Genetic basics of colour inheritance

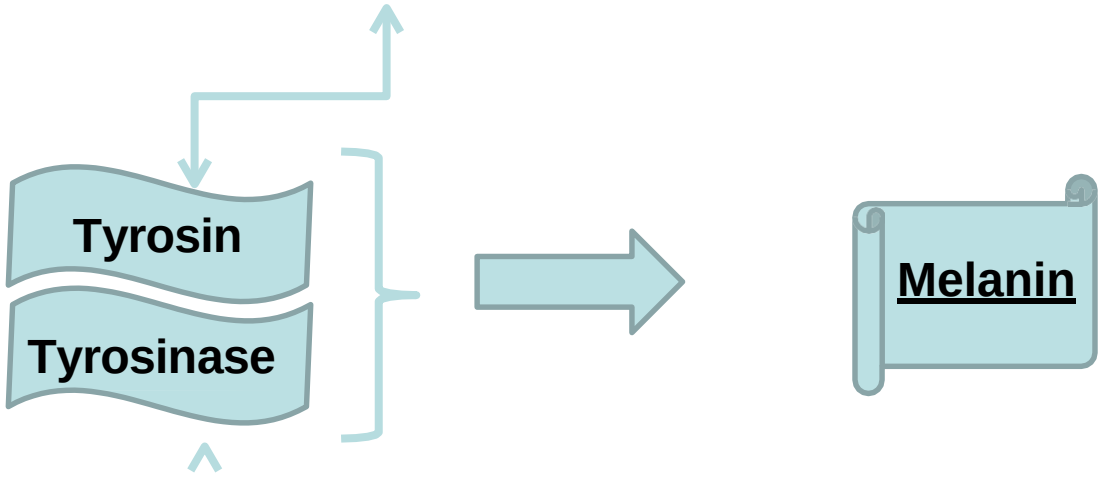
Functional basics and connections between colour gene arts Author: Lothar Quoll

The pigment is carrier of the color

The pigment is stored in the form of pigment grains in hair and epithet cells.

The chemical basis of the pigment is melanin

Melanin is a chemical Connection which is produced by oxidative reactions from an amino acid to the tyrosine.



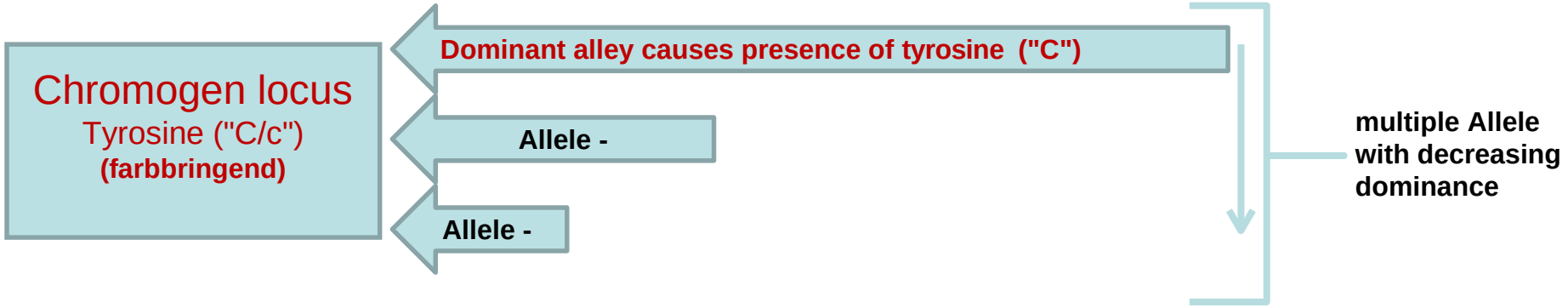
The enzyme tyrosinase plays an important role in this reaction process.

If one of the two reaction partners is missing, no melanin can be formed – the animal shows no coloration - it is white.

This means that a colouring occurs only when the both reaction partners tyrosine and tyrosinase are present.

