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Gene linkage

Modul no. 1: Animal Genetics

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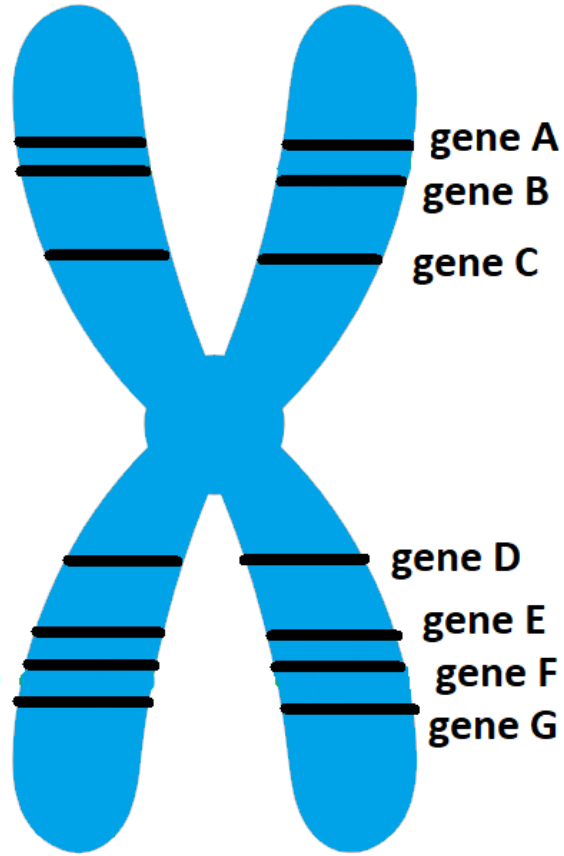
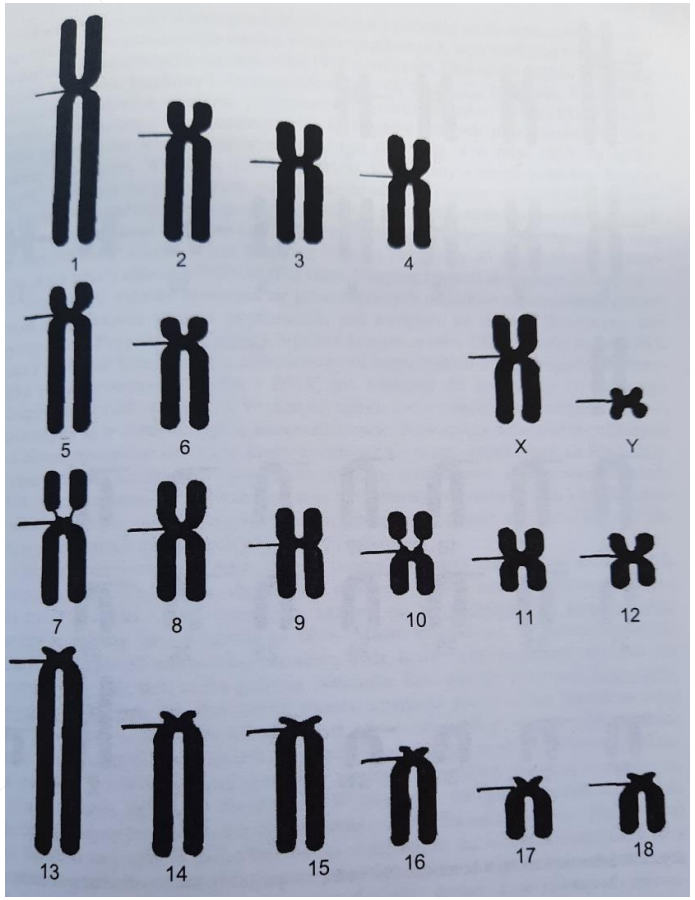
Gene – basic unit of heredity

- Most chromosomes contain a great many genes.





