BASIC GENETICS

UNDERSTANDING, SELECTING, PRESERVING

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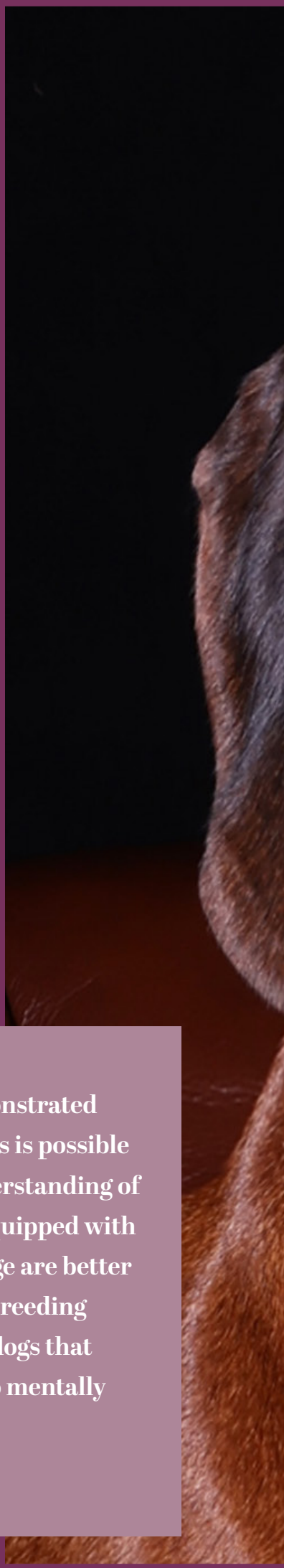


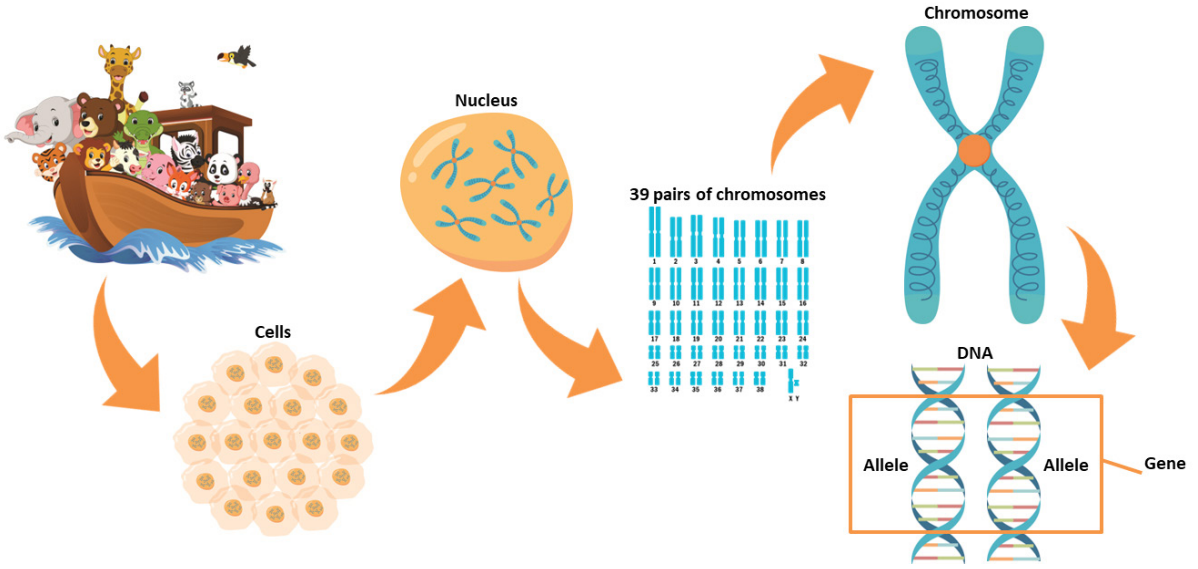
“History has repeatedly demonstrated that breeding high-quality dogs is possible without a comprehensive understanding of genetics. However, breeders equipped with fundamental genetic knowledge are better positioned to make informed breeding decisions aimed at producing dogs that are not only physically but also mentally healthy.”

