

# Basic Equine Genetics

E.L. Johnson, PhD • University of Florida

The science of genetics has not been utilized as efficiently in horse production as in the production of other livestock species. This has occurred because horses are used primarily for recreation, whereas other livestock species are used primarily to produce food and fiber. Additionally, the more economically important traits of most livestock can be evaluated rather objectively, i.e., size, length and weight can be measured accurately. Horses are primarily selected for conformation, athletic ability, intelligence and other traits that are very difficult to measure. However, selection for genetically controlled traits can be used effectively in horse production.

To utilize genetics adequately and purposefully in horse production, the producer must have a basic understanding of genetics. In each horse there is a certain portion of characteristics that are due to genetics and a certain portion that are due to environment (feed, training, etc.) The genetic influence is that portion of characteristics or traits that is passed from parent to offspring. Traits are determined by this genetic material that is passed from immediate sire and dam to the individual.

Each body cell contains a complete copy of the genetic material in its nucleus (Figure 1). This genetic material is contained in chromosomes, which are long, slender, thread-like structures that are paired. These pairs are not exact duplicates, because one of each pair is received from the sire and one from the dam. The basic unit of inheritance is the gene. Genes are located on chromosomes and each individual horse has 32 pairs of chromosomes. When the stallion produces sperm or the mare produces an egg, the reproductive cells split and provide a cell that has only one strand of each pair of the chromosomes in each cell as demonstrated in Figure 2. At mating, the egg and sperm come together to produce a single cell that has a complete set of 34 pairs of chromosomes as shown in Figure 3. Therefore, each parent contributes one half of the genetic makeup of an individual.

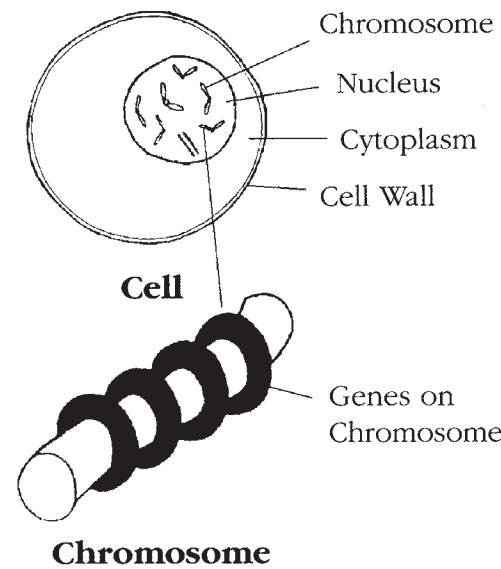


Figure 1 — Source: 4-H, BGMU-4

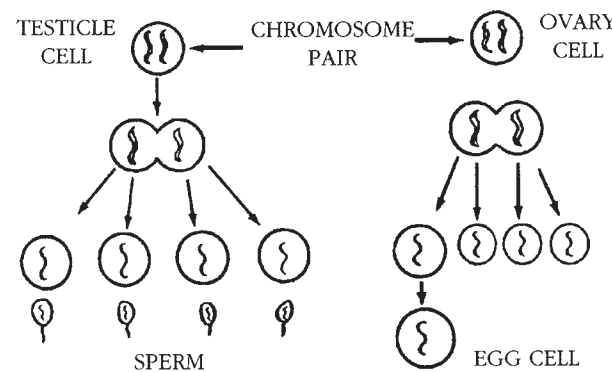


Figure 2 — Source: 4-H 195

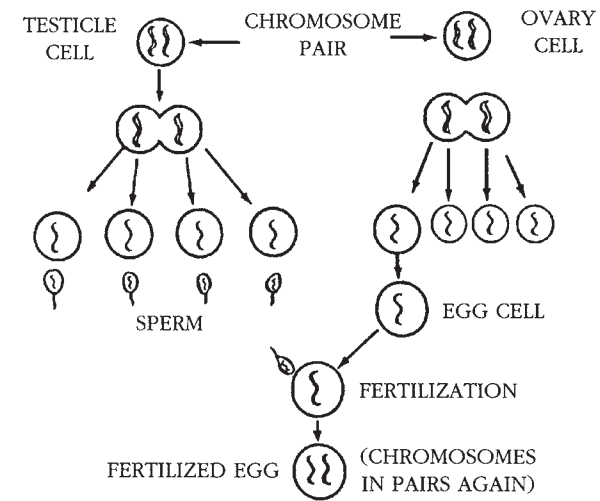


Figure 3 — Source: 4-H 195

Genes are located at various locations (loci) along the chromosomes. Genes control the expression of traits and correspond to chemical structures (messengers) that determine individual traits. As chromosomes are paired, so too are genes. The paired genes (alleles) may or may not be identical. Genes that are located at the same physical position (locus) on a chromosome are called alleles. They may or may not be identical. If the paired genes are identical, then the individual is considered to be homozygous or the same for that pair. If they are not identical, the individual is considered to be heterozygous or different for that pair. Individuals that are homozygous for a particular gene have only one allele to pass on to their offspring, whereas heterozygous individuals can pass on either of the two different alleles possessed in their genetic makeup (Figure 4).

