In this issue

Plant molecular biology

Plant biology has been a major discipline of the natural sciences for more than a century because plants provide us not only food, oxygen and shelter, but also the greenery and beauty all around us. From the Linnean era of taxonomy and systematics still dominant in the last century when plant biology was a rather descriptive science, we have certainly come a long way. Back in the early part of the last century, initially, many discoveries of far-reaching significance were made by simple tools such as the light microscope, for example, the discovery of double fertilization, or by just plain penetrating insight such as employed for discovery of the laws of heredity by Gregor Mendel or their rediscovery by Correns, DeVries and Tschermak-Synegegg. Yet again it was keen observation and insight that led to further advancement in genetics, the discovery of transposons by Barbara McClintock in maize in the forties, being an outstanding example.

Important advances were also made in plant physiology with rather simple tools and techniques. The discovery that photosynthesis consisted of both light and dark reactions (and one that was the key to formulation of current ideas) was made on the basis of very simple experiments and the premise that the Q_{10} of a photochemical reaction is 1, but that of chemical reaction is generally between 2 and 3. Again, with the simplest of experimental set-ups, a major chapter was opened in plant physiology, i.e. of hormones.

Nevertheless, new tools and techniques were needed for further progress. The electron microscope was one new tool at the heart of the new cell biology that enabled a magnificent inside view of the cell. But it is the acquisition of the powerful technique of molecular biology in the sixties and seventies that made an even greater impact and brought about a truly far-reaching revolution in plant biology that we are witnessing today. Serious research began to be pursued on nucleic acids and RNA polymerases. Thus, came the discovery of DNA in chloroplasts and the beginning of a new sub-discipline of organellar molecular biology, leading also to new concepts of cardinal importance, e.g. the origin of higher cells through endosymbiosis. Later, in the mid-seventies, when the recombinant DNA techniques came to be employed, another significant transition began in the nature of researches in plant biology. Thus, pioneers like Lawrence Bogorad (we are fortunate in having him as a contributor to this special section) began isolating and cloning from plants the very first genes. However, as years went by, the concept of what is molecular biology itself has undergone a radical change. From an earlier somewhat restrictive usage, molecular biology now embraces any and all aspects of plant biology where one sought to investigate and understand cellular events at the molecular level. Molecular biology now included studies on organelles, cytoskeleton, membranes, control of cell division, cell fate, differentiation and morphogenesis that includes the determination of shape of whole organs. By the nineties, molecular biology was touching every aspect of plant growth and differentiation so much so that there was no longer any need to use the word 'molecular' to define the nature of these studies (this is when founders of modern journals, even though dealing with molecular biology, decided to do away with the word 'molecular', calling them for example, simply, '*Plant Cell*' or the '*Plant Journal*'.

We have attempted in the special section (**pages 143–279**) to bring together essays on some of the most important areas that are revolutionizing the understanding of plant biology. By deliberate choice and planning we have left out purely biotechnological aspects and have emphasized the basic, fundamental researches which are at the heart of our understanding of growth and development of plants. The section begins with general articles of an introductory nature, written by two of the great pioneers of this revolution. Arthur W. Galston (**page 143**), who has made many important contributions to plant biology in a career spanning more than four decades, has been very much in the limelight recently due to the final acceptance (after many years of controversy) of his proposal made long ago that flavins may be the chromophore for the blue light photoreceptors in plants. The results of the early basic studies on action spectra have now been verified by the isolation of the cryptochrome genes and remarkably cryptochromes also exist in animals, with much the same basic structure. Another distinguished contributor is Lawrence Bogorad who has been a pioneer of molecular biology researches on plants, being responsible for cloning of the first plant gene, the large sub-unit of ribulose-bisphosphate carboxylase which is the ubiquitous carbon dioxide fixing enzyme in plants. His essay provides (**page 153**) a general glimpse of the rise of plant molecular biology.

The articles representing the core section begin with a contribution by Tyagi (**page 161**) who surveys the area of plant genes emphasizing the extraordinary role light plays in governing their expression. The essay leads the reader to special *cis*-acting elements that have been discovered in the promoters of many genes of plants and to which special *trans*-acting protein factors bind, emphasizing regulation by light through such photoreceptors as the phytochromes and cryptochromes. Nothing, however, is accomplished in either plant or animal cells without complex connecting chains of interacting molecules or other factors between a primary causative agent such as light and the genes. The article by Clark and colleagues (**page 170**) gives an account of the various key players such as calcium ions and the inositol phosphates that relay various kinds of messages from photoreceptors or other environmental signals, touching also on some more recent developments.

