Linking Plant and Animal Traits to the Genes That Shape Them

To improve agricultural productivity worldwide, the Agricultural Research Service is working with other agencies in the U.S. Department of Agriculture, other federal departments, universities, international research organizations, and agricultural industries to make use of newly developed genomic technologies. The ultimate objective is to develop dependable means to link desirable extrinsic, or phenotypic, traits of plants and animals to the heritable genes that intrinsically govern them.

For example, for many decades, USDA has helped farmers keep records of their crops and livestock. These include notations on properties such as udder depth and milk production in dairy cattle and disease resistance and yield in peanuts, potatoes, and many other crops. In the last 10 years, great strides have been made toward understanding the inherent genetic, or genotypic, material that conveys those traits—invisible to us, but expressing itself in observable, describable ways.

Several major cooperative ventures have potential to accelerate the understanding and use of massive amounts of genotypic and phenotypic data now being gathered for both plants and animals. One of these is the National Plant Genomics Initiative (NPGI), which began in 1998. It is a cross-governmental project for plant genomics coordinated by an Interagency Working Group (IWG) comprising multiple federal agencies.

Initial IWG members included representatives from USDA, National Science Foundation (NSF), U.S. Department of Energy (DOE), National Institutes of Health, U.S. Office of Management and Budget, and Office of Science and Technology Policy. Today, the U.S. Agency for International Development and the U.S. Forest Service have also been added, and the IWG operates under the auspices of the National Science and Technology Council.

All the information developed through the NPGI research program is made broadly available to scientists around the globe, whatever their affiliation. Since there is a tremendous push to accelerate breeding of both plants and animals using genotypic and phenotypic information, industry and international cooperation is vital, as well.

ARS's scientific agenda tracks along with NPGI's research goals of connecting basic biological discoveries to applied sciences. Beyond sequencing, ARS is working to unravel functional genomics and systematic biology to solve scientific mysteries that would be impossible without genomic information and tools.

Animal genomics also has an IWG, much like the one developed for the NPGI. ARS leads the IWG for domestic animal genomics that coordinates research projects for this scientific sector. USDA, NSF, DOE, and the Food and Drug Administration are members of this IWG.

Other notable milestones:

• Since ARS had, for many years, maintained a corn, or maize, stock center at the University of Illinois, the agency was able to provide genetic material for NPGI's project. The center has since expanded its operations to accommodate growth of stocks resulting from NPGI activities. Recently, the completion of the corn-genome sequence—funded by USDA, NSF, and DOE—was announced.

• The first genomic sequence of an insect—the red flour beetle, a stored-product pest—has been completed, uploaded, and published by ARS researchers in Manhattan, Kansas.

• In animal genetics, significant strides are being made—particularly in the cattle industry—in predicting animals' ability to transmit desirable traits to progeny. Dairy bulls with the highest predicted transmitting ability are sought for breeding, but today's progeny testing is a laborious and time-consuming task, and evaluation of the data is costly in time and money.

At the Henry A. Wallace Beltsville (Maryland) Agricultural Research Center, ARS scientists have been working with industry to apply current genomic tools to characterize dairy cattle phenotypic traits. SNPs (see Glossary, p. 22) generated by ARS researchers may be better able to predict bulls with the most desirable traits, and these genetic markers are freely available in a library developed with an industrial partner.

• At ARS's Meat Animal Research Center (MARC) in Clay Center, Nebraska, scientists have provided more than 50,000 SNPs to the beef cattle industry. These strides in genomic sequencing of beef cattle have provided data on genes that may also be helpful in perpetuating desirable beef cattle traits. With colleagues at ARS's Animal Improvement Programs Laboratory at Beltsville, MARC scientists have annotated and uploaded SNPs for cattle and swine.

• In 2006 and 2007, some major milestones were reached in animal agricultural research. Annotated draft genome sequences were completed for chickens and cattle, and sequencing was begun for swine and horse genomes.

Today's goal is to use newly developed genomic tools to understand and improve genetic traits such as disease resistance, animal health, feed efficiency, and product quality—features that are difficult to measure with quantitative genetics approaches.

ARS continues to focus on using the newest technologies to help growers and farmers efficiently produce the best, most abundant, and safest agricultural food products for consumers here and abroad, for today and beyond.

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