Heritability 101: The Functionality of Heritability

Breeding animals is a very complex feat that isn't for the faint of heart. Yes, there are puppies being born in every backyard it seems without any understanding or ultimate goal except for the almighty dollar. Let's do our due diligence and gain a bit more basic knowledge about genetics as a whole and how it applies to our breed.

A litter is a result of all the genes from both paternal side and maternal side recombined to form the genetics of each puppy in the litter. Each puppy in the litter has its own genetic identity from the same parents. Genes that are found in the nucleus of every cell are recombination from **both** parents. The DNA that is only from the maternal side is found in the mitochondria in every cell signified as mDNA. In the midpiece of the sperm is the mitochondrion (the energy producer of the sperm). In the process of fertilization, the head of the sperm is only part that enters the ovum (egg). The head of the sperm in the nucleus containing the dog's contribution to the pups genetics (50%) (Figure1). Since bitches are multi-ovulators, semen from more than one dog can be used to fertilize eggs (dual sired mating). So, following a dual sired breeding, we have to genetically test for the sire of each pup in the litter. And, the only source of mitochondrial DNA (mDNA) (Figure 2). We will leave the mitochondrial DNA information for another time.

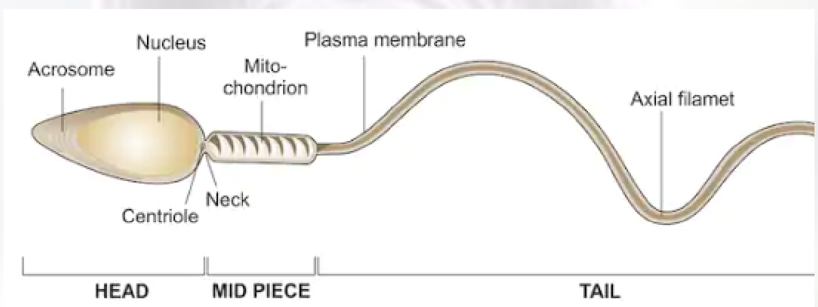


Figure 1

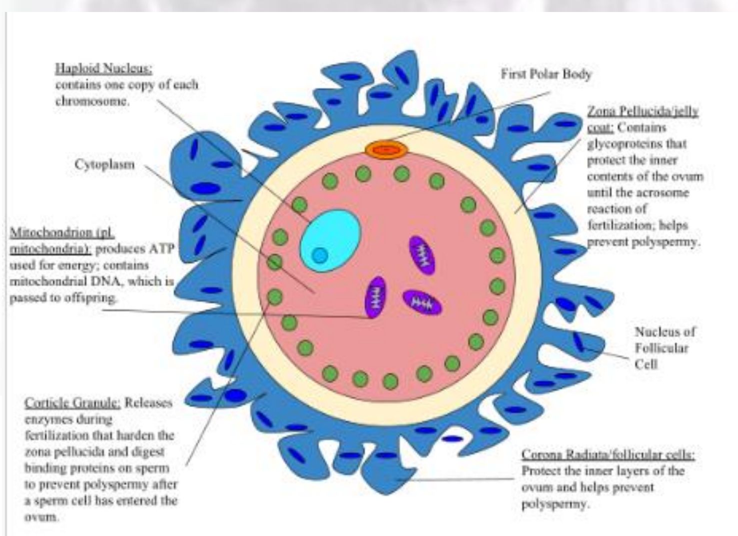
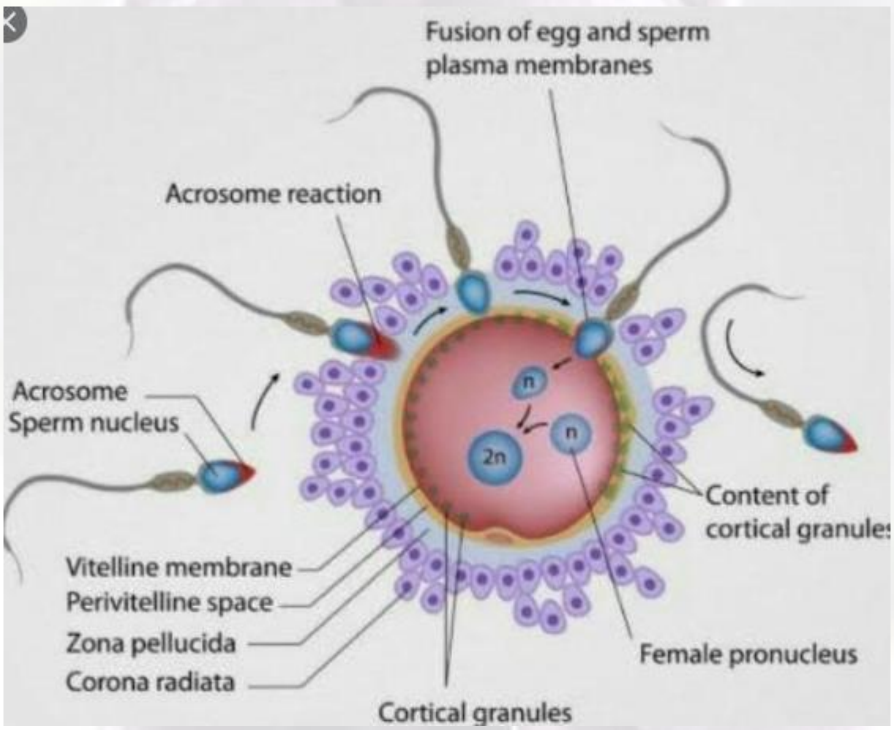


