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Two major considerations impelled Ronald Phillips [University of Minnesota and Director of the National Research Initiative of the U.S. Department of Agriculture (USDA)], and Michael Freeling (University of California, Berkeley), to organize a recent colloquium, ''Protecting our Food Supply: The Value of Plant Genome Initiatives'' (Stanford, CA, June 2–5). First, the increased wealth of the developing countries has allowed their populations to make major changes to their diet, particularly by increasing the consumption of meats. To support this internal demand, these countries are steadily increasing their purchases of food on the world market, reducing supplies, and causing prices to rise. Some analysts are predicting that this trend, coupled with the loss of arable land worldwide, will lead to world food shortages within the next 30 years.

A second impetus for the colloquium was the large-scale sequencing of crop–plant genes that has been initiated by a number of companies, beginning in 1996 with a collaboration between Pioneer Hi-Bred International, Inc., and Human Genome Sciences, Inc. (HGS) to sequence maize ESTs. As reported at the colloquium, the amount of sequence data generated by the Pioneer/HGS project has already surpassed that from both the *Arabidopsis* and rice EST programs. Sequencing initiatives by other companies were also alluded to at the meeting. Private investment in lieu of public support of these programs only serves to further underscore the potential value of plant genomics to agriculture.

The Stanford colloquium was organized to explore the possibility that plant genomics might help to meet the increasing demand for food and to debate whether public financial support was required to ensure that these technologies were available to the broadest groups of researchers.

Politics Overtakes Science

It was clear from the first minutes of the colloquium that there were two simultaneous agendas. The organizers had intended to focus on the scientific issues involved in the value of crop genomics to agricultural science, and the details of how best to conduct such research, whereas many of the participants were intent on debating the practical matters of funding and organizing a program. The reason for these different emphases was that when the colloquium was conceived, there was no apparent way to fund a new, large federal program, but by the time the meeting took place, Senator Christopher S. Bond (R-MO) had requested both the National Research Council (NRC) of the National Academy of Sciences and the Interagency Working Group (IWG) to make recommendations on the value of and best approach to plant genome initiatives (Fig. 1).

The IWG was formed at Bond's request to make recommendations on the plant genome initiative; it consists of representatives from the USDA, National Science Foundation (NSF), National Institutes of Health, Department of Energy (DOE), Office of Science and Technology Policy, and the Office of Management and Budget. Senator Bond had been persuaded by the U.S. Corn Growers Association that a corn genomics initiative was both urgent and of strategic economic importance.

The value of crop genomics was addressed by several speakers, and two views emerged: one economic and the other humanitarian. The economic view was that much of the increasing value of crops will be provided by genomics, and whoever controls the associated intellectual property rights will benefit greatly. This was underscored by Takuji Sasaki's announcement that his laboratory in Nara, Japan, will receive $100 million next year, and large budgets in the following years, for a 7-year program to sequence the rice genome. Like the Pioneer/HGS maize database and those of other U.S. companies, the rice genomic sequence may not be in the public domain. The announcement of a Japanese initiative to sequence a cereal genome at a cost of ~$500 million was stunning, as the only U.S. investment in plant genomic sequencing is the *Arabidopsis* program, with a NSF/DOE/USDA combined annual budget of $4 million.

Figure 1 Senator Christopher S. Bond (R-MO) headed the effort to earmark funding for plant genome initiatives.

The humanitarian view proposed that crop genomics will also benefit subsistence agriculture in developing countries by making it easier to improve the germ plasm of native crops. This potential, however, would likely be dependent on a public domain genomics program, in contrast to the existing private databases.

Cereal Synteny

The potential synergy of genomics pro-

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grams on different cereal crops was emphasized by Mike Gale (John Innes Center, Norwich, UK), in a presentation that was a highlight of the colloquium. Gale illustrated the genomes of several cereals as concentric rings, with the smallest genome in the center and progressively larger genomes toward the outside. Each ring consisted of a species' chromosome complement, arranged head to tail. The rings are aligned using RFLPs, made possible by the conservation of DNA sequence for some regions and the amazing degree of synteny among cereals. This colinearity of the genomes can be exploited for both understanding and manipulating cereals. Mutations in one species correspond to QTLs for the same trait in another species. Rice has one of the smallest genomes among the cereals and has amassed a considerable collection of genomics technology, such as ESTs, YAC, and BAC libraries. In an example of how cereal synteny can be put to practical use, Gale is collaborating with Takuji Sasaki to isolate the wheat *Ph* gene by using molecular markers in wheat that flank this locus. The *Ph* gene has been identified as an important gene in wheat by its ability to control pairing among homologous chromosomes among the three different wheat subgenomes, and its manipulation may contribute to the introduction of new genes into cereal germ plasm.

Getting Cereal Genomics Programs Under Way

A much more controversial issue concerned the best approach to crop genomics, including how to set priorities for research in this area. Christopher Somerville (Carnegie Institution of Washington), one of the few speakers to address the details of current plant genomics efforts, gave an overview of the *Arabidopsis* program, highlighting what they have learned in their own plant genome efforts and what might be useful to other groups attempting to initiate such programs in species with larger genomes. On the last day, the meeting participants broke into teams to discuss key issues and make recommendations for developing genomics programs, but unfortunately the time allotted was too little to allow a consensus to be reached on this important issue. Nevertheless, those recommendations that were formulated will be a part of the process of the NRC to respond to Senator Bond's request.

The one consensus was that a major effort to produce ESTs from corn and rice should be launched as soon as possible and a genomic sequencing effort on rice should also be given serious consideration. It was clear that a planning team is needed to determine the specific goals and strategies of a cereal or crop genomics effort, reconciling the technical capabilities and available resources with the desired targets.

It was emphasized that cereal genomics should not be conducted at the expense of the *Arabidopsis* genome project. In fact, there was wide agreement that funding for the *Arabidopsis* project should be increased to accelerate its progress. Genomic information on *Arabidopsis* is considered to be an essential complement to genomic data from other plants, including crop species. At the same time, *Arabidopsis* alone is unlikely to provide all the information needed to understand the genomes of cereals or for the practical implementation of genomics to improve cereal performance. The Human Genome Project has proven the value of conducting comparative genomic research on both a model organism(s) and on the target organism *Homo sapiens*. The same type of approach will be required for any plant effort where utilization for crop improvement is the eventual goal.

Funding Secured for Crop–Plant Genomics

Meanwhile, the U.S. Corn Growers Association announced that they are working hard to have $10.8 million earmarked from the Agricultural Research Service budget this fiscal year and $100 million in each of the next several years from the USDA. Research funding agencies abhor earmarking, which forces them to fund unplanned efforts using existing resources. Nevertheless, with pressure to balance the budget, there is little prospect for significant budget increases, and in the end earmarking may be the only way to create a new initiative of significant scope, such as crop genomics.

All of these efforts came to fruition July 15 when Senator Bond won acceptance of a measure to add $40 million to the NSF budget for Plant Genome Initiatives. Bond, who chairs the Senate Veteran's Affairs/Department of Housing and Urban Development/Independent Agencies Committee, secured the funding during the markup procedure. With the funding provided by Bond, the initiative has been expanded beyond corn to include other economically significant crops, such as rice, soybeans, and wheat. The expectation is that responsibility for funding and administering the initiative will ultimately be shared among the IWG agencies. The measure now goes to a House–Senate conference committee where it may be altered. However, with both the White House and Senate behind the measure, it seems likely that there will be a major plant genome initiative launched this fiscal year.