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Topic: Multiple Alleles

Multiple Alleles

Multiple Alleles:

The word allele is a general term to denote the alternative forms of a gene or contrasting gene pair that denote the alternative form of a gene is called allele.

Three or more kinds of genes occupying the same locus in individual chromosome are referred to as multiple alleles. In short many alleles of a single gene are called “multiple alleles.”

Characteristics of Multiple Alleles:

1. The study of multiple alleles may be done in population.

2. Multiple alleles are situated on homologous chromosomes at the same locus.

3. There is no crossing over between the members of multiple alleles.

4. Multiple alleles influence one or the same character only.

5. Multiple alleles never show complementation with each other.

6. The wild type (normal) allele is nearly always dominant while the other mutant alleles in the series may show dominance or there may be an intermediate phenotypic effect.

7. When any two of the multiple alleles are crossed, the phenotype is of a mutant type and not the wild type.

Examples of Multiple Alleles:

1. Blood Groups in Man:

Several genes in man produce multiple allelic series which affect an interesting and important physiological characteristic of the human red blood cells.

The red blood cells have special antigens properties by which they respond to certain specific components (antibodies) of the blood serum.

The antigen-antibody relationship is one of the great specificity like that between lock and key. Each antigen and its associated antibody has a peculiar chemical configuration.

Landsteiner discovered in 1900 that when the red cells of one person are placed in the blood serum of another person, the cells become clumped or agglutinated.

If blood transfusions were made between persons of two such incompatible blood groups, the transfused cells were likely to clump and shut out the capillaries in the recipient, sometimes resulting in death.

However, such reactions occurred only when the cells of certain individuals were placed in serum from certain other persons. It was found that all persons could be classified in to four groups with regard to the antigen property of the blood cells.

Large numbers of persons have been classified in to these four groups by means of the agglutination test and the distribution of blood groups in the offspring of parents of known blood groups has been studied.

The evidence shows that these blood properties are determined by a series of three allelic genes I^A, I^B and i, as follows:

Blood groups	Genotype
AB	I^AI^B
B	I^BI^B or I^B i
A	I^AI^A or I^A i
O	ii

I^A is a gene for the production of the anti-gin A. I^B for antigen B, and i for neither antigen.

The existence of these alleles in man and the case with which the blood groups can be identified have obvious practical applications in blood transfusion, cases of disputed percentage and description of human populations. The alleles of these genes which affect a variety of biochemical properties of the blood, act in

such a way that in the heterozygous compound I^AI^B, each allele exhibits its own characteristics and specific effect.

The cells of the heterozygote contain both antigens A and B. On the other hand, I^A and I^B both show complete dominance over i, which lacks both antigens.

PARENTS		CHILDREN	
Phenotypes	Genotypes	Phenotypes	Genotypes
O X O	ii X ii	O	ii
O X A	ii X I^AI^A or I^Ai	O, A	ii, I^Ai
O X B	ii X I^BI^B or I^Bi	O, B	ii, I^Bi
O X AB	ii X I^AI^B	A, B	I^Ai, I^Bi
A X A	I^AI^A or I^Ai X I^AI^A or I^Ai	A, O	I^AI^A, ii
A X B	I^AI^A or I^Ai X I^BI^B or I^Bi	A, AB, O, B	I^Ai, I^AI^B, ii, I^Bi
A X AB	I^AI^A or I^Ai X I^AI^B	A, B, AB	I^AI^A, I^Bi, I^AI^B
B X B	I^BI^B or I^Bi X I^BI^B or I^Bi	B, O	I^BI^B, ii
B X AB	I^BI^B or I^Bi X I^AI^B	A, B, AB	I^AI^A, I^BI^B, I^AI^B
AB X AB	I^AI^B X I^AI^B	A, B, AB	I^AI^A, I^BI^B, I^AI^B

Table showing possible blood types of children from parents of various blood groups.

2. Rhesus Blood Group in Man:

A very interesting series of alleles affecting the antigens of human blood has been discovered through the work of Landsteiner, Wiener, Race, Levine, Sanger, Mourant & several others.

The original discovery was that the red cells are agglutinated by a serum prepared by immunizing rabbits against the blood of Rhesus monkey.

The antigen responsible for this reaction was consequently called as Rhesus factor and the gene that causes this property was denoted as R-r or Rh-rh.

It was found that the infants suffering from this anaemia are usually Rh-positive and so are their fathers; but their mothers are Rh-negative.

The Rh^+ foetus developing in the uterus of an Rh^- mother causes the formation of mother's blood stream of anti Rh- antibodies.

These antibodies, especially as a result of a succession of several Rh^+ pregnancies, gain sufficient strength in the mother's blood so that they may attack the red blood cells of the foetus.

The reaction between these antibodies of the mother and the red cells of her unborn child provokes haemolysis and anaemia (Erythroblastosis fetalis). this may be serious enough to cause the death of the newborn infant or abortion of the foetus.

The blood stream of a mother who has had an erythroblastotic infant is a much more potent and convenient reagent than sera of rabbits, immunized by blood of rhesus monkeys for testing the blood of other persons to distinguish Rh^+ from Rh^- individuals.

There are several different Rh antigens which are detected by specific antisera. Thus; an Rh^- woman immunized during pregnancy by the Rh^+ children may have in her blood serum antibodies that agglutinate not only Rh+ red cells but also cells from a few persons known to be Rh^-.