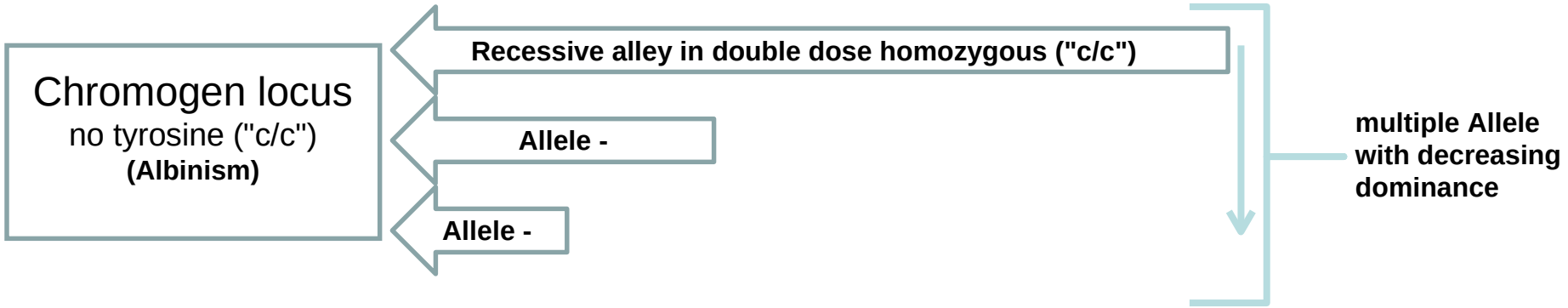
The presence or absence of tyrosine and tyrosinase are genetically determined.
The amino acid tyrosine is controlled by a gene locus called "chromogenic" (colour-bringing).

Chromogen locus → „Farbbringend“



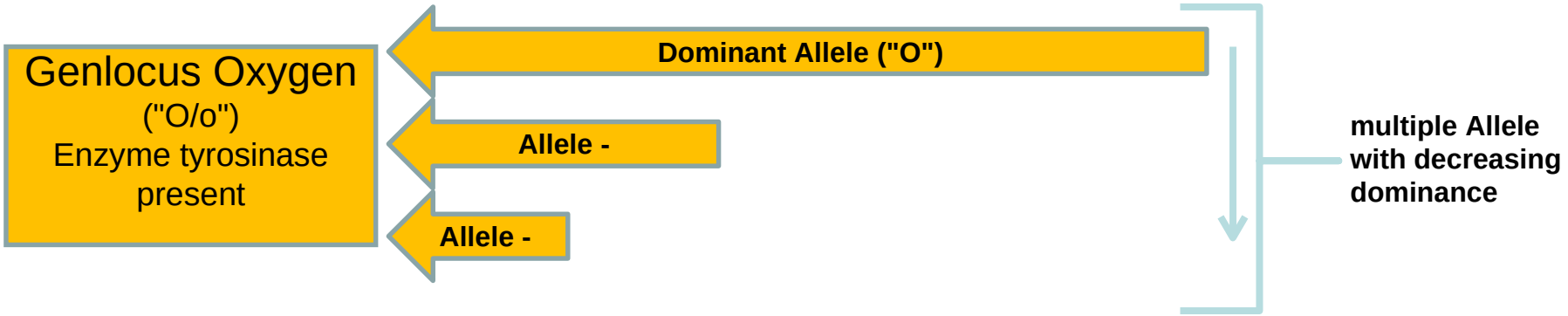
Animals bearing the dominant alley "C" in homozygous or heterozygous form are - in the simultaneous presence of tyrosinase - *dyed*.

Chromogen locus → "Albinism"



