

Plant Physiology: Past, Present, and Future

The 75th anniversary of *Plant Physiology* comes at a very exciting time in the history of plant biology. We are currently experiencing an unprecedented acceleration in the pace of scientific progress (as our Society's recent publication of the 1,400-page textbook *Plant Biochemistry and Molecular Biology* [3] bears testament!). The completion of the genomic sequences of some of the most intensively studied multicellular organisms such as *Drosophila melanogaster* (1), *Caenorhabditis elegans* (13), *Arabidopsis* (12), and soon human and rice, has created new research directions, experimental approaches, and opportunities. For the first time, our laboratory toolbox is so powerful that it is now possible to envisage a whole-systems approach to gene and protein function and to study the function of all genes of a particular species within cellular, organismal, and evolutionary contexts. Equally dramatic have been the changes in the publishing landscape: online publication of journals has forever altered the way scientists relate to the literature.

When the American Society of Plant Physiologists was 50 years old in 1974, the Journal (in its 48th year) published a series of eight retrospective articles that summarized 50 years of progress in plant biology (2, 4, 6–9, 14, 15). Many groundbreaking insights and original discoveries were made during those first 50 years (11), but plant physiologists still had insufficient mechanistic understanding of the biological processes they were studying. The advent of new molecular tools has changed all that: Virtually every day, plants become less and less of a "black box."

In this issue, we present 42 short commentaries that attempt to summarize conceptual breakthroughs in plant biology during the past 25 years. In a perfect world, we would have asked even more members of the Society to offer their perspectives, but alas, neither this world nor this project is perfect. Given limitations of space and resources, not every field could be covered. By selecting only 42 fields, many other areas in which there has also been substantial progress had to be omitted. Undoubtedly, many important individual contributions were not cited, particularly as the objective of the authors was not to write comprehensive reviews, but to illustrate how our thinking about plants and our experimental approaches have changed in their respective fields over the course of the past 25 years. Given the rapid progress in plant biology in recent years, such brevity did not come easily, and I am sure that each author struggled to be as objective as possible in deciding what to include. The resulting commentaries are fascinating taken one at a time, but together they demonstrate just how far plant biology has come in a relatively short while.

Three major technological advances stand out as being crucial in accelerating the pace of plant biology in the past 25 years: 1) the development of molecular tools, 2) the development of plant transformation by *Agrobacterium tumefaciens* and other means, and 3) the widespread adoption of *Arabidopsis* as a model organism by thousands of biologists. Our series of commentaries begins with an analysis of these three breakthroughs. The remaining articles draw from research in the following areas: whole plant physiology and biochemistry; signal transduction; developmental, cell, molecular biology and genetics; and biotechnology.

In the foreword to the first issue of *Plant Physiology* (10), the Journal's founders noted:

"It is evident. . . that these two lines of investigation, practical and fundamental, must always go hand in hand. There can never be a logical separation of these two aspects of our science. Likewise, there can never be a logical separation of the pure physiologists from the practical physiologists. Our tasks are one and we must learn to march together in their performance."

This anniversary issue, 75 years later, is a testament that this statement is just as true today as it was then! The modern tools of plant biology are not only allowing us to answer important questions in basic biology, but are also proving profitable to the farmer and the marketplace. Plant biologists are making tangible contributions to agricultural productivity. Although history teaches us that science is extremely unpredictable, there can be little doubt that the next 25 years will witness a revolution in plant biology of unprecedented scope that will dramatically impact both basic and applied research. The interconnection between biology and various disciplines such as applied mathematics, physics, and chemistry will be crucial in the next decade. New experimental tools that aid in the investigation of gene function at the subcellular, cellular, organ, organismal, and ecosystem levels and new bioinformatics tools for analyzing and extracting meanings from system-based databases will be developed. These technologies will not come cheaply, but they promise to pay great dividends.