Figure 2

Fertilization, however, needs a bit of basic information. The ovum is the source of the maternal contribution of the pups genetics (50%). A bitch is a multi-ovulater or sheds multiple eggs each estrus period which makes her a litter-bearer. A general guideline for total sperm number in an ejaculate is 10 million sperm cells per pound of body weight. A dog the size of a corso at 130 pounds will produce an average of 1.300 billion sperm cells per ejaculate. It is a misnomer that “it only takes 1 sperm to fertilize an egg” because it takes many sperm to breakdown the zona pellucida for the “1” sperm to actually enter the cytoplasm of the egg (ovum). Once the head sperm penetrates the ovum, the midsection and the tail of the sperm fall off and are reabsorbed (Figure 3). So, where do the genes recombine? When the head of the sperm (which is actually the male pronucleus containing the genes of the male) joins with the ovum pronucleus (which contains the genes of the female) half the embryo genetics from the sperm -n- (haploid) and half the genetics from the egg -n- (haploid) make a whole -2n- (diploid) zygote (fertilized egg that develops into the embryo).

Figure 3



Each breeding that results in at least 1 viable offspring has the potential to contribute to the Cane Corso gene pool. We must do our part to ensure the survival of our breed. An understanding of the genetics of our dogs and the genetics of the male or female that we want to use in a breeding is the responsibility of each breeder of corsos. In the horse business there is a saying, if you want to make a million dollars in the purebred horse business, start with 2 million. Another saying is, “Breed the best to the best and hope for the best” – not just the corso closest to us. Same principle applies in the world of purebred dogs…. It is the goal of this article to give us a glimpse in the complexity of the genetic expression of the Cane Corso..

Did you know that Genetic Expression or **PHENOTYPE** has 2 components? The first is **GENOTYPE** or alleles that are inherited from the parents and the second is **ENVIRONMENT**. Let's look at this a bite at a time.

