SINGLE GENE INHERITANCE

Basic terminologies

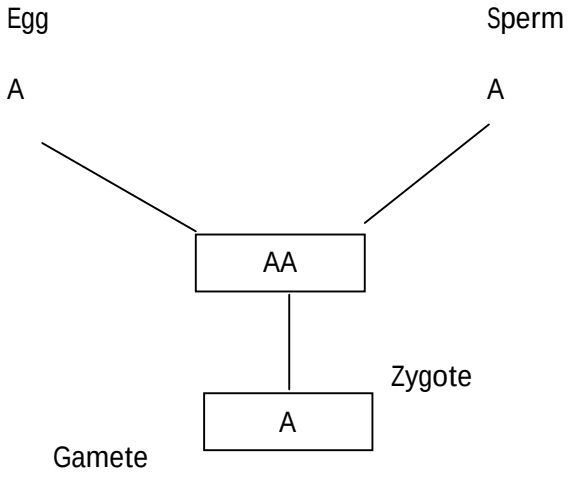
1. **Phenotype**: a distinctive trait possessed by an organism or the appearance or discernible character of an individual is called a phenotype. The trait may be visible to eye or it may require special tests for its identification. The phenotype is the result of gene products brought to expression in a given environment.
2. **Genotype**: the genetic make-up of an individual is called the genotype. For example, if two gametes say A1 and A2, the offspring that will result will have genotype A_1A_2 or if egg produces A and sperm produces A, the zygote that will result will have genotype AA i.e. A x A AA

Genotype may be classified into (i) homozygous genotype and (ii) heterozygous genotype

HOMOZYGOUS GENOTYPE

The union of gametes carrying identical alleles produces a homozygous genotype. A homozygote produces only one kind of gamete. For example, if the two uniting gametes from egg and sperm are A and A. The zygote resulting from this will be a homozygous genotype

i.e.



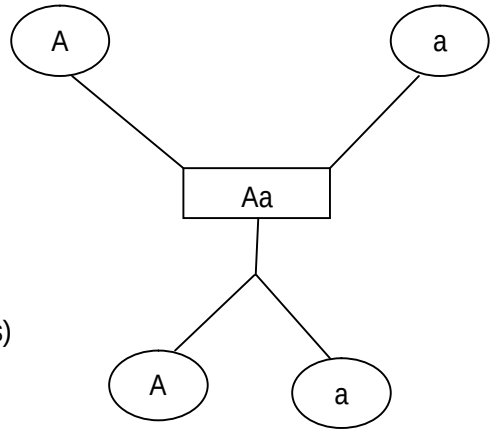
And the gamete possible from the homozygous genotype is A

HETEROZYGOUS GENOTYPE

The union of gametes carrying different alleles produces a heterozygous genotype, and different gametes are produced by a heterozygote.

Example

Uniting gametes, say egg (A) and sperm (a) i.e



Zygote (heterozygous)

Possible gametes are

3. Gene: the basic unit of inheritance is the gene

4. Alleles: the alternative form of the gene is called the allele. There are two common types of alleles and these are:

(i) Wild-type or Normal allele

(ii) Mutant allele or abnormal trait

The wild-type can also be designated as normal alleles. The allele that occurs most frequently in a population is usually referred to as wild type or normal and this allele is usually dominant. As a result of mutation i.e. a sudden change in gene function or conformation, there is alternation or loss of the specific wild type function and new allele are formed. The new allele arising as a result of mutation of the wild (normal) type is called the **mutant allele.**

SYMBOLS FOR ALLELES

To discriminate between wild type and mutant alleles, a system is often used. In this system, the initial letter of the name of the mutant trait is recessive, the lower case letter(s) is used. If it is dominant, the upper case letter is used. The contrasting wild type trait is denoted by the same letter, but with "+" as a superscript.

For example, ebony is a recessive body colour mutation in fruit fly (Drosophila melanogaster). The normal wild type body is gray using the above system, ebony by the symbol e, while gray is denoted e^+.

With ebony mutation as an example, the responsible locus may be occupied by either wild type allele (e^+) or mutant allele (e). A diploid fly may thus exhibit three possible genotypes as follows:

e^+/ e^+: Gray homozygote (i.e. wild type allele),

e^+/e : gray heterozygotes (wild type),

e/e : ebony homozygote (mutant allele).

