

GENOMICS AND ANIMAL AGRICULTURE

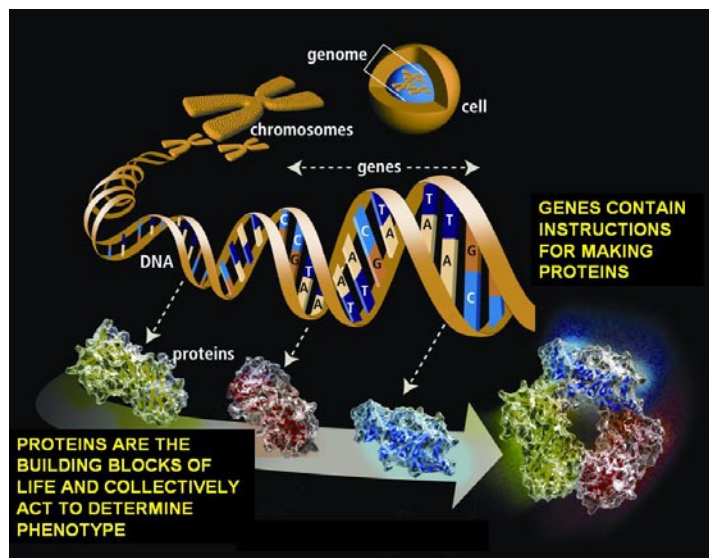
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A lot of people have heard of the human genome project, but not too many people know what it is all about, or how it has had an effect on animal agriculture.

Living organisms are made up of cells, and located inside the nucleus of each cell is DNA (deoxyribonucleic acid). **DNA** is shaped like a double helix and made up of pairs of **nucleotides**. The entire genetic makeup, or **genome**, of an organism is stored in one or more chromosomes inside each cell. A **gene** is a stretch of DNA that specifies all of the amino acids that make up a single protein. Although genes get a lot of attention, it's the proteins that perform most life functions and even make up the majority of cellular structures. Proteins are large, complex molecules made up of smaller subunits called amino acids. Chemical properties that distinguish the 20 different amino acids cause the protein chains to fold up into specific three-dimensional structures that define their particular functions in the cell. There are thousands of proteins in the body (encoded by thousands of genes). You can think of DNA as a set of instructions written in a universal language.



There are thousands of proteins in the body (encoded by thousands of genes). You can think of DNA as a set of instructions written in a universal language. **Genomics** is the study of all of the nucleotide sequences in the chromosomes of an organism.

What is the human genome project?

In 1990, the National Institutes of Health (NIH) and the Department of Energy joined with international partners in a quest to sequence all 3 billion nucleotides in the human genome. This concerted, public effort was the Human Genome Project. A high-quality, "finished" sequence of the human genome was completed in 2003. The human genome contains 3.2 billion nucleotide bases, commonly abbreviated as "A, C, T, and G". The average gene consists of 3000 bases, but sizes vary greatly, with the largest known human gene being dystrophin at 2.4 million bases. The human genome is estimated to contain 20,000-25,000 genes and the order of almost all (99.9%) nucleotide bases is exactly the same in all people. The more closely related two people are, the more similar their genomes. Scientists estimate that the genomes of non-related people—any two people selected at random off the street—differ at about 1 in every 1,200 to 1,500 DNA bases, or "letters." Whether that's a little or a lot of variation depends on your perspective. There are more than three million differences between your genome and anyone else's. On the other hand, we are all 99.9 percent the same, DNA-wise. About 90 percent of human genome variation comes in the form of single nucleotide polymorphisms, or SNPs (pronounced "snips"). As their name implies, these are variations that involve just one nucleotide, or letter. If the genome were a book with 3 billion letters, every person's book would contain the same paragraphs and chapters, arranged in the same order. Each book would tell more or less the same story. One person's book might contain a SNP typo on page 303 that is lacking in the book of another person. For more information see <http://www.genome.gov>.

So what does the human genome project have to do with animal agriculture?

Animal breeders have been remarkably successful at developing a diverse range of breeds. Consider the difference between a Chihuahua and a Great Dane.

Traditional genetic improvement of livestock relied on developing breeding values, or estimates of progeny performance, for animals based on their performance, and that of their relatives. Selection of animals with the best breeding value for production traits has been very effective. Over the past 50 years the selection of animals with the best breeding values has doubled the amount of milk that a dairy cow produces in a year, and halved the amount of feed needed to produce a pound of pork. However, selection has not been as successful for traits that are difficult to measure such as disease resistance, or traits which are not available until late in an animal's life, such as fertility or longevity.

The technology breakthroughs that were developed during the sequencing of the human genome brought DNA sequencing costs down which made it economically feasible to sequence the genomes of other species.



The cow, chicken, and pig genomes have all recently been sequenced and this has led to the discovery of many thousands of naturally-occurring DNA sequence variations between individuals, in the form of SNPs (<http://www.animalgenome.org>). Researchers are now working to determine which variations are associated with desirable characteristics, such as disease resistance. It is thought that using information on variation in DNA sequence between animals will improve the accuracy of breeding values, that is give breeders more confidence they are selecting the best animals. Additionally, because DNA is available from birth, it may be possible to predict the genetic potential of animals at a

very young age, and keep only the very best animals for breeding purposes. This may pave the way for producers to select animals to become parents of the next generation based on breeding values calculated from DNA marker data alone, a process called "whole genome-enabled selection".

Genomic technologies also offer new opportunities to develop management systems to optimize the production environment based on an animal's DNA genotype. For example, the genotype of some beef and dairy cattle may be better suited to grass-based production systems. It may also be possible to select animals that are able to grow to a certain size using less feed, or that are more resistant to certain diseases. The potential of these technologies is safer and more nutritious food produced with less environmental impact and greater animal welfare due to lower levels of disease.