S5 BIOLOGY (GENETICS)

SHORT COMINGS OF MENDEL'S LAWS OF INHERITANCE/CONDITIONS UNDER WHICH MENDEL'S LAWS CAN NOT APPLY

(i) Codominance or incomplete dominance.
(ii) When Linkage occurs.
(iii) When Multiple alleles exist.
(iv) When alleles of the genes are located on the same chromosome (genes are linked).
(v) When gene interactions occurs like epistasis and complex genes.
(vi) When Lethal genes exist.
(vii) When environmental factors influence phenotypes.
(viii) When organisms are haploid or polyploids.
(ix) When Mutations occurs.

CODOMINANCE AND INCOMPLETE DOMINANCE

INCOMPLETE DOMINANCE.

This is a condition whereby a gene is neither dominant nor recessive over the other.Thus the F1, offspring are intermediate between the two parents in appearance. For example,

(i) when a red flowered rose plant is crossed with a white flowered one, the offspring produced were pink flowers which are an intermediate colour between white and red. The heterozygous condition produces different phenotypes from the homozygous state of either allele.

(ii) In production of blue Andalusian fowls by crossing pure-breeding black and splashed white parental stocks.

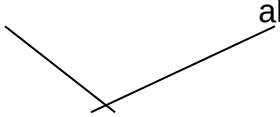
In genetics, genes responsible for incomplete dominance will have both of their alleles represented by capital letters but of different kinds.

EXAMPLE.

In a domestic fowl, a cross between pure breeding black and pure breeding splashed white parental stock fowls, produced F1 offsprings, all were blue Andalusian fowls.
(i) What phenotypes were produced in the F1 offsprings.
(ii) What will be phenotypes of the offsprings when the F1 offsprings interbreed.

(i) Let B represent allele for black coat while W represent allele for white coat.

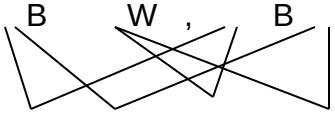
Parents phenotype : Black coat fowl, X White coat fowl
Parents, Genotype : BB WW
Meiosis :
Gametes : all B all W



F1 genotype : BW
F1 Phenotype : Blue coat.

(ii) Selfing the F1 offsprings

Parents, phenotype : Blue coat X Blue coat
Parents, genotype : BW BW
Meiosis
Gametes : B W , B W
Random fertilization,



Genotype of the F2 offsprings, BB BW BW WW
Phenotype of the F2 offsprings : 1 Black, 2 Blue, 1 white

CODOMINANCE.

It is a condition whereby the genes controlling contrasting characteristics are neither dominant nor recessive over each other. The F1 offsprings do not show intermediate characteristic but instead both characteristics of the two pure line parents express itself independently and both characteristics will appear in the offspring. The genetic crosses of incomplete dominance condition is done like for codominance, where the two genes are represented with capital letters of different kinds. Examples of Codominance include,

(i) Coat colour in some breeds of cattle like in a cross between a black bull and a white cow. The F1 offsprings are all roan, they show patches of black and white coat.

(ii) In inheritance of coat colour in cats, where a cross between a cat with black coat with one with a yellow coat, produced all offsprings with tortoise shell coat.

(iii) Inheritance of sickle cell anaemia.

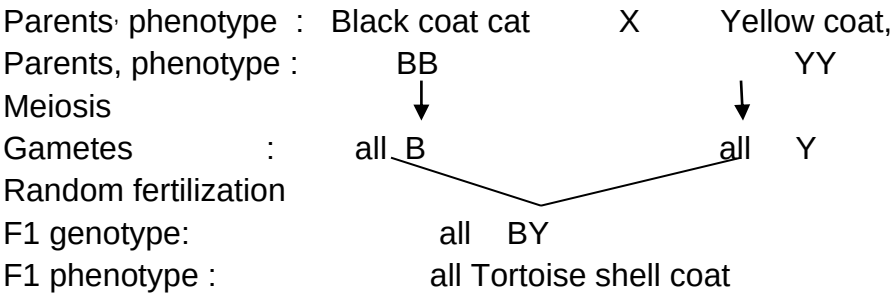
(iv) In human ABO blood group system.

In genetics, genes responsible for codominance will have both of their alleles represented by capital letters but of different kinds just like for incomplete dominance.

EXAMPLE.

Consider (ii) above , where in In inheritance of coat colour in cats, a cross between a cat with black coat with one with a yellow coat, produced all offsprings with tortoise shell coat.

Let B represent allele for black coat, while Y represent the allele for yellow coat.



Give the phenotype ratio of the offsprings when the F1 offsprings are selfed.

EXERCISE

1.In the guinea pig (Cavio) there are two alleles for hair colour, black and white and two alleles for hair length, short and long. In a breeding, experiment, all the F_1 phenotypes produced from a cross between pure breeding, short- black haired and pure breeding long white- haired parents produced offsprings which were short black haired. What will be phenotypes of the F2 offsprings, show your working clearly. Assuming that random and independent assortment of the chromosomes determining colour and length of the hair occurred during meiosis.

2. A cross between long stemmed plant producing red flowers and short stemmed one producing white flowers produced all Offsprings with short stems but producing pink flowers. Determine the phenotype ratio of the Offsprings when the F1 Offsprings are selfed. The genes controlling stem length and flower colour in this plant are not linked. Show your working clearly.

LINKAGE

Linkage is where several genes are carried on the same chromosomes. While linked characters are characteristics controlled by genes carried on the same chromosomes. There are two types of linkages,

(i) Autosomal Llinkage.
(ii) Sex likage.

AUTOSOMAL LINKAGE.

This is where several genes controlling particular characteristics are llocated on same non-sex chromosomes called autosomal chromosome.

Human cells posses 46 chromosomes, these chromosomes form 23 homologous pairs. From the first upto 22nd pairs, are chromosomes that carry genes controlling several body characteristics and they are referred to as autosomal chromosomes. While the 23rd pair of chromosomes are the sex chromosomes. They carry genes that contol secondary sexual characteristics in males and females. There are two types● of sex chromosomes, The X-chromosomes and the Y-chromosomes.

Linkage exhibits the following,

- Several alleles of the different genes for different characters are carried on the same chromosome.
- It does not allow random and independent assortment and fail to conform to the mendel،s Di-hybrid F2 phenotype ratio of 9 :3 :3 :1 andt instead produces a variety of unique Di-hybrid F2 phenotype ratios i.e 3 : 1 when no crossing over occurs, 6 : 2 : 2 : 6 and 4 : 1 : 1 : 4 when crossing over occurs since crossing over seperates linked genes and permits combination of new alleles.
- It suppresses variations and lowers proportions of the recombinants.
- Includes autosomal and sex linkages.
- In most breeding experiments involving linkage, the offsprings in F1 generation tend to produce equal number of the parental phenotypes and smaller number of phenotypes showing new combinations (recombinants) which occur less frequently than the parents phenotypes.

- Any one linkage group are transmitted together and linkage groups found in particular species corresponds to the number of different types of chromosomes, determining various characteristics of the species. For example, In maize, there are 10 pairs of chromosomes and 10 different linkage groups.