Living organisms, including humans and dogs, are comprised of cells - the smallest biological units that constitute all life on Earth. These cells serve as the fundamental building blocks of the body or organism, and they are specialized to perform specific tasks, with several hundred different cell types existing. Collectively, these cells form tissues, organs, and other essential components. Each cell contains, among other components, a cell nucleus housing our DNA - the genetic material, or, in other words, our genome.

DNA is densely packed within chromosomes. A dog possesses 78 chromosomes, occurring in two versions, one inherited from each parent, resulting in 39 pairs. There are 38 pairs of regular chromosomes, known as autosomes, and two sex chromosomes, namely X and Y. Females have two X chromosomes, while males have one X and one Y chromosome.

Each chromosome comprises a DNA molecule, equating to two molecules for each pair. The DNA molecule houses genes, which, in turn, regulate protein production. Proteins play a pivotal role in determining the various characteristics of the body, encompassing both physical appearance and behavioural traits.

A gene represents a delimited region on the chromosome with a specific function. Dogs possess around 19,000 genes, and each gene can manifest in numerous variants. A locus, or loci in the plural, designates a gene's precise position (address) on a specific chromosome. Since individuals typically possess two copies of each chromosome, this implies having two variants of each gene - one inherited from the mother and the other from the father. These gene variants are referred to as ***alleles***. Two alleles at the same locus collectively form a ***genotype***.

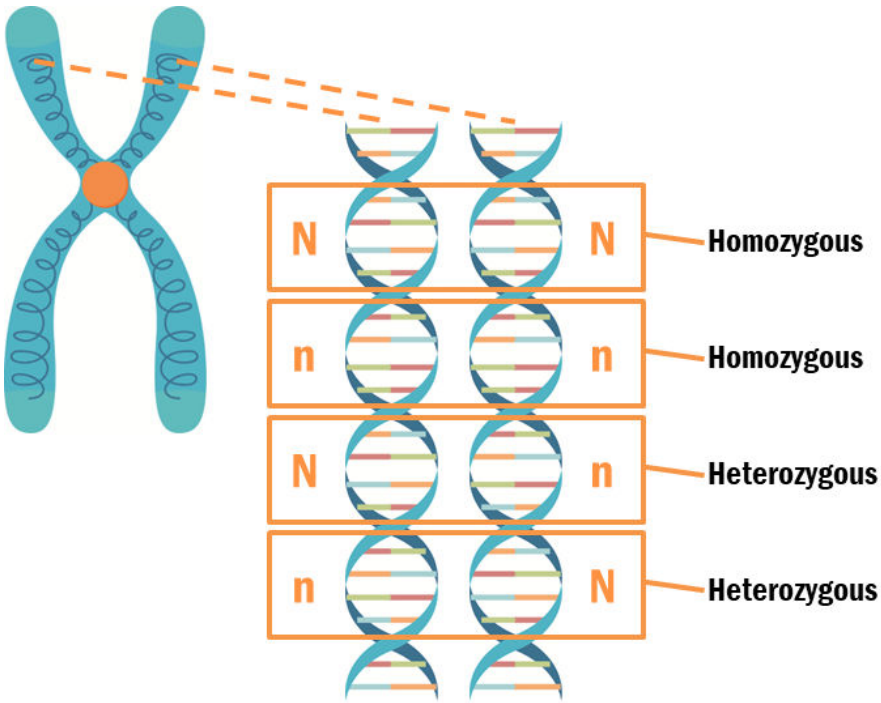


DOMINANT AND RECESSIVE GENE VARIANTS

Certain gene variants exert more significant influence than others, taking precedence and being the ones expressed. By "expressed," we refer to what can be seen or observed, precisely termed as *phenotype*. Gene variants that exhibit dominance are termed *dominant* and are represented by uppercase letters (e.g., N). In contrast, gene variants that defer to the dominant ones are termed *recessive* and are represented by lowercase letters (e.g., n).