Funding of plant biology by governments and private sources has increased steadily in the past 25 years and has been critical to the spectacular achievements of the last quarter century. In the United States, the ongoing support of plant biology by NSF and DOE Division of Energy Biosciences was supplemented significantly by the USDA competitive grants program (1978–present) and by innovative programs such as the NSF postdoctoral fellowships in plant biology (1983–1994), the tri-agency (DOE, NSF, and USDA) programs of various kinds (1987, 1992–1994), and the plant genome funding by NSF (1998–

present). The development of new and innovative programs by private granting agencies was critical to these research developments. Among the more prominent programs launched by private foundations and corporations were the McKnight Foundation grants program in 1983, the Agrigenetics Corporate Limited Partnership (1981–1988), and the Rockefeller Foundation's worldwide support of rice biology research (1985–2000). The main sources of funding for starting new plant research programs in Europe and in Japan were, respectively, the EC (1990–present) and the Scientific Research on Priority Areas and Basic Research for Innovative Biosciences programs (1987–present). Especially encouraging and innovative was the funding and coordination by various national and international agencies of the multinational Arabidopsis genome research project (1990–present).

Given the enormous power of the new tools of molecular biology now at hand, even the substantial increases in funding that we have enjoyed of late are insufficient to fuel the juggernaut of scientific progress. Indeed, we live in a time unprecedented in the history of botanical science. The determination of the Arabidopsis genome sequences laid the groundwork that will make possible phenomenal strides in applied and basic research in the next 10 years (5). We are now at the brink of elucidating the function of all the genes of Arabidopsis and other selected species. Plant scientists now have the technology to conduct basic research that can be rapidly translated into applied gains, such as increased crop yields, more nutritious foods, homegrown energy feedstocks, and life-saving medicines. Plant biologists need to be proactive and vocal in bringing this message to various funding agencies as well as to the public at large.

The content of this anniversary issue was thoroughly discussed with many colleagues, and I am extremely grateful for their input and suggestions. Drs. Maarten Chrispeels, Kenneth Keegstra, Hans Kende, Sharon Long, Peter Minorsky, and Chris Somerville deserve particular credit for helping me put this volume together. A project of this size and scope demands a clear image of the big picture and the collaboration of scientists in many diverse fields. We hope that our readers will find that the articles we have selected are representative of this exciting era in plant biology. I would also like to thank the Editorial Board for their exceptional commitment to the science of plant biology and to the Journal. As always, I extend heartfelt thanks to the staff of *Plant Physiology*: Melissa Junior, Lauren Ransome, Kim Davis, Stephanie Butto, and publications director Nancy Winchester. I am also very grateful to Karen Bird and Darryl Pettway who help me here at the Plant Research Laboratory, Michigan State University. The professionalism and enthusiasm of all these people have made this anniversary issue, and indeed every issue, a reality.

Isaac Newton once wrote, "If I have seen further, it is by standing on the shoulders of giants." In the same spirit, I enjoy the honor of being the Editor-in-Chief of the preeminent journal in plant physiology because I, too, stand upon the shoulders of giants. The six previous Editors-in-Chief of *Plant Physiology*, Charles A. Shull (University of Chicago, 1926–1945), Walter F. Loehwing (State University of Iowa, 1945–1953), David A. Goddard (University of Pennsylvania, 1953–1958), Allan H. Brown (University of Minnesota, 1958–1963), Martin Gibbs (Brandeis University, 1963–1991), and Maarten Chrispeels (University of California, 1992–2000), have all been invaluable in giving *Plant Physiology* the stature it enjoys today. Given the revolution in plant biology, however, we must not be complacent. As the new Editor-in-Chief of *Plant Physiology*, I aim to make a good journal even better by increasing the impact of what our Journal publishes. It is my hope that 25 years hence, when the editors of *Plant Physiology* contemplate the 100th anniversary issue, they will thumb through back issues of *Plant Physiology* and marvel at the many truly novel mechanistic and conceptual insights that our Journal will have published since our 75th anniversary.

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