Pig karyotype diagram - 38 chromosomes

Source: Pawlina E., Geringer H., Kosowska B., Kruszyński W., 2008. Genetyka zwierząt Przewodnik do ćwiczeń. Wyd. AR we Wrocławiu

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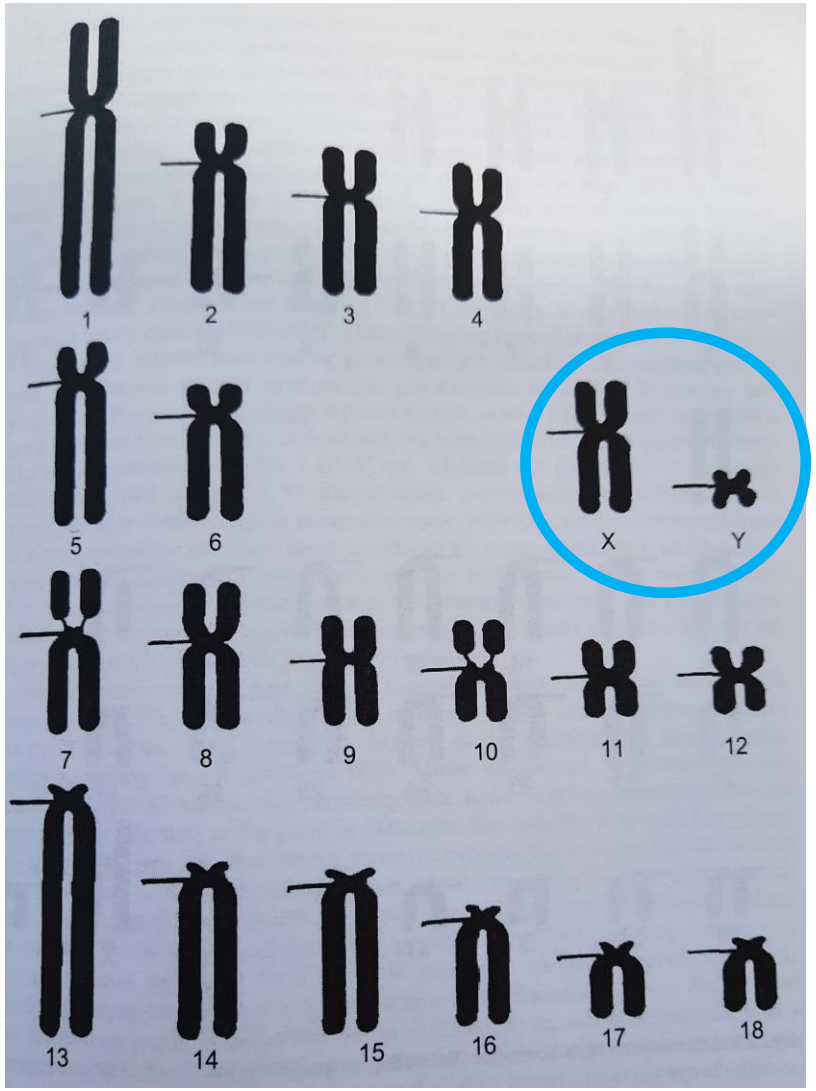
Karyotype = autosomes + sex chromosomes

- Out of 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.