For a recessive allele to be expressed, i.e., become noticeable, the genotype must consist of two identical alleles. Even if a recessive allele is not expressed, overshadowed by a dominant one, the individual still carries the allele, which its offspring can inherit.

Whether a gene variant is dominant or recessive provides no information about whether the characteristic (phenotype) the gene variant encodes for is positive or negative. It only indicates whether a single set of gene variants is sufficient for the characteristic to be expressed - a dominant trait - or if the gene variant requires a double set - a recessive trait. When two identical gene variants form the genotype, it is called *homozygous*, and when two different gene variants form the genotype, it is termed *heterozygous*.



MUTATIONS

The millions of cells that constitute both humans and dogs continually undergo division, replacing old cells with new ones. Two identical copies of the dividing cell are created during each cell division. Prior to cell division, the genetic material is replicated to ensure a complete set of genetic information in each cell. However, the replication process sometimes does not function as intended, resulting in mutations. If a mutation occurs, for example, in a germ cell - such as a sperm or egg cell - the alteration can be passed on to the dog's offspring. Some mutations that occur are entirely benign; in exceptional cases, they may even be advantageous. However, other mutations can have a negative impact on the individual's health and, in the worst case, be fatal.

Since each gene variant exists in (at least) two copies - one from the mother and one from the father - there is often a non-mutated "backup copy." In many cases, the non-mutated copy can compensate for the function of the gene variant that is not functioning as intended.

The vast diversity in the appearance of today's dog breeds arises from our initial selective breeding of individuals with different mutations, often linked to the dogs' physical characteristics. These mutations have since been stabilized in the various breed populations, meaning the individuals within a breed population have become genetically homozygous (similar) for these mutations.

INHERITANCE OF TRAITS FROM PARENT TO OFFSPRING

How a trait is inherited from parent to offspring depends on several factors, including:

Number of Involved Genes and External Factors:

- **Simple inheritance:** The trait is controlled by a single gene or a few genes.
- **Polygenic inheritance:** The trait is controlled by multiple interacting genes.
- **Multifactorial inheritance**: The trait is influenced by multiple genes interacting with external environmental factors (e.g., lifestyle).

Location of Controlling Genes:

- **Autosomal inheritance:** Genes on autosomal chromosomes, excluding the sex chromosomes.
- **Sex-linked inheritance:** Genes on sex chromosomes, i.e., X or Y.
- **Mitochondrial inheritance:** The trait is encoded in DNA situated outside the cell nucleus in structures called mitochondria, known as mtDNA. This type of DNA is passed on to the next generation through egg cells; therefore, only the mother contributes mtDNA to her offspring.

Strength of Gene Variants:

- **Recessive inheritance:** The trait is determined by a recessive gene variant (allele) and is expressed only if the individual inherits the same gene variant from both parents.
- **Dominant inheritance:** The trait is regulated by a dominant gene variant (allele) and is expressed if the individual inherits the gene variant from either parent.