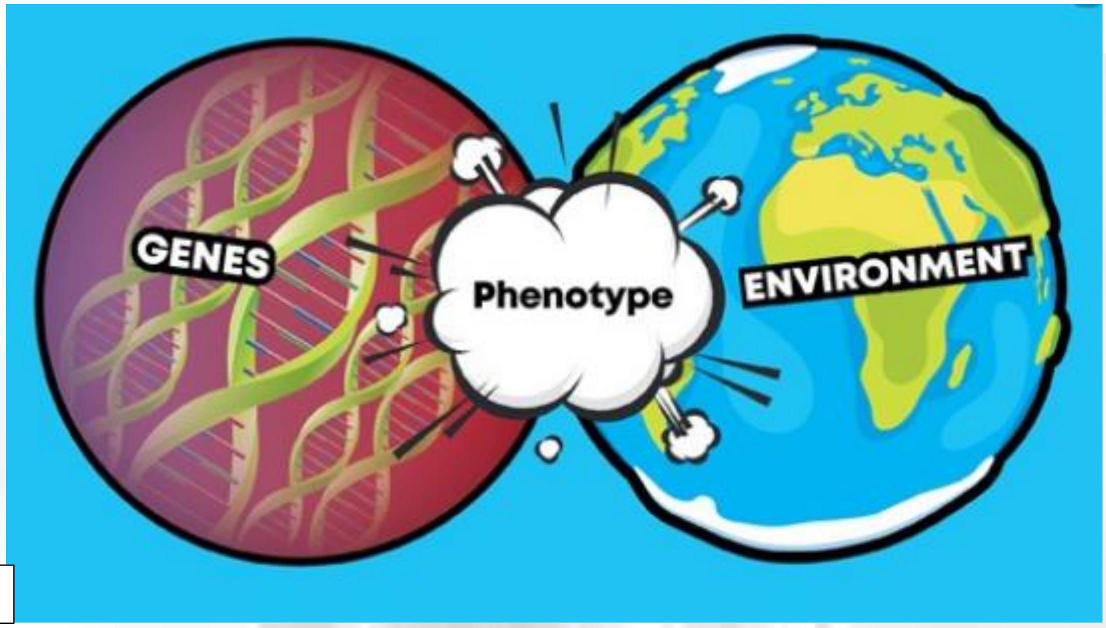


Figure 4

Inheritance vs Heritability.

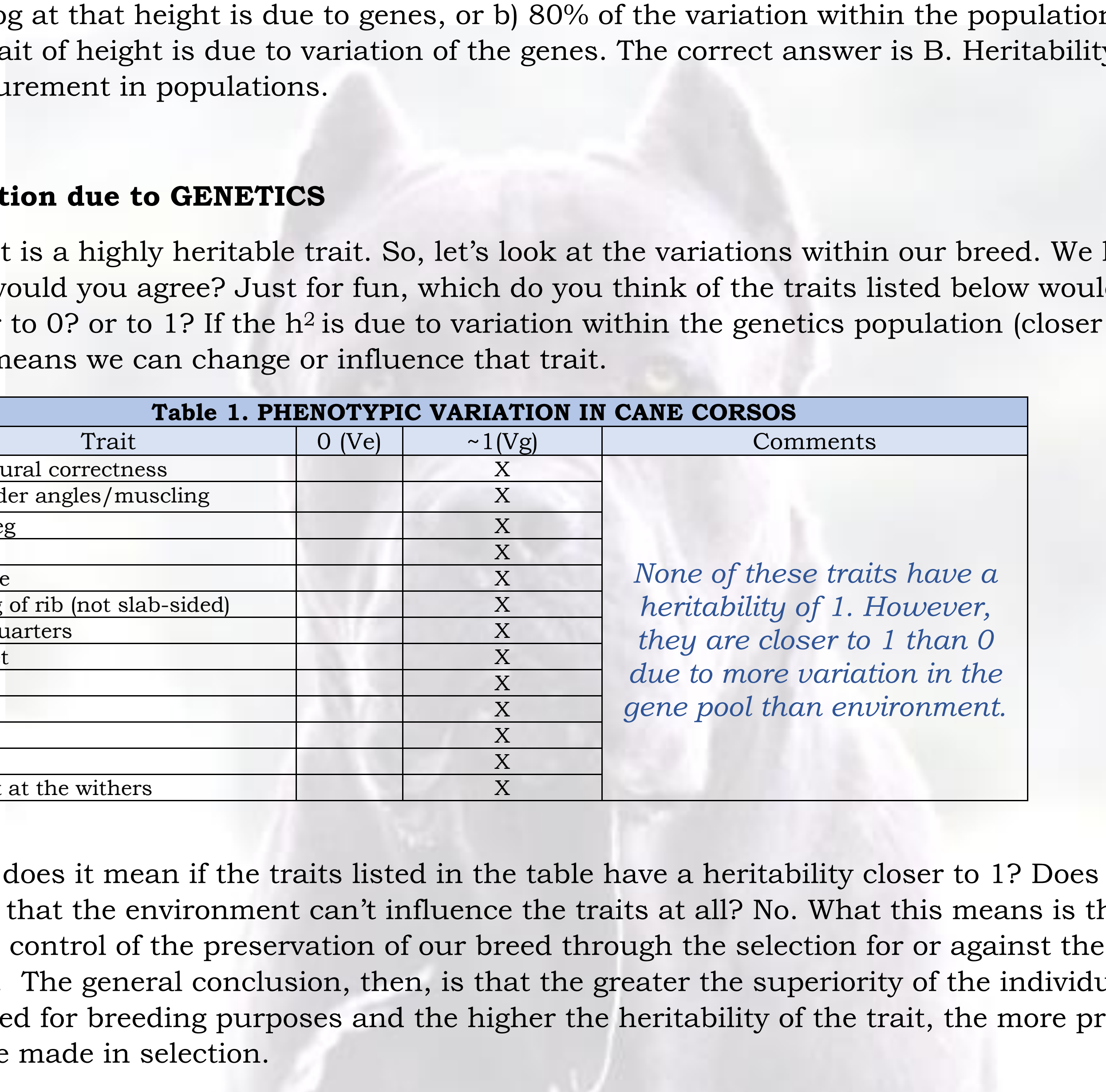
Inheritance describes how traits are passed from one generation to the next like coat color. If a Corso gets a *d* (dilution allele) from each of the parents, the pup will more than likely be a "blue" or "formentina" because *dd* tells the pups hair to be a dilution.

