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Editorial

Changing Technologies with a Constant Goal: Finding Out How Plants Function

Biology has become an increasingly exciting discipline in the last quarter of the 20th century, and the ever-accelerating pace of new discoveries in the biological sciences is mirrored in plant biology and in the pages of this journal. Not only did the size of the journal grow 5-fold between 1960 and 1990, but the types of questions that people can answer have changed as a result of the development of new technologies. For example, although plant biologists have been interested in plant hormones for more than 50 years, questions that seemed intractable in the 60s and 70s, such as the identity of hormone receptors, or the identity of enzymes that catalyze steps in hormone biosynthesis, are suddenly tractable because molecular genetics has come to the aid of biochemistry to create a new research methodology. Such work spans the spectrum from whole-plant research to biochemistry to molecular biology, and often involves the characterization of mutants. We are now making progress in identifying hormone receptors, components of the signal transduction pathways, and the transacting factors that bind to promoter response elements to turn on the genes that encode the enzymes that modify plant growth.

Given these dramatic changes in what we can find out, I thought it might be instructive to conduct a longitudinal survey of the subject matter of articles published in our journal. I chose one volume from each of the following years, 1963, 1978, 1988, and 1995, looked at every paper, and assigned it to one of the categories that we now use to subdivide our table of contents. When papers seemed to fit more than one category, I made what seemed like a reasonable choice. The categories and the percentage of papers in each category are listed in Table I. A few papers could not be assigned, but this had little impact on the total percentages. I chose 1963 as a starting point because this was well after the emergence of biochemistry and before the advent of molecular biology. I found the results (see Table I) so surprising that I want to share them with the readers of the journal.

1. Since 1963, the numbers of papers in **metabolism and biochemistry** declined from a high of 40% to about 25%. This category includes molecular biology (previously nucleic acids), but there are very few molecular biology articles in the journal. In the 60s many of our colleagues were grinding up plants and plant parts and assaying enzyme activities, or feeding plants radioactive metabolites and following their fate. Biochemical papers are very different now and deal with the discoveries of new pathways, the regulation of enzymatic activities, and even the three-dimensional structure of enzymes. When complete genomes are sequenced, we will see a renewed interest in biochemistry to study the activities of proteins such as transcription factors or protein kinases that are not part of the traditional metabolic pathways. Bioinformatics will allow us to uncover the identities of many proteins. In addition, activities of many enzymes can only be measured after expression of their cDNAs in heterologous systems, either because they are extremely nonabundant and/or too unstable for purification.

2. **Growth and development** (which includes the study of the traditional five hormones and new signaling molecules) has consistently attracted about 20% of the papers. Some of the people who published papers in the 1963 volume, Winslow Briggs and Jan Zeevaart, for example, still regularly contribute to our journal. The papers from their laboratories and in this field in general, however, reflect changing technologies. The once popular "spray-and-pray"approach was first replaced by measuring changes in hormones and in the appearance of enzymes and later by changes in mRNA populations. In the 90s we are publishing papers on the analysis of hormone-insensitive mutants, the effects of newly discovered signaling molecules such as methyl jasmonate, salicylic acid, and brassinosteroids, and the analysis of components of hormone signal-transduction pathways. Progress in the field of hormone biosynthesis has depended largely on the availability of mutants and the expression of the relevant genes in heterologous systems. Unfortunately, we have seen relatively few papers in developmental genetics as it relates to morphogenesis.

3. **Whole-plant physiology** has grown slightly in popularity, increasing perhaps from 15 to 20%. This subfield now includes the responses of plants to physical stresses, a subject that was seldom investigated in the 60s. Papers on long-distance transport, root-shoot relationships, plant-water relations, and carbon partitioning now use more sophisticated methodologies (fluorescent dye movement, pressure probes, and transgenic plants) than were used in the past. The field of stress physiology overlaps with all other fields, including biochemistry, cell biology, signal transduction, and developmental biology.

