Ministry of Higher Education
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Lecture : 10

PLEIOTROPHY and MULTIPLE ALLELES

Pleiotropism

In general one gene affects a single character. But many genes are known to affect more than one character such genes are known as pleiotropic genes and the condition is termed as pleiotrophy. An example of a pleiotropic gene in human beingsis the recessive gene s which produces sickle cell anemia in the ss homozygotes. These gene causes changes in two or more parts of characters, which are not related, then the gene is said to be pleiotropic gene. E.g. In cotton the Punjab hairy lintless gene lic produces seeds without lint. This gene also causes incomplete lancinations of the leaf, reduction in boll size and fertility. In a plant a gene may produce red pigment in several organs, such as flowers stem, leaves but still it is not correct to say that the gene is pleiotropic because the gene has only one general effect, the production of pigment. A gene for wing may be vestigial gene can be called as bristle gene or a fecundity gene. A number of other recessive genes produce marked and often detrimental effect in human beings. They are referred as syndromes.

Penetrance

Most genes produce identical phenotypes in all the individuals in which they are present in the appropriate genotype. For example, all the seeds having the w gene governing the seed shape in pea, in the homozygous state (ww) have uniformly wrinkled shape. Similarly, those seeds that have either WW or Ww genotype are uniformly round. The ability of a gene to produce identical phenotypes in all the individuals carrying it in the appropriate genotype is known as complete expressivity. As opposed to this, many genes have

incomplete expressivity in that they produce variable phenotypes in the individuals that have this gene in the appropriate genotype.

Expressivity

In general, genes express themselves in all the individuals in which they are present in the appropriate genotype, this is known as complete penetrance. But many genes do not produce the concerned phenotype in all the individuals which carry them in the appropriate genotype. Such a situation is known as incomplete prenetrance. When a gene is present in the appropriate genotype, the per cent of individuals in which it is able to express itself is a measure of its penetrance. Thus the chlorophyll deficiency gene in lima beans has a penetrance of 10 %. Almost all the genes showing incomplete penetrance exhibit incomplete expressivity as well. Thus incomplete penetrance is in fact an expression of incomplete expressivity in that some individuals show such a small expression of the gene that the trait is not detectable.

Isoalleles

These alleles, which are similar but on testing it proves to be a different one. Blood group A person have three slightly different types such as IA1, IA2, IA3 which are similar but found to be different after testing.

Pseudoalleles

Pseudoallelism is a state in which two genes with similar functions are located so close to one another on a chromosome that they are genetically linked . Term given by Morgan 1928 and Lewis 1948, This means that the two genes pseudoalleles are nearly always inherited together Since the two genes have related functions, they may appear to act as a single gene. In rare cases, the two linked pseudoalleles can be separated, or recombined One hypothesis is that pseudoalleles are formed as a result of gene duplication events, and the duplicated genes can undergo gene evolution to develop new functions

Characteristic of pseudoalleles

- These are closely linked allele within which crossing over occur
- They affect the same character

Example

- Red eye colour of Drosophila has different mutants like white and apricot
- They affect pigmentation i e affect the same character So, they are allelic
- They can undergo recombination, i e they are nonallelic

