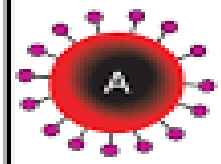
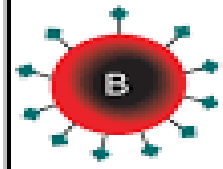
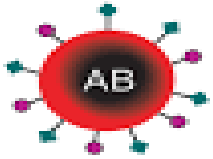
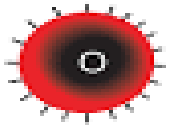
## ***LAB – 5 -***

# ***Multiple Alleles***

An allele is a gene type which affects certain characteristics of an organism; each gene usually have only two possible alleles dominant or recessive (A and a). Multiple alleles therefore are more than three alleles contained in one gene (A, a, A1, A2, A', etc.). A good examples of multiple alleles are the blood groups in human and rabbit fur color which are determined by a single gene with a series of alleles, each resulting in different trait.

## ***1- Blood groups and Rhesus factor (Rh) in human***

The discovery of human blood groups was reported by Dr. Karl Landsteiner in 1900.Landsteiner's work led to the establishment of the Abo system used to group human blood into different types, based on the presence or absence of certain markers on the surface of red blood cells. The four main blood types are A, B, O, and AB. The basis for the four blood groups is the presence of naturally occuring antigens and antibodies in the blood of individuals in various combinations. In the ABO blood groups the factors that determine the antigens and antibodies are inherited, the antigen appearing in the progeny only if present in at least one parent. The two antigens that were discovered by Landsteiner are called A and B and are found on the surface of the erythrocytes. The antibodies are found in the serum and they are known as anti-A and anti-B. The antigens determining the four blood groups are the result of the expression of three alleles A, B and O; the first two being dominant to O.

| | Group A | Group B | Group AB | Group O |
|---|---|---|---|---|
| Red blood cell type |   |   |   |   |
| Antibodies in Plasma |  Anti-B |  Anti-A | None |  Anti-A and Anti-B |
| Antigens in Red Blood Cell |  A antigen |  B antigen |  A and B antigens | None |

The blood group A and B show the codominance inheritance which means that both the A allele and the B allele are equally expressed. Thus only four phenotypes (A, B, AB, and O) can be recognized, although six genotypes occur as illustrated in this table .

| **genotype** | **Phenotype** |
|---|---|
| $I^AI^A$ $I^Ai$ | A |
| $I^BI^B$ $I^Bi$ | B |
| $I^AI^B$ | AB |
| ii | O |

**<u>** Which is the Universal donor? What is the condition required to be a universal donor?</u>**

Blood group O is considered as Universal donor.The condition required is that the blood group is without any antigens on RBC to react with antibodies of plasma of other blood groups.O group is without any antigens on RBC, so it is considered as universal donor.

**** Which is the Universal recipient? What is the condition required to be a Universal recipient?**

Blood group AB is considered as Universal recipient. Any blood group without antibodies in the plasma to react with the antigens of the donor is

considered as universal recipient. AB group is without any antibodies in plasma. Hence AB is considered as universal recipient.

**** Why is the determination of the blood types of the donor and of the recipient important in transfusions?**

Red blood cells have different antigens in the outer surface of their plasma membrane; for example, the antigens A and B of the ABO system are glycoproteins of the membrane. If a donor has red blood cells with antigens not present in the red blood cells of the recipient (lacking of transfusion compatibility) the immune system of the recipient recognizes these molecules as actual antigens (i.e., foreign substances) and triggers a defense response producing specific antibodies against those antigens. The transfused red blood cells then are destroyed by these antibodies and the recipient individual may even die.

** **What is the basis and method of blood group testing?**

The ABO phenotype of any individual is ascertained by mixing a blood sample with antiserum containing anti-A or anti-B;

_ If a clump is formed with anti-A the blood is of 'A' type.

_ If the clump is formed with anti-B, the blood is of 'B' type.

_ If the clump is formed with both anti A and anti-B antibodies, the blood is 'AB' type.

_ If no clump is produced with either of the antibodies, the blood is of 'O'type

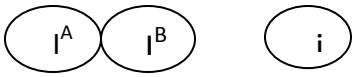
**** What is the genetic basis of blood types in ABO system in man?**

Genetical basis for blood types is due to the presence of three types of alleles $I^A$, $I^B$, $I^O$. It was explained by Bernstein.