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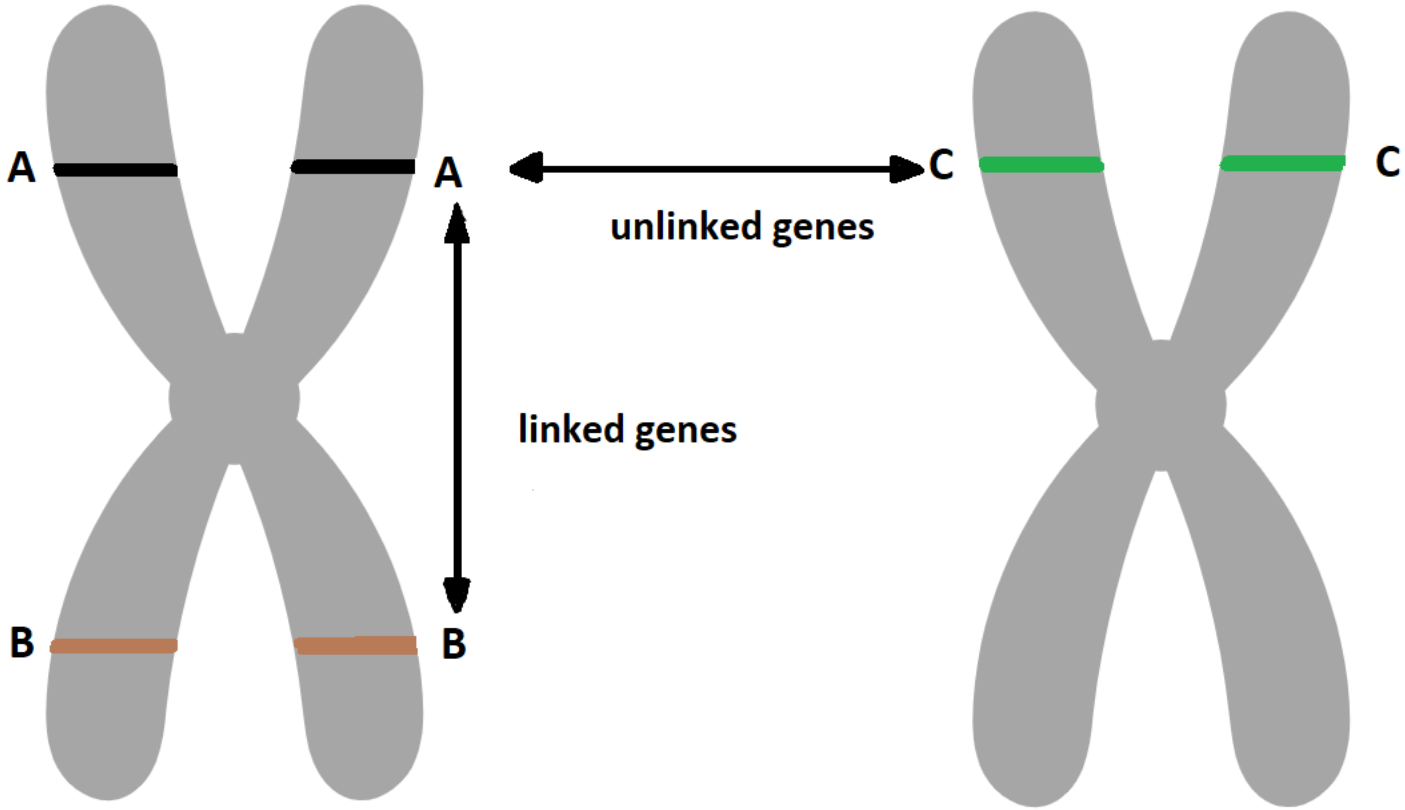
Gene – the basic unit of heredity

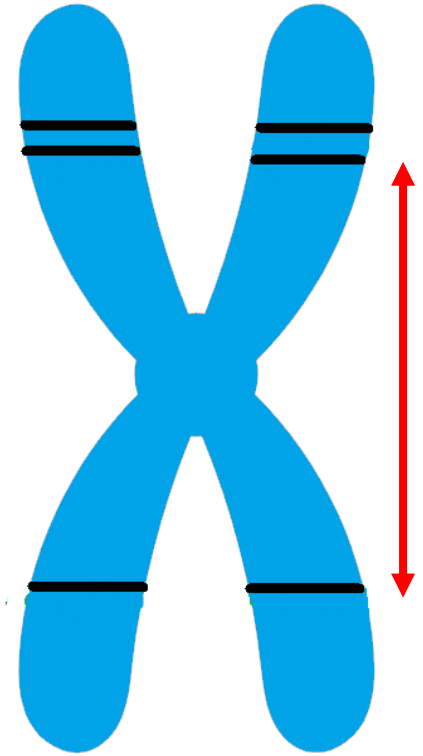
- Genes located on the same chromosome tend to inherit together. We say that they are linked, and this phenomenon is called linkage.



Source: own study based on Zintegrowana Platforma Edukacyjna Ministerstwa Edukacji Narodowej, https://zpe.gov.pl/

Gene linkage

- **distant** (loose) – genes are on the same chromosome, but there is enough distance between them for recombination processes during meiosis to occur and move genes between homologous chromosomes.



Source: Red. Naukowa Świtoński M., 2023. Genetyka ogólna i weterynaryjna. Wyd. Nauk. PWN Warszawa

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Gene linkage

- **close** (strong) – genes are very close to each other on the same chromosome, which leads to them being inherited more often together.

