8. Gene linkage

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Genetic linkage also known as genetic inheritance refers to the transmission of traits from one generation to another through genes.

Gene – basic unit of heredity

Almost all genetic information is located in the chromosomes, located in the nucleus of the cell. The set of all chromosomes in the somatic cells of a given organism constitutes its karyotype. Each plant and animal species has a fixed and characteristic number of chromosomes. The normal pig karyotype shown in the picture contains 38 chromosomes.

Karyotype = autosomes + sex chromosomes

Among all the chromosomes of a given species in the karyotype, two are responsible for the sex of the animal and we call them sex chromosomes. The sex chromosomes in the porcine karyotype are: XX sows and XY boars.

Gene – the basic unit of heredity

Genes located on one chromosome tend to be inherited together. We say that they are coupled, and this phenomenon is called coupling. Those genes that are on different chromosomes are unlinked genes.

Gene linkage

Each chromosome contains a large number of genes that are located some distance apart or close to each other. Those that are some distance away can move between homologous chromosomes in the process of recombination during meiosis. We call such genetic connections loose.
Those genes that are very close to each other on the same chromosome are often inherited together. We call such a genetic link strong. Genes can be linked in cis and trans. Genes on homologous chromosomes can be cis-linked when dominant alleles are on one chromosome, or trans if the dominant alleles are on different chromosomes.

Linked traits

Thus, linked traits are traits whose genes have their locus on the same chromosome. These traits are inherited together, forming a linkage group. The number of linkage groups corresponds to the number of homologous chromosome pairs in a cell. The external manifestation of linked traits is a reduction in the diversity of phenotypic forms because the phenomenon of linkage restricts the number of types of gametes produced by heterozygous individuals.

Types of linked traits

There are two types of coupling:

- absolute linkage
- relative linkage.

Absolute linkage occurs when there is no crossing over between the genes. Relative linkage occurs when there is crossing over between genes. Individuals with a recombined gene arrangement are produced in relation to the parental gene arrangement.

Segregation of linked genes

Crossing over - the phenomenon of exchange of genetic material between non-sister chromatids of homologous chromosomes. It occurs during the prophase I of meiotic division, hence it is also called meiotic recombination. The resulting new forms are called recombinants. This phenomenon, which leads to the creation of new genetic forms, is the main cause of genetic variability in a population and the basis for determining the linkage between any segments of DNA.
The process occurs during the prophase of the first meiotic division on non-sister chromatids. During crossing over, an unstable connection called a chiasma is formed between two chromatids (oriented in the same direction). As a result of completed crossing over, there can be a permanent exchange of chromosome segments between homologous chromosomes either closer to the telomere or between two chiasmata. This leads to the formation of recombinant gametes with a different allelic arrangement than the parental gametes. The process of crossing over is a random event and occurs at random locations. However, the randomness of this phenomenon at a specific chromosomal location has a limiting effect on the occurrence of crossing over nearby (interference phenomenon).
The chromatid that participated in the exchange acquires a combination of alleles from both the paternal and maternal origins, unlike the situation before crossing over. In that case, the chromosome, and thus its chromatids, had a set of alleles from only one parent, as dictated by the principle that within a pair of homologous chromosomes, one originates from the father and the other from the mother.
Crossing over does not occur with a constant frequency. Crossing over is more likely to occur on long segments of the chromosome than on short segments. It more frequently occurs in meiosis in females than in males.

Gene linkage – pleiotropy

A form of gene cooperation is the phenomenon of pleiotropy. Occurs when one gene influences the development of several traits. Pleiotropy can be true and apparent.
True pleiotropy occurs when a pleiotropic gene affects several distinct centers. Example: the gene for platinum color in foxes. Platinum foxes, unlike standard colored individuals, are less lively and more excitable. Individuals homozygous for this gene are not viable.
In the case of apparent pleiotropy, a gene controls a specific trait that, in turn, influences (depending on environmental influences) the variation of other traits. For example, the gene responsible for feather curliness in poultry also affects, among others, the metabolic rate, heart function, and digestive processes. However, these changes are a consequence of abnormal feathering, which does not protect the bird from excessive heat loss.

The interaction of different genes from different loci in shaping the phenotype

In the case of many traits, genes from different allele pairs, through their combined action, result in the emergence of a new form of qualitative trait. The interaction between genes from different allele pairs in shaping the phenotype is called allelic interaction.
Examples of allelic interaction:

- Epistasis (the expression of one allele pair is dependent on the presence of another allele pair).
- Additive gene action (multiple genes from different loci contribute to a single trait, resulting in varying degrees of expression).

Thank you for your attention!