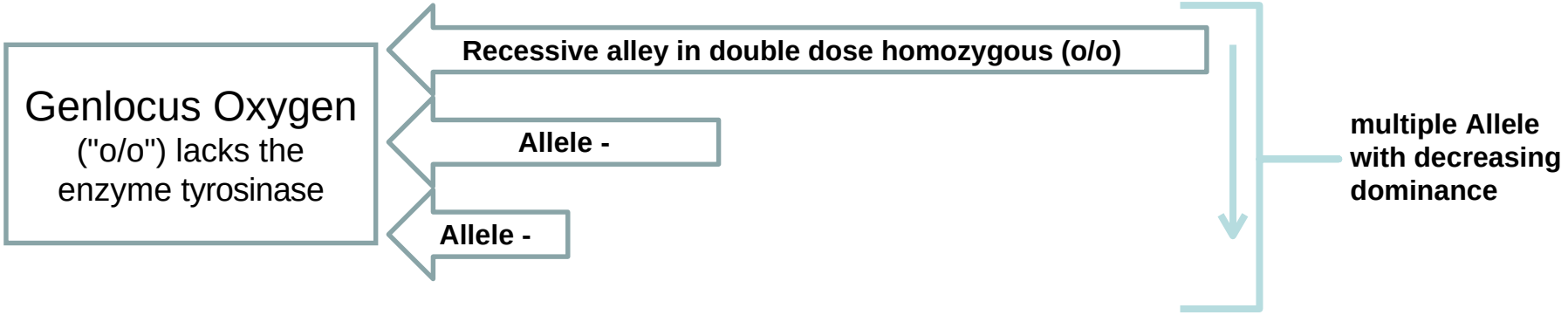
The recessive alleles at chromogen locus cause the complete absence of tyrosine, animals that carry "c/c" in double dose, i.e. homozygous, do not have tyrosine. thus, no melanin can be formed even in the presence of tyrosinase, these animals are therefore not pigmented.
This form of pigment deficiency, which is due to the genotype "c/c", is called *Albinism.*

Genlocus for the enzyme tyrosinase (oxygen)



The dominant allele "O" causes the presence of the enzyme tyrosinase. Animals that have "O" in homozygous or heterozygous form - are with simultaneous presence of ("C" - *Chromogen locus Tyrosine)*

Pigmented.



The recessive allele "o" causes the absence of the enzyme tyrosinase. Animals that have "o" in double dose, i.e. animals with the genotype "o/o" do not have tyrosinase. Even if tyrosine is present, i.e. if the genotype "C/C" or "C/c" is present on the chromogene locus, this tyrosine cannot be oxidized to melanin because the necessary enzyme is missing. The animals are

White

However, they differ from the white color of the albinos of the "c/c" animals, since in the "o/o" animals the chemical basis of the *pigment, the tyrosine, yes*, *is present, even in* the *absence of the enzyme tyrosinase,* a *small part* of the tyrosine *can be oxidized by other mechanisms to melanin. It is not yet known what factors are actually involved. It is known only* that these *replacement mechanisms are mainly limited to the eye, so that a certain pigment enrichment is given in the iris.*

Difference - Effects:

Albino: **Animals with the genotype "c/c" are extremely sensitive to lightdue to the absence of pigment. Neither skin nor hair show pigmentation, even the iris of the eye is unpigmented, so that the strongly bloodied eye background can shine through, whereby these animals have the *red eyes* typical of the albino.**
In addition, albinos show a very reduced resistance to infections and other unfavourable environmental influences, so that their life expectancy is reduced.

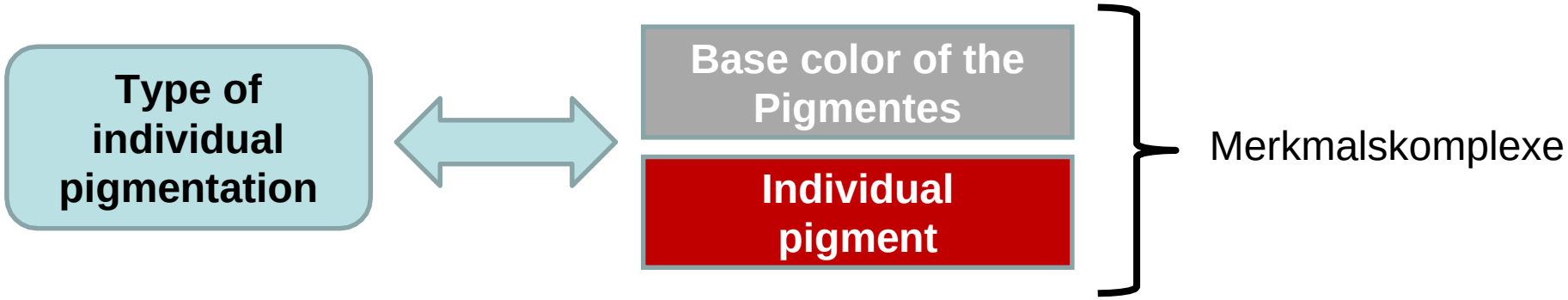
White **animals with the genotype "o/o" therefore have not, like the real albinos, red eyes, but by the presence of a small amount of melanin blue *eyes.* This form of pigment deficiency is also associated with negative effects on animal health. White animals with blue eyes often show a pronounced inner ear numbness, sometimes also disorders in the area of the central nervous system.**

The third possibility of *whitening* is based on a simply dominant gene, the so-called prevention factor. This factor prevents the accumulation of pigment in the hair, while skin, nose and eyes show complete pigmentation.