Source: Red. Naukowa Świtoński M., 2023. Genetyka ogólna i weterynaryjna. Wyd. Nauk. PWN Warszawa

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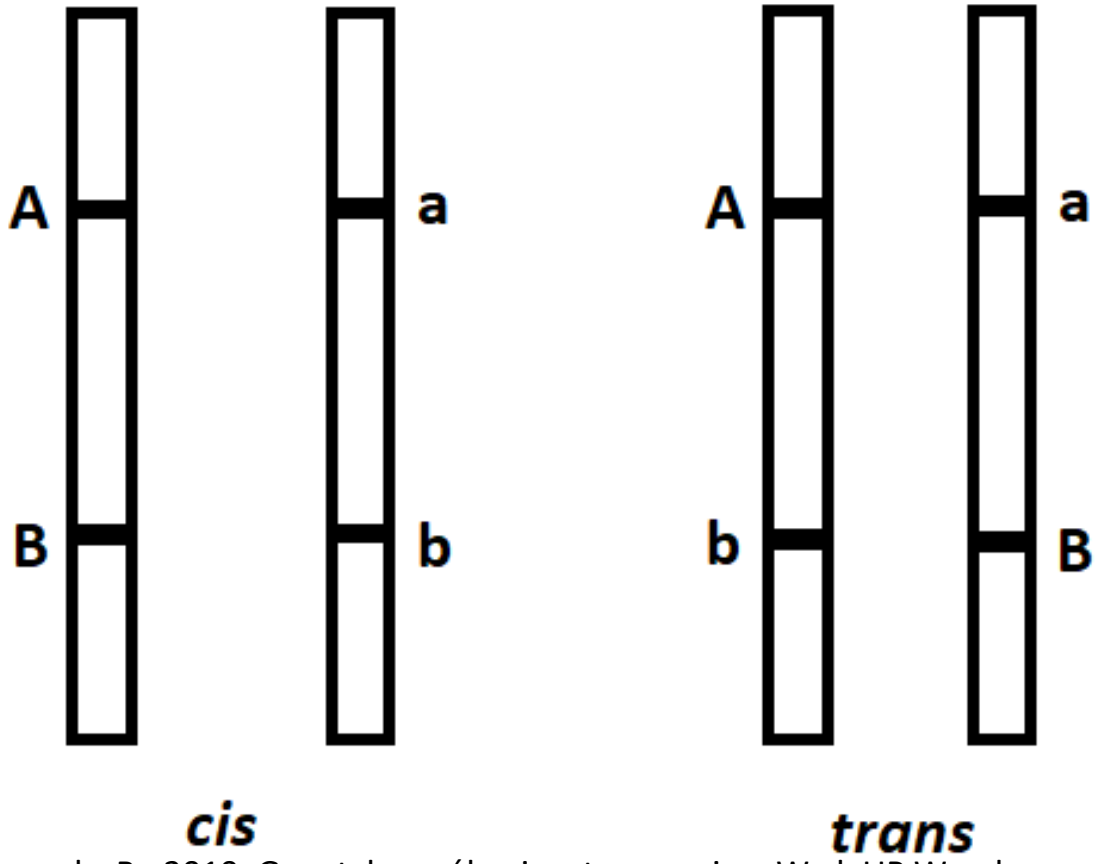
Gene – the basic unit of heredity

- Genes can be linked in cis and trans



Source: own study based on Kosowska B., 2010. Genetyka ogólna i weterynaryjna. Wyd. UP Wrocław

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Linked traits

- Traits whose genes have their loci 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.

Source: own study based on Kosowska B., 2010. Genetyka ogólna i weterynaryjna. Wyd. UP Wrocław

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Types of linked traits

- **Absolute linkage** - occurs when there is no *crossing over* between 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.

Source: own study based on Kosowska B., 2010. Genetyka ogólna i weterynaryjna. Wyd. UP Wrocław

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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.

Source: Wójcik E., Smalec E., 2010. Wymiana chromatyd siostrzanych w chromosomach. KOSMOS Problemy Nauk Biologicznych T. 59, nr 3-4, 513-526.