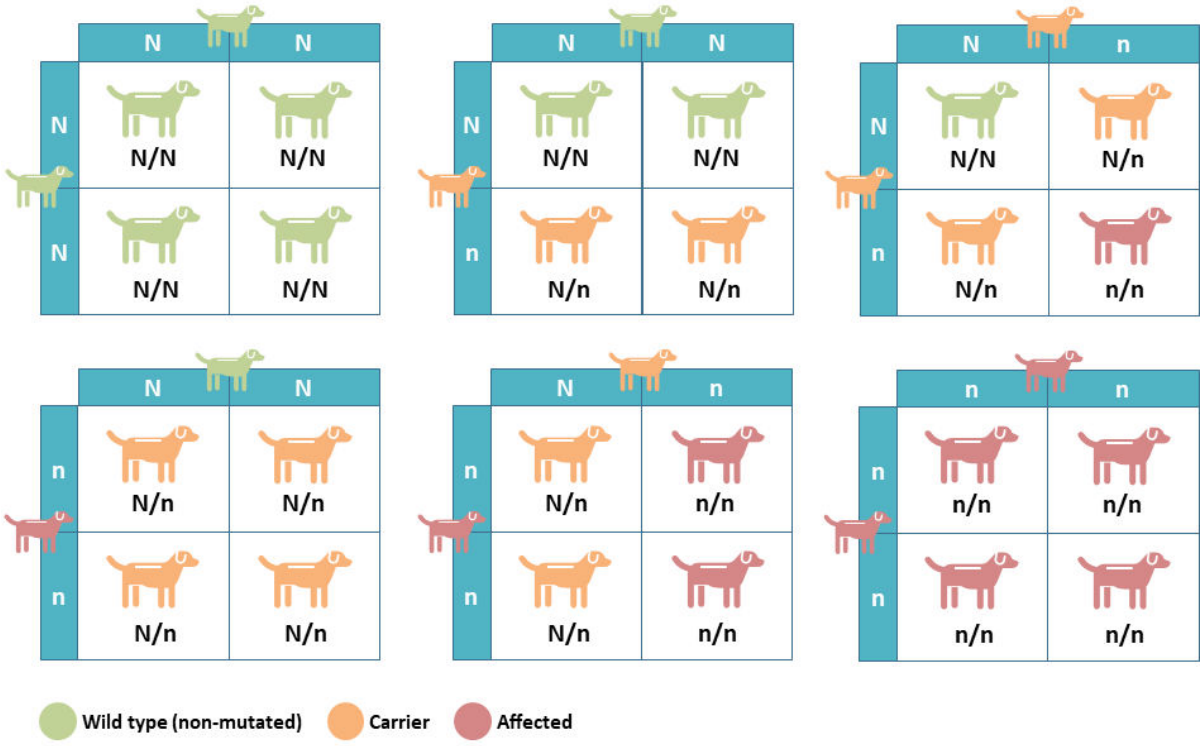
Therefore, the inheritance of an individual trait (health, behaviour, appearance) from parent to offspring is determined by a combination of the above-mentioned factors. To further complicate matters, there are also nearby genes whose gene variants are "linked," known as ***haplotypes***, which are always inherited together.