MULTIPLE ALLELES

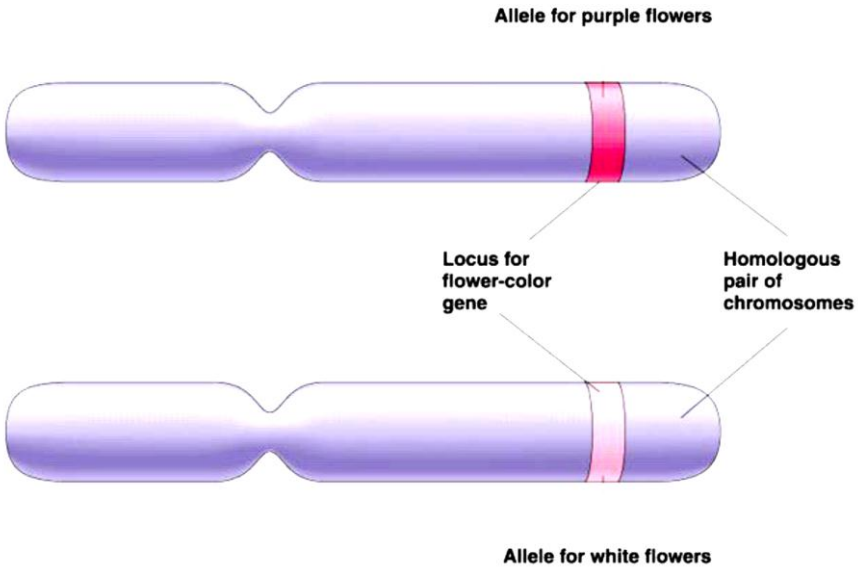
Allele is a shorter term than allelomorph (another form) is the alternate form of gene. Many genes have two alternate forms but several other have more than two alternate forms. More than two alleles at the same locus give rise to a multiple allelic series. Multiple alleles can be defined as a series of forms of a gene situated at the same locus of homologous chromosomes. According to Mendel, each gene had two alternate forms or allele morphs are being dominant and the other being recessive. Dominant being the wild type from which recessive mutant was evolved through mutation. Likewise, a wild type can mutate in many ways and produce many mutant forms and a mutant can again undergo another mutation and give rise to a new mutant. Hence, a gene can exist in more than two allelomorphs. Usually wild type allele is dominant over its recessive allele. wild allele is represented as + .

Multiple alleles can be defined as a

- series of forms of a gene
- situated at the same locus of homologous chromosomes
- affecting same character.

Multiple alleles are

- different forms of the same gene
- that is the sequence of the bases is slightly different in the genes located on the same place of the chromosome.



Multiple alleles are alternative states at the same locus. Remember: each individual will only have two alleles for a trait but there are several alleles to choose from.) The classical example for multiple alleles is human blood group self incompatibility in tobacco, coat colour in rabbit, self incompatability genes in brassica.

The number of possible genotypes in a series of multiple alleles is ½ n (n+1)

n = no of alleles

- Di-allelic genes can generate 3 genotypes.
- Genes with 3 alleles can generate 6 genotypes.
- Genes with 4 alleles can generate 10 genotypes.
- Genes with 8 alleles can generate 36 genotypes

Important features of multiple alleles

1) Multiple alleles always belong to the same locus and one allele is present at a locus at a time in a chromosome

2) Multiple alleles always control the same character of an individual

3) Wild type allele is dominant over other alleles

4) There is no crossing over in the multiple alleles

5) In a series of mutiple alleles wild type is always dominant

6) When two mutant types are crossed wild form cannot be recovered

7) The cross between two mutant alleles will always produce mutant phenotype. Examples of multiple alleles are 1) fur colour in a rabbit, 2) ABO blood group in man 3) Wing type in drosophila 4) Eye colour in drosophila etc. Fur colour in Rabbit. In rabbit, three alternate forms of genes, which controls coat colour. C causes wild type and its alleles.

Skin colour in rabbit

In rabbits, four kinds of skin colour are known.

Possible genotypes	CC, Cc^{ch}, Cc^{h}, Cc	$c^{ch}c^{ch}$	$c^{ch}c^{h}$, $c^{ch}c$	$c^{h}c^{h}$, $c^{h}c$	cc
Phenotype	Dark gray	Chinchilla	Light gray	Himalayan	Albino

$c^{h}c^{h}$, $c^{h}c$ - Himalayan (white except black feet nose ear tail)

cc - Albino (complete white).

Agouti

This has full colour and is also known as wild type. This colour is dominant over all the remaining colour and produces agouti colour in F1 and 3:1 ratio in F2 when crossed with any of the other three colours in rabbits. C represents this colour.

Chinchilla

This is lighter than agouti. This colour is dominant over Himalayan and albino and produces chinchilla in F1 and 3:1 ratio in F2 when crossed either Himalayan or albino. This is represented by c^{ch}.