**There are many other blood grouping systems known in addition to the ABO series; for example the N and M series and the well known Rh+ and Rh- groups.**

**EXAPLE/** What is the probability that a couple whose blood types are AB and O will have a type A child?

**$I^AI^B$ X ii**




**$I^Ai$ 50% , $I^Bi$ 50%**

## ***Rhesus factor (Rh)***

Rh is a type of antigen. It was first detected in the RBC of Rhesus monkey and later in man. Rh antigen (D) is present in the persons who are considered as Rh positive. Rh antigen is absent in the persons who are considered as Rh negative.

| **Reaction with Ab** | **Ab** | **Ag** | **genotype** | **phenotype** |
|---|---|---|---|---|
| + | absent | D | RhRh, Rhrh | $Rh^+$ |
| - | absent | absent | rhrh | $Rh^-$ |


## ***MN blood system***

The MN blood system is a third (in addition to the ABO and the Rh) system of blood antigens also related to proteins of the red blood cell plasma membrane. The inheritance pattern of the MN blood system is autosomal with codominance, a type of lack of dominance in which the heterozygous manifests a phenotype totally distinct from the homozygous. The possible phenotypical forms are three blood types:

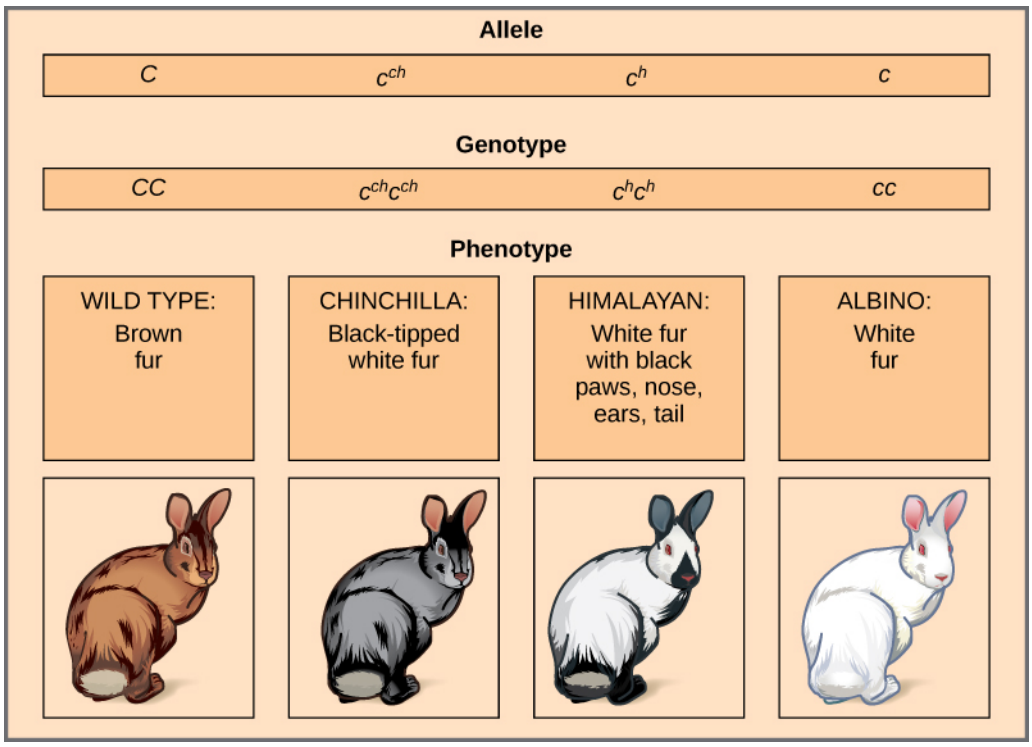
type M blood (MM)

type N blood (NN)

type MN blood (MN)

## 2- Fur color in rabbits

Fur color in rabbits is inherited as a series of multiple alleles. In the case of rabbits, there are four alleles and each one is expressed with a different phenotype. Look over the summary table below:




$$C > c^{ch} > c^{h} > c$$

**EXAMPLE/** Suppose you cross a chinchilla rabbit ($c^{ch}c^{h}$) with a dark graywh rabbit ($Cc^{h}$). What are the possible offspring?

$Cc^{h}$ X $c^{ch}c^{h}$

C $c^{h}$ $c^{ch}$ $c^{h}$

genotype ratio: 1 $Cc^{ch}$ : 1 $Cc^{h}$ : 1 $c^{ch}c^{h}$ : 1$c^{h}c^{h}$

phenotype ratio: 2 dark gray : 1 chinchilla: 1 Himilayan

**EXAMPLE/** What happens when you cross a dark gray (Cc) and a white rabbit?

genotype ratio: _____

phenotype ratio: _____

**EXAMPLE/** A chinchilla rabbit is mated with a Himilayan. Some offspring are white.What are the parent genotypes?

genotype ratio: _____

phenotype ratio: _____

**EXAMPLE/** Would it be possible to obtain white rabbits if one rabbit is white and the other is chinchilla?

genotype ratio: _____

phenotype ratio: _____

**EXAMPLE/** Would it be possible to obtain Himilaya rabbits if one rabbit is $Cc^{ch}$ and the other is $c^{h}c$?

genotype ratio: _____

phenotype ratio: _____

**EXAMPLE/** A type B woman whose mother was type O marries a type O man. What are the possible phenotypic ratios of their offspring?