Another possibility of *whitening* arises from a homozygous recessive genotype in that genlocus which is responsible for checking, i.e. for the distribution of pigmented and unpigmented hair across the body. The check-locus includes a variety of alleles that require white badges to varying degrees. The dominant allele on this checking locus causes badgeless coloration in the base color given by the genotype to the corresponding other genloci. The other alleles in decreasing dominance determine an extended white check, wherein both in the extent and in the form of the white badges there is an enormous variance, which is possibly also determined by modifying additional gene locations.

Mechanisms for different pigmentation

We got to know the two Genloci, which are responsible for making coloring possible at all.



The basic color of the pigment
depends on the type of melanin formed

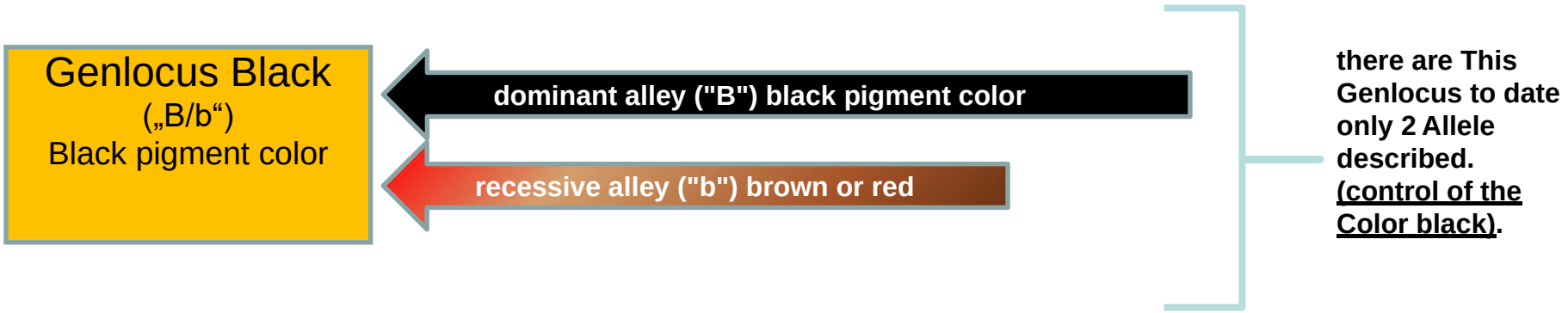
Eumelanin
black - brown

Phaeomelanin
reddish - yellow

These two forms of melanin result from different levels of ***oxidation*** from the ***same compound. The color of the pigment is*** controlled by a ***genlocus called Black ("B").***

The dominant alley is responsible ***for black pigment color, the recessive for brown and red.***

First feature complex - Genlocus_Black ("B")



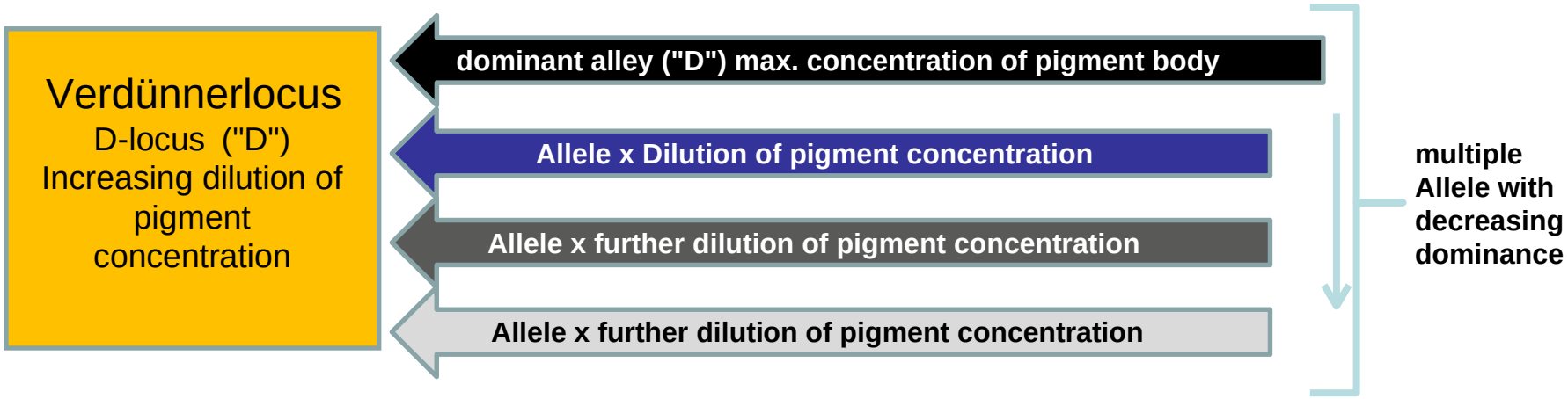
Although only 2 alleles are described on this genelocus, it can be assumed that either the B-Locus itself comprises several (multiple) alleles, or that epistatic (Genlocis suppress the other genlocis) acting gene places modify the pigment color.