The "slash" is used to indicate that the two allele designations represent the same locus on two homologous chromosomes. Also, if a dominant such as wrinkled (Wr), the three possible designations would be:

Wr^+/Wr^+

Wr^+/Wr and

Wr/Wr

The advantage of this system is that further abbreviation may be used when convenient. The wild type allele can simply be denoted by the + symbol using **ebony** as an example under consideration in a cross. The three designations genotypes can also be written as:

+ / +: gray homozygote (wild type)

+ / e: gray heterozygote (wild type)

e / e: ebony homozygote (mutant allele)

Also for wrinkled, we have similar results as follows:

+/+

+/Wr

Wr/Wr

This system described above works well with alleles which are either dominant or recessive to one another. If there is no dominance, we may simply use the upper case letters and superscript to denote alleles. e.g.

R^1 and R^2 or L^M and L^N or IA and I^B.

ALLELIC RELATIONSHIPS

Possible allelic relationships are:

1. Dominant and recessive alleles
2. Incomplete dominance
3. Co-dominant or intermediate alleles
4. Lethal alleles
5. Multiple alleles

DOMINANT AND RECESSIVE ALLELES

The allele which can phenotypically express itself in the heterozygote as well as in the homozygote is called a dominant factor, and whenever one of a pair of alleles can come to phenotypic expression only in a homozygous genotype we call that allele a recessive factor.

Upper case and lower case letters are commonly used to designate dominant and recessive alleles respectively.

Usually, the genetic symbol corresponds to the first letter in the name of the mutant (abnormal) trait is used. For example, lack of pigment deposition in the human body is an abnormal recessive trait called **albinism.** Using A to represent the dominant (normal) allele and "a" to represent recessive (albino), three possible genotypes and two phenotypes are possible, i.e.

Genotypes	**Phenotypes**
AA (homozygous dominant)	Normal pigment
Aa (heterozygous)	Normal pigment
aa (homozygous recessive)	Albino (no pigment)

If the mutant gene is recessive, the symbol would be a lower case letter(s) corresponding to the initial letter(s) in the name of the trait. Its normal wild-type dominant allele would have the same lower case letter but a + as superscript. For example, black body colour in fruit fly is governed by a recessive gene b, and the wild type (gray body) is dominant allele b^+.

If the mutant trait is dominant the base symbol would be an upper case letter without a superscript. e.g. lobe shaped eyes in Drosophila (fruit fly) are gene L and wild type (oval eye) by its recessive allele L+.

Here, we need to remember that the case of the symbol indicates the dominance or recessive of the mutant allele to which the superscript + for wild type must be referred. After the allelic relationships have been defined, the symbol + by itself may be used for wild type and the letter alone may designate mutant type.

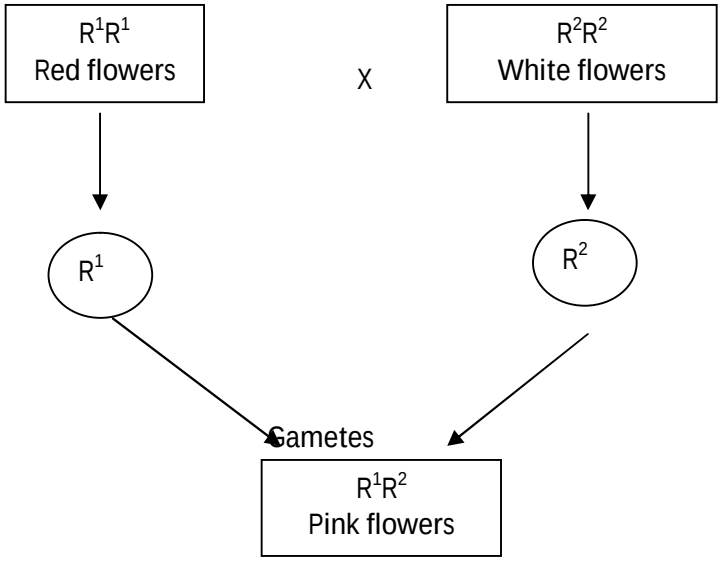
PARTIAL OR INCOMPLETE DOMINANCE

When two parents with contrasting traits are crossed or mated and in the offspring produced, neither of the parental traits masked the other, then we say that incomplete or partial dominance had occur. Incomplete or partial dominance in the offspring is based on the observation of intermediate phenotypes generated by a cross between parents with contrasting traits. For example, if plants with red flowers are crossed with another with white flowers, and the offspring produced have pink flowers. It appears that neither red nor white flower colour is dominant.

