Now, molecular plant physiology

Annual Review of Plant Physiology and Plant Molecular Biology 1989. Vol. 40. W. R. Briggs, ed. Annual Reviews Inc., Palo Alto, USA, 1989. 613 pp.

As the techniques, ideas and approaches of molecular biology have become incorporated in all the disciplines of biology, quite appropriately, plant molecular biology has also been included in the *Annual Review of Plant Physiology* starting with volume 39.

The twenty articles in this volume deal with a wide variety of topics, such as *Azolla–Anabaena* symbiosis, plasma membrane ATPase, intracellular pH, ion channels, interactions between nuclear and organellar genomes, photomorphogenesis, development of herbicide-resistant crop plants, isoprenoid biosynthesis, xyloglucans, phenylpropenoid metabolism, endosperm mobilization, and xylem cavitation and embolism.

Intracellular pH is turning out to be of far more importance in triggering growth and developmental changes than has been realized so far. The activity of proton-ATPase is regulated by pH and membrane potential. Besides regulating cytosolic pH, H^+-ATPase is emerging as a master enzyme and most of the plant hormones also interact with it. However, the notion of protons acting as second messengers of hormones is still controversial. Calcium ions and calmodulin are also very important mediators of various cellular processes, e.g. phosphorylation of H^+-ATPase and phytochrome-regulated chloroplast movement. Though the turnover of phosphoinositols and diacylglycerol-regulated release of calcium ions have been demonstrated in a few plants, it is not known if the elements of signal transduction steps are arranged and operate in a circuit similar to that found in some of the animal systems. There is reason to believe that an understanding of the mechanism of H^+-ATPase modulation by various effectors could clarify an important regulatory circuit. Patch clamp studies have demonstrated the presence of ion channels in the membranes of higher plants. Their role in the signal transduction pathway in plants remains to be elucidated. Polyamines are associated with rapid cell division but their precise role remains unknown and there is no evidence that they act as growth regulators, hormones or second messengers.

The obligate symbiont associated with the water fern *Azolla* may well belong to the genus *Nostoc* and not *Anabaena*. Its filaments are associated with the apical meristem of each stem and are partitioned as new leaves develop. In the *Azolla–Anabaena* association, NH_4^+ derived from fixed nitrogen is transported to the fern where it is assimilated by the glutamate synthase.

During plastid development, a proper coordination of gene expression between plastid and nuclear genomes is of paramount importance. The regulatory information seems to flow in both directions. The development of chloroplasts also affects the expression of some of the nuclear genes coding for the chloroplast proteins. The nuclear genes for plastid proteins are largely regulated at the transcriptional level, while in the plastids, multigene transcriptional units are formed and the stability of RNA is very important in regulating gene expression. Surprisingly, the synthesis of nuclear-coded RbcS (small subunit of ribulose bisphosphate carboxylase) is independent of the plastid-coded RbcL (large subunit), but both accumulate in stoichiometric amounts because there is a rapid proteolysis of unassembled excess subunit. RbcS is coded by 3 to 12 related genes all of which seem to be expressed in the leaves of a given species; their expression is highly coordinated with plastid development.

A fine recent example of the application of plant physiology and molecular biology has been the development of herbicide-resistant crop plants. Corn lines resistant to sulphonylureas developed by Pioneer Hi-Bred are being field-tested and are anticipated to be released in early 1990s. Sulphonylureas inhibit acetolactate synthase (ALS) which is required for the synthesis of isoleucine, leucine and valine. As animals lack ALS, the low toxicity to them can be explained. As most of the crop plants are not yet amenable to direct transformation, regeneration of plants from cell lines resistant to sulphonylureas and other ALS inhibitors (such as imidazolinone) has been accomplished. Once the transformation becomes possible, the herbicide resistance genes could also be used as reporter genes to introduce genes for traits such as disease resistance and nutritional qualities, which cannot be scored readily at cell level.

The incorporation of recombinant DNA techniques has completely transformed the field of plant physiology and exciting advances are occurring on several fronts.

M. M. JOHRI

Molecular Biology Unit
Tata Institute of Fundamental Research
Bombay 400 005