As earlier stated, any one linkage group are transmitted together but independent of the genes in the other linkage groups and do not show independent assortment and do not

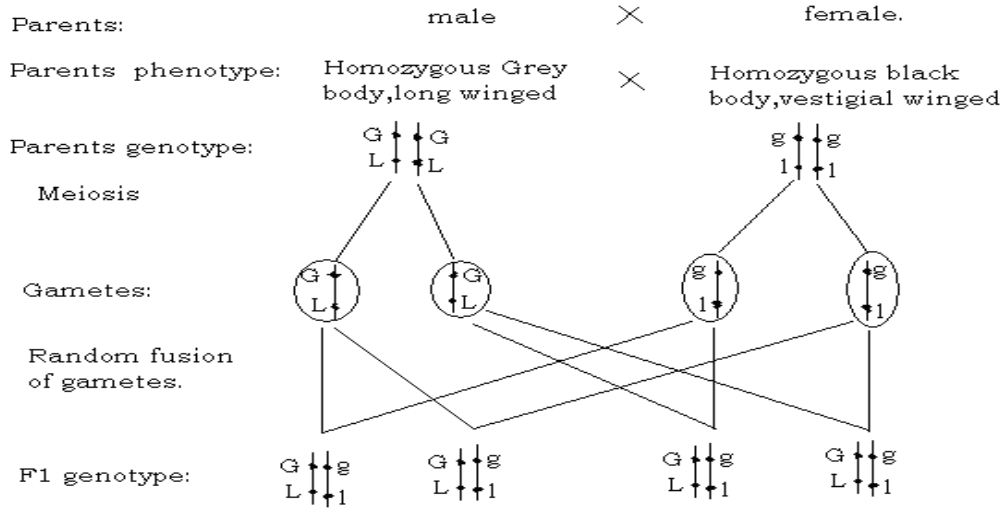
conform to the mendelian Di-hybrid phenotype ratio of 9: 3: 3:1. However, in a breeding experiments involving linkage, produce a variety of unique Di-hybrid phenotype ratios i.e. 3: 1, 6: 2: 2: 6. Etc.

INHERITANCE INVOLVING LINKAGE GROUPS.

Consider a cross between pure-breeding grey-bodied long winged and black bodied vestigial winged drosophila. All the F1 offsprings were grey bodied, vestigial winged. Determine the phenotype ratio of the F2 offsprings. Assuming the two contrasting characteristics are linked.

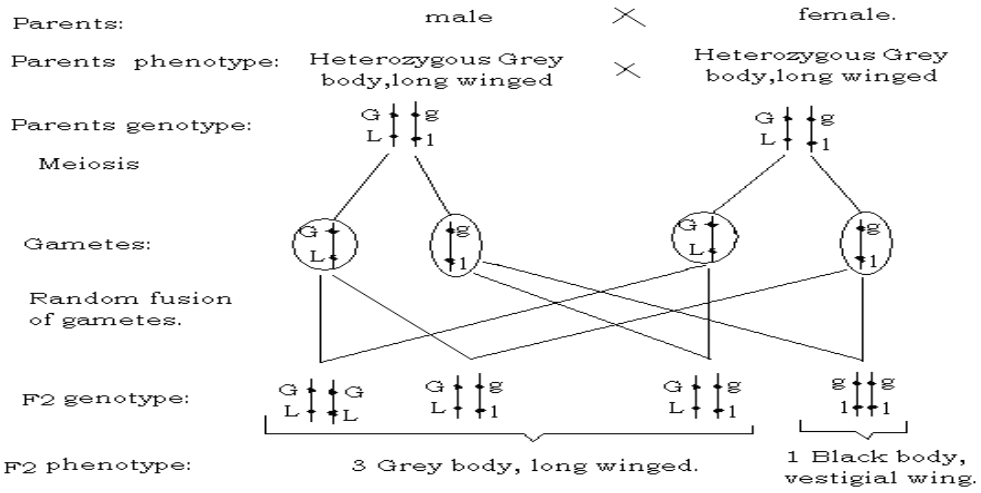
Let

G represents an allele for grey body
g represent an allele for black body
L represents an allele for long wings
l represent an allele for vestigial wing

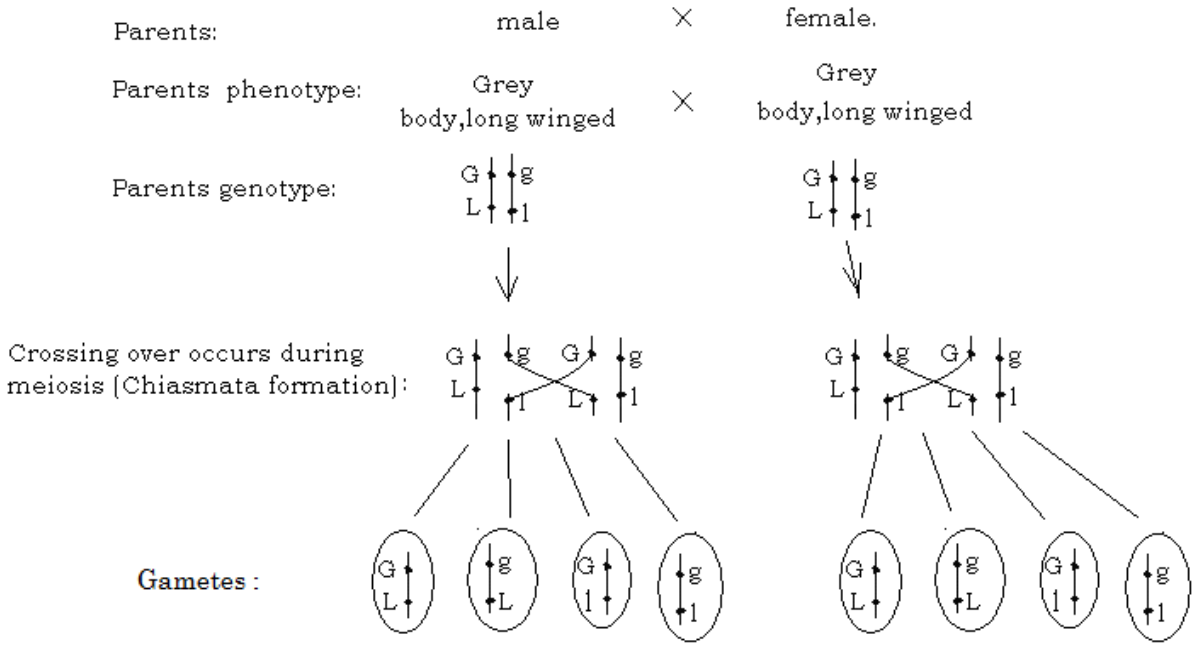


F1 phenotype: All F1 offsprings are heterozygous grey body, long winged.

SELFING THE F1 OFFSPRINGS (SELF FERTILIZATION OF F1 OFFSPRINGS)



RECOMBINATION OF LINKED ALLELES / SEPERATION OF LINKED ALLELES DUE TO CHIASMATA FORMED THAT LEADS TO CROSSING OVER.



Random fusion of gametes can be shown by a punnette square.

EXERCISE

1. A homozygous purple flower short- stemmed plant was crossed with a homozygous red-flowered long- stemmed and the F_1 phenotypes had purple flowers and short stems. The genes controlling colour and height of the the stem are linked. If the F_1 generation was selfed.