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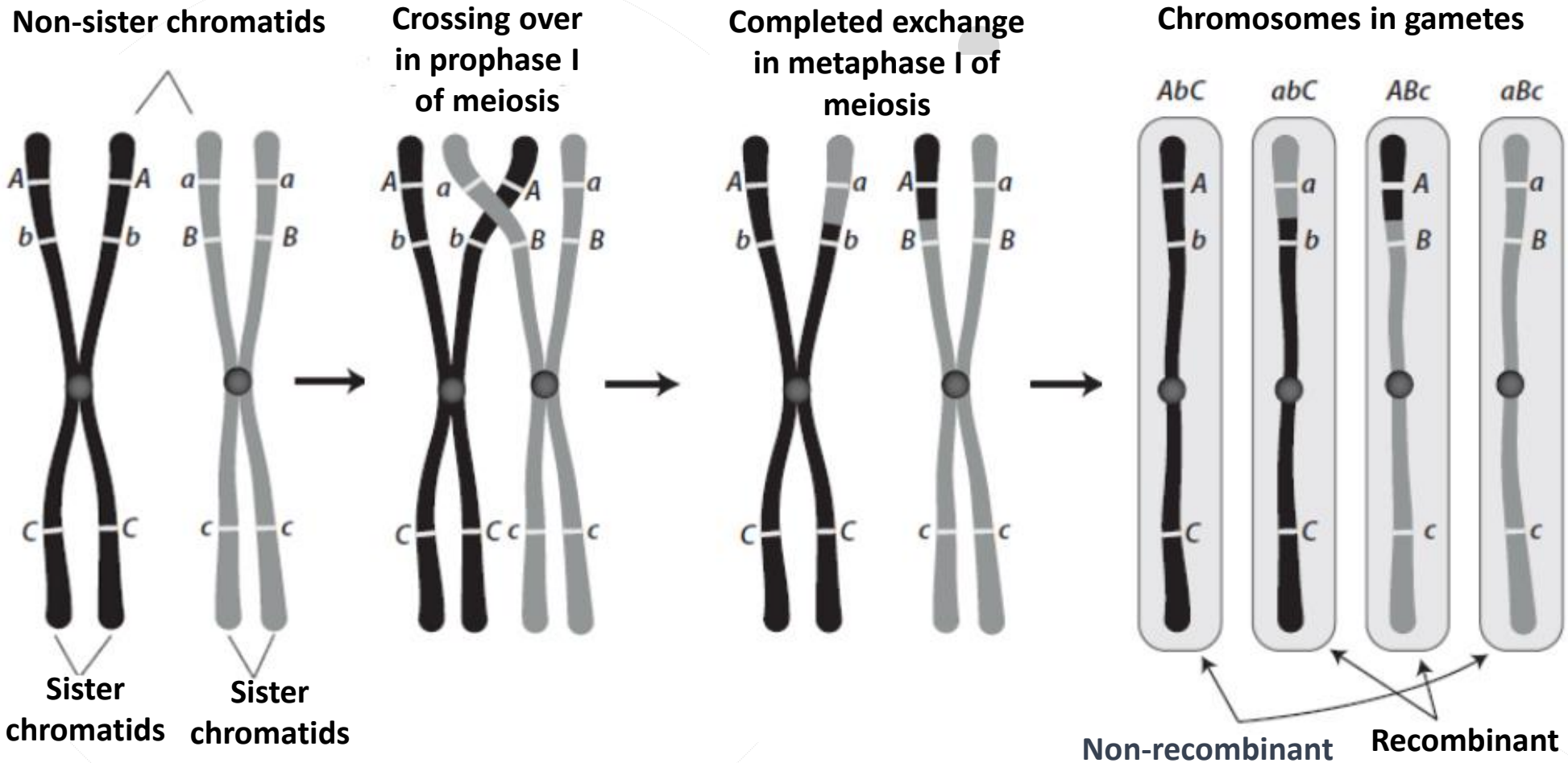
Segregation of linked genes



Source: from Tomáš Urban, Ph.D.

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Segregation of linked genes

- ***Crossing over*** - the frequency of the process depends on the distance between genes on the chromosome. **The closer genes are located to each other, the stronger their linkage is**, and the less likely they are to be separated onto two different homologous chromosomes.

Source: Wójcik E., Smalec E., 2010. Wymiana chromatyd siostrzanych w chromosomach. KOSMOS Problemy Nauk Biologicznych T. 59, nr 3-4, 513-526.

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Gene linkage - pleiotropy

- When one gene influences the development of multiple traits.
- Types of pleiotropy: true and apparent.
- **True pleiotropy** occurs when a pleiotropic gene affects multiple distinct pathways. An example is the gene responsible for the platinum coat color in foxes. Platinum foxes, unlike normally pigmented individuals, are less viable and more excitable. Homozygous individuals for this gene are not capable of survival.

Source: Charon K.M., Świtoński M., 2000. Genetyka zwierząt. Wyd. Naukowe PWN

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Gene linkage - pleiotropy

- When one gene influences the development of multiple traits.
- Types of pleiotropy: true and apparent.
- 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.

Source: Charon K.M., Świtoński M., 2000. Genetyka zwierząt. Wyd. Naukowe PWN

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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 non-allelic interaction.
- Examples of non-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).

Source: Charon K.M., Świtoński M., 2000. Genetyka zwierząt. Wyd. Naukowe PWN

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Thank you for your attention!

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