Since some red pigment is produced in the F_1 intermediate coloured pink flowers, dominance appears to be incomplete or partial.

If the resulting F_1 of the above cross are further crossed *inter se* (i.e. selfing) i.e. $F_1 \times F_1$, the resulting F_2 generation will give a genotypic ratio of (1:2:1) showing that only one pair of allele determines these phenotypes. The genotypic ratio (1:2:1) of the F_2 generation is identical to that of Mendel's monohybrid cross.

The crossing describe above can be represented as follows:



F_1

and for F_2 generation, we have:

F_1 vs. F_1 above. i.e.

F_1 / F_1	R^1	R^2
R^1	R^1R^1	R^1R^2
R^2	R^1R^2	R^2R^2

Therefore, proportion of red flower in the Punnett square above is

$\frac{1}{4}R^1R^1 = 0.25\ R^1R^1$ red flower,

and

$^2/_4\ R^1R^2 = \frac{1}{2}\ R^1R^2 = 0.50R^1R^2$ = pink flower

and

$\frac{1}{4}\ R^2R^2 = 0.25R^2R^2$ = white flower

Therefore, the genotypic ratios are: 0.25: 0.50: 0.25 → 1:2:1

Because there is no dominance, however, the phenotypic ratio is identical to the genotypic ratio, and since neither of the alleles is recessive, it is not necessary to use upper or lower case letters and hence the reason for using R^1 and R^2 to represent red and white alleles. It is also possible to use other designations such as W^1 and W^2 or C^R and C^W where 'C' represents colour.

CODOMINANT OR INTERMEDIATE ALLELES

Alleles which lack dominant and recessive relationships may be called intermediate or co-dominant alleles. This means that each allele is capable of some degree of expression when in the heterozygous condition. The heterozygous genotype gives rise to a phenotype distinctly different from either of the

homozygous genotypes. Usually, the heterozygous phenotype resulting from co-dominance is intermediate in character between those produced by the heterozygous genotypes.

SYMBOLISM FOR CO-DOMINANT ALLELES

For co-dominance or intermediate alleles, all upper case base symbols with different superscripts are used. The upper case letters shows that each allele can express itself to some degree even when in the presence of its alternative allele or heterozygous.

A good example of this is the MN-blood group in humans. The alleles governing the MN blood group system in humans are co-dominant and may be represented by the symbols L^M and L^N. The base letter (L) being assigned in honour of its discoverers (**Karl Landsteiner and Philip Levine**). An individual may exhibit either one or both of them. The MN system is under the control of an autosomal locus found on chromosome 4 and two alleles designated L^M and L^N. Because humans are diploid, three combinations are possible, and each resulting in distinct blood type.

Genotype	**Phenotype/Blood group**
L^ML^M	M
L^ML^N	MN
L^NL^N	N

A mating between two MN parents may produce children of all three blood types i.e.

$L^ML^N \times L^ML^M$

Female/Male	L^M	L^N
L^M	L^ML^M	L^ML^N
L^N	L^ML^N	L^NL^N

From the table above, proportion of L^ML^M = ¼ = 0.25, and

L^ML^N = $^2/_4$ = ½ = 0.50, and

L^NL^N = ¼ = 0.25

From the Punnett square above, we have ¼ L^ML^M or $0.25L^ML^M$

½L^ML^N or $0.50L^ML^N$

And ¼L^NL^N or $0.25L^NL^N$

Co-dominance results in distinct evidence of the gene products of both alleles. Individual expression of each allele is apparent.

Example I:

Coat colour of the Shorthorn breed of cattle represents a classical example of co-dominance allele. Red is governed by the genotype C^RC^R, roan (mixture of red and white) by C^RC^W, and white by C^WC^W.

a. When roan Shorthorns are crossed among themselves, which genotypic and phenotypic ratios are expected among their progeny?
b. If red shorthorns are crossed with roans and the F1 progeny are crossed among themselves to produce the F2, what percentage of the F2 will probably be roan?

