Contributions of Plant Breeding and Genomics Research to U.S. Wheat for Food and Agriculture: Some Research Opportunity and Priorities[1]

The wheat crop is vital to the U.S. food supply and economy. It is a widely grown crop noted for its adaptability to a wide array end-uses and agricultural production conditions. Wheat's genetic diversity is responsible for a rather strong national security of production because production limitations in one area of the US, such as drought, may not occur in other areas, thus annual production stability is a general rule. But this stability ignores the fact that wheat remarkably has been selected for different end-uses corresponding to rather well-defined production zones. Thus, while total wheat production may not vary dramatically from year-to-year, there are local areas where a specific disease or climatic impacts have dramatic economic impacts. A case in point is the Fusarium head blight [scab] disease which has emerged as a severe production limitation in the northern Great Plains, both in grain yield losses and in making the grain unusable for human food uses. This is only one of a score of diseases and pests that cause economic duress at the farm level. Drought, excessive heat and cold, and other climatic or soil-related factors add to local year-to-year instability in yields and quality.

The "genomic revolution" offers new approaches which, if adopted in modern plant breeding programs, can address previously intractable production and end-use problems in wheat. This note presents some of the research and varietal development priorities that have been identified by a group of wheat researchers Priorities in wheat research are similar to those in other commodities, both major and minor. We urge significant additional commitment to research support to public sector research programs.

Genomics and plant breeding research contribute to all of the six thematic areas under discussion, as evident from examples given below. The priorities emphasized in this brief especially relate to the research urgently needed for wide application and adoption of the products from genomic research.

Agricultural and Environmental Quality

- Crop pest resistance to reduce pesticide usage and residues.
- Increased efficiency of mineral uptake and utilization by crop plants to reduce usage and off-site transport as contaminants.
- Disease and pest resistant varieties for use in minimum tillage agriculture.

Agricultural Security:

- Genetic resources collection and conservation, including multisite backup of collections at USDA and other locations, new collections to meet new needs, *in situ* conservation, evaluations of germplasm to locate genes for current and future needs, using genomic tools to assess diversity.

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[1] These notes have been assembled by the members of a National Science Foundation Plant Genome Research Program research project "The Structure and Function of the Expressed Portion of the Wheat Genomes". (NSF DBI-9975989). The priorities are representative of those we expect will be held by the larger wheat research community and a fuller inventory of research can be assembled. The investigators include 13 scientists from eight states, and the project is managed by Principal Investigator C.O. Qualset and Project Manager P.E. McGuire at the University of California Genetic Resources Conservation Program, Davis, CA [coqualset@ucdavis.edu.
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- Preemptive plant breeding to meet potential crop production crises, facilitated by genetic resources and markers.

Genomics and Food and Fiber Production:

- Genome sequencing and mapping of important regions of wheat chromosomes of wheat and its progenitor species.
- Development of molecular markers.
- Discovery and isolation of critical genes from within wheat and from other species.
- Gene transfer methodologies.
- Bioinformatics for efficient data analysis.
- Use of these tools to facilitate gene transfer to varieties of all of the wheat market classes of the U.S., for pest resistance, biotic and abiotic stress tolerance, metabolite transformation and translocation in growing plants, creating superior combinations of grain yield determining factors.

Obesity, Human Nutrition, and Food Science:

- Wheat is a universal food, but not accessible to a sizable number of people who have wheat allergies or gluten intolerance (celiac condition). Genetic modifications to inactivate the causal factors would be great boon to this component of the U.S. population. Correcting wheat and other food plants, such as peanut, for such toxic factors is doable with the aid of genomics. What is more basic than a peanut butter sandwich, denied of people with sensitivity to peanut butter or wheat flour?
- Other examples apply as well.

Food Safety:

- Microbial pathogens and saprophytes grow on plant parts harvested for food, making the food product unsuitable for consumption without special treatments. Genomics can aid in breeding crops resistant to those organisms, providing and 'organic' solution to food safety problems.

Rural and Community Development:

- Support the adoption of greater diversity
  in crops for large impact economic commodities
  the 'smaller' crops for niche markets
  heirloom varieties
  organic crop management systems
  for home gardens
- Losses due to diseases or excessive application of pesticides is a common occurrence in all of these situations. Genetic resistance to diseases has been the traditional means of protecting food crops. Genomics and breeding can be applied to all crops and will aid in transfer of critical genes for pest resistance.