What would be the F2 generation considering that

(i) There was no crossing over.

(ii) Crossing over had occurred.

(Show your working clearly in (i) and (ii)).

2. (a) Describe main steps of the Mendel;s Di-Hybrid experiment.

(b) Outline challenges Mendel must have faced in his Di-hybrid Experiment.

(c) Rats heterozygous for genes R and Q were mated with those homozygous recessive for both genes. The offsprings formed from this cross are shown in the table below.

Genotype	Numbers
RrQq	105
rrqq	103
Rrqq	25
rrQq	29

(a) State the phenotype ratio of the results shown in the table above.

(b) Using the appropriate genetic symbols explain how the above results were achieved after mating between the two genotypes stated above.

(c) In what other ways could the above result be different. Explain using appropriate genetic symbols provided above.

SEX-LINKAGE.

This is where several genes are located on the same sex chromosome or X-chromosome.

In humans, there are 23 pairs of chromosomes within the cell, each pair of chromosomes is structurally the same except in only one pair, the 23rd pair of the homologous chromosomes, which show structural differences in males and females. These are the sex chromosomes or heterosomes. All other chromosomes are known as **autosomal chromosomes** or **autosomes**. These chromosomes show similar structures in males and females.

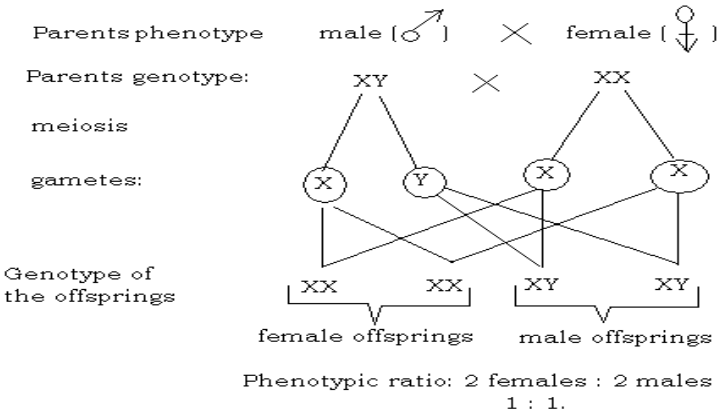
The sex chromosomes are of two types, the X chromosomes and the Y chromosomes. The X chromosome is larger and rod shaped, while in drosophila it is hooked. While the Y chromosomes is lighter, smaller and Y shaped.

SEX DETERMINATION IN HUMANS AND OTHER ORGANISMS.

In humans and other mammals, sex is determined by the two sex chromosomes, the X-chromosome and the Y-chromosome. The genotype of the sex chromosomes for males is XY, while that for females is XX. During gamete formation where meiosis occurs, the sex chromosomes segregate in a typical Mendelian fashion such that all the ova formed contains only X chromosomes, while in males, half of the sperms formed contain Y chromosomes and the other half contains X chromosomes.

During fertilization, if an ovum carrying only X chromosome fuses with a sperm also carrying an X chromosome, the resulting offspring will be a female with a genotype XX and if a sperm carrying a Y chromosome fuses with an ovum carrying X chromosome, the offspring will be a male with a genotype XY.

GENETIC CROSSES SHOWING SEX DETERMINATION IN MAMMALS/HUMANS



Organisms that produce same types of gametes, where all the reproductive cells (ova) contain X chromosomes are known as ***Homogametic***. For example, the human female produces only one type of gametes with the entire ovum carrying only the X chromosomes. And organisms that produce gametes of two different types, where some reproductive cells (gametes) contain X chromosomes while others contain Y chromosomes are known as ***Heterogametic sex***. For example in the humans, males produce 2 types of gametes, half sperms contain X chromosomes, the other half contain Y chromosomes. In humans the XX genotype is homogametic, whereas the XY genotype is heterogametic.

Generally the genotype of the female is XX and that of male is XY. These characteristics of genotypes of the sex chromosomes are found in most animals

including humans, but in the case of birds, moths and butter flies the sex genotypes are reversed. The females are XY and the males are XX.

In some insects, such as the grasshoppers, the Y chromosome may be absent entirely and so the male has the genotype X0 while the female chromosome is XX.

In Humans, the genotypic sex can be determined by examining non-dividing cells. These are cells in a resting state, when such non-dividing cells contain two X chromosomes (XX), the XX chromosomes present appear as a tightly coiled dark-staining body called the ***Barr body***. A non-dividing cell containing XY chromosomes lack Barr bodies. Therefore female cells contain a Barr body, whereas Male human cells lack Barr bodies.

THE ROLE OF Y CHROMOSOME IN ORGANISMS.

In some organisms, the Y chromosome does not carry any genes and described as genetically empty or inert.
In humans, the Y chromosome carries a gene known as ***sex related Y gene*** (SRY gene). The ***SRY gene*** determines production of proteins called ***testis determining factor***. This factor switches on other genes, causing embryo to develop male organ structures. The testes develop and hormones which promote the development of male sexual organs and secondary sexual characteristics are secreted. The SRY genes also activate a gene on chromosome 19 that stimulates production of a protein called **mullerian Inhibiting substance**, they suppress the development of female structures and destroy female structures early in their development.
Lack of testis determining factors results in the development of female genital organs. Therefore all embryos are females unless active testis determining factor makes them males.

In Drosophila, genes determining male characteristics are carried on the autosomes and their effects to determine the male phenotypes are masked by the presence of more than one X chromosomes and the male characteristics only appear in presence of only one X chromosome. This is referred to as **Sex-limited inheritance**. In Drosophila, The male is XY and the female XX. The role of the Y chromosome is to ensure proper functioning of the sperms but does not induce male characteristics. In Drosophila male sex is determined by the number of X chromosomes relative to the set of autosomal chromosomes present. For example, the genotypes, XX, XXY and 3 sets of autosomes produce a female. Whereas, the genotypes, X0, XYY plus three sets of autosomes present produce a male. A drosophila possesses three sets of autosomes.

SEX LINKED AND SEX LIMITED CHARACTERS

Sex linkage is where the genes are carried on sex chromosomes. Where genes are carried on X chromosomes it is X linkage. In some cases, a few genes may be located on Y chromosomes, this is a Y linkage. Many of genes are carried on X chromosomes.
Examples of sex linked (X linked) conditions in humans include,

- Haemophilia or Bleeder's disease.
- Red-green colour blindness.
- Muscular dystrophy/ Duchenne muscular dystrophy (DMD).
- Premature balding.

Red and white eyes in Drosophila is another sex linked (X linked) trait.

GENERAL CHARACTERISTIC FEATURES OF SEX LINKED CHARACTERS.

(i) Are determined by recessive alleles while the dominant allele determines normal conditions.
(ii) The genes controlling the character are carried on X chromosomes only, The Y chromosome does not carry any genes,
(iii) In a population, the heterozygous individuals are females and they are called carriers. Carrier females are phenotypically normal and do not suffer from the conditions.
(iv) Sex linked characters are more common among males than females.
(v) The recessive alleles are transmitted to the male offsprings by their mothers.
(vi) The mothers transmit the recessive alleles to their sons while the daughters inherite one of their X chromosomes carrying either recessive or dominant allele from the father and one being inheritated from the mother.
(vii) Offers mainly disadvantageous characters to individuals.
(viii) Frequency of colour blindness is higher than that for haemophilia in a population.

