant biologists not only critically review their work, but also provide a comprehensive description of the subject by citing recent literature of other workers. Almost all the articles in this volume provide relevant conclusions of the themes with salient/summary points. These features along with excellent coloured pictures, schematics and tables have made the volume impressive and useful as a textbook both for students and researchers.

The structure and character of the articles and presentation style of the *Annual Review of Plant Biology* have significantly changed over the years. Because of rapid advancement in molecular biology and development of highly sophisticated tools and their extensive use in different areas of plant science, the reviews in the volume exhibit more rational discussion and openness without much speculation/assumption. This volume contains 23 reviews authored by about 85 experts from 21 countries of Africa, America, Asia and Europe. Each article has its own character with a specific theme and approach. For convenience, they are broadly classified under themes like transport and transporters, metabolism, signalling and regulatory network, development and evolution, and finally, the techniques and applied botany. At many points, however, the articles of different groups overlap.

The volume begins with an wonderful review by Van Montagu (Ghent University, Belgium), who is widely known as a renowned plant biotechnologist specifically in the field of agriculture biotechnology. He has nicely described his early life and school days and subsequently his scientific career in the university. The description of his horrifying experience of World War II during his school days is remarkable. The first part of the review describes how the specific circumstances during his university education led him to develop a fascination/dedication for research in biochemistry. During this time, the discovery of the double

helical structure of DNA and emergence of molecular biology attracted him to work in the area of this new science. Being an organic chemist, he was fascinated by the work of the Nobel laureate, Har Gobind Khorana in the area of chemical synthesis of ribo and deoxyribonucleotides.

Van Montagu has described his experience and interaction with many laboratories and provided a good sketch of the development of biological science, including the discovery of Ti plasmid, expansion of DNA science and its application as well as recombinant technology during the last half of the 20th century.

He has summarized how the basic principles of operation of *Agrobacterium* induced gall formation, subsequent discovery of Ti plasmid and T-DNA had implications on the progress of molecular genetics and development of plant transgenic technology, which brought revolutionary changes in the field of agriculture, medicine, environment and bioenergy. Van Montagu's efforts to develop and expand pro-poor biotechnology are commendable. I fully shared the views of Van Montagu, who in the conclusion of his review argues against the barrier between fundamental and applied research. He is right in opining that biotechnology and its applications in different fields to improve the quality of life are the by-product of imaginative and curious human mind, and scientific inquisitiveness. Discovery of the double helical structure of DNA and the model proposed by Watson and Crick, an area of basic research, was never believed to bring unimaginable practical implications in subsequent research in the areas of biotechnology, genetic engineering and applied research in biological sciences. Finally and most appropriately, Van Montagu opines that efforts should be made to modulate the regulatory rules of application of technology that should benefit not only the developed world, but also meet the demands of the unprivileged in the developing countries. The editors have rightly invited him to write the article, when plant biotechnology is drawing the attention of a large number of plant biologists in recent years.

Plant transport, which was considered as a classical theme, has come up in a big way in recent years with the development of new ideas in understanding the complex nature of channels/transporters and their association with cell-signalling. The

area of study is important in the background of our poor understanding of delivery systems in different cellular compartments, molecular mechanisms of transport, regulatory network, including tight regulation of molecular and metabolic processes and system regulations. Some of the reviews under the theme also highlight the involvement of signals, both intrinsic and extrinsic, and their modulating effect on transport.

The molecular basis of regulatory network of anion channels, an area of recent interest in the field of transport research, is reviewed by Barbier-Brygoo and associates. The article summarizes the physiological importance of the anion channels, identification of gene families encoding the transporter systems emphasizing the functional genomics for their integrated functions in plants. They have explained how the diversity in substrate specificity, cellular localization and their regulatory processes, including post-transcriptional modifications ensure their involvement in a wide range of physiological functions. Finally they have raised several questions that have to be unambiguously answered, specifically the complex regulatory network of anion transport like crosstalks and coordination between transport pathways. The next article under the theme relates to transporters of the plastid envelope. In addition to a short introduction on the endosymbiotic origin of plastid in eukaryotic cells and its significance in establishing link between the organelle and the host cell, the review focuses on the current understanding of metabolic link of plastid with cytoplasmic environment through transporter proteins of the plastid envelope. Although the authors have critically discussed the structure and function of various transporter systems harboured in the plastid envelope, their molecular genetics as they conclude are still poorly worked out. Two more articles on plant transport cover transporters associated with sulphur assimilation, and transport of nutrients from soil by arbuscular mycorrhizal (AM) symbioses. The former article by Takahashi and his associates describes how sulphur is cycled in ecosystems where sulphate uptake plays a major role on conversion of sulphate to organic sulphur compounds. The authors, with recently available data and coloured schematic illustrations, have summarized the diversified sulphur assimilation pathways with distinct biochemical char-