DISEASES IN RHODESIAN RIDGEBACKS

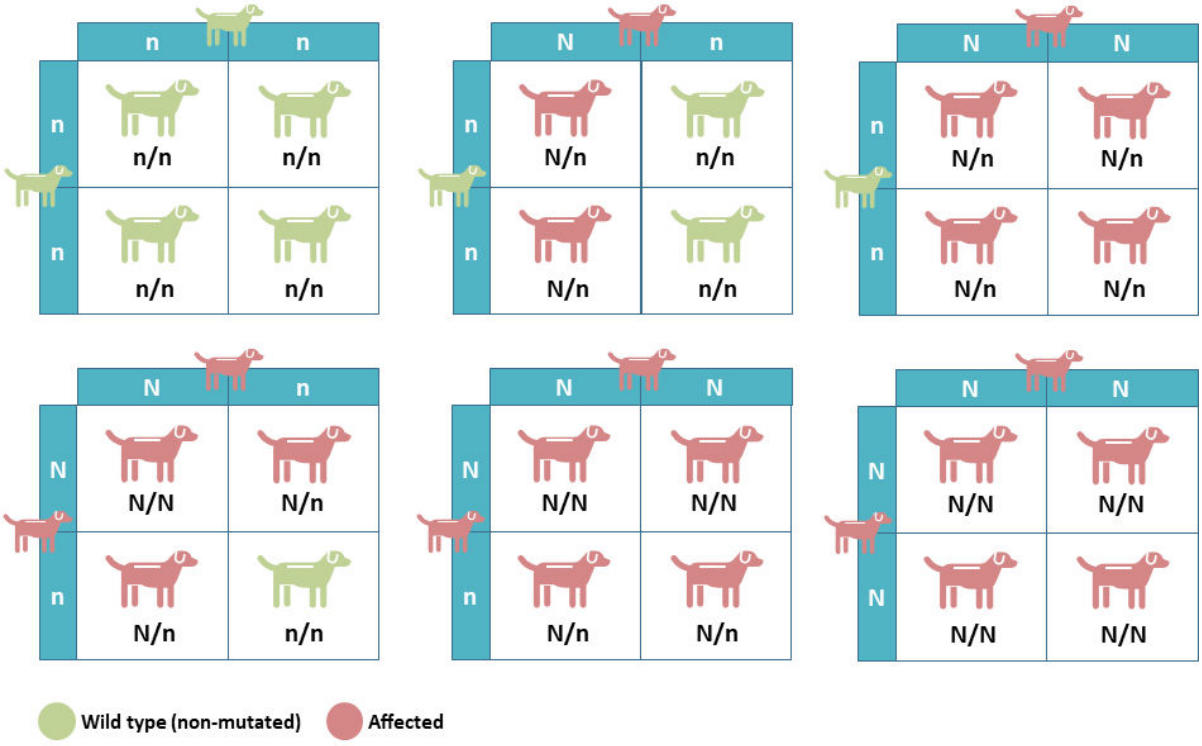
In dogs, diseases with simple dominant inheritance are rare, simply because a dog carrying the "faulty" gene variant becomes ill and consequently is excluded from breeding. On the other hand, recessive traits can be inherited unnoticed over several generations, as dogs often possess a "healthy" gene variant alongside the "faulty" gene variant, keeping them in good health. The expression of the trait and the onset of illness occur only when a dog acquires two faulty gene variants, posing an increased risk in cases of inbreeding.

For the Rhodesian Ridgeback, there are currently a few diseases that can be genetically tested, and they are inherited in one of the following ways:

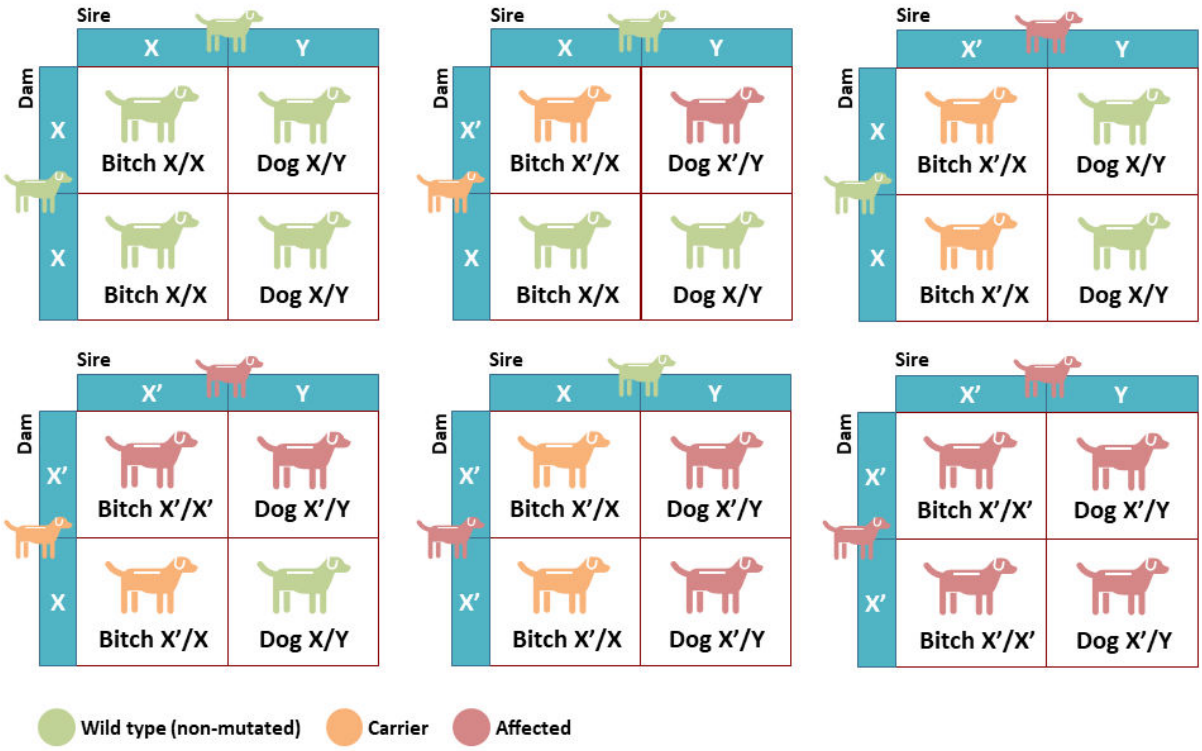
- **Autosomal (non-sex-linked) Simple Recessive Inheritance:**
  The trait is inherited on autosomal chromosomes and requires the gene variant in a double set, i.e., one from each parent, to be expressed. Examples of traits with autosomal recessive inheritance include JME, EOAD, DM, Dilute (D-locus), and liver colour (B-locus).