Solution

Given genotypes are

Red = C^RC^R

Roan = C^RC^W

White = C^WC^W

a. Roan x Roan = C^RC^W x C^RC^W, using Punnett square:

Female/Male	C^R	C^W
C^R	C^RC^R	C^RC^W
C^W	C^RC^W	C^WC^W

The F_1 produced from the table when roans are crossed themselves gives $¼C^RC^R$, $½C^RC_W$ and $¼C^WC^W$ or $0.25C^RC^R$, $0.50C^RC^W$ and $0.25C^WC^W$.

The phenotypic ratio will be $0.25C^RC^R$, $0.50C^RC^W$ and $0.25C^WC^W$ = 1:2:1

Therefore, the phenotypic ratio 1:2:1, corresponds to the same genotype ratio.

b. Red x roam = C^RC^R x C^RC^W. Then using Punett square for the crossing:

	C^R	C^R
C^R	C^RC^R	C^RC^R
C^W	C^RC^W	C^RC^W

Form the table above, we have

2/4 C^RC^R = ½ C^RC^R

and

2/4 C^RC^W = ½ C^RC^W

:. The F1 from the table above is ½ C^RC^R: ½ C^RC^W

To produce F2, the F1 can be mated *inter se* or when there is selfing we have:

F1 x F1

i.e. male

	(1) ½ C^RC^R (M)	½ C^RC^W(M)
½ C^RC^R (F)	(1) ¼ C^RC^R(F) x C^RC^R(M)	(2) ¼ C^RC^R (F) x C^RC^W (M)
½ C^RC^W(F)	(2) ¼ C^RC^W(F) x C^RC^R(M)	(3) ¼ C^RC^W (F) x C^RC^W (M)

Note:

The m and f are only used to indicate male and female involved in the crossing.

From the table above, three types of matings are possible for the production of F2. There relative frequencies of occurrence may be calculated using the mating table. The 1, 2, and 3 in the table shows the type of matings possible.

1. Is the mating of $C^RC^R_F$ x $C^RC^R_{(m)}$ (i.e. red x red) produces only red C^RC^R progeny, but only one-quarters of all matings are of this type. Therefore, only ¼ of all the F2 should be red from this source.
2. The matings C^RC^W x C^RC^R i.e. roan female x red male are expected to produce ½ C^RC^R (red) and ½ C^RC^W (roan) progeny. Half of all matings are of this kind. Therefore ½ x ½ = ¼ of all the F_2 progeny should be red and ¼ should be roan from this source.
3. The mating C^RC^W (female) x C^RC^W (male) i.e. roan x roan is expected to produce ¼C^RC^R (Red), ½C^RC^W (Roan), and ¼C^WC^W (white) progeny. This mating type constitutes ¼ of all crosses. Therefore, the fraction of all F2 progeny contributed from this source is ¼ x ¼ = 1/16 C^RC^R, ¼ x ½ = 1/8 C^RC^W and ¼ x ¼ = 1/ 16 C^WC^W.

LETHAL ALLELES

The phenotypic manifestation of some genes causes the death of individual either in the pre-natal or post-natal period prior to maturity. Such factors are called **lethal genes**.

A fully dominant lethal allele is one which kills in both the homozygous and heterozygous conditions and occasionally arises by mutation from normal allele. Individuals with a dominant lethal die before they can leave progeny.

Recessive lethal kill only when homozygous and may be of two kinds viz:

a. One which has no obvious phenotypic effect in heterozygotes and
b. One which exhibits a distinctive phenotype when heterozygous

Example:

A completely recessive lethal (l) can sometimes be identified in certain families

Genotype	**Phenotype**
LL, Ll	Normal
ll	Lethal

Or

The amount of chlorophyll in some plants is controlled by an incompletely recessive gene which exhibits a lethal effect when homozygous and a distinctive phenotypic effect when heterozygous.

Genotype	**Phenotype**
CC	Green (normal)
Cc	Pale green
cc	White (lethal)

Example II:

The absence of legs in cattle (amputated) has been attributed to a completely recessive lethal gene. A normal bull is mated with a normal cow and they produce an amputated calf usually dead at birth. The same parents are mated again.

a. What is the chance of the next calf being amputated?

b. What is the chance of these parents having two calves, both of which are amputated?

Solution

If phenotypically normal parents produce an amputated calf, they must both be genetically heterozygous i.e.