acteristics in different cellular and subcellular compartments. The review focuses on transcriptional and post-transcriptional regulation of sulphate transport and metabolism. The other review by Smith and Smith defines the role of arbuscular mycorrhizas in plant nutrition and growth. These are two distinct pathways, one directly through epidermis of the root and the other by AM fungal hyphae into the cortex of the roots. The pathways described involve different cell types and also different transporters with, however, independent and coordinated regulatory systems. The delivery of the nutrients from the soil, including nitrogen and phosphorus, is critically discussed with citation of the current literature.

Plant metabolism is a broad area of our continuing interest in plant science. The review by Millar and associates describes our current understanding of mitochondrial structure and function, emphasizing transporter systems that link oxidative phosphorylation with cytoplasm. In addition, the review provides a critical discussion on respiratory regulation of plant development and plant response to stress. It also provides an excellent analysis of the recent literature covering the molecular nature of this respiratory regulation, with a concluding remark on the complex nature of spatial and temporal changes in respiration in response to environmental changes. The other article of current interest relates to biochemistry and molecular biology of folates, cofactors for one-carbon transfer reactions. Folate research has significantly advanced in the post-genomic era. The description of the genes for folate synthesis and turnover, molecular mechanism of folate synthesis, compartmentalization of the enzymes for folate biosynthesis, metabolism and their subcellular localization has been the focus of the review. In the background of dietary importance of folate, Hanson and Gregory III have suggested the strategy to modulate its levels through genetic and metabolic engineering. The last article on the theme of plant metabolism tells the story of plant nucleotide sugars. Several genes responsible for the formation of nucleotide sugars are identified. The nucleotide sugars, the donors for synthesis of polysaccharides, glycoproteins and glycolipids are formed from sugars directly or indirectly derived from photosynthesis. The review by Bar-Paled and

O'Nelly, however, focuses on the salvage of sugars from glycans for synthesis of nucleotide sugars and finally with a brief analysis of the role of nucleotide sugars on plant growth and development. Formation of specific nucleotide sugars in plants covers the large part of the review, basically textual in nature.

This volume contains a large number of articles on plant regulatory network and signalling systems indicating current trends in plant science. The networks associated with phosphorus, potassium, nitrogen and calcium signalling are reviewed with beautiful illustrations.

Phosphorus, a key component of several essential cell components, plays a significant role in signal transduction and it is acquired mostly by uptake of inorganic phosphate (Pi) through the roots. In addition to regulated uptake of Pi from the soil, plants develop several coordinated responses to conserve, recycle and remobilize internal Pi. Chiou and Lin have focused on how plants employ local and systemic machineries to elicit coordinated responses to the changes in the status of external phosphate. The role played by phytohormones modulating gene expression and changing root architecture is outlined with excellent illustrations. Similar to phosphorus signalling, another chapter by Tsay and co-authors describes the progress made over the past few years on nitrogen and potassium signalling. The authors have focused on how signal transduction pathways involving sensors, kinases, ligases and transcriptional factors mediate transcriptional responses, alteration in root architecture and uptake activity induced by soil nitrogen and potassium. The review outlines the integration of these responses

of plants to compete and survive in nutrient-limiting environment.

The review on ubiquitin–protein ligase is one of the important articles of this volume on protein biochemistry, especially in the area of protein catabolism. By quoting recent literature, Hua and Vierstra have critically discussed steps in post-translational modifications of the protein, including tagging it with ubiquitin (Ub), a small polypeptide. The ligation of the protein with Ub involves ATP-dependent reaction cascade and Ub–protein ligase enzymes. The review, however, focuses on the current understanding of the organization and structure of Cullin-RING ligases (CRLs), a class of Ub ligases, which have been shown as central to several important processes in plants. These CRLs are discussed as sensors of light and hormones and are involved in several signalling networks. The authors have provided a table with extensive references summarizing functionally characterized CRL substrate adapters in *Arabidopsis thaliana*. The review is informative and useful for those interested in protein catabolism and plant regulation.