- **Autosomal (non-sex-linked) Simple Dominant Inheritance**
  The trait is inherited on the autosomal chromosomes but requires the gene variant in a single set, i.e., from one parent, to be expressed. Examples of traits with autosomal dominant inheritance include the ridge.



- **Sex-Linked (X-Linked) Simple Recessive Inheritance**
  The trait is inherited on the sex chromosomes, usually the X-chromosome, and requires the gene variant in a double set to be expressed. A male dog with a mutated copy of the gene variant (X') becomes ill because males have only one X chromosome (and one Y chromosome), inheriting the trait from their mother. A female dog, having two X chromosomes, can be a healthy carrier of the trait but may pass it on to her offspring. Male puppies inheriting the mutated trait will then become ill. Examples of traits with X-linked recessive inheritance include Hemophilia B.



When correctly applied, genetic tests open a world of possibilities for breeding combinations that breeders might otherwise steer clear of due to familial clinical concerns. However, the misuse of genetic tests can cast a shadow over the essence of breed preservation.

Most diseases and defects impacting our dogs exhibit a polygenic or multifactorial inheritance, indicating their development relies on the interaction of multiple genes and occasional influences from different environmental factors. Examples of these conditions include allergies, idiopathic epilepsy, hypothyroidism, RR IVA, SLO (Symmetrical Lupoid Onychodystrophy), osteochondrosis, specific types of cancer, and more. What unites these conditions is the mystery surrounding their mode of inheritance, requiring management in breeding practices through methods separate from genetic testing.

Each Rhodesian Ridgeback carries several gene variants linked to potential health issues. Yet, these genetic footprints often remain concealed in the vigour of a healthy dog. Therefore, excluding healthy heterozygous carriers of diseases we can test for from breeding may prove to be a flawed strategy. Beneath the surface of carriers lie beneficial gene variants. For example, the same Rhodesian Ridgeback that carries the JME gene variant might also carry beneficial regulatory genes for other conditions, protecting its offspring from being affected by that condition.

Hence, genetic tests must be embraced as the breeding tool they are designed to be - ensuring the careful orchestration of breeding pairs. The focus should be on avoiding the combination of carriers and producing offspring vulnerable to specific diseases. Conditions with unknown inheritance patterns must be managed by ensuring great genetic diversity in the breed and maintaining an open dialogue between breeders and stud dog owners, steering clear of the inadvertent doubling of latent disease traits in our breeding combinations.