

6. Multiple alleles

Generally, a gene has two alternative forms called alleles. Usually one of them is dominant over the other. The two alleles of a gene determine the two contrasting forms of a single character. Ex. Tall (T) and dwarf (t) plant height in garden pea. But in many cases, several alleles of a single gene are known to exist and each one of them governs a distinct form of the concerned character or trait. Such a situation is known as multiple allelism and all the alleles of a single gene are called multiple alleles. Many genes in both animals and plants exhibit multiple alleles. Ex: Blood group in human beings, fur colour / coat colour in rabbits and self-incompatibility alleles in plants.

1. Blood groups in human beings: On the basis of presence / absence of certain antigens, four blood groups in human beings have been established by Karl Landsteiner in 1900. The blood group system in human beings is believed to be controlled by a single gene generally designated as “I.” The gene “I” has three alleles. – I^A , I^B and i . Allele I^A controls the production of antigen A, I^B controls the production of antigen B and i does not produce any antigen. Individuals with the genotype $I^A I^A$ or $I^A i$ produces antigen ‘A’ and are classified in blood group A. individuals with genotype $I^B I^B$ or $I^B i$ are classified in blood group B. Individuals with genotype ii are grouped in ‘O’ blood group and such individuals produce neither antigen A nor antigen B. individuals with genotype $I^A I^B$ produce both antigens A and B and hence classified as ‘AB’ blood group.

Human blood groups, their antigen, antibody and compatible blood groups for transfusion:

Blood group	Genotypes	Antigen found	Antibody present	Compatible blood group
A	$I^A I^A$ or $I^A i$	A	B	A and O
B	$I^B I^B$ or $I^B i$	B	A	B and O
AB	$I^A I^B$	AB	None	A, B, O and AB (Universal recipient)
O	ii	None	AB	O (Universal donor)

2 Fur or coat colour in rabbits: The fur colour in rabbits is a well-known example of multiple alleles. In rabbits, the fur colour is of four types *viz.*, agouti, chinchilla, himalayan and albino. It is due to multiple alleles of a single gene 'C'.

Phenotype	Gene symbol	Genotype
1. Agouti	C	CC, Cc ^{ch} , Cc ^h , Cc
2. Chinchilla	C ^{ch}	c ^{ch} c ^{ch} , c ^{ch} c ^h , c ^{ch} c
3. Himalayan	C ^h	c ^h c ^h , c ^h c
4. Albino	c	cc

The order of dominance for fur colour in rabbits can be represented as follows:

C	>	c ^{ch}	>	c ^h	>	c
Agouti	>	Chinchilla	>	Himalayan	>	Albino
Full colour or wild type		Mixture of coloured and white hairs over the body		Main body is white, while the tips of ears, feet, tail and snout are black		No pigment and with pure white fur colour

3 Self-incompatibility alleles in plants: A series of self-incompatibility alleles insures cross pollination in many plants. Such alleles were described first in tobacco and later they were found in several other plant species like *Brassica*, radish, tomato, potato etc. In these species, self-incompatibility is governed by a single gene 'S' which has multiple alleles *viz.*, S1, S2, S3, S4 and so on.

Characteristic features of multiple alleles:

1. Multiple alleles always belong to the same locus in a chromosome.
2. One allele is present at a locus at a time in a chromosome.
3. Multiple alleles always control the same character of an individual. However, the phenotypic expression of the character will differ depending on the alleles present.
4. There is no crossing over in a multiple allelic series.

5. In a multiple allelic series, wild type is almost always dominant over the mutant Type.
6. A cross between two strains homozygous for mutant alleles will always produce a mutant phenotype and never a wild phenotype. In other words, multiple alleles do not show complementation.
7. Further, F₂ generations from such crosses show typical monohybrid ratio for the concerned trait.

Pleiotropism:

Many characters are governed by several genes, reverse is also true. It means, many single genes or possibly all influence several characters. A gene having more than one phenotypic effect (manifold effects) is called pleiotropic gene and such phenomenon is referred to as pleiotropy or pleiotropism.

A pleiotropic effect may be either due to a true pleiotropic gene or due to closely linked gene. If the side effects of a gene are beneficial, it helps in crop improvement.

On the other hand, if the side effects are unfavourable, such pleiotropy is not useful in plant breeding. A good example of pleiotropy has been reported in wheat. A gene governing awns in onas variety also enhance yield and seed weight. Side effects of major genes are studied by the use of isogenic lines. Isogenic lines are genotypes or strains which have one locus different only. The pleiotropic genes are found in all the crop plants.

Pseudo alleles: Two alleles each of two or more tightly linked genes affecting the same function as a result of which, they appear as multiple alleles. (Or) Alleles, which have two separate gene loci, but often inherit together due to close linkage and have very rare chance of crossing over are called pseudo alleles. Eg: Lozenge eye in *Drosophila*.

Iso allele: An allele which is similar in its phenotypic expression to that of other independently occurring allele is called isoallele