Course: Fundamentals of Genetics
Class: - Ist Year, IInd Semester

Lecture No. XV

Title of topic: - Multiple alleles: Blood group genetics

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Alleles

Alternate forms of a gene is known as allele. Alleles are of two types *viz*., either dominant and recessive or wild type and mutant type.

Characteristic features of alleles:

1. They occupy the same locus on a particular chromosome.
2. They govern the same character of an individual. (T and t – control plant height)
3. A haploid cell has a single copy of an allele for a character. A diploid cell has two copies of an allele for a character, while a polyploidy cell has more than two copies of an allele for a character.
4. An individual may have identical alleles at the corresponding locus of homologous chromosomes in the homozygote or two different alleles in the heterozygote.
5. The alleles may be dominant and recessive or wild and mutant types.

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_AI_A or I_Ai produces antigen 'A' and are classified in blood group A. individuals with genotype I_BI_B or I_Bi 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_AI_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, AB and O 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 Full colour or wild type	>	Chinchilla Mixture of coloured and white hairs over the body	>	Himalayan Main body is white, while the tips of ears, feet, tail and snout are black	>	Albino 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 toabacco 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*., S_1, S_2, S_3, S_4 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, F_2 generations from such crosses show typical monohybrid ratio for the concerned trait.