Aa x Aa

Normal Normal

Therefore this crossing will produce

	A	**a**
A	AA (normal)	Aa (normal)
a	Aa (normal)	aa (amputated)

Therefore, from the table above, we would have

¼ AA, 2/4 or ½ Aa and ¼ aa

Total normal = ¼ AA + ½ Aa = ¾ normal and ¼ amputated (dies). This means that there is a 25% chance of the next offspring being amputated.

b. The chance of the first calf being amputated and the second calf also being amputated is the product of the separate probabilities i.e.

¼ x ¼ = 1/16

In some case, the allele responsible for a lethal effect when homozygous may result in distinctive mutant respect to the phenotype. An example of this can be seen clearly when agouti mice are crossed. Crosses between the various combinations of the two strains yielded unusual results.

For example

Cross A = Agouti x agouti

(AA) x (AA) → All agouti

A x A = AA = F_1

Result of cross A is that all F1 are agouti (AA) and they will survive.

Cross B, yellow mice x yellow mice = 2/3 yellow and 1/3 agouti.

i.e

AA^Y x AA^Y

	A	A^y
A	AA (agouti)	AA^Y (yellow)
A^y	AA^y (yellow)	A^YA^Y lethal

From cross B, result of F1 are 2/3 yellow (i.e. AA^y) and 1/3 agouti (AA) but A^YA^Y is lethal and die before birth.

For cross C

Agouti X yellow i.e.

AA x AA^Y

	A	A
A A^Y	AA AA^Y	AA AA^Y

From this table, we have 2/4 AA = ½ AA = ½ agouti and 2/4 AA^Y = ½ yellow.

For cross C, the result is ½ agouti AA and ½ AA^Y yellow all survived.

MULTIPLE ALLELES

Information stored in any gene is extensive and mutations may modify this information in many ways. Each change has the potential of producing a different allele. Therefore, at any given locus (i.e. the position or place on a chromosome occupied by a particular gene or one of its alleles) on the chromosome, the number of alleles within a population of individuals need not be restricted to only two. When three or more alleles are found for any particular gene, the mode of inheritance is called **Multiple allelism.**

The concept of multiple allele refers to a definite group of animals or population not to a single individual which always has only two genotypes of a given series in its genotype.

Common examples of concept of multiple alleles are

i. Coat colour in rabbits
ii. The ABO blood types in humans

COAT COLOUR IN RABBIT

The coat colour of the ordinary or wild type rabbit is referred to as agouti or individual have banded hairs, the portion nearest the skin being gray, succeeded by a yellow band and finally a black or brown tip.

Apart from agouti, the albino rabbit has also been identified. These rabbits are totally lacking in pigmentation. Crosses of homozygous agouti and albino individual produce uniform agouti F1, inter breeding of the F1 produces and F2ratio of 3 agouti: 1 albino. Other individuals, lacking yellow pigment in the coat, have a silvery – gray appearance because of the optical effect of black and gray hairs. This phenotype or type of rabbit is called the Chinchilla. Crosses between chinchilla and agouti produce all agouti individuals in the F1 and a 3 agouti: 1 chinchilla ration in the F2. Therefore, genes determining Chinchilla and agouti appear to be alleles, with agouti being dominant.

If however, the cross chinchilla x albino is made, the F1 are all chinchilla, and the F2 shows 3 chinchilla: 1 albino. Here again genes for chinchilla and albino are also allele and agouti, chinchilla and albino are said to form a multiple allele series. Apart from agouti, chinchilla and albino, another type of rabbit phenotypes common is the Himalayan rabbit. The coat is white except for black extremities on nose, ears, feet and tail. Eyes are pigmented, unlike albino. These four rabbit phenotypes have been identified and the gene symbols often assigned are

agouti C^{+}

Chinchilla C^{Ch}

Himalayan ^{Ch}

Albino c

From several crosses of rabbit types, the following dominance interrelationships or hierarchy has been established:

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

Based on this it is possible to predict F1 and F2 progeny for two crosses and deduce their genotypes.

Phenotypes and their associated genotypes for this series in rabbit are as follows:

Phenotype	**Genotype**
Agouti	$C^{+}C^{+}$, $C^{+}C^{ch}$, $C^{+}c^{h}$, $C^{+}c$
Chinchilla	$C^{ch}C^{ch}$, $C^{ch}c^{h}$, $C^{ch}c$
Himalayan	$c^{h}c^{h}$, $c^{h}c$
Albino	cc

In the table above, ten different genotypes were derived.