4. **Cell biology-membranes-ions** has grown steadily as a field from 6 to 14%. There was almost no study of cell organelles other than mitochondria and chloroplasts 30 years ago, and I assigned papers on ion uptake by excised roots and tissue disks to this group because ion transport is now studied in isolated vesicles, which comes presently under cell biology. Cell biology now includes the study of a whole range of organelles (vacuoles, the plasma membrane, peroxisomes, and elements of the cytoskeleton), the cell cycle, the cell wall, and signal transduction pathways. Light

Table I. *Analysis of subject matter areas in the pages of Plant Physiology: 32-year profile*

Classification	Vol. 38:1963	Vol. 62:1978	Vol. 87:1988	Vol. 107:1995
Biochemistry, metabolism, molecular biology	40[a]	30	25	27
Photosynthesis and respiration	14	16	15	8
Whole plant physiology	16	14	20	20
Cell biology, membranes, ions	6	10	14	14
Developmental biology, gene regulation, hormones	17	23	21	18
Microbial physiology and plant-microbe	7	7	4	13
Papers using whole plants (higher plants)	27	27	30	32

[a] All numbers are percentages.

and electron microscopy, antibodies, in vitro transport assays, isolation of organelles, and complementation of mutants are just a few examples of the range of technologies that are currently used by plant cell biologists.

5. Papers on **bioenergetics** (chloroplast and mitochondrial-based processes) are not as numerous as they once were, and they have dropped from about 15% in earlier years to 8% in 1995. Further analysis shows that the study of plant mitochondria has almost completely disappeared, with the exception of papers on the alternative oxidase pathways. Papers on photosynthesis can be divided into in vitro and in vivo (whole plant) studies. Tom Sharkey is one of our hardest working monitoring editors, which demonstrates that whole-plant photosynthesis is well represented in the bioenergetics section. I suspect that as many people are studying chloroplasts as before, but they are now cell biologists or are interested in how light turns on genes for chloroplast proteins, and these papers turn up in other classifications. Unfortunately, scientists working on bioenergetics (light reactions) seem to be abandoning us for other journals that have a biochemical or biophysical orientation.

6. The field of **plant-microbe interactions** was almost nonexistent in the pages of our journal, but some papers were published on microbial physiology and biochemistry. Although those subjects have disappeared, the interactions between plants and other organisms (symbionts, pathogens, and pests) now account for nearly 15% of the published papers. This area has really blossomed in the past 10 years and a special associate editor, Sharon Long, was appointed in 1992. I hope that we will see increased submissions on interactions of plants with mycorrhizae, nematodes, and insects in the future.

There are, of course, other ways to classify the subject matter in the papers published since 1963. For example, I could have combined all of the papers on photobiology or on mineral nutrition (whether whole-plant or transmembrane ion transport). Maybe someone else will delve deeper into such historical developments. I only used one other criterion to determine the questions that interest our colleagues: Do they study primarily whole plants or in vitro preparations? The number of scientists using whole plants remained steady at 30%. Traditional subjects such as water relations, whole-plant photosynthesis, and photomorphogenesis are now supplemented by the characterization of mutants or the study of plants that express transgenes. Developments in gene cloning, plant transformation, and the emergence of Arabidopsis as a model system are in large measure responsible for the increase in whole-plant papers. This seems a little counter-intuitive because molecular biology is reductionist in its approach. Nevertheless, plant biologists appear to be true to their calling; they want to know how whole plants work and they are willing to use all available tools to figure this out.

This issue marks the end of my first 5-year term as the editor-in-chief of this journal. My major goals for this 5-year term were to steer *Plant Physiology* in a new direction with a new editorial structure and faster reviewing procedures, and to help it maintain its position as the best journal that covers all of plant biology. It is my impression that we are on track toward achieving these goals, although improvements are still possible. We are concentrating on strong, well-documented papers, distributed over nearly all areas of experimental plant biology, that significantly enhance our understanding of how whole plants work. I thank all of you who have helped us by sending us fine research papers, who have contributed *Updates*, and who have critically analyzed the submitted papers. I particularly thank the journal editorial staff at ASPP headquarters, whose dedication makes it possible to maintain the highest publication standards for our journal. I look forward with enthusiasm to my second 5-year term.

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