With only 2 alleles, the variety of possible pigment colors (regardless of the dilution colors) that lie between black and yellow can hardly be explained. Whether these intermediate colours (tan colours, red, brown) are produced by a different mixing ratio of eumelanin and phaeomelin or other intermediates in melanin synthesis is not yet clear.

Second characteristic complex (gene locations for the distribution of pigment)

Here, too, a distinction is made between two forms of distribution: on the one hand, the pigment distribution in the individual hair can vary, on the other hand, the pigment distribution on the body surface of the animal.
These two forms of distribution are often fluid and are neither phenotypically nor genetically clear to separate from each other.

1. Pigment Distribution in Individual Hair - Verdünnerlocus Dilution-locus („D“)



This pigment dilution first turns black into "blue", with further dilution "grey" and finally "Silver", brown becomes "Liver" by pigment dilution ***(chocolate brown, red or yellow becomes "apricot").***

It is difficult to estimate how many alleles are actually present on this genelocus; the transitions are fluid, since in principle a stepless variation of the pigment concentration is possible.

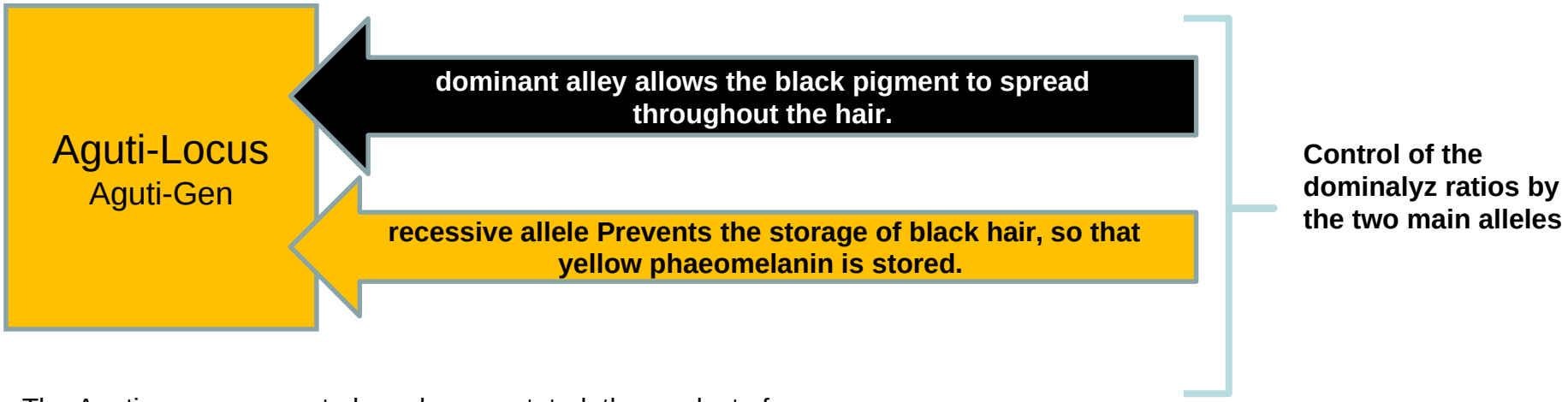
2. Pigment distribution in single hair - Distribution of pigment Aguti-Locus

The second gene location that influences the distribution of pigment in the individual hair is the so-called Aguti locus Locus.