By selective absorption two kinds of antibodies may be separated from such a serum, one known as anti-D which agglutinates (= coagulates) only Rh^+ cells, the other known as anti-C which agglutinates particular rare types of Rh^- .

Another specific antibody, known as anti-c agglutinates all cells that lack C. With these three antisera, six types of blood can be recognized.

Studies of parent and children show that persons of type Cc are heterozygous for an allele C determining C antigen. CC persons are homozygous

for C and cc are homozygous for c. There is obviously no dominance, each allele producing its own antigen in the heterozygote as in the AB blood type.

No anti serum is available for detecting d; the alternative to D. D^+ persons may be heterozygous or homozygous. However, the genotypes of such persons may be diagnosis from their progeny; for example D^+ person who has a d^- child is thereby shown to be Dd.

Two other specific antibodies, anti-E and anti-c have been found. These detect the antigens E and e determined by a pair of alleles E and e.

The three elementary types of antigens C-c, D and E-e, occur in fixed combinations that are always inherited together as alleles of a single gene.

Wiener and Fisher showed the existence of a series of eight different alternative arrangements of these three types of Rh antigens and expressed them by means of following symbols.

The Rh System of Alleles:

Fisher's symbols	Wiener's symbols	
CDE	R^z	Rh-Positive
CDe	R^1	
cDE	R^2	
cDe	R^0	
CdE	r^Y	Rh-Negative
Cde	r'	
cdE	r''	
cde	r	

Thus, allelism is determined by cross-breeding experiments. If one gene behaves as dominant to another the conclusion is that they are alleles and that they occupy identical loci in homologous chromosomes when two genes behave as dominant to other gene.

They should occupy identical loci in the chromosome. When more than a pair of alleles occurs in respect of any character in inheritance the phenomenon is known as multiple allelism.

There is not much difference between the two theories of Wiener and Fisher. Wiener opinion is that there are multiple variations of one gene whereas according to the view of Fisher three different genes lying very close together are responsible for differences.

Importance of Multiple Allelism:

The study of multiple alleles has increased our knowledge of heredity. According to T.H. Morgan a great knowledge of the nature of gene has come from multiple alleles. These alleles suggest that a gene can mutate in different ways causing different effects.

1. Pseudo alleles:

Alleles are different forms of the same gene located at the corresponding loci or the same locus.

Sometimes it has been found that non-homologous genes which are situated at near but different loci affect the same character in the same manner as if they are different forms or alleles of the same gene.

They are said as pseudo alleles. These pseudo alleles which are closely linked show re-combinations by crossing over unlike the alleles.

2. Penetrance and Expressivity:

Simply a recessive gene produces its phenotypic effect in homozygous condition and a dominant gene produces its phenotypic effect whether in homozygous or heterozygous condition.

Some genes fail to produce their phenotypic effect when they should. The ability of a gene to produce its effect is called penetrance.

The percentage of penetrance may be altered by changing the environmental conditions such as moisture, light intensity, temperature etc.

A gene that always produces the expected effect is said to have 100 percent penetrance. If its phenotypic effect is produced only 60 percent of the individuals that contains it then it is said to show 60 percent penetrance.

In Gossypium a mutant gene produces crinkled leaf. While all the leaves produced in the normal season are crinkled but some of the leaves which are produced late in the season do not show this character and are normal.

It represents that penetrance is zero or in other words the gene is non-penetrant.

3. Isoalleles:

Sometimes, a dominant gene occurs in two or more forms. These multiple dominant alleles will produce the same phenotypic effect in homozygous condition but their effect will show a small difference in heterozygous state.

In Drosophila, the gene for red eye colour is dominant over white.

The red gene will produce dark red colour in the homozygous condition but in combination with the white allele the gene for red colour produces a dark red colour in flies from Soviet Russia but the same combination in the flies coming from the U.S.A. produces a light red colour.

It does mean that dominant gene for red colour occurs in two forms. These are said as isoalleles.

4. Xenia:

The immediate effect of foreign pollen on visible characters of the endosperm is called xenia. The 'xenia' term was given by Focke (1800).

This has been studied in maize plant. If a white endosperm variety is open pollinated in the field where there are also plants of the yellow endosperm variety then the cobs that develop will contain a mixture of yellow and white seeds.

The yellow colour of the endosperm in the yellow seeds is the result of fertilization by pollen from the yellow variety. The yellow colour indicates that the seeds are hybrids and the white seeds are homozygous.

The yellow colour of the endosperm is dominant over white and when the plants raised from the yellow seeds are self-pollinated, yellow and white seeds are produced in the ratio of 3:1.

Another example of xenia may be exemplified. If a sweet corn (maize) is pollinated by a starchy variety, the endosperm is starchy because the starchy gene introduced by the pollen is dominant over its sugary allele.

5. Metaxenia:

It is the term used to describe the effect of foreign pollen on other tissues belonging to the mother plant, outside the endosperm and embryo. It is sometimes evident in the fruit and seed coats.

In cucurbitaceous fruits, the skin colour is affected by the pollen grains; in oranges, the colour and flavour of the fruit is influenced by the pollen parent.

The same is true of fuzziness and hair length in cotton. It has been suggested that metaxenia effects may be due to certain hormones secreted by the endosperm and embryo.