Heritability, on the other hand, is the amount of trait variation that is determined by genetics in a population. Heritability can be mathematically calculated for populational studies (represented as h^2). Heritability is represented between 0 and 1. It is a way to measure how much the differences in a dog's DNA can explain the differences in their traits. It is important to note that an estimate of the heritability of a trait is specific to one population in one environment, and it can change over time as circumstances change.

$$Vp = Vg + Ve$$

[Vp = total variance; Vg = variation in genetics; Ve = variation in environment]

A heritability close to zero indicates that almost all of the variability in a trait among dogs is due to environmental factors and can't be changed genetically. A heritability close to one indicates that almost all of the variability in a trait comes from genetic differences that can be selected for or against. For example, what do you expect the heritability to be for a dog to be born with 4 legs, 0 or 1? What is the level of variability (h^2) in this example? The answer is closer to 0. Let's look at another example, if we measure heritability of a dog's height at the wither is 0.80 or 80%, what does that mean exactly? a) 80% of the variation the dog at that height is due to genes, or b) 80% of the variation within the population on the trait of height is due to variation of the genes. The correct answer is B. Heritability is a measurement in populations.



Variation due to GENETICS

Height is a highly heritable trait. So, let's look at the variations within our breed. We have a few, would you agree? Just for fun, which do you think of the traits listed below would be closer to 0? or to 1? If the h^2 is due to variation within the genetics population (closer to 1), that means we can change or influence that trait.

Table 1. PHENOTYPIC VARIATION IN CANE CORSOS			
Trait	0 (Ve)	~1(Vg)	Comments
Structural correctness		X	*None of these traits have a heritability of 1. However, they are closer to 1 than 0 due to more variation in the gene pool than environment.*
Shoulder angles/muscling		X	
Fore leg		X	
Feet		X	
Topline		X	
Spring of rib (not slab-sided)		X	
Hindquarters		X	
Tail set		X	
Hocks		X	
Skin		X	
Head		X	
Bite		X	
Height at the withers		X	

What does it mean if the traits listed in the table have a heritability closer to 1? Does it mean that the environment can't influence the traits at all? No. What this means is that we are in control of the preservation of our breed through the selection for or against these traits. The general conclusion, then, is that the greater the superiority of the individuals selected for breeding purposes and the higher the heritability of the trait, the more progress will be made in selection.