Following these more general contributions dealing with nucleic acids and signal transduction, are articles on the regulatory effects of light on plants. Sharma (**page 178**) discusses the all-pervasive role of phytochromes in plants, red and far-red light absorbing photoreceptors that can sense the prevailing light conditions in the environment and instruct a seed or a tuber, through appropriate signalling, whether to germinate or not, or, later, guide a seedling whether or not to expand its leaves, mature into a plant and flower, or to shed leaves in the autumn if it has grown into a tree. As readers will learn, the photoreceptor itself moves to the nucleus, regulating gene expression directly. Like Sharma, Khurana (**page 189**) too discusses light effects on growth and development, but his forte is blue light. Almost a century ago, Darwin noted the role of blue light in phototropism, but it is the JK224 mutant of *Arabidopsis* (which Khurana discovered while working with Poff in USA in 1990 and now renamed *nph*) that has led the way to our current understanding of phototropism. In the article, he gives an account of the *NPH*-coded photoreceptor as also the one coded by *CRY* genes as well as the *CRY* photoreceptors that are important for other blue light effects on plants like control of extension growth of hypocotyl and stem.

Plant growth and development are regulated by many other molecules. Johri and Mitra (**page 199**) discuss the all important role of hormones. Although the first hormones, such as the auxins, were discovered in the early part of the last century – again through pioneering researchers who extended Darwin's observations on phototropism – the mechanism of their action has long been a mystery. The same was true of some other plant hormones like gibberellic acid and cytokinins discovered somewhat later in the middle of the last century. However, with the discovery of receptors, some of which seem to take the hormone to the nucleus, the mystery of hormone action is now beginning to unfold.

The contribution by Grover and his students (**page 206**) concerns an emerging area of great importance to plant biotechnology, that of molecular biology of plant stress. A beginning has been made in understanding how stress may be perceived and how special proteins could move to the nucleus and bind to promoters of many special plant genes, whose transcription and translational products then enable the plant to withstand stress. Another new area that has emerged in plant and animal biology is 'organelle molecular biology'. The special aspects of the molecular biology of chloroplasts, in particular the cross-talk between the nucleus and the organelle, the autonomy as well as interdependence and related matters are discussed by Régis and Silva Lerbs-Mache (**page 217**). The articles on photoreceptors, signalling cascades and organellar molecular biology are followed by the subject of control of cell division and organ formation. The former is presented by Heberle-Bors (**page 225**), whereas the contribution of Vijayraghavan (**page 233**) gives a skilful overview of the homeotic genes discovered in plants in recent years and the manner in which they control such morphogenetic events as the formation of sepals, petals, stamens or pistils in flowers of plants. Plant embryology, which dominated the Indian botanical scene in the fifties and well into the sixties, is finally going molecular. The transition from the descriptive to an analytical phase is covered in a thought-provoking article by Raghavan (**page 244**).

The above articles give an overview of progress of research in some of the most important areas of plant biology. Yet, the newest and the most rapidly emerging area of plant biology is 'genomics'. There has been much excitement recently on account of two parallel achievements – the nearly complete sequencing of chromosomes 2 and 4 in *Arabidopsis* (by the time the issue is in print *Arabidopsis* should have been sequenced completely) as also the DNA microchips. The article by Maheshwari *et al.* (**page 252**) surveys this progress. A natural follow up of genomics is proteomics, the study of amino acid sequence and function of proteins discussed by Dubey and Grover (**page 262**). And finally, Sopory and Maheshwari (**page 270**) survey the plant molecular biology scene in India. Is it a dismal scene? For the size of a country like ours, and given its ancient tradition of acquiring knowledge and its dissemination by *gurus* and *rishis*, we should be a major force internationally. But sadly this is not true and we seem to be lagging behind China and even smaller countries like Korea or Singapore where certain centres have gained international respect. Here, we have attempted to make some recommendations which hopefully will get noticed in the right quarters for serious consideration. The government has certainly taken many commendable initiatives in the last decade by setting up many units and centres of plant molecular biology. But once again urgent correctives are required to step up research specially in our universities. Or else, we may helplessly watch a revolution pass us by!

The editors of this special section thank Nirmala Maheshwari who not only took care of the correspondence with the authors, but made significant improvements in many write-ups including this. Our grateful thanks are also due to several colleagues at the International Centre for Genetic Engineering and Biotechnology specially Sunil Mukerjee, Suresh Nair and Sudipto Chattopadhyay for reading manuscripts in their areas and offering suggestions for improvement.

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