Plant Physiol. (1996) 112: 1–2

Editorial

Plant Physiology Has Become Plant Biology, A Cross-Disciplinary Science

The tools of molecular biology, gene cloning, and plant transformation have revolutionized the study of plants into a new plant biology. There is renewed excitement among geneticists, morphologists, cell biologists, biochemists, whole plant physiologists, developmental biologists, and pathologists, and the reasons are obvious: we have powerful molecular tools available to us to help answer very complex interdisciplinary questions. We can create transgenic plants in which specific genes are up- or down-regulated and we can seek answers to old hypotheses.

The question that plant physiologists want to know is: how do plants "do it"? How do they make a flower, assimilate nutrients, transport water, cope with salt, make the transition from vegetative to reproductive growth, transport sucrose, fend off pathogens, make seeds, recognize self, grow taller in the shade, become green in the light, and, yes, make their roots grow down and their shoots grow up? Are plants that synthesize more osmolytes consequently more resistant to osmotic stresses? Is carbon partitioning affected when we increase the synthesis of sucrose? Does phloem loading depend quantitatively on ATP synthesis in the companion cells? Does systemic acquired resistance involve the transport of a signaling molecule? How many genes control the identity of floral organs? How does blue light cause stomata to open? How do we figure out the answers to these questions?

Some of the excitement is generated by the practical applications of this work. For example, if we can grow plants that synthesize more osmolytes, they might resist drought or salinity in the field and be more adaptable for greater crop production in difficult-to-farm or salinized regions of the world. If we can figure out how resistance genes work, we might be able to protect crops from pathogen damage.

Researching these and other questions requires a partnership, the marriage of different subdisciplines, because the questions themselves are interdisciplinary, and answering them requires that we understand how to use an extensive array of tools. This has important repercussions for the way we conduct research in our laboratories. Do we train students to think critically in different disciplines so that they can carry out these exciting research projects themselves? Or do we collaborate with other labs? How can we be sure that we have assimilated the concepts that underlie a research area very different from the one in which we were trained?

My laboratory encountered such an entirely new frontier when, a few years ago, we cloned the cDNA for a tonoplast protein that was later identified as a water channel protein, or aquaporin. Aquaporins are proteins that allow water to go through a membrane. They are found in the tonoplast as well as in the plasma membrane, and their discovery has thrown new light on the concept of transcellular water flow. The obvious follow-up question was: could we use this discovery to make drought-resistant plants? We can make transgenic plants in which the aquaporin genes are up- or down-regulated; that is the easy part. The evaluation of the water relations of those plants is the more important, and for my lab, the more difficult part.

Before I can get started with such a project in earnest, I will have to write a credible research proposal. The reviewers may say that I have no expertise in this new field, and they would be right. So, should I collaborate or should I proceed alone and have my proposal checked by a water relations expert? To get the funds it will be essential that I design the right experiments and measure the parameters that meaningfully describe the water relations of the transgenic plants. Experimental design must be rigorous and the data must be properly presented and interpreted. Otherwise, I will risk publishing interpretations that confuse rather than clarify the questions at hand. Who should review the proposal that describes this research?—colleagues with experience in molecular techniques or water relations experts? The answer is "both," of course, because the work should meet the high standards of both groups. In addition, reviewers may have to take the responsibility of indicating their own limitations when evaluating proposals or research results.

Different labs will choose different paths, either in-house expansion or collaboration with others, but whatever path is chosen, this new, crossover trend has important implications for our discipline. In an editorial in *Plant Physiology* (1995, Vol. 108, No. 3, pp. 883–884), Sharon Long drew attention to the need to train graduate students broadly, preferably by incorporating one complexity level above and one below the student's specialty. Thus, she pointed out, a developmental biologist should also be trained in whole plant physiology. Suppose the developmental gene you just cloned turns out to be a protein that is part of the secretory machinery in other organisms. What does that say about the role of the secretory process in development? Isn't secretion a constitutive process? Suppose the researchers in my lab create an antisense aquaporin plant that, relative to the wild type, grows more slowly when well watered but shows less inhibition of growth when water is withheld; such a plant may appear to be more drought resistant, but is the reduced level of aquaporins responsible? Will our students and postdocs have the necessary training to grasp the implications of these results and to design the next experiment?

The new plant biology gives us the opportunity to ask broad questions that cut across several disciplines. This is a major change and a challenge for all of us. The labels of yesterday—biochemistry, physiology, biophysics, genetics, development—are disappearing because the problems we want to address require tools and knowledge from many disciplines simultaneously. Many may want to cling to the "plant physiology" moniker, but we are all fast becoming plant biologists whose science crosses many disciplines.

Maarten J. Chrispeels, Editor-in-Chief
E-mail mchrispeels@ucsd.edu; fax 1–619–534–4052