Molecular Biology of Plant Developement

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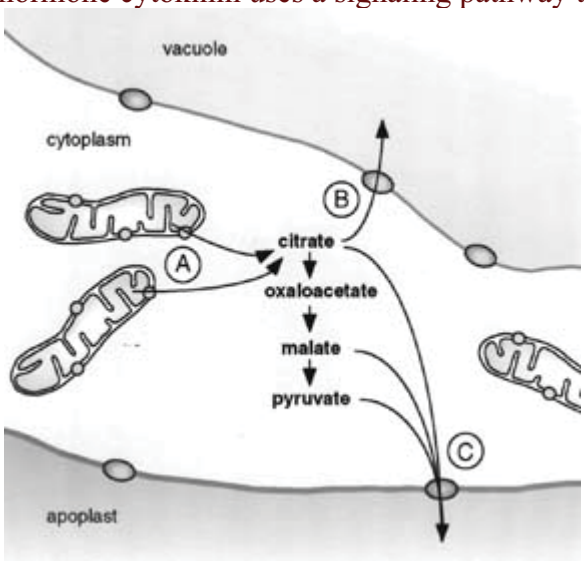
During the life of a plant, genetic programs unfold that control development from the sprouting of shoots to the opening of leaves and the fading of blooms. A challenge faced by plant developmental biologists is to explain the wonders of plant growth in modern scientific terms, that is, gene expression patterns, hormone responses, and signal transduction pathways. My efforts to do so have resulted in a book published by Cambridge University Press entitled Molecular Genetics of Plant Development. The book is intended for advanced students and those who want to apply the concepts of modern molecular biology and genetics to plant development.

Our research interests are also directed toward finding the molecular mechanisms that control various plant processes. We are particularly keen to discover the effects of auxin and cytokinin, plant hormones that promote root and shoot development. One line of our research into the action of the hormone cytokinin has crossed paths with interesting aspects of signaling systems in human physiology involving the immune system.

Cytokinin and Immunophilins

It is always a surprise to find that some aspect of the complex physiology of humans is also shared by plants. An unexpected connection has been revealed in the role of proteins called immuno-philins. Immunophilins interact with immunosuppressive drugs that are administered in human transplantation therapy to prevent the rejection of transplanted organs such as kidneys, livers, or hearts. The drugs act by binding to immunophilins, and the resulting complexes block the development of immune cells that reject foreign materials in the body, including transplants. What do immunophilins do in plants? We do not know, but in humans, they are associated with proteins involved in transduction pathways and hold signaling proteins poised to respond to small growth signals. In plants, it has been found that the hormone cytokinin uses a signaling pathway that somehow involves immunophilin proteins.



In collaboration with a research team in France, we are using immuno-philins to find components of the cytokinin signal transduction pathway in Arabidopsis. To identify these components, a search was undertaken using immunophilins as "bait" in the yeast 2-hybrid system to fish out plant proteins with which they associate. The yeast 2-hybrid is a powerful tool for this purpose because the system imposes a stiff genetic selection to find proteins that associate with each other. In plants, the immunophilins represent a family of similar genes. We have found a "protein partner" in Arabidopsis for the smallest member of the immunophilin family, a protein similar to FKBP12 in animal systems. The function of the protein is unknown, and our challenge is to discover its possible role in signaling pathways in Arabidopsis.

Aluminum Resistance

We are also engaged in exploring the mechanism and finding the genes involved in aluminum resistance in plants. Aluminum toxicity is one of the most widespread agronomic problems in world agriculture. In acid soils, naturally occurring aluminum blocks root growth, and affected plants show other deficiency disorders. Plant breeders have long sought aluminum-resistant traits in a variety of crops but need to identify the genes. Our goal is to isolate aluminum-resistant mutants in Arabidopsis that can be used as tools to guide us to the genes. To this end, we and our collaborators at the USDA Plant Soil and Nutrition Laboratory at Cornell have developed a collection of aluminum-resistant mutants. The mutants belong to two groups. Mutants in one group prevent aluminum uptake by releasing from their root tips organic acids, such as malic and citric acid, that chelate aluminum and prevent its uptake. Mutants of the other group alkalinize the soil immediately surrounding their root tips, reducing the solubility of aluminum. The mutants should be extremely valuable in leading us to the genes that confer aluminum resistance.