Very Short Answer Questions (PYQ)

[1 Mark]

Q.1. State a difference between a gene and an allele.

Ans. Gene contains information that is required to express a particular trait whereas allele are the genes which code for a pair of contrasting traits.

Q.2. A garden pea plant (A) produced inflated yellow pod, and another plant (B) of the same species produced constricted green pods. Identify the dominant traits.

Ans. Inflated green pod is the dominant trait.

Q.3. A garden pea plant produced axial white flowers. Another of the same species produced terminal violet flowers. Identify the dominant traits.

Ans. Axial, violet flower.

Q.4. A garden pea plant produced round green seeds. Another of the same species produced wrinkled yellow seeds. Identify the dominant traits.

Ans. Round yellow seed is the dominant trait.

Q.5. A geneticist interested in studying variations and patterns of inheritance in living beings prefers to choose organisms for experiments with shorter life cycle. Provide a reason.

Ans. This is because many generations can be obtained (in a short time) and selection of character becomes faster.

Q.6. Write the possible genotypes, Mendel got when he crossed F1 tall pea plants with a dwarf pea plant.

Ans. Possible genotypes: Tt and tt.

Q.7. How many kinds of phenotypes would you expect in F2 generation in a monohybrid cross?

Ans. Three.

Q.8. Mention any two contrasting traits with respect to seeds in pea plant that were studied by Mendel.

Ans. Round/Wrinkled, Yellow/Green

Q.9. What are ‘true breeding lines’ that are used to study inheritance pattern of traits in plants?

Ans. True breeding lines are plants which have undergone continuous self-pollination for several generations. These are homozygous for traits.

Q.10. Mention the type of allele that expresses itself only in homozygous state in an organism.

Ans. Recessive allele.

Q.11. Write the percentage of F2 homozygous and heterozygous populations in a typical monohybrid cross.

Ans. The ratio of a typical monohybrid cross is 1 : 2 : 1 where 50% are homozygous and 50% are heterozygous populations. (25% homozygous dominant, 25% homozygous recessive)

Q.12. Name the type of cross that would help to find the genotype of a pea plant bearing violet flowers.

Ans. Test cross.

Q.13. Why, in a test cross, did Mendel cross a tall pea plant with a dwarf pea plant only?

Ans. To determine the genotype of the tall plant, whether it is homozygous dominant or heterozygous, as dwarfness is a recessive trait which is expressed only in homozygous condition and he was sure of genotype of dwarf plant.

Q.14. Name the stage of cell division where segregation of an independent pair of chromosomes occurs.

Ans. Anaphase-I of Meiosis-I.

Q.15. In a dihybrid cross, when would the proportion of parental gene combinations be much higher than non-parental types, as experimentally shown by Morgan and his group?

Ans. When the genes are linked.

Q.16. Mention the combination(s) of sex chromosomes in a male and a female bird.

Ans. Male bird – ZZ, Female bird – ZW

Q.17. Write the types of sex determination mechanisms the following crosses show. Give an example of each type.

Q. Female XX with Male XO

Ans. Male heterogamety, Grasshopper.

Q. Female ZW with Male ZZ

Ans. Female heterogamety, Birds

Q.18. How many chromosomes do drones of honeybee possess? Name the type of cell division involved in the production of sperms by them.

Ans. Drones possess 16 chromosomes. Mitosis is involved in the production of sperms.

Q.19. A male honeybee has 16 chromosomes whereas its female has 32 chromosomes. Give one reason.

Ans. Male honeybee develops from unfertilised female gamete (Parthenogenesis) and thus has 16 chromosomes whereas female develops by fertilisation and thus has 32 chromosomes.

Q.20. What is a mutagen? Name a physical factor that can be mutagen.

Ans. All the physical and chemical factors that induce mutation are called mutagens. UV radiation and X-rays are physical mutagens.

Q.21. What is point mutation? Give one example.

Ans. Mutation arising due to change in a single base pair of DNA is called point mutation.

Q.22. Give an example of a human disorder that is caused due to a single gene mutation.

Ans. Sickle-cell anaemia.

Q.23. Mention two causes of frame-shift mutation.

Ans. Insertion and deletion of three bases or multiples of three bases cause frame-shift mutation because the reading frame remains unaltered from that point onwards.

Q.24. State the chromosomal defect in individuals with Turner's syndrome.

Ans. Monosomy of sex chromosome in females (XO condition).

Q.25. Name the event, during cell division cycle that results in the gain or loss of chromosome.

Ans. Failure of segregation of chromosomes.

Q.26. Name one autosomal dominant and one autosomal recessive Mendelian disorder in humans.

Ans. Huntington's disease is an autosomal dominant disorder and sickle-cell anaemia is an autosomal recessive disorder.

Q.27. A human being suffering from Down's syndrome shows trisomy of 21st chromosome. Mention the cause of this chromosomal abnormality.