Variation due to ENVIRONMENT

The second contribution of Phenotypic Variation is **Ve** or Variation of expression from the environment. In terms of heritability (h^2) it is calculated near 0. In specific terms, this variation is known as Phenotypic Plasticity. In 2014, P. Bateson published, "An important contributor to the differences between individuals derives from their plasticity. Such plasticity is widespread in organisms from the simple to the most complex. *Adaptability* *plasticity* enables the organism to cope with a novel challenge not previously encountered by its ancestors. *Conditional plasticity* appears to have evolved from repeated challenges from the environment so that the organism responds in a particular manner to the environment in which it finds itself. The resulting phenotypic variation can be triggered during development in a variety of ways, some mediated through the parent's phenotype. Sometimes the organism copes in suboptimal conditions trading off reproductive success against survival. Whatever the adaptedness of the phenotype, each of the many types of plasticity demonstrates how a given genotype will express itself differently in different environmental conditions—a field of biology referred to as the study of *epigenetics*."

Phenotypic plasticity, the capacity of a single genotype to exhibit variable phenotypes in different environments and is often highly adaptive. Understanding plasticity requires knowing the environment, physiological mechanisms, and fitness outcomes. Fitness refers to an individual's ability to pass on its genetics. All plasticity is physiological, but can manifest as changes in biochemistry, physiology, morphology, behavior, or life history. Phenotypic plasticity can be passive, anticipatory, instantaneous, delayed, continuous, discrete, permanent, reversible, beneficial, harmful, adaptive or non-adaptive, and generational. Virtually any abiotic or biotic factor can serve to induce plasticity, and resulting changes vary from harmful susceptibilities to highly integrated and adaptive alternative phenotypes.

Dogs have extremely high phenotypic plasticity compared to other mammals, leading to huge differences in size, behavior, body shape, and disease susceptibility between breeds. This diversity makes them ideal subjects for research surrounding the genetic bases of various skeletal and muscular conditions.

What do all of the variations of environment (phenotypic plasticity) have to do with our Corsos? Let's list a few with their heritabilies.

- Skeletal Growth and Development 0.2-0.4
- Muscular Growth and Development 0.3-0.35
- Reproductive success 0.05-0.17

For each one these environmental variations, a book can be written with contributions from every breeder. What could be the number 1 variable that could influence each of these phenotypes? Nutrition. Whether you are a "I feed only RAW" to "I feed only KIBBLE" with many iterations in between, the challenge is to know what your Corso's nutritional needs are at different stages of its life. Also, please understand that every Corso may not be fed exactly the same way at the same time in their lives. Just like us, some Corsos are "easy keepers" and some have a higher metabolism or "hard keepers". Each Corso has a genetic predisposition to be a certain size, but it is up to the owners to provide nutrition to reach the Corsos' potential. Not only does nutrition play a role in Corso growth, but also meeting the needs of a reproductively sound Corso. Reproductive efficiency or fitness is the final output of reaching maturity of the individuals selected to preserve our breed. If the corso doesn't have a minimum body fat percentage, reproductive hormones that are derived from cholesterol will not be produced at top efficiency. The three primary hormones that control the reproductive system are Estrogen, Progesterone, and Testosterone. These are derived from cholesterol just as in humans.

Around every turn there is a challenge for every owner of our breed. Genetic Testing is valuable resource and learning about any genetic disorders within each dog. The more we know about our individual dogs, the more genetically sound our dogs will become. We must make the best choices for our breed. We must strive to be preservation breeders. We must be open minded and work together for the betterment of our breed. The takeaway message from this article is to realize the vast differences within our breed stem from the outside influences used to re-establish the Corso. We fail this breed more than this breed fails us. While the variation in environment will have a marked influence and at times moreso than genetics, we as breeders and owners determine where the breed will go. We are in control of the soundness of our breed and must make openminded decisions based on actual science and not opinion.