THE ABO BLOOD TYPE

The simplest example of multiple alleles is that in which there are three alleles of one gene. This situation exists in the inheritance of the ABO blood types in humans.

Just like the MN blood system, one combination of alleles in the ABO system exhibits a co-dominance mode of inheritance. However, the ABO antigens are distinct from the MN antigens and are under the gene, located on chromosome a. the various blood types different antigens. Antigens molecules upon exposure to antibodies evoke an immune reaction.

Note:

An antigen is any substance usually a protein that causes antibody production when introduced into a living organism while antibody or antibodies is/are Y-shaped protein molecules that acts to neutralize a specific antigen in a living organism.

When a specific antigen meets a proper antibody the two forms a complex and initiate a reaction that tends to destroy the antigen and their carrier. The member of the multiple allelic series of genes can specify whether on not an immune reaction takes place between two systems. The most common blood group difference in humans involves the ABO system.

When the blood of individuals of certain genotypic constitution is mixed, the red blood cells may form clumps or agglutination.

Mixing the blood of two individuals of identical or proper genotypes does not lead to clumping. Agglutination prevents the free flow of blood in the veins and oxygen transfer, therefore, it can cause death.

For example, there will be clumping when individual with blood group A is mixed with B and AB. Similarly blood group B mixed with A and AB will cause clumping.

When O type individual is mixed with A, B and AB there will be clumping

Blood types acceptable for transfusion are

Blood group	**Type acceptable for transfusion**
A	A, O
B	B, O
AB	A, B, O
O	O

At the ABO gene locus three major alleles are known. The O blood type is determined by the homozygosity of the recessive io alleles. Alleles IA and IB are co-dominant. Different designations may be used and for convenience, we can use the symbols IA, IB and IO for the three alleles. The 'I' designation stands for **ISOAGGLUTINOGEN** which is another term for **antigen.**

If we assume that I^A and I^B alleles are responsible for production of A and B antigens and that I^O do not produce any detectable. A or B antigens, the various genotypic possibilities and appropriate phenotype for each on the general characteristics can be written as:

Genotype	Phenotype or blood group	Antigens	Antibodies	Clumping with	Blood type acceptable for transfusion
I^AI^A or	A	A	Anti – B	B, AB	A, O

I^AI^O					
I^BI^B or I^BI^O	B	B	Anti – A	A, AB	B, O
I^AI^B	AB	A, B	Neither	Neither	A, B, O
I^OI^O	O	Neither A nor B antigen	Anti – A and Anti B	A, B, and AB	O

In the table above, it must be noted that alleles I^A and I^B both behaves dominantly to allele I^O, but co-dominantly to each other.

It is possible to test easily that three alleles control ABO blood types by examining potential offspring from many combinations of matings as shown in the table. If we assume heterozygosity, we can predict which phenotypes can occur. The hypothesis that three alleles control ABO blood types in human population is now universally accepted.

MEDICOLEGAL ASPECTS OF THE ABO SERIES

Compatible blood transfusion can be achieved and decisions about disputed percentage more accurately made. The latter cases can occur when newborns are inadvertently mixed up in the hospitals or when it is uncertain whether a specific male is the specific male is the father of a child. In both cases, an examination of the ABO phenotypes as well as other inherited antigens of the possible parents and the child may help to resolve the situation. The table below also demonstrates numeracy cases where it is impossible for a parent of a particular ABO phenotype to produce a child of certain phenotype. The only mating that can result in offspring of all four phenotypes is between two heterozygous individuals, one having the A phenotype and the other having the B phenotype. e.g. crossing I^AI^O x I^BI^O, will produce children having all the blood group A, B, AB and O i.e.

	I^A	I^O
I^B	I^AI^B	I^BI^O
I^O	I^AI^O	I^OI^O

Genotype and phenotypes blood group in this table will be

Genotype	Phenotype / blood group
I^AI^B	AB
I^BI^O	B
I^AI^O	A
I^OI^O	O

On a genetic ground alone, a male or female may be unequivocally ruled out as the parent of a certain child. On the other hand, this type of genetic evidence never proves parenthood.