Ans. Due to non-disjunction, 21st pair of chromosomes fail to separate during oogenesis. Therefore, the egg possesses 24 chromosomes instead of 23. When such an egg fuses with a sperm, the zygote will have three copies of chromosome 21 causing trisomy.

Q.28. A haemophilic son was born to normal parents. Give the genotypes of the parents and son.

Ans.

Father : 44 + XY

Mother : 44 + XX^h

Son : 44 + X^hY.

(X^h = X chromosome with gene for haemophilia)

Q.29. Write the genotype of (i) an individual who is carrier of sickle cell anaemia gene but apparently unaffected, and (ii) an individual affected with the disease.

Ans.

Hb^AHb^S

Hb^SHb^S

Q.30. Why is it that the father never passes on the gene for haemophilia to his sons? Explain.

Ans. Haemophilia is a sex-linked recessive disease and the defective gene is present on X chromosome only and not on Y chromosome. Father never passes X chromosome to the son as father only contributes Y chromosome to the son.

Q.31. Why do normal red blood cells become elongated sickle shaped structures in a person suffering from sickle cell anaemia?

Ans. Due to point mutation, glutamic acid (Glu) is replaced by valine (Val) at the sixth position of β-globin chain of haemoglobin molecule. Under oxygen stress erythrocytes lose their circular shape and undergo polymerisation to become sickle-shaped.

Q.32. Name the respective pattern of inheritance where F1 phenotype

(a) does not resemble either of the two parents and is in between the two.

(b) resembles only one of the two parents.

Ans.

(a) Incomplete dominance.

(b) Dominance.

Very Short Answer Questions (OIQ)

[1 Mark]

Q.1. Define the term genetics.

Ans. The branch of biology which deals with the study of heredity and variation is called genetics.

Q.2. Who coined the term gene?

Ans. Johannsen in 1909.

Q.3. Who is the 'Father of Genetics'?

Ans. Gregor Johann Mendel is called the 'Father of Genetics'.

Q.4. What is a hybrid?

Ans. The product of a hybridisation process which is heterozygous and mixture of both genetically dissimilar parents is called hybrid.

Q.5. What is meant by genotype?

Ans. The genetic constitution of an organism is called genotype.

Q.6. What is meant by phenotype?

Ans. The observable or external morphological characteristics (features) of an organism constitute its phenotype.

Q.7. Who rediscovered Mendel's laws of heredity?

Ans. Hugo de Vries, Carl Correns and von Tschermak.

Q.8. Define a gene pool.

Ans. The aggregate of all the genes and their alleles, present in an interbreeding population is known as a gene pool.

Q.9. What is genome?

Ans. The total set of genes, in the haploid set of chromosome is called genome.

Q.10. What are alleles?

Ans. The alternative forms of a gene are called alleles.

Q.11. What is monohybrid cross?

Ans. The cross between two plants, with respect to a single contrasting character is called monohybrid cross. e.g., Tall (TT) × Dwarf (tt)

Q.12. Define dihybrid cross.

Ans. The cross between two plants with two contrasting characters is called dihybrid cross.

e.g., RRYY (Round yellow seed) × rryy (Wrinkled green seed)

Q.13. Define heterozygous.

Ans. When dissimilar or different pairs of alleles are present for a character, it is called heterozygous condition, e.g., Tt.

Q.14. Define homozygous.

Ans. When similar pair of alleles are present for a character, it is called homozygous, e.g., TT.

Q.15. Define dominant factor.

Ans. The factor or allele of a character which expresses its effect in the presence of its alternative allele is called the dominant factor.

Q.16. Define recessive factor

Ans. The factor or allele of a character which fails to express its effect in the presence of its alternative allele and only expresses itself in the homozygous state is called the recessive factor.

Q.17. What does movement of alleles into different gametes demonstrate?

Ans. It demonstrates segregation.

Q.18. Name the inheritance where both the genotypic and phenotypic ratios are same.

Ans. In incomplete dominance, the inheritance pattern has the same genotypic and phenotypic ratio of 1 : 2 : 1.

Q.19. When a tall pea plant was self-pollinated, one-fourth of the progeny were dwarf. Give the genotype of the parent and dwarf progenies.

Ans. Genotype of parent is Tt and the genotype of dwarf progenies is tt.

Q.20. What is the genetic basis of wrinkled phenotype of pea seed?

Ans. Wrinkled seed shape is a recessive trait. It expresses only under homozygous condition of alleles.

Q.21. How many type of gametes are produced by the individual with genotype AABBCCDD and AaBbCcDd?

Ans. One type of gamete by individual (AABBCCDD) and sixteen (= 42) type of gametes by individual AaBbCcDd.

Q.22. If the frequency of a parental form is higher than 25% in a dihybrid test cross, what does that indicate about the two genes involved?

Ans. It shows that the two genes are linked.

Q.23. What are pleiotropic genes?

Ans. A single gene that governs multiple phenotypic effects is called a pleiotropic gene.