Himalayan

The main body is white while the tips of ear, feet, tail and snout are coloured. This colour is dominant over albino and produces 3:1 ratio in F2 when crossed with albino. This is represented by c^{h}**.**

Albino

This has pure white fur colour and is recessive to all other types. This is represented by c. Thus the order of dominance for fur colour in rabbits can be represented as follows.

Agouti	Chinchilla	Himalayan	Albino
(C)	(cch)	(ch)	(c)

ABO Blood group in man.

Antibody

Antibody is a type of protein, which is commonly referred to as immunoglobin. It is usually found in the serum or plasma. The presence of antibody can be demonstrated by its specific reaction with an antigen.

Antigen

An antigen refers to an substance or agent, which when introduced into the system of vertebrate animal like cow, goat, man etc induces the production of specific antibody, which binds specifically to this (Antigen) substance Antigen are located in the red blood corpuscles (RBC). If a person has a particular antigen in his RBCs, his serum has usually antibodies against the other antigen. In human RBC two types of antigens viz A and B are present. Depending upon the presence or absence of antigen A and B the blood group in man is of four types viz A, B, AB and O. A person with blood group A has antigen A on the surface of RBCs: protein with blood group B will have antigen B those with blood group AB have antigens A and B; and those with blood group O have no antigen on the surface of their RBCs.

Blood Group	Genotype	Antigen found	Antibody present	Compatible blood group
A	I^AI^A, I^Ai	A	B	A and O
B	I^BI^B, I^Bi	B	A	B and O
AB	I^AI^B	AB	None	A,B, AB,O
O	ii	None	AB	O

Recent studies shows that antigen is galactosamine and B is galactose Antibodies A, B, AB and None and are naturally present in the serum of individuals having A,B,AB, and O blood group respectively. The agglutination or coagulation of RBCs leads to clotting of blood due to interaction between antigen antibody. The blood group B cannot be transferred to an individual having blood group A because the recipient has antibody against antigen B which is present on the RBCs of blood group B. Similarly the reverse transfusion is not possible. The blood group AB does not have antibody A and B. Hence individuals with AB blood group can accept all types of blood, viz., A, B, AB and O. Such individuals are known as **universal acceptors** or recipients. The O blood group does not have any antigen and has antibody against antigen A and B, It cannot accept blood group other than O. Individuals with blood group O are known

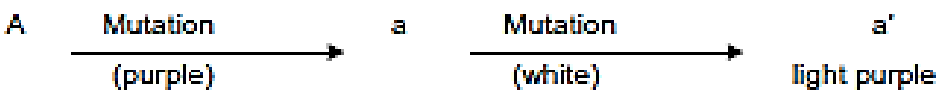
as **universal donors**, because transfusion of blood group O is possible with all the four blood types. The consideration of Rh (rhesus) type is important in blood transfusion. Each blood group has generally two types of Rh group, viz positive and negative. The same type of Rh is compatible for blood transfusion Opposite type lead to reaction resulting in death of the recipient. These are few examples of multiple alleles Now it is believed that multiple alleles are present almost for all genes.

Multiple alleles in plants

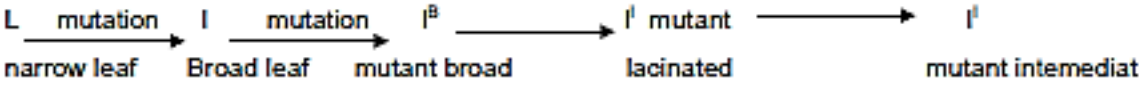
The classical example of multiple alleles in plants is 'self incompatability alleles' which prevents self fertilization.

Multiple alleles in Maize

Multiple allelic series affecting seed color is seen in Maize.



Multiple allele in cotton



For information

- About 30% of the genes in humans are di-allelic, that is they exist in two forms.
- About 70% are mono-allelic, they only exist in one form and they show no variation.
- A very few are poly-allelic having more than two forms.

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