

Genomics of Food

Tom Zinnen
Biotechnology Policy and Outreach Specialist
The Biotechnology Center
UW-Madison/Extension

Genetics is the study of genes: heritable factors governing the traits of an organism. Genomics is the study of the genome: the collection of all the genes of an organism. For example, humans have about 30,000 genes in their genome. Genetics originally involved the study of one or a few genes at a time. The part of genetics called genomics tries to get a global view of all the genes of an organism.

Comparing Classical Genetics and Genomics

In classical genetics, scientists follow a line of inquiry like that used by Gregor Mendel when he founded genetics in the 19th Century: start by studying a trait, then move on to studying the pattern of inheritance of the trait; classical geneticists can then find the location of the gene on a chromosome, then clone the gene, and sequence its DNA. In genomics, scientists start by sequencing all the DNA of an organism, then they identify all the genes, and map the gene on the chromosome, and then try to determine the trait or functions of all the genes.

Themes of Genomics: Sequence to Find and Map Genes, and then Figure out Their Functions

In crops and as for other organisms, genomics involves these themes:

- Identifying all the genes through DNA sequencing
- Mapping the location of all the genes on all the chromosomes
- Figuring out all the functions of the genes and the genes' products
- Studying when, where and how are genes turned on or off
- Comparing the genomes of different organisms to analyze which genes are present, which are absent, and how are the genes organized, regulated and expressed.

In studies of development—the process of cells growing and differentiating into tissues, organs and organisms—genomics asks, "What genes are expressed when and where during development from a single cell to an adult?" To study adaptation to environment, genomics asks, "What genes are expressed when and where in response to various triggers, such as hormones, environmental changes, and disease?"

Genomics and Food

Genomics can battle disease and help feed the world. All food comes from living things: crops, livestock, microbes. —Food genomics is the genomics of crops, livestock and microbes. — Genomics will give us new insights to how our food grows. —These insights will generate new opportunities for improving how our food grows, tastes, and nourishes us. Genomics will also help us better understand the disease interactions between humans and foodborne pathogens or toxins, and speed development of ways to detect, diagnose, treat, cure or prevent foodborne diseases. For example, researchers first sequenced all 4,288 genes in the harmless lab strain K12 of the E. coli bacterium. Then they sequenced the harmful foodborne O157:H7 strain. They expected to find only about 50 new genes in O157:H7, but they found nearly 1000. Each gene unique to the harmful strain is a potential target for diagnosis of the O157:H7 strain —and for drugs to fight it. Furthermore, knowing the genome of humans will speed our understanding of how humans respond to infection by the bacterium.

What Makes a Good Model Organism of Genomics? —Small, Fast, Simple and Cheap

. Arabidopsis thaliana was the first plant genome to be sequenced. Although it's not a crop plant, Arabidopsis is a great model plant. That's because it's small, it takes only 35 days to grow from seed to flower to seed, it has only 5 chromosomes, and its genome is both compact and "succinct" in that it has very little repetitive DNA. Genomics will help us better know how crops grow. —Tools, strategies and insights from Arabidopsis will make it easier, faster and cheaper to complete the sequence and analysis of the genomes of major crops such as rice, corn, wheat and potatoes.

Functional Genomics: How do you figure out what a gene does?

How do you figure out what 20,000 genes do? —Currently genomic scientists have ways of quickly sequencing DNA and figuring out where genes are in the sequence and mapping the location of the genes relative to other genes on the DNA. —But just because you know the DNA sequence of a gene, does that mean you know its functions? —Unfortunately, it doesn't. —

Next: —Explore the Genomic Mapping Analogy in our handouts section

Examine a campus map where buildings are indexed by name only. You can know the location and name of every building, but you don't yet know what goes on in each building. —Likewise, researchers are currently working to figure out ways to quickly guess and then reliably test the possible functions of the thousands of genes they first detected by sequencing rather than by analyzing the pattern of inheritance of a trait.