Q.24. What is gene locus?

Ans. It is the particular location or position where a gene is located on a chromosome.

Q.25. How much is one map unit for expressing distances between genes on a chromosome?

Ans. One map unit is equivalent to 1% recombination.

Q.26. If two genes are located far apart from each other on a chromosome, how the frequency of recombination will get affected?

Ans. Frequency of recombination will be higher.

Q.27. What is crossing over?

Ans. The phenomenon of exchange of chromosomal segments between the homologous chromosomes during meiosis is called crossing over.

Q.28. What is non-disjunction?

Ans. The inability of homologous chromosomes to separate out during meiosis in an individual is called non-disjunction. As a result of this, some gametes get both chromosomes, while others receive neither.

Q.29. What is meant by linked genes?

Ans. The genes which tend to transmit together as a unit, as they are located very close on the same chromosome are called linked genes.

Q.30. Define mutation.

Ans. Mutation can be defined as a sudden change in genetic sequence of an individual which may lead to variation of characters.

Q.31. Name one physical and one chemical mutagen.

Ans. Physical mutagen—UV rays; Chemical mutagen—5-Bromouracil.

Q.32. Name two factors responsible for genetic variation in an organism.

Ans. Recombination and crossing over.

Q.33. Name one disease which is caused due to point mutation.

Ans. Sickle-cell anaemia.

Q.34. Which chromosomes are called autosomes?

Ans. All the chromosomes that do not determine the sex of an individual are called autosomes.

Q.35. Who first observed the X-chromosome in the form of an X-body?

Ans. Henking (1891).

Q.36. What is polyploidy?

Ans. The phenomenon of failure of cytokinesis after cell division resulting in increase of whole set of chromosome in an organism is called polyploidy.

Q.37. What is aneuploidy?

Ans. The phenomenon of failure of segregation of chromatids during cell division as a result of gain or loss of chromosome(s) is called aneuploidy.

Q.38. What is the cause of Klinefelter's syndrome?

Ans. It is a genetic disorder caused due to the extra X-chromosome resulting into a karyotype with 47 chromosomes, XXY.

Q.39. What is monosomic condition?

Ans. The presence of a chromosome as a single copy in a diploid cell is termed as monosomic condition.

Q.40. For the expression of traits, genes provide only the potentiality and the environment provides the opportunity. Comment on the veracity of the statement.

Ans. Phenotype = Genotype + Environment

(Trait) (Potentiality) (opportunity)

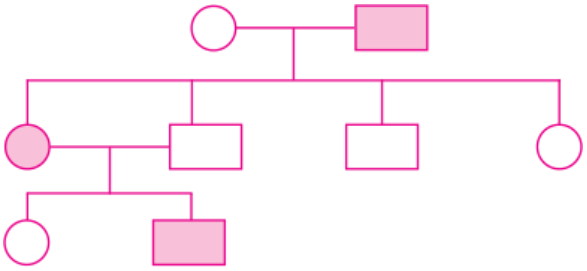
Q.41. Give an example of a chromosomal disorder caused due to non-disjunction of autosomes.

Ans. Down's Syndrome.

Q.42. The egg of an animal contains 10 chromosomes, of which one is X-chromosome. How many autosomes would there be in the karyotype of this animal?

Ans. There will be 9 pairs of autosomes in the karyotype of this animal.

Q.43. Observe the pedigree chart and answer the following questions:



Q. Identify whether the trait is sex-linked or autosomal.

Ans. The trait is sex-linked.

Q. Give an example of a disease in human beings which shows such a pattern of inheritance.

Ans. Haemophilia, Colour blindness

Q.44. A haemophilic man marries a normal homozygous woman. What is the probability that their daughter will be haemophilic?

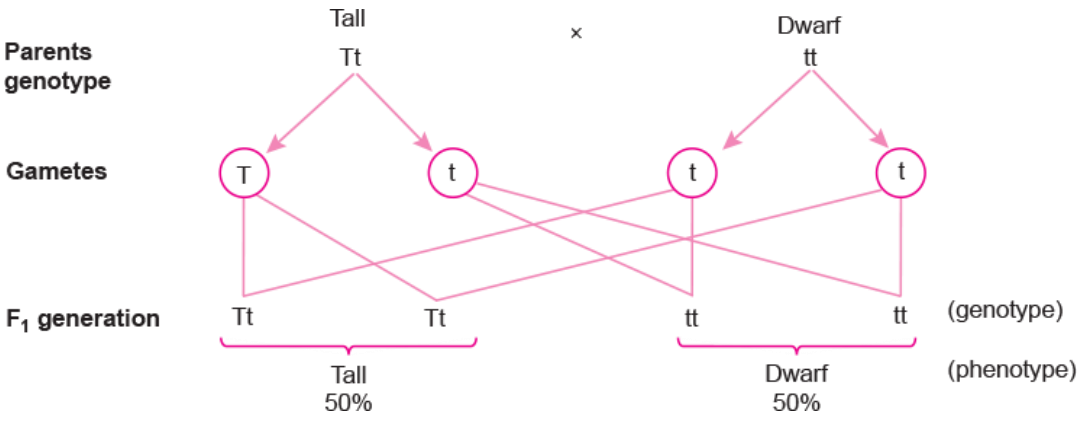
Ans. 0% because only one X chromosome will carry the haemophilia gene. So, she will be a carrier.