The name Aguti refers to an allele of this gene-local, which determinates after a wild nag determinant of aguti coloration. This aguti color corresponds to the camouflage color observed in most wild animals. In northern regions - which are snow-covered for most of the year - the white color. In our regions, the colours black-brown-yellow are adapted to the seasonal change.

The classical Aguti gene causes a black-yellow banding of the single hair, which is caused by alternating storage of eumelanin (black) and phaeomelanin (yellow).

The type of banding can vary, so that obviously not only one, but several Aguti genes exist with different expression.



The Aguti gene appears to have been mutated, the product of which is dominant compared to the original gene

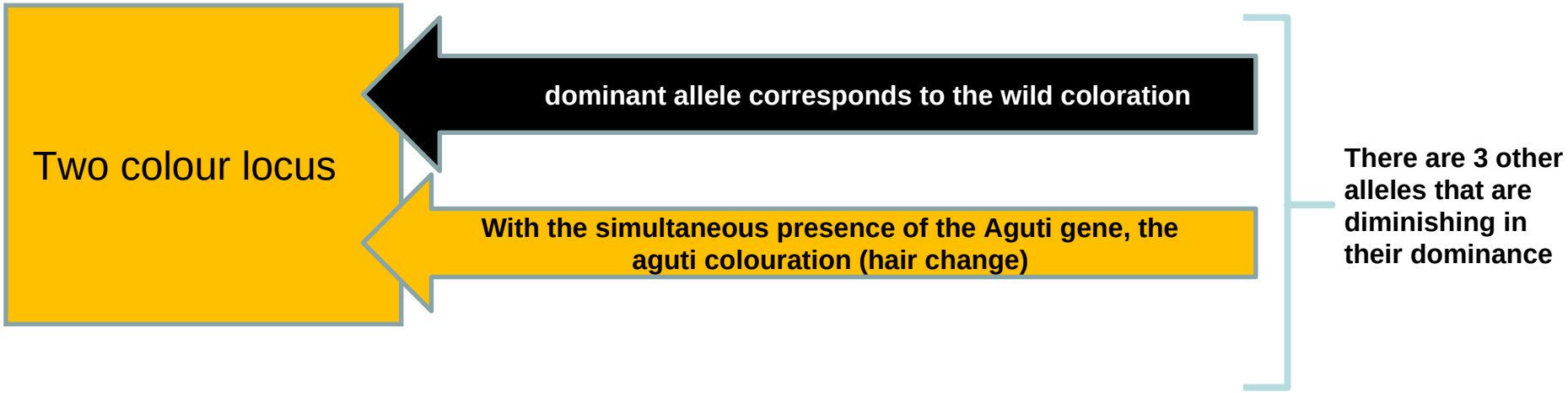
The fact that the gene that allows the complete black coloration of the hair is dominant on the Aguti locus is also to be regarded as an interesting aspect of domestication coloration.

Normally, the wild color is considered as the starting color, from which the color variants of the pets have arisen by mutation and subsequent breeding processing/ preference of the mutants.

More alleles at the Aguti-Locus_(Two-tone locus)