Trait	Average Heritability Estimate
Height at withers	45-50
Body weight	25-30
Body length	35-40
Heart girth circumference	20-25
Canon bone circumference	20-25
Pulling power	20-30
Running speed	35-40
Walking speed	40-45
Trotting speed	35-45
Movement	40-50
Temperament	25-30
Cow Sense	Moderate to high
Type and conformation	Moderate
Reproductive traits	Low
Intelligence	Moderate to high

Table 1. — Heritability Estimates for Certain Traits in Horses

Homozygous		Heterozygous
AA	parent	Aa
A A	gametes	A a

Figure 4

There are two basic types of genetic action: qualitative and quantitative. In qualitative gene action, a trait such as speed is influenced by a number of genes that all have some influence on the trait.

In traits affected by qualitative gene action, there are three primary types of gene action that affect the trait. The types of gene action are dominance, codominance and partial dominance. Dominance is defined as the ability of the gene to mask or cover up its recessive allele. Only one dominant gene is required to display a particular trait, whereas two recessive genes are required for a recessive trait to be exhibited. An example is Combined Immune Deficiency (CID), in which it takes two recessive genes for the trait to be exhibited. Figure 5 shows that if an animal possesses one dominant gene (shown by uppercase letters), it will appear normal but is a carrier of the recessive gene. The phenotype (or appearance) of a heterozygous CID/cid individual is normal. The result of mating a heterozygous individual with a homozygous normal (dominant) individual would be the production of individuals that would appear normal, although half would be carriers and half would be homozygous normal. It would not be possible, however, to know the genotype (genetic makeup) of a particular foal from such a mating.

Codominance in gene action results in an intermediate state between the two parents. An example of codominance is blood type (Figure 6). Each blood type is different and known and thus indicates the genotype. Partial dominance also results in an intermediate state but not necessarily an exact intermediate state.

CID/CID = Normal Phenotype and Genotype		
CID/cid = Normal Phenotype, Carrier Genotype		
	CID	CID
CID	CID/CID	CID/CID
cid	CID/cid	CID/cid
offspring = 2CID/CID	}	100% Normal Phenotype
2CID/cid		50% Normal Genotype
		50% Carrier Genotype

Figure 5. — Mating of Homozygous Normal with Heterozygous Carrier

Genotype	Blood Type
P <sup>a</sup> P-	A
P <sup>b</sup> P-	B
P P	O
P <sup>a</sup> P <sup>b</sup>	A/B - co-dominant

a,b, - are alleles of the "P" blood group system

**Figure 6. — Examples of Codominance using the Blood Antigen Locus "P"**

Most traits in horses are influenced by quantitative gene action. That is, many genes have an effect on the same trait. The effects of many of these genes are added together to produce the trait in the horse. Therefore, each gene has only a small effect on the trait. An example of this is racing speed. Racing speed is affected by such factors as size; length of leg; coordination; efficiency of the heart, lungs, and muscles; and other mental traits that affect the desire and determination of the horse. These traits are affected by many genes that combine to influence the racing speed of the horse. Heredity (the genetic component) is only one of two major factors that affect the horse. The other factor that has a great deal of influence is environment. Things such as nutrition and training are part of the environmental effects that exert influence on the amount of a horse's genetic potential that is expressed. Some traits or characteristics are primarily affected by the environment (such as reproductive ability), whereas others are affected primarily by genetics (such as coat color) and still others by both (such as mature size, longevity, racing speed).

All traits have a heritability estimate. The heritability estimate is essentially the percentage of a horse's expressed trait that is due to genetics. The percentage that is due to genetics indicates the probability of that being passed from one generation to the next. Specifically, the heritability

estimate of a trait refers to the ability to select horses to mate based on superior performance of the trait and to predict the improvement in the offspring. Some traits are highly heritable and others are low. In any selection process, greater progress can be made when keeping the number of traits selected to a minimum. If a horse is selected for only one trait, then greater selection pressure (horses more outstanding for that trait) can be applied on that trait. Selecting for traits that are highly heritable also greatly increases the chance for improvement. For the traits that have a low heritability estimate, much greater success can be achieved by controlling the environment and management regimes.

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#### Reviewers

- Clinton G. Depew, PhD • Louisiana State University  
T. A. Olson, PhD • University of Florida
- Section Chief • Clinton G. Depew, PhD • Louisiana State University