Short Answer Questions-I (PYQ)

[2 Marks]

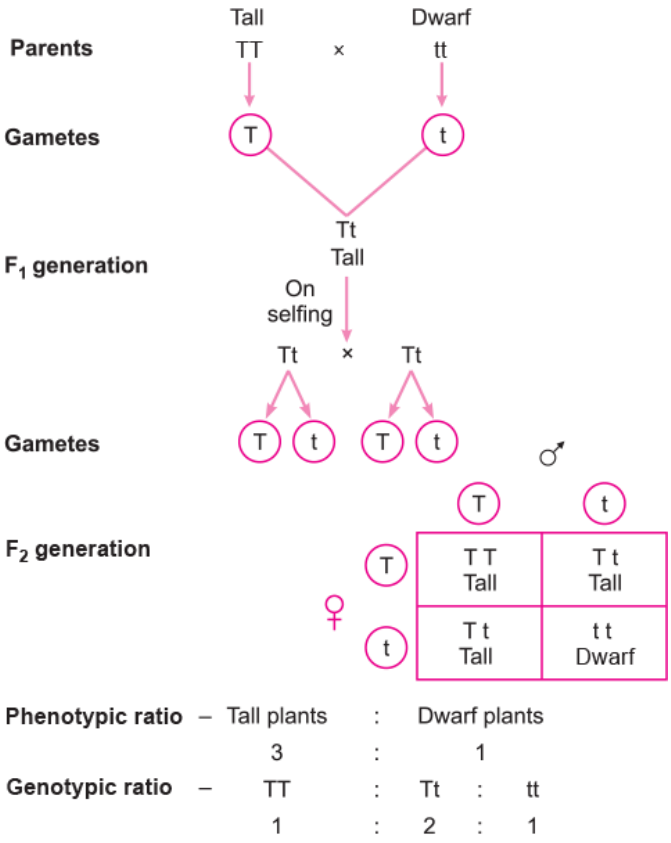
Q.1. During a monohybrid cross involving a tall pea plant with a dwarf pea plant, the offspring populations were tall and dwarf in equal ratio. Work out a cross to show how it is possible.

Ans.



Q.2. With the help of a Punnett square, find the percentage of homozygous talls in a F_2 population involving a true breeding tall and a true breeding dwarf pea plant.

Ans.

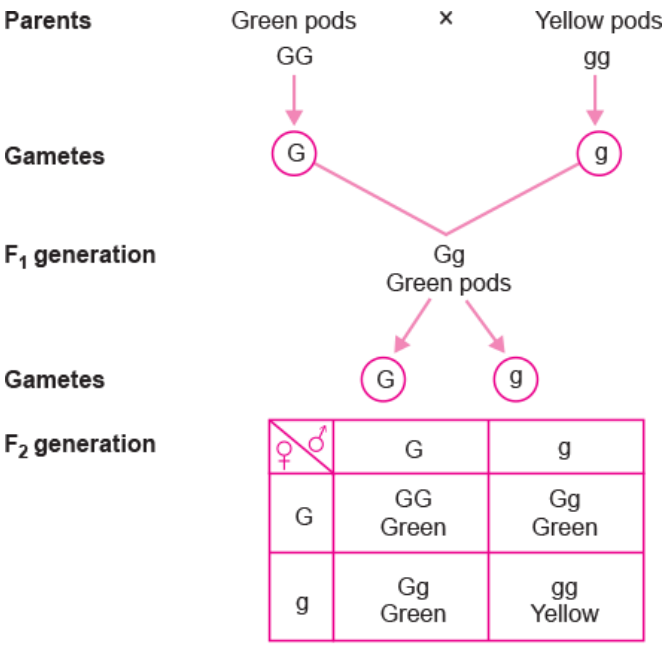


Monohybrid cross of true-breeding pea plant

Percentage of homozygous tall = 1/4×100 = 25%

Q.3. With the help of a Punnett square, find the percentage of heterozygous individuals in a F_2 population in a cross involving a true breeding pea plant with green pods and a true breeding pea plant with yellow pods respectively.