EXAMPLES OF SEX LINKED CHARACTERS.

HAEMOPHILIA.

Is a condition in which the. blood does not clot normally. It often results into excessive bleeding both internally and externally in times of injuries. This condition mainly arises due to lack of clotting factor VIII (also called antihaemophiliac globulin, AHG). The gene for factor VIII is carried on the X chromosome. Haemophilia is a sex linked (X linked) character caused by the recessive allele, the normal allele is the dominant.
In all sex- linked traits, females who are heterozygous are described as carriers of the trait they are phonotypical normal but half their gametes carry the recessive gene which can possibly be transmitted to their offspring in the next generation.

The cases of sex- linked traits i.e. haemophilia affect more males than females. This is because the females only suffer from the disease when in a homozygous recessive conditions, but the recessive genes are relatively rare in a population. In addition in the heterozygous females, both dominant and recessive alleles are present, the recessive allele is normally masked (overshadowed) by the appropriate dominant gene which occurs on the other X chromosome. In the other hand when the recessive gene occurs in males., it expresses it self because the Y chromosome cannot carry any corresponding dominant gene since it is presumed to be empty and can not be masked by any other dominant normal gene.

SEX LINKAGE INVOLVING MONOHYBRID INHERITANCE.

These include,

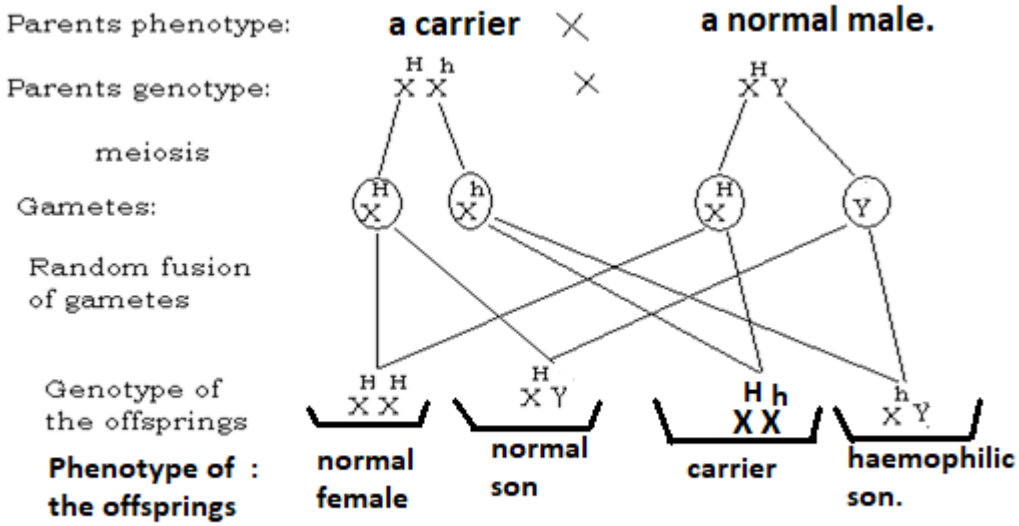
- Inheritance of haemophilia in humans.
- Inheritance of colour blindness.

EXAMPLE:

In situation where a carrier hemophiliac female marries a normal male, they may have children with phenotypes as shown below.

Let

H represent normal allele for blood clotting
h represent abnormal allele for hemophilia
XX represents female sex chromosomes.
XY represents male sex chromosomes.



Phenotype Ratio : 3 normal : 1 haemophilic

RED-GREEN COLOUR BLINDNESS.

This is a condition in which a person cannot distinguish between red and green colours. It is caused by recessive allele carried on the X chromosome. The pattern of inheritance of red-green colour blindness is similar that of haemophilia. But the frequency of the colour blindness is higher than that for haemophilia. This is because colour blind individuals can not only distinguish between red and green colours but this does not lead to the death of the persons suffering from colour blindness. So, the colour blind person survives until they reproduce offsprings, transmitting their recessive allele to the next generations, the recessive allele frequency increase in a population. While a haemophilic individual can excessively bleed to death in times of injuries. So, many of them die before they can reproduce. The recessive allele in this way is prevented from being passed from one generation to the next and their allele frequency decreases in a population.

MUSCULAR DYSTROPHY.

Duchenne muscular Dystrophy (DMD) is a tragic, wasting disease affecting infant children mainly boys, where muscles of the body are replaced by fibrous tissue, resulting into progressive body weakness and difficulty in breathing. This disease can result to death of the sufferer at an early age (before the age of 20 years is reached).

The gene for DMD is sex linked and found on the X chromosome. The allele for DMD codes for an enzyme that induces the replacement of muscle by fibre.

NOTE:

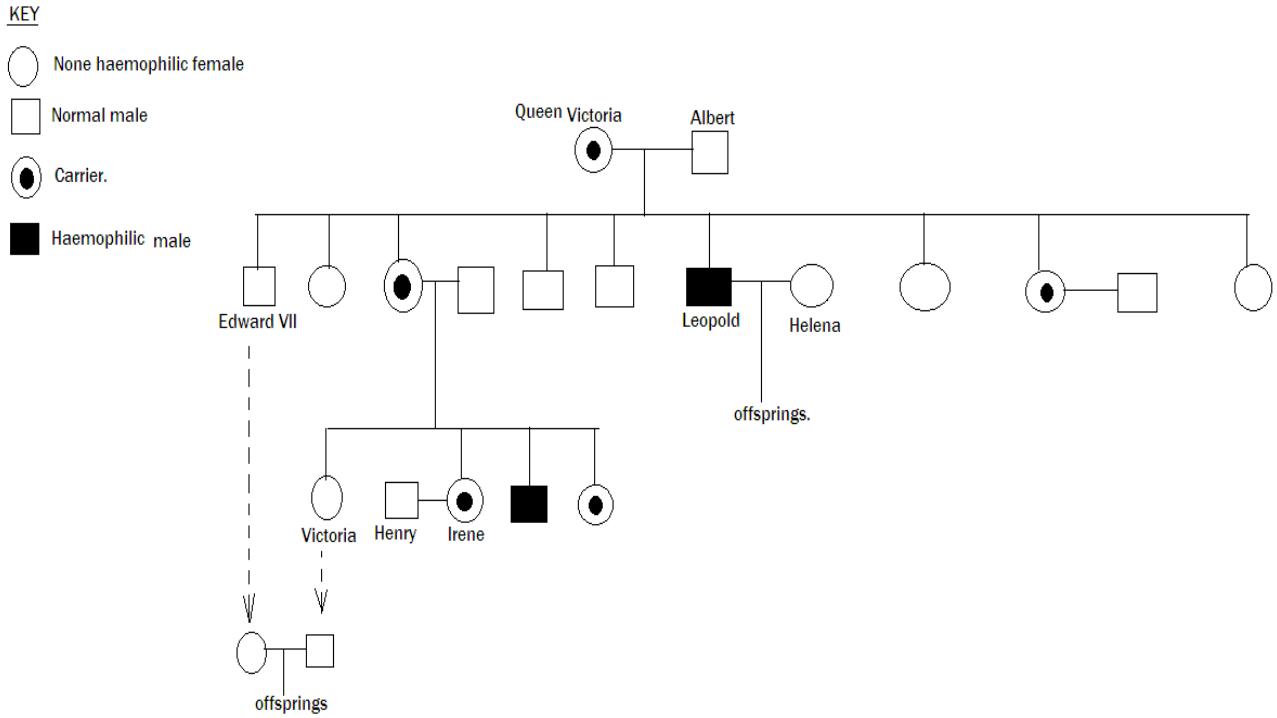
Y chromosomes are very short and do not carry many genes. In humans, there are very few examples of Y-linked inheritance but abit disputed. However one cited example of Y-linked inheritance in human is the ***"porcupine men"***. These men had thick, spiny, and dark skin. It was believed that the genes for the porcupine men are carried on Y chromosomes, although some authors have disputed this fact in that, the condition is probably due to a dominant gene carried on an autosomal chromosome.