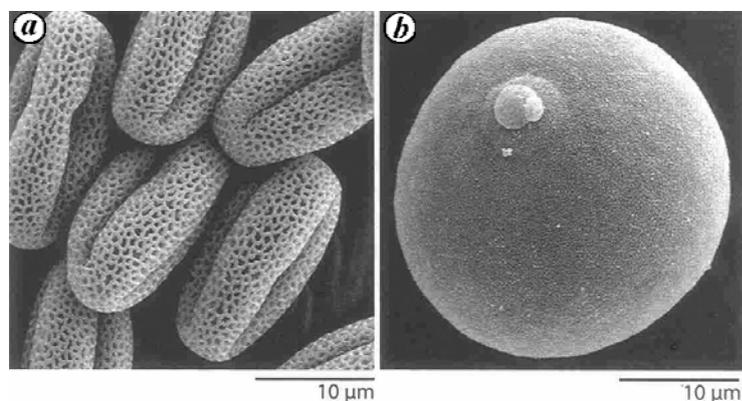
Blue light photoreceptors, their structural, photochemical and molecular properties, and their role in regulating several functions in plants and animals are reviewed by multiple authors of different laboratories from Europe and USA. This review is characteristically different from earlier reviews written on the subject, because it covers plant and animal cryptochromes and their involvement in signalling mechanism with some common features, which are likely to generalize the function of the photoreceptors in diverse systems. The illustra-

tions of cryptochrome structure, including their crystal structures and mechanism of their function with examples from plants and animals have made the review impressive. On the other hand, a critical discussion on the signals generated by mechanics associated with walls, cells and tissues controlling plant morphogenesis is a new and interdisciplinary approach in the area of signal network research. In this review the authors have tried to summarize the mechanical basis of cell and tissue growth, and translation of growth and geometric outputs of plant structures. Mechanical forces are suggested by Mirabet and his associates to be the sensors to regulate gene expression and plant growth pattern.

Plant development, including the molecular mechanisms involved in various developmental programmes, has become another current area of research in plant science. This volume includes four articles covering asymmetric and symmetric cell division and modulation of developmental pattern by Rasmussen and his associates; phenotypic determination by interaction of diverse epigenetic networks with mRNA transcriptome by He and his colleagues; genetic modulation of pollen exine, a cell-wall polymer with a focus on the molecular regulation of biosynthesis of sporopollenin reviewed by Ariizumi and Toriyama and finally, a critical review of molecular basis, different factors, including asymmetric cell division and other regulatory networks in specifying germlines in plants authored by Berger and Twell.

There are four reviews on diversified areas of plant evolution like evolution of sex chromosomes, evolution of photosynthesis, evolution of specified metabolisms in plants, and finally evolution of plant cell walls.

While describing sex chromosomes in land plants, Ming and his associates provide a critical review on the mechanism of sex determination, the rise and evolution of sex chromosomes and characteristics of the chromosomes in land plants, including different groups of bryophytes, gymnosperms and angiosperms. A table summarizing examples of land plants with homomorphic and heteromorphic chromosomes makes the review informative. The review on evolution of photosynthesis is an addition to several earlier reviews on the origin and evolution of the process. Blankenship, one of the authors of the review, has written several



Scanning electron micrograph of mature pollen grains. **a**, Reticulate exine surface structure in *Arabidopsis*. **b**, Smooth exine surface in rice. Panel (**b**) courtesy of S. Fujii (Tohoku University, Japan).

articles in the area during the last decade emphasizing on early evolution of photosynthesis with molecular evidences for evolution of the process. The present review is an exhaustive description of the non-oxygenic origin of photosynthesis and subsequent evolution of oxygenic photosynthesis with emphasis on manifestation of novel biosynthetic pathways of photosynthetic cofactors and alterations in electron transport carriers, pigments and protein complexes. The review touches upon few important points like mechanism of evolution, genetic evidence of evolution and endosymbiotic events. On the other hand, Pichersky and Lewinsohn have provided a different story of evolution describing how each plant lineage develops a mechanism for synthesis of specialized metabolites appropriate for its environment. They have, however, focused on a critical discussion on how plants independently evolved to synthesize metabolites that already exist in other plant lineages or synthesize different metabolites, which carry out the same function, examples indicating convergent of evolution in plant-specialized metabolites. Continuing on the theme, Popper and his associates describe evolution and diversity of plant cell wall, the field that had earlier drawn less attention. The review compiles literature in the area like variation and diversity in the composition of cell wall in plants and algae, cell-wall communication and differentiation and cell-wall diversity. The authors have emphasized on how terrestrialization, transition from saline to freshwater, and subsequent evolution of land plants have resulted in a dramatic alteration in cell-wall composition of the aquatic and land plants.