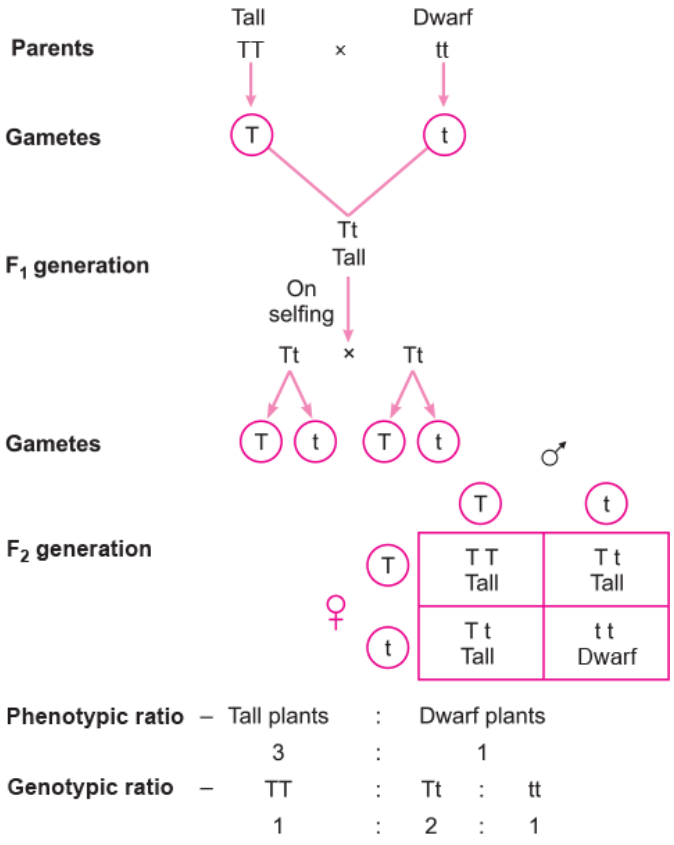
Ans.



% age of heterozygous individuals: $\frac{2}{4} \times 100 = 50\%$

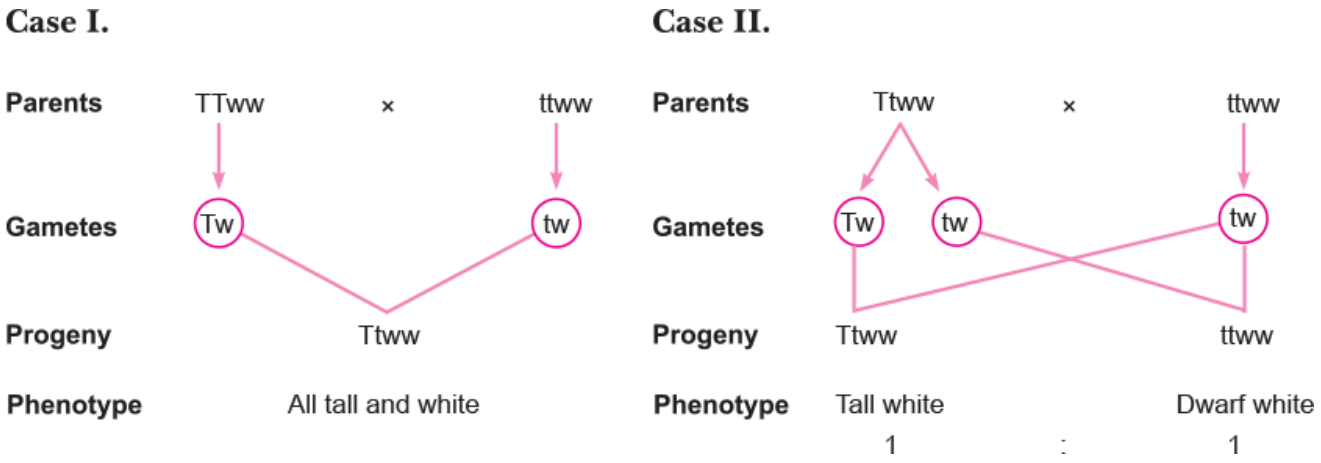
Q.4. In a typical monohybrid cross the F2 population ratio is written as 3:1 for phenotype but expressed as 1:2:1 for genotype. Explain with the help of an example.

Ans. This is a case of Mendel's monohybrid cross.



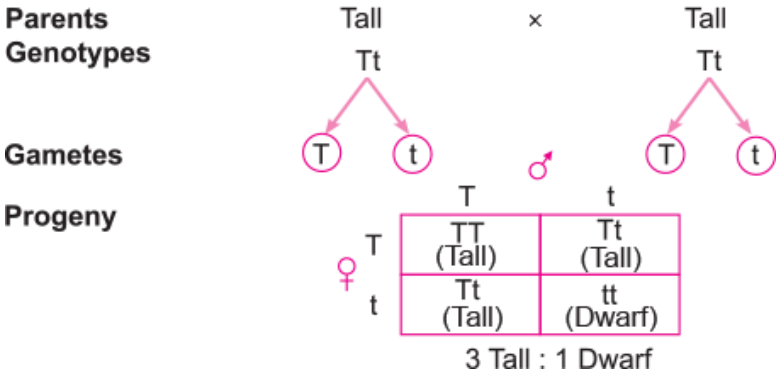
Q.5. How would you find genotype of a tall pea plant bearing white flowers? Explain with the help of a cross. Name the type of cross you would use.