**EXAMPLE/** A type A woman whose father was type B marries a type B man whose mother was type A. What are the possible phenotypes of their offspring?

**EXAPLE/** What is the probability that a couple whose blood types are AB and O will have a type A child?

**EXAMPLE/** A woman who has heterozygous type A blood has a baby with type O blood. The man she claims is the father of the child says he is not. If he has type AB blood, could he be the father of the child? Prove your answer.

Blood group of woman is ‘A’ $I^Ai$
Blood group of child is ‘O’ ii
Blood group of man is ‘AB’ $I^AI^B$
If woman is ‘A’ and the man ‘AB’ the genotypes of their children will have the blood groups either A or AB or B, but not O. So the said person is not the father of the child.

**Example/** If mother is with O group and father with A blood group (homozygous). What is the genetic probability of their children being O or A for their blood group?

When the mother is O group with ii genotype which is recessive and father is homozygous A group with $I^AI^A$ genotype which is dominant all their children are A group with $I^Ai$ . But O group is not possible.

**EXAMPLE/** A Rh positive woman, whose father is Rh negative, marries a Rh negative man. Isthere any possibility that their child be a Rh negative?
Ans. Yes, there is a possibility of having Rh negative child.
The woman is Rh positive (Rh +ve), but her father is (Rh –ve). So the genotype of the
woman is heterozygous Rhrh , Man is Rh –ve (rhrh)

Rhrh X rhrh
Rh rh rh
Rhrh, rhrh

So there is 50% chance of having Rh –ve (rhrh) child.

**EXAMPLE/** A woman with type O blood and a man who is type AB have are expecting a child. What are the possible blood types of the kid?
The child blood group either A or B but not be O.

**EXAMPLE/** What are the possible blood types of a child whose parents are both heterozygous for B blood type?
The possible blood types of a child is :
B blood type = 3 ; O blood type = 1

**EXAMPLE**/ What are the chance of a woman with type AB and a man with type A having a childwithtype O?
No chance for the blood type O in progeny

**EXAMPLE**/ Determine the possible genotypes and phenotypes with respect to blood type for acouple who's blood types are homozygous A and heterozygous B.
Male is $I^AI^A$, Female is $I^Bi$. Both are crossed, thenThe possible genotype and phenotypes among the progeny is :
50% blood type = AB $I^AI^B$
50% blood type = A $I^Ai$

**EXAMPLE/** Jill is with blood type O. She has two older brothers with blood types A and B. What are the genotypes of her parents with respect to this trait?
Jill blood type O, 2 brothers blood type A and B, then
The genotypes of her parents are $I^Ai$ (Male) $I^Bi$ (Female)

**Example/** A test was done to determine the biological father of a child. The child's blood type is A and the mother's is B. Dude # 1 has a blood type of O and Dude # 2 has blood type AB. Which Dude is the biological father?
Dude # 1 blood type 'O' Dude # 2 blood type 'AB'
Dude # 2 is the biological father of AB.

**EXAMPLE/** One parent is A blood type and the other parent is B blood type. Give their respectivegenotypes if they produce a large number of children whose blood types are :
(1) All AB (2) Half AB and other half B
(3) Half AB and other half A (4) 1/4 AB, 1/4 A, 1/4 B, 1/4 O
(1) **If both the parents are homozygous then all the children will be AB.**
$I^AI^A$ X $I^BI^B$
AB
All will be AB
(2) **If A homozygous and B is heterozygous.**
$I^AI^A$ X $I^Bi$
$I^AI^B$, $I^Ai$
Half AB and other half A
(3) **If B is homozygous and A is heterozygous.**
$I^Ai$ X $I^BI^B$
$I^AI^B$, $I^Ai$
Half AB and other half B
(4) **If both the parents are heterozygous, then**
$I^Ai$ X $I^Bi$
$I^AI^B$, $I^Ai$, $I^Bi$, ii
1/4 AB, 1/4 A, 1/4 B, 1/4 O

**EXAMPLE/** A case was brought before a judge in which a woman of blood group O presented a baby with blood group O which she claims her child ; and brought it against a man of blood group AB whom she claimed was the father of the child. What bearing might the blood type information have on the case?

Blood group of woman is ‘O’

Blood group of child is ‘O’

Blood group of man is ‘AB’

If woman is ‘O’ and the man ‘AB’ the genotypes of their children will have the blood groups either A or B, but not O. So the said person is not the father of the child.

**EXAMPLE/** A woman has blood type A MM. She has a child with blood type AB MN. Which of theollowing blood types could not be that of the child’s father? Explain your reasoning.

George O NN

Tom AB MN

Bill B MN

Claude A NN

Henry AB MM

The child’s blood type has a B allele and an N allele that could not have come from the mother and must have come from the father. Therefore, the child’s father must have a B and an N. George, Claude, and Henry are eliminated as possible fathers because they lack

either a B or an N.