A nother example of genes linked to Y chromosomes are those controlling hairy ear rims in humans.

PEDIGREE.

This is a chart of the ancestral history of a group of related individuals showing inheritance of sex linked characters such as haemophilia or other characters.

THE FIGURE BELOW SHOWS A PEDIGRE FOR TRANSMISSION OF HAEMOPHILIA FROM QUEEN VICTORIA.



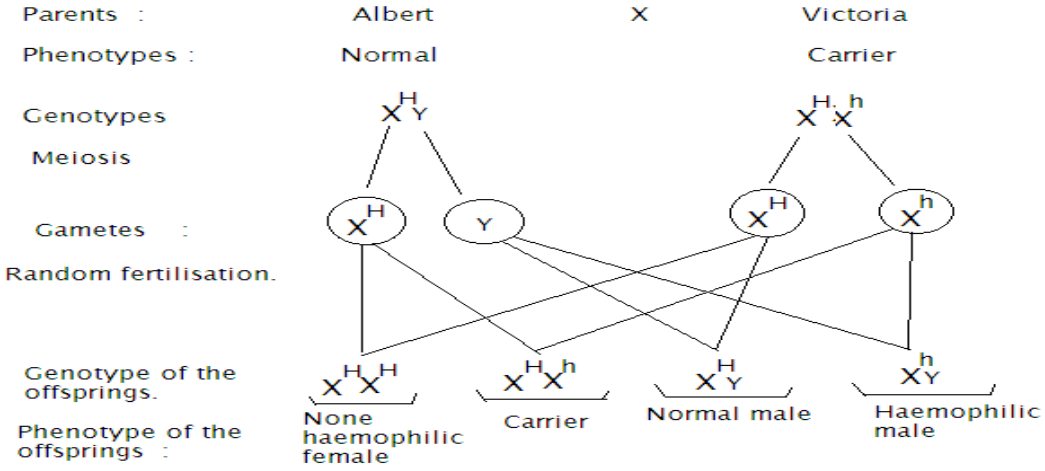
From the pedigree above,

(a) State the genotype of the Queen victoria and albert.

(b) What percentage of the offsprings produced by the Leopold and Helena wil be normal and not suffer from the disease. Clearlly show your working.

(c) Explain using appropriate genetic symbols why interbreeding between Edward VII and Descendant Victoria will be recommended.

GENETIC CROSSES ILLUSTRATING INHERITANCE OF HAEMOPHILIA FROM QUEEN VICTORIA.



SEX LINKAGE INVOLVING DI-HYBRID INHERITANCE.

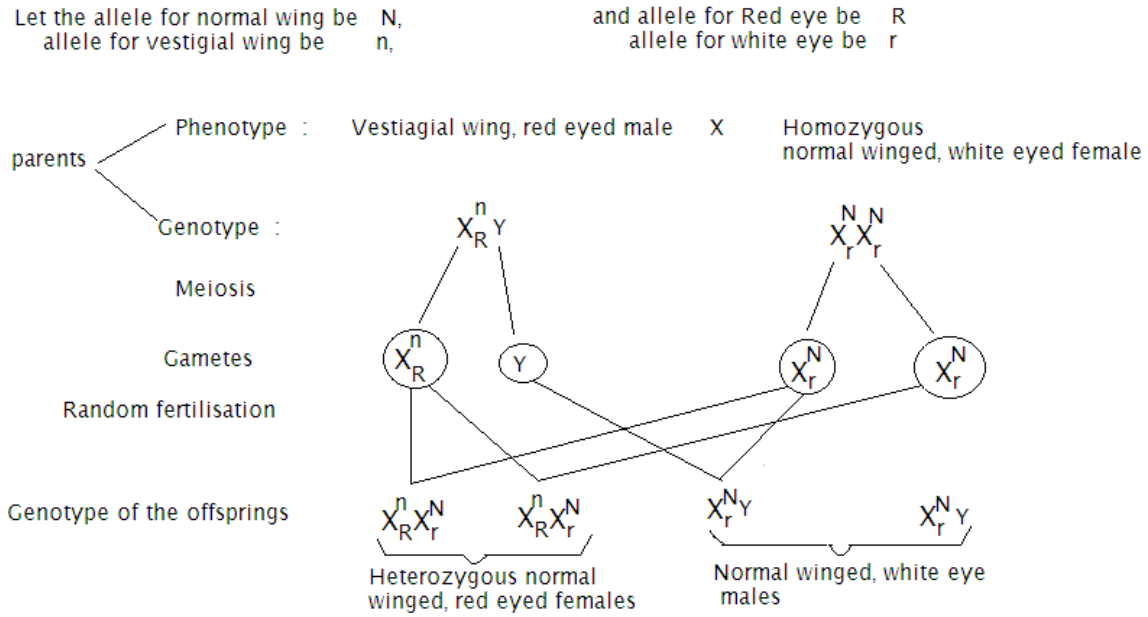
EXAMPLE.

(1)In the fruit fly drosophila, vestigial wing is recessive to normal and white eye colour is recessive to red eye. These genes are on the X chromosome and in drosophila the heterogametic sex is male.