Ans. It can be done by a test cross. This is done by crossing the plant with homozygous recessive parent. If the ratio of progeny is 1 : 1, then the genotype of the plant is heterozygous.



Q.6. When a tall pea plant was selfed, it produced one-fourth of its progeny as dwarf. Explain with the help of a cross.

Ans. Production of one-fourth dwarf progeny on selfing of a tall pea plant indicates that the plant is heterozygous. This can be explained with the cross as follows:



Q.7. A teacher wants his/her students to find the genotype of pea plants bearing purple coloured flowers in their school garden. Name and explain the cross that will make it possible.

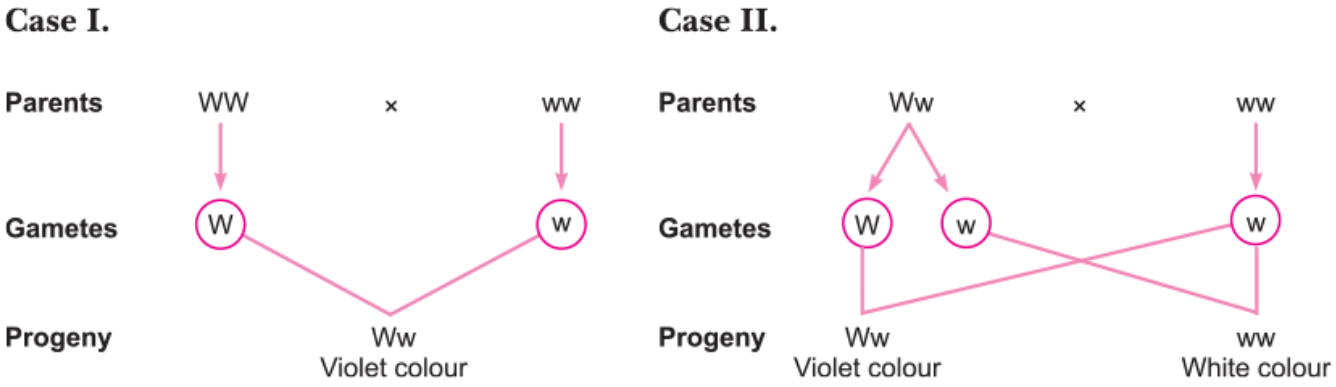
Ans. Test cross will be done.

Test Cross

It is a method devised by Mendel to determine the genotype of an organism.

In this cross, the organism with unknown dominant genotype is crossed with the recessive parent.

In a monohybrid cross between violet colour flower (W) and white colour flower (w), the F_1 hybrid was violet colour flower. The test crosses are:



If all the F1 progeny are violet colour, then the dominant flower is homozygous and if the progenies are in 1 : 1 ratio, then the dominant flower is heterozygous.

Q.8. Explain co-dominance with the help of one example.

Ans. Co-dominance

● The alleles which are able to express themselves independently, even when present together are called co-dominant alleles and this biological phenomenon is called co-dominance.

For example, ABO blood grouping in humans.

● ABO blood groups are controlled by gene I. Gene I has three alleles IA, IB and IO/i.

● IA and IB produce RBC surface antigens sugar polymer A and B, respectively, whereas i does not produce any antigen. IA and IB are dominant over I hence IA and IB are dominant alleles and I is recessive allele as in Iai and Ibi.

● When IA and IB are present together, both express equally and produce the surface antigens A and B, hence show co-dominance.

● Since humans are diploid, each person possesses any two of the three 'I' gene alleles, resulting into six different genotypic combinations and four phenotypic expressions.

Table showing the genetic basis of blood groups in human population

Allele from Parent 1	Allele from Parent 2	Genotype of off spring	Blood groups of off spring
I^A	I^A	I^AI^A	A
I^A	I^B	I^AI^B	AB
I^A	*i*	I^Ai	A
I^B	I^B	I^BI^B	B
I^B	*i*	I^Bi	B
i	*i*	*ii*	O

Q.9. When does a geneticist need to carry a test cross? How is it carried?

Ans. Geneticists carry out a test cross to find out the genotype of the unknown parent. This is carried out by crossing the progeny with the double recessive parent.

Q.10. What is a test cross? How can it decipher the heterozygosity of a plant?

Ans. A cross to analyse whether genotype of dominant individual is homozygous or heterozygous is called test cross.