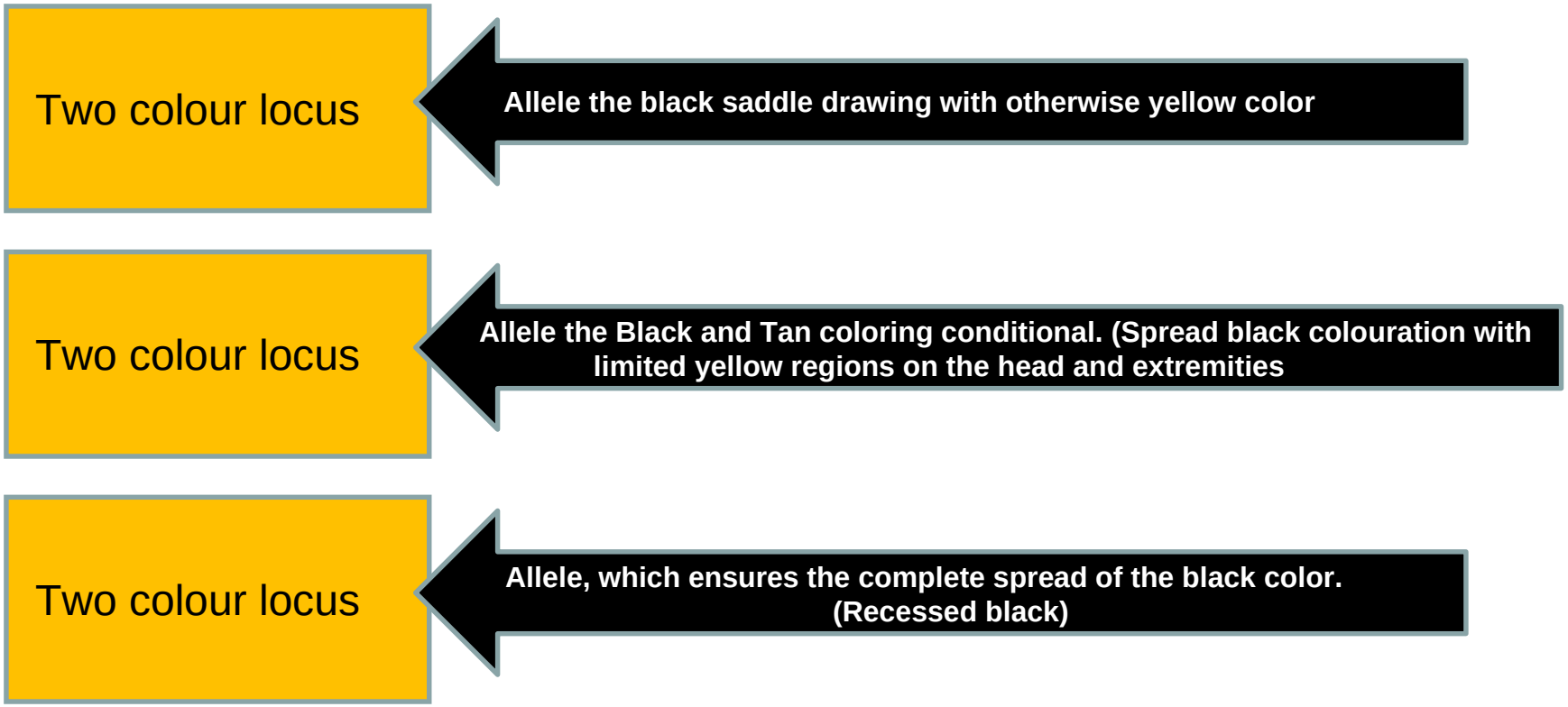
According to Little, the Aguti Locus has other alleles, such as an allele, which requires the formation of a black saddle with otherwise yellow colour, or an allele that colours the black-and-tan, - d. i. pronounced black coloration with restricted yellow areas in the area of the head and extremities - caused.

According to the latest scientific studies, however, the latter alleles (black saddle and black-and-tan coloring) are to be assigned to a separate gene ***locus,*** which is called ***zweifarbikeitslocus*** (two-tone locus).



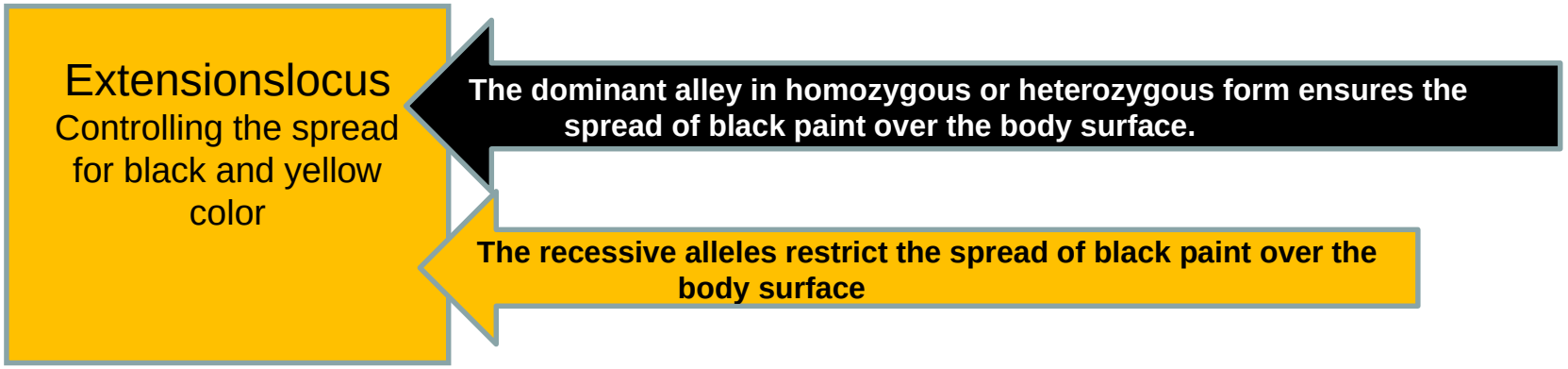
The color of the single hair seems to be darker and darker towards the back, which is mainly due to the fact that the balance between black and lighter bands is shifted more and more in favor of the black hair rings.

