Progress in the Plant Genome Initiative

Editor's Note: In last month's SJ column, we compared the Plant Genome project with the Human Genome project. The most striking fact is that the human genome project was completed in less than 10 years. Another obvious difference with respect to sequencing technology is that plant genomes pose problems because of their size and repetitive content, as well as the number of different species involved. Rather than one genome, several species must be targeted to cover agriculturally important plants. In this month's column, information presented is from a report brief prepared by the National Research Council (NRC) which evaluated the National Plant Genome Initiative (NPGI).

Since human life would be impossible without plants, understanding plants, how they grow and how they produce essential products has never been more important.

Basic plant genome research serves a wide diversity of agricultural and environmental purposes, as well as contributing to basic scientific discovery. For example, by increasing knowledge of how plants cope with extreme environmental stresses, plant genomics research can help scientists more precisely breed or engineer plants that can thrive as climates change. This knowledge is particularly important with respect to how water is used to grow crops. Economically viable production of fuels from plant biomass, in quantities that could contribute to a reversal of the world's dependence on fossil fuels, will require increases in plant productivity and advances in plant biomass-to-fuel conversion.

NRC Assessment of the NPGI

The report concludes that NPGI has been successful overall. The program has contributed to revolutionary breakthroughs in genome sequencing of plants, including Arabidopsis (a small flowering plant related to cabbage and mustard), rice, and soon maize.

Far more than just genomics, the technologies and information developed by NPGI and the Arabidopsis 2010 Project are the primary platforms for basic research in fundamental plant science—including genetics, biochemistry, physiology, developmental biology, evolutionary biology, and population biology. Plant genome scientists have made excellent use of research on model species to explain basic biological principles in more complex species and subsequent application to crop improvement.

Some of the major breakthroughs that have resulted from these programs include: discovery of receptor molecules that bind to nearly all of the major plant hormones; a detailed understanding of how these receptors control subsequent plant developmental programs; knowledge of how exposure to winter-like temperature affects plant systems, knowledge of how to encourage the flowering and fruiting of plants by treating seeds, bulbs, or seedlings to induce a shortening of the vegetative period), and the correct photoperiod (a recurring cycle of light and dark periods) leads to flowering; how the flowers, leaves, and roots are built; and how plant "immune systems" control the different types of pathogen defense. Most of these breakthroughs are being translated to practical applications in crop species.

The first 10 years of NPGI have made a strong start toward understanding the fundamental challenge of how plants work. In order to most effectively translate knowledge from the basic science at the core of NPGI into commercial innovation, additional tools and methods for enhanced transfer from model systems to crop species should be developed.

In addition to advancing basic science, NPGI has contributed to training a large number of students and postdoctoral fellows, which in turn has created a pool of employees for growing enterprises in all bioscience sectors in the United States and abroad.

The case for continuing the program is straightforward: plant genomics provides a foundation for rapid, fundamental, and novel insights into the means by which plants grow and reproduce, produce organs and tissues essential to human nutrition and energy production, how plants adapt to different and often difficult environments, and how they help stabilize ecosystems.

To move forward, the NRC committee recommends steps to significantly broaden NPGI 's mission to include the basic biology of economically relevant traits in model and crop species, deeper investigations into plant diversity and adaptation to various ecological niches, and continued expansion of translation to breeders and farmers. These changes are justified by the knowledge to be gained from comparative genomic analyses within and across species, and by the need to understand how plants function to provide the conditions required for human survival.

Certainly, the need for increased food and fiber is continuously amplified by a burgeoning world population. The national plant genome initiative as with the human genome program, offers insights that can lead to rapid changes in systems not possible with our current knowledge base.

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Correction: Sugar Beet, December 2008 contained a misprint. The correction follows: At the outset of the human genome project in the mid-1980s, there was heated debate over the merits of a project scheduled to take 15 to 20 years and to cost in excess of $3 billion.