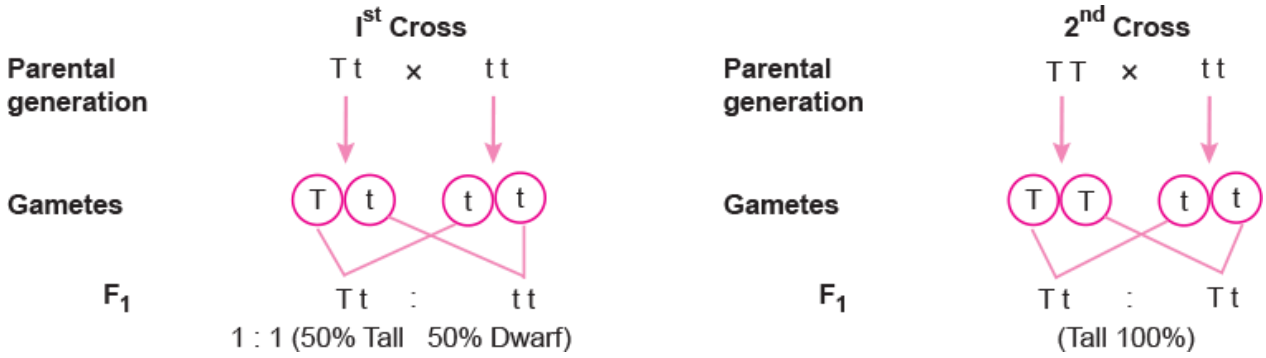
On crossing with a recessive parent, if 50% of progeny have dominant trait and 50% have recessive trait then the plant is said to be heterozygous.

Q.11. Two independent monohybrid crosses were carried out involving a tall pea plant with a dwarf pea plant. In the first cross, the offspring population had equal number of tall and dwarf plants, whereas in the second cross it was different. Work out the crosses, and explain giving reasons for the difference in the offspring populations.

OR

Work out a cross to find the genotype of a tall pea plant. Name the type of cross.

Ans. This type of cross called a test cross.



In the first cross the tall parent plant is heterozygous for the trait, in second cross tall parent plant is homozygous for the trait, hence the respective observation.

Q.12. How does a test cross help to determine the genotype of an individual?

Ans. In a test cross the individual of unknown genotype is crossed with the recessive parent. If all progenies are dominant, then the genotype exhibits homozygosity and if the progenies have a dominant to recessive ratio 1 : 1, then the genotype exhibits heterozygosity.

Q.13. With the help of one example, explain the phenomena of co-dominance and multiple allelism in human population.

Ans. ABO blood group in human being is an example of multiple allelism and co-dominance. There are three alleles for the gene I, i.e., IA, IB, and i, thus, exhibiting multiple allelism.

When IA and IB are present together the blood group is AB. Both A and B blood groups are expressed. This is called co-dominance.

Q.14. Explain pleiotropy with the help of an example.

Ans. Pleiotropy is the phenomenon in which a single gene exhibits multiple phenotypic expression. The pleiotropic gene affects the metabolic pathways, resulting in different phenotypes. For example, phenylketonuria is caused by mutation in the gene coding the enzyme phenylalanine hydroxylase.

Q.15. Who proposed chromosomal theory of inheritance? Point out any two similarities in the behaviour of chromosomes and genes.

Ans. It was proposed by Sutton and Boveri.

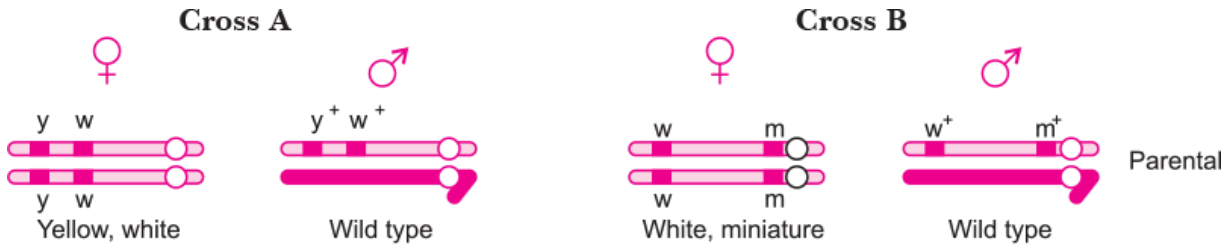
Similarities:

(i) Both genes and chromosomes occur in pairs in a diploid cell (2n).

(ii) Both of them separate out during gametogenesis to enter into different gametes.

(iii) Paired condition is again restored by fusion of gametes.

Q.16. Study the figures given below and answer the question.



Identify in which of the crosses is the strength of linkage between the genes higher. Give reasons in support of your answer.

Ans. In Cross A because the genes are closely placed. Lesser the distance between genes greater is the strength of linkage.

Q.17. Write the scientific name of the fruit-fly. Why did Morgan prefer to work with fruit-flies for his experiments? State any three reasons.

Ans. Drosophila melanogaster is the scientific name of fruit fly. Morgan preferred work with fruit flies because:

(i) It is grown in simple synthetic medium.

(ii) It completes the life cycle in only two weeks.

(iii) It is capable of producing large number of progeny at a time.