The three other alleles on the two-farbikeitslocus (colour locus) with decreasing dominance



The presence of this recessive black allele is disputed by many authors. In fact, it seems rare. The black color of the German Shepherd is probably due to this recessive black alley.

The extension locus (Extensionslocus) for black colour



**The Extensionslocus is the gene locus that determined the distribution of black and yellow pigment.
This gene locus influences the expansion of the black pigment over the body surface.
The dominant alley on this genelocus allows a complete spread of the black pigment.
Animals that carry this alley in homozygous or heterozygous form are monochrome black.**

The recessive alleles at this gene site more or less severely restrict the spread of black paint over the body surface.

Another recessive allele, called a black mask factor, is responsible for the formation of a black mask with otherwise yellow or reddish coloration. The black mask factor is recessive compared to the black expansion factor and dominant against an allele, which allows the expansion of the black pigment in the hair dress at all and thus causes monochrome yellow color in black nose and dark eyes.

Summary of the black-yellow distribution (Aguti-Locus)

Aguti-Locus:

- **Dominant alley: allows the spread of the black pigment throughout the single hair**
- **Aguti Allele: conditional restriction of the spread of the black pigment – thus black-yellow or black-grey ringing** of **the** single **hair.**
- **Recessive allele: does not allow** the **spread of black pigment in** single **hair – thus monochrome yellow hair**

Zweifarbikeitslocus:

- **Dominant allele: Black-yellow (or black-grey) Grau)- distribution according to the wild coloration (different hair banding in different** body **regions).**
- **Factor of black saddle**
- **Factor of Black and Tan coloring conditional**
- **Recessive alley: conditionally monochrome black drawing**

Ausdehnungslocus (Expansionlocus):

- **Dominant alley: causes the expansion of the black pigment over the whole body, thereby monochrome black drawing.**
- **Current sestation factor (Brindle factor**): **conditional current.**
- **Black mask factor: conditional black mask with otherwise yellow coloration**
- **Recessive allele: conditionally monochrome yellow drawing with black nose and dark eyes.**

According to this different determination of monochrome black, black can occur either as a dominant or as a recessive property.

For example, black of the shepherd's dog is to be regarded as recessive black (as homozygous appearance of the recessive allele on the two-coloured locus).

The color of the eyes

The color of the eyes is partly determined independently of the coat color.

Correlations with the hair color can be found in the real albinos, where the general absence of pigment makes the eyes appeared.
In addition, there is a lack of blue eyes in the case of tyrosinase in white fur colour.
In most dog breeds, the eye color shows a flowing variation, regardless of the coat color, which goes from yellow to light brown to dark brown.
Dark eye color is dominant over light eye color; A genlocus with multiple alleles is likely to be responsible.

The color of the nose mirror

The color of the nose mirror is closely related to the skin or skin color.

A brown nose mirror, we find in all dogs that do not have a black pigment, these are all dogs that are homozygous at the B-Locus for the recessive allele and therefore do not form black eumelanin, but only yellow or red phaeomelanin.
All animals that have the dominant alley in homozygous or heterozygous form at the B-Locus have a black nose mirror, even if the spread of the black pigment
is prevented by the recessive allele at the Agutilocus or by the recessive allel of the expansion series. Albinos have a flesh-colored nose mirror according to their generalized pigment deficiency.
Occasionally, pink spots can occur on a dark nose mirror, which must be considered as a local pigmentation deficiency and are considered a fault in most breeds.