Potential phenotypes in the offspring of parents with ABO blood type combinations assuming heterozygosity whenever possible

		F_1 phenotypes OR Potential Offspring			
Genotypes	**Phenotypes**	**A**	**B**	**AB**	**O**
I^AI^O x I^AI^O	A x A	¾	-	-	1/4
I^BI^O x I^BI^O	B x B	-	¾	-	¼
I^OI^O x I^OI^O	O x O	-	-	-	All
I^AI^O x I^BI^0	A X B	¼	¼	¼	¼
I^AI^O X I^AI^B	A x AB	½	¼	¼	-

I^AI^O x I^OI^O	A x O	½	-	-	½
I^BI^O x I^AI^B	B x AB	¼	½	¼	-
I^BI^O x I^OI^O	B x O	-	½	-	½
I^AI^B x I^OI^O	AB x O	½	½	-	-
I^AI^B x I^AI^B	AB x AB	¼	¼	½	-

How to calculate number of genotypes when numbers of alleles are known

The number of genotypes within alleles present in the series can be expressed at anytime by using the following formula:

$$N = \frac{n^2 + n}{2}$$

where, N = Number of genotypes from a given number of alleles (n)

A single pair of alleles at a given locus produces three genotypes. By the same token, a series of multiple alleles produce six genotypes. It must therefore be noted that as the number of genes in a series of multiple alleles increase, the variety of genotype rise still more rapidly

Example

Number of alleles in series (n)	Number of genotypes (N)
n = 2	$\frac{2^2 + 2}{2} = 3 = N$
n = 3	$\frac{3^2 + 3}{2} = 6 = N$
n = 4	$\frac{4^2 + 4}{2} = 10 = N$

n = 5	$\frac{5^2 + 5}{2} = 15$
n = 6	$\frac{6^2 + 6}{2} = 21$, etc

Study questions and answers on blood type

Example 1: A woman accused of abandoning a baby claims that she never gave birth to any baby. The blood types of the woman and the baby are as follows

Woman	AB	cc	dd	Ee	M
Baby	O	Cc	D	ee	N

Could the woman have born the baby?

Solution

Let us start with the ABO group and see if she could have born a type O baby. The thing to check is whether she could contribute any of genes to the child.

She does not have to contribute all of then, because the father will of course supply gene also. The ABO data show that she is telling the actual truth because an AB woman produces only AI and IB gametes and hence cannot have a type O i.e. I^OI^O child.

The MN data are also supportive because an M woman cannot have N child, she could only have an M or an MN depending on the genotype of the father.

Example II: After delivery in the hospital, there was a mix u of two babies in a maternity ward, both babies and their parents are blood typed. Match each child with its proper parents.

Mother 1	O	Cc	D	Ee	M
Father 1	AB	cc	D	ee	MN
Mother 2	A	cc	dd	ee	N
Father 2	O	CC	D	ee	N
Baby 1	A	Cc	dd	Ee	M
Baby 2	A	Cc	dd	ee	N

Answer:

Couple 1 can have an M or MN baby, but not AB N. Couple 2 has no E value and hence cannot have Ee baby. Thus, baby 1 belongs to couple 1, and baby 2 belongs to couple 2.

Example III:

What blood type could a child born of a type O mother and a type B father?

Solution

Since the mother is type O, the genotype of the mother is then I^OI^O and the genotype of the mother is then I^OI^O and the gamete she could produce is I^O and father is type B blood, the genotype of the father is then I^BI^B or I^BI^O and gamete the father can give is I^B.

∴

I^B x I^O

From father From mother

I^BI^O (child) in F1

Therefore the genotype of the child produced is I^BI^O, meaning that the blood type of the child is B, because B is behaving dominantly in I^BI^O.

Example IV: A woman has a baby and that either of the two men could be its father. The blood group phenotypes of the individuals are

Mother	**O**	**Cc**	**D**	**Ee**	**M**
Child	**O**	**CC**	**D**	**ee**	**M**
Male 1	**A**	**Cc**	**dd**	**EE**	**MN**
Male 2	**B**	**Cc**	**dd**	**Ee**	**N**

Based on these phenotypes, can either male be excluded from paternity? Explain your reasoning.

Solution

Male 1 is excluded because the baby must have received a C allele from its father. Male 2 is equally excluded because the baby must have received an M allele from its father.