Q.18. In a dihybrid cross white eyed, yellow bodied female Drosophila crossed with red eyed, brown bodied male Drosophila produced in F_2 generation, 1.3 per cent recombinants and 98.7 per cent progeny with parental type combinations. This observation of Morgan deviated from Mendelian F_2 phenotypic dihybrid ratio. Explain, giving reasons, Morgan's observations.

Ans. Morgan saw that when the two genes in a dihybrid cross were situated on the same chromosome, the proportion of parental gene combinations were much higher than the non-parental type. Morgan attributed this due to physical association or linkage of two genes and coined the term linkage to describe this physical association of genes on a chromosome and the term recombination to describe the generation of non-parental gene combinations.

Q.19. Linkage and crossing-over of genes are alternatives of each other. Justify with the help of an example.

Ans. In Drosophila a yellow bodied white eyed female was crossed with brown bodied red eyed male. The F_1 progeny produced when intercrossed, it was observed that the F_2 phenotypic ratio of Drosophila deviated significantly from Mendel's 9 : 3 : 3 : 1. The genes for eye colour and body colour are closely located on the 'X' chromosome, showing linkage and therefore, these are inherited together. Recombinants were formed due to crossing over but at low percentage.

Q.20. How does the gene 'I' control ABO blood groups in humans? Write the effect the gene has on the structure of red blood cells.

Ans. Gene 'I' has three different alleles $I^A, I^B, i\ I^A$ produces A type of sugar which results in A group I^B produces B type of sugar which results in B group Produces no sugar which result in O group The sugar polymers protrude from the surface of plasma membrane of RBCs which are characteristics of each blood group.

Q.21.

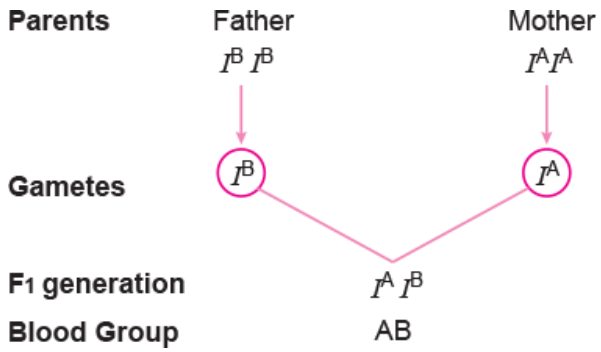
(a) Why is human ABO blood group gene considered a good example of multiple alleles?

(b) Work out a cross up to F_1 generation only, between a mother with blood group A (Homozygous) and the father with blood group B (Homozygous). Explain the pattern of inheritance exhibited.

Ans.

(a) This is because more than two alleles govern the human ABO blood group gene.

(b)



The cross exhibits co-dominance. When the two alleles I^A and I^B are present together, both the alleles express each other equally forming the blood group AB.

Q.22. Human blood group is a good example of multiple allelism and co-dominance. Justify.

Ans. Multiple allelism: Generally in an individual or population, only two alleles of a trait govern the character, but in case of ABO blood group, three alleles I^A, I^B and i are found to govern blood group in human population. This is multiple allelism.

Co-dominance: Allele I^A and I^B when present in an individual, both being dominant express their own types of sugars or traits. Thus, exhibiting co-dominance.

Q.23. Give an example of a gene responsible for multiple phenotypic expressions. What are such genes called? State the cause that is responsible for such an effect.

Ans. Gene causing phenylketonuria causes multiple phenotypic expressions. Such genes are called pleiotropic genes. This effect of multiple phenotypic expressions is caused due to single gene mutation.

Q.24. Differentiate between male and female heterogamety.

Ans.

Sl. No.	**Male heterogamety**	**Female heterogamety**
(*i*)	Male produces two types of gametes (while female produces only one type of gamete)	Female produces two types of gametes (while male produces only one type of gamete)
(*ii*)	XY and XO type are two types of male heterogamety	ZW type is a type of heterogamety

Q.25. Explain mechanism of sex determination in birds.

Ans. In birds, females are heterogemetic and males are homogametic. Females have one Z sex chromosome and one W sex chromosome. Males have a pair of Z sex chromosome. If Z sperm fertilises Z ovum, a male offspring is produced, and if Z sperm fertilises W ovum a female offspring is produced.

Q.26. Explain the mechanism of sex determination in insects like Drosophila and grasshopper.

Ans. In grasshopper, the mechanism of sex determination is of the XO type. In females, the eggs bear a pair of X chromosomes along with the autosomes. On the other hand, there are two types of sperms formed in males–one having a X chromosome and other without X chromosome. Hence, grasshopper shows male heterogamety.

Q.27. Differentiate between "ZZ" and "XY" type of sex-determination mechanisms.

Ans. ZZ type is seen in birds. The males are homogametic (ZZ) and females are heterogametic (ZY). Sex is determined by the type of egg getting fertilised.