The two reviews under the theme 'Techniques and applied botany' relate to fluorescence imaging and genetic engineering, the techniques that have significantly contributed to the expansion of knowledge in plant science.

In many laboratories, small molecular weight fluorescent dyes are used to examine the dynamics, both spatial and temporal, of plant regulators and signalling molecules. Summarizing the recent data generated through the fluorescence imaging techniques, Swanson and associates have attempted to explain regulation of diverse developmental and physiological processes of plants induced by alteration in the levels of Ca^{+2} , pH

and reactive oxygen species. The article with graphics and illustrations has emphasized how these fluorescent dyes in addition to well-studied GFP could be used to image the regulators and their cellular functions.

Food biotechnology, in recent years, is drawing attention both in developing and developed countries. New ideas and new techniques in biotechnology and genetic engineering are emerging to improve the quality of foods. The review is written by seventeen authors from Africa, America, Asia and Europe indicating global concern about this area of plant biotechnology research. Studies to have desired nutritional and caloric character in foods have gained importance specifically after the post-genomic era. Cassava, a shrub is one of the major sources of calories in sub-Saharan Africa. Its root is the main source of carbohydrates. The multi-authored review focuses on the strategy of the Biocassava (BC+) programme for developing genetically biofortified Cassava with better nutritional quality. For obvious reasons, this type of biotechnological approach by plant scientists has relevance primarily for underdeveloped and developing countries, where many people suffer from malnutrition. The review concludes with the future plan of BC+ programmes to target biofortification of food crops in Africa, and their commercial application with better technologies and management.

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This volume has an eclectic collection of 27 articles reviewing areas from the origin of life to optogenetics, including protein folding, bacterial organelles and the mechanism of myosin motor activity.

Martin Chalfie points out that mechanosensory ion channels transduce mecha-

nical stimuli to electrical signals extremely rapidly, but are very sparse – around 50 transducing channels per sensory neuron. They have, consequently, been much more difficult to characterize than, say, rhodopsin, which is also reviewed in this volume and is present in 4×10^7 copies per rod photoreceptor cell. Candidate mechanoreceptors have been found in several families of ion channels, but confirmatory evidence is lacking in most cases. The channels are likely to mediate auditory transduction in hair cells of the inner ear and insect flight sensors, among other systems. The gating mechanism is yet to be elucidated, but may involve tethering to intra- and extracellular scaffolds, thus experiencing strain on membrane deformation.

Anders Carlsson has reviewed actin dynamics which is crucial for cellular function. Actin is maintained in a non-equilibrium distribution by continuous input of energy, which results in such phenomena as travelling waves, which may be responsible for oscillations at cell edges. These oscillations, in turn, may be used by the cell to sample its environment. However, mechanisms linking actin polymerization to oscillations have yet to be elucidated.

The cell membrane is made up of a lipid bilayer within which proteins reside. The distribution of specific lipids among membranes of different compartments of a given eukaryotic cell and between the two leaflets of a specific membrane can be quite non-uniform. Leventis and Grinstein review the inner leaflet distribution and function of phosphatidyl serine (PS), which is most enriched in the plasma membrane. Appearance of the lipid on the outer leaflet (and hence the exterior of the cell) can trigger major events – such as attraction of clotting factors when exposed on platelets, or signalling phagocytes to engulf and devour cells undergoing programmed cell death. PS in the inner leaflet probably functions continuously in several contexts, many of which are still being analysed. How the asymmetric distribution is set up and the extent of such asymmetry in organelles is yet to be elucidated.

A statistical mechanics perspective and advances in experimental techniques have revolutionized our view of protein folding. Thirumalai *et al.* predict that the time for folding scales with the size of the protein – which has some experimen-