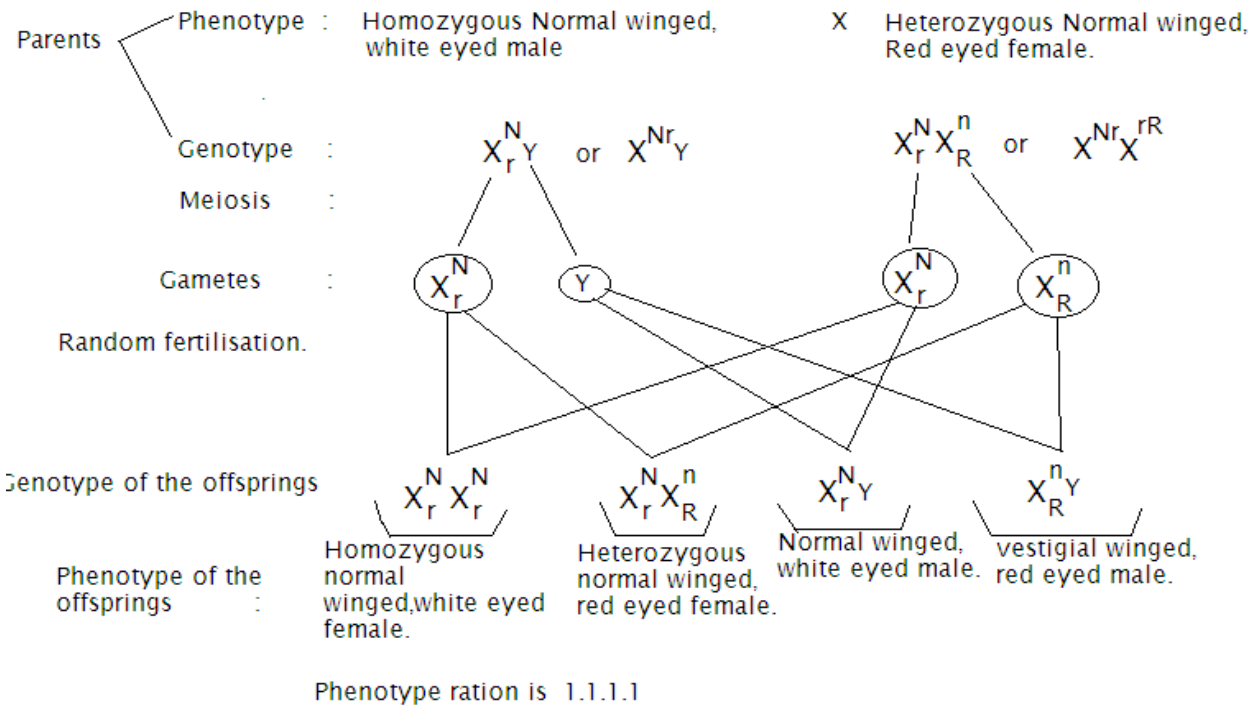
a). What phenotype would be expected in the F_1 of a cross between a vestigial winged, red- eyed male and a homozygous normal winged, white eyed female.

b) What phenotypes would be expected in the F_2 generation when F_1, flies inter breed? Show clearly all your working from (a).

SOLUTION.


Let the allele for normal wing be N,
allele for vestigial wing be n,
and allele for Red eye be R
allele for white eye be r
parents
Phenotype :
Vestiagial wing, red eyed male
X
Homozygous
normal winged, white eyed female
Genotype :
Meiosis
Gametes
Random fertilisation
Genotype of the offsprings
Heterozygous normal
winged, red eyed females
Normal winged, white eye
males

(b)


Parents
Phenotype :
Homozygous Normal winged,
white eyed male
X
Heterozygous Normal winged,
Red eyed female.
Genotype :
or
Meiosis :
Gametes :
Random fertilisation.
Genotype of the offsprings
Phenotype of the
offsprings :
Homozygous
normal
winged,white eyed
female.
Heterozygous
normal winged,
red eyed female.
Normal winged,
white eyed male.
vestigial winged,
red eyed male.
Phenotype ration is 1.1.1.1

EXERCISE

1. (a) Explain why,

(i) colour blinded is more common in males than females in a population.

(ii) Frequency of colour blindness is higher than that ofnhaemophilia.

(b) When a carrier marries haemophilic male, what will be the phenotypes of their children.

2. In drosophila the genes for wing length and for eye colour are sex linked. Normal wing and red eye are dominant to miniature wing and white eye.

a). In a cross between a miniature wing., red- eyed male and a homozygous normal wing white- eyed female explain fully the appearance of i). F_1 ii). F_2 genotypes. Show your working clearly.

b. Crossing a female from F_1 above with a miniature, white eyed male gave,

- Normal wing, white eyed males and females = 35
- Normal wing, red- eyed males and females = 17
- Miniature wing, white eyed male and females = 18
- Miniature wing, white eyed males and females = 36.

Account for the appearances and number of the phenotypes shown above.

3. (a) In cats, the genes controlling the coat colours are carried on the X chromosomes and are codominant. A black-coat female mated with a ginger coat male produced a litter consisting of black male and tortoiseshell female kittens. What is the expected F_2 phenotypic ratio? Explain the results.

(b) State all the features/characteristics common to all sex linked characters.

4. A red-green colour-blind boy discovered that one of his grandfathers was the last member of

the family to have the defect. Was it his maternal or paternal grandfather?

5. (a) Explain why sex linked characters are more common among males than their counter parts the females in a population.

(b) In drosophila the allele for normal wing (N) and red eyes (R) are dominant over alleles for vestigial wing (n) and white eyes (r) which are recessive. The genes determining these characters are sex linked. And in drosophila the males are the heterogametic. What will be the phenotypes of the offsprings in a cross between

vestigial winged red eyed male with heterozygous normal winged red eyed females. Assuming reciprocal cross over occurred during meiosis.

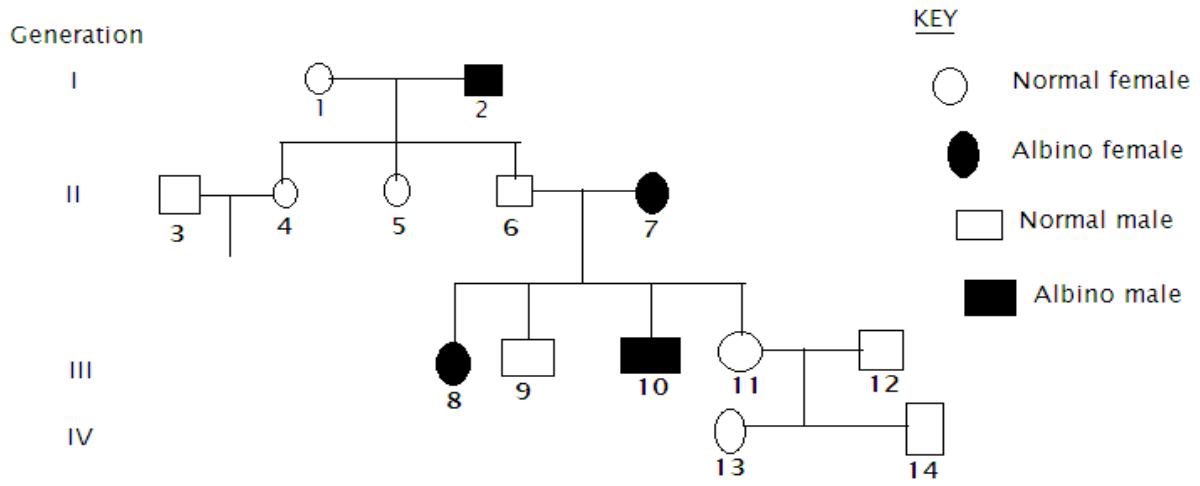
6. In cats, short hair is dominant over long hair, the gene involved is autosomal. Another gene which is sex linked produces yellow coat colour, its other allele produces black coat colour and the heterozygous combinations produces tortoise shell coat colour.

(a) If a long haired black male is mated with a tortoise shelled female homozygous for short hair, what kind of offsprings will be produced in the F1.

(b) (i) If the F1 cats are allowed to interbreed freely among themselves, what are the chances of obtaining long haired females.

(ii) A part from being sex linked, what else can you say about the inheritance of the gene for coat colour.

7. The figure below shows part of a family tree (pedigree) of a mammal. Several members have the condition called Albinism in which no melanin pigment is produced in the body.



(a) The albino condition is controlled by recessive alleles **a** while the normal pigment level is controlled by the dominant allele **A**. The genes controlling albinism are autosomal and not sex linked but inherited independently.

(i) Determine the phenotypes of the males and female offsprings in the generation II after mating between the two parents in generation I.

(ii) What will be the genotypes of the males and female children in generation III when individuals 6 and 7 are mated.

Show clearly your working in a (i) and (ii) above.

(b) Sate the possible genotype of person 11 and 12.

(c) Give characteristic features exhibited by an albino individual.

8. Colour blindness is determined by a recessive allele **b** while the allele **G** for green colour of the pupil of the eye is dominant over the allele that controls the brown colour of the eye.

(a) Explain why there are more colour blind individuals than the haemophilic ones in a population.

(b) What will be the phenotype of children when a carrier woman, brown eyed is mated with a normal man for the disease whose is heterozygous green eyed. Assuming random and independent assortment. Clearlly show your working.

SEX LIMITED CHARACTERS

Are those characteristics which are determined by genes whose phenotypic expression appear in only one sex in male or female due to presence of one of the sex hormones. These hormones are principally responsible for secondary sexual characteristics as beard development, plumage in birds, manne in lions, breasts in females.

Sex limited characters include, Lactation in female mammals, facial hair in male humans. Sex limited genes may be carried on autosomes and affected by levels of hormones present in the body.

CROSSING OVER AND GENE MAPPING

Crossing over arises due to chiasmata formation during prophase I of meiosis between homologous chromosomes. It is the main cause of genetic variation in organisms of the same species. In addition, they also indicate relative positions of genes on their specific chromosomes and the order in which they occur. The further a part two linked genes are, the more likely it is that chromosome will break at region at some point between them.

Cross over frequencies and **cross over value (COV)** is the percentage of the offsprings which may arise from separation of the genes or crossing over. Crossing over corresponds to a unit distance, for example, a COV of 1% is equal to a distance of 1unit. The crossover value (COV) is calculated using the information or formula,

$$\textbf{COV} = \frac{\text{Number of recombinants}}{\text{Total number of offsprings}} \times 100\%$$

Cross over values demonstrates that genes are arranged linearly along the chromosomes. It is important to note that the crossover frequency reflects the relative positions of genes on chromosomes and distances apart between them because the

further apart linked genes are on the chromosomes, the greater the chances of crossing over occurring between them, and the greater the crossover frequency.

GENE MAPPING

The major significance of calculating crossover frequency is that it enables geneticists to produce maps showing the relative positions of genes on chromosomes.

Consider the following crossover values as determined by a series of breeding experiment involving four genes, P, Q, R and S. The cross over values between the genes is as follows,

R - P = 14%
R - S = 8 %
S - P = 6 %
Q - R = 10%
Q – P = 24%

To calculate the sequence and distance a part of the genes, the following procedures are carried out.

(i). A line is drawn to represent the chromosome.

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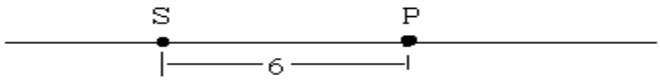
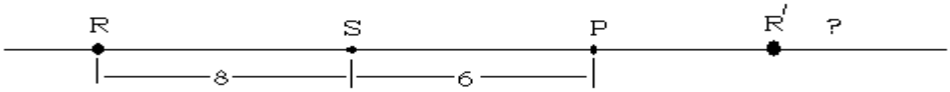
(ii). Insert the positions of the genes with the least COV in the middle of

Chromosome that is S - P = 6%.

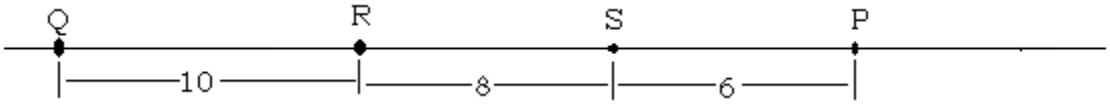


(iii) Examine the next largest COV which is R - S = 8% insert both possible

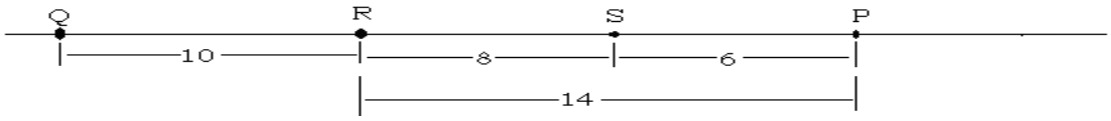
positions of R on the chromosome relatives to S.



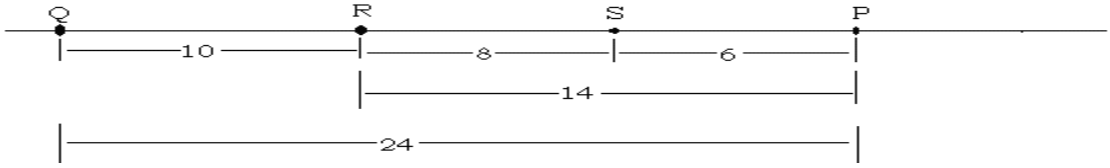
(iv). Repeat the procedure for the next largest i.e. Q - R = 10 % this means that the right hand position of R is incorrect



(v). Repeat the procedure for the next larges COV for R - P = 14 % .this confirms the left hand position for gene Q.

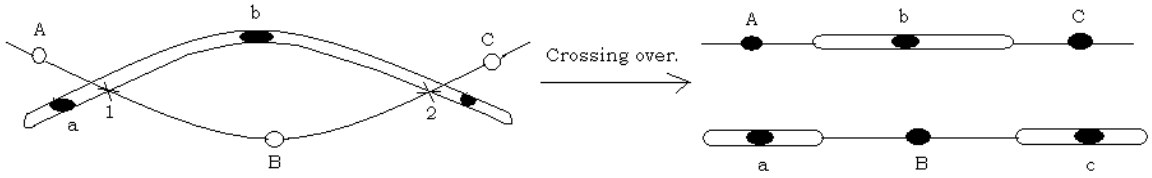


(vi) Finally repeat the procedure for the last next larges COV for Q - P = 24 %.



A problem which arises in preparing chromosome maps in that of double cross over, particularly when considering genes which are widely separately.

For example, A pair of homologous chromatids, one carrying the dominant alleles A, B, and C and the other carrying the recessive alleles a, b and c and chiasmata are formed at two points 1 and 2. When the homologous chromosomes separate double crossing over occurs. This results into sequences of genes which are different, however, the sequences of the gene loci and the distances between them remain the same.



EXERCISE

If the crossover values between genes A, B, and C, are

A-B = 4%
B-C = 6%
A – C = 10 %
Construct possible chromosome maps representing positions of the genes on the chromosome.

2. Consider the following cross over frequencies determined by a series of breeding experiments between the genes B, F, H, M and V, as

H – M = 48%
H – F = 10%
F – V = 4%
B – M = 21%
H – V = 6%
B – F = 17%
M – F = 38%

Construct an appropriate gene chromosome map using the above cross over frequencies.

MULTIPLE ALLELE

This is where a phenotypic characteristics of an individuals is controlled by many alleles occurring at a specific gene locus, however, only two of such alleles may occupy the same gene loci of homologous chromosomes.

Characteristics controlled by multiple alleles include; eye colour and coat colour in mice and blood group in humans

Multiple alleles can result in offsprings with characteristics which differ from both parents.

INHERITANCE OF A, B, O BLOOD GROUPS

A good example of such multiple alleles is provided by the alleles controlling the ABO blood group system in humans. Blood group is controlled by an autosomal gene. The gene locus is represented by the symbol I, which stands isohaemoglutinogen. Blood group in individuals is determined by the types of mucopolysaccharides that function as antigens (agglutinogens) on the plasma membrane of blood red blood cells. There are 3 alleles represented by the symbols A, B, and 0. The alleles A and B are dominant to O which is recessive to both alleles A and B. Alleles A (I^A) and B (I^B) codes for the enzymes that are involved in the formationof the antigens A and B respectively and allele O (I^O) does not code for any known proteins. Individuals of blood group A have antigens A only, those of blood group B has antigens B, The AB blood groups have both antigens A and antigen B and group O has neither antigens A nor antigens B. The genotypes for different blood groups are shown below,

A person whose genotype is I^AI^A or I^AI^o will belong to blood group A
A person with genotype I^BI^B or I^BI^0 will belong to blood group B
Genotype I^AI^B belongs to blood group AB

Genotype I^0I^0 belongs to blood group O.

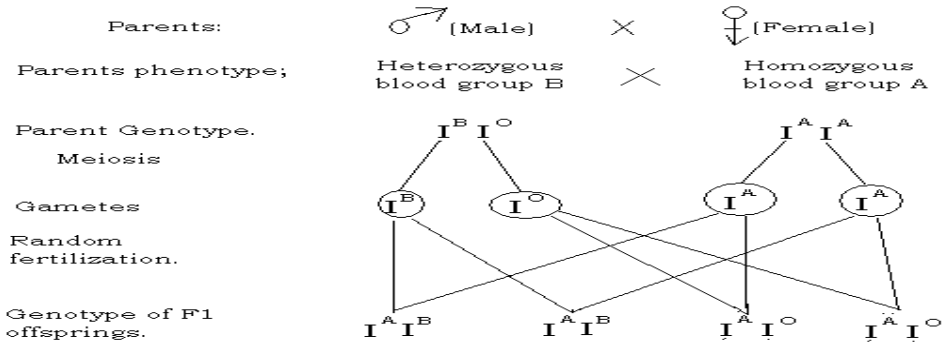
NOTE:

When both allele **A** and **B** occur together they show equal dominance with respect to one another called co-dominance.

The A, B, 0 blood group system Can be inherited in the normal mendelian fashion e.g. mating between a woman homozygous for blood group **A** and A man heterozygous for blood group **O** will produce offspring with the following blood group types.

Let,

An allele for blood group A be A
An allele for blood group B be B
And the recessive allele for both blood groups be 0.



Phenotype of offsprings: Blood groupAB = 2
Offsprings heterozygous for blood group A = 2.

EXERCISE

Qn.1 Explain using appropriate genetic symbols the possible blood groups of children whose parents are both heterozygous, the father being blood group A and the mother blood group B.

If these parents have non-identical twins what is the probability that both twins will have blood group A.

Qn.2. A blue-eyed man marries two wives, both brown eyed. Two children, one brown eyed, the other blue-eyed are born to the first wife. The second wife bears three children, all brown eyed.
(a) State the possible genotypes for the (i) man (ii) first and second wives.
(b) State the genotypes for all the children of the first wife. Clearly show your working.

(c) Give reason(s) for the suggested genotype of the second wife.

Qn.3. A woman whose blood group is O, Rh^- marries a group AB, Rh^+ man. What are the possible blood groups of their children? Explain your working.

LETHAL ALLELES

This is a condition where a single gene determines several characteristics that includes mortality or death of an individual.

EXAMPLES.

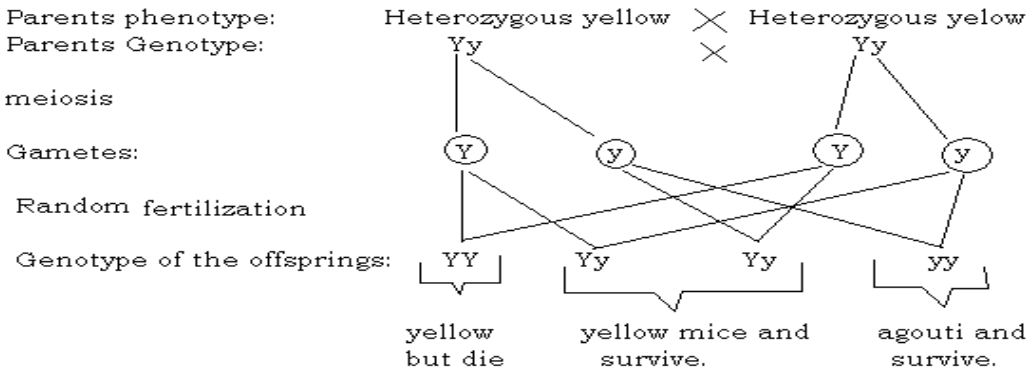
In human certain recessive genes may lead to internal adhesion or congestion of the lungs resulting into death of babies at birth.

Another example of a single recessive gene affects formation of cartilage and produces congenital deformation leading to fetal and neonatal death.

The effects of a lethal gene are clearly shown by the inheritance of fur colour in mice, wild mice have grey coloured fur a condition known as agouti. The grey colour is determined by recessive alleles. Some mice have yellow fur. The yellow colour is controlled by the dominant alleles. Cross breeding heterozygous yellow mice produces offsprings in the ratio of 2 heterozygous yellow and 1 agouti fur mice. In this case the homozygous dominant yellow fur mice die. Examination of the uteri of heterozygous yellow mice in the above cross revealed dead yellow fetuses.

Let,

Y represents an allele for yellow fur.
y represents an allele for agouti fur.



EXERCISE.

1. Chickens with shortened wings and legs are called creepers.

(i) When creepers are mated to normal birds they produce creepers and normal birdswith equal frequency.

(ii) When creepers are mated to creepers they produce two creepers to one normal.

(iii) Crosses between normal birds produce only normal progeny.

(a) Explain these results using your knowledge of genetics.

(b) Using suitable symbols work out the genotypes and phenotypes of the offsprings of the first, second and third crosses.

(c) State the genotypes of the parents in the third cross and explain your answer.

2. Manx cats do not have tails. When a manx cat is mated with a normal tailed cat, approximately half of the offsprings are long tailed and approximately half are manx. When two manx are mated, the ratio of offsprings is 2 manx to 1 tailed cat.

(i) What does this suggest about the inheritance of the manx condition in cats.

(ii) Show by means of a cross, the inheritance of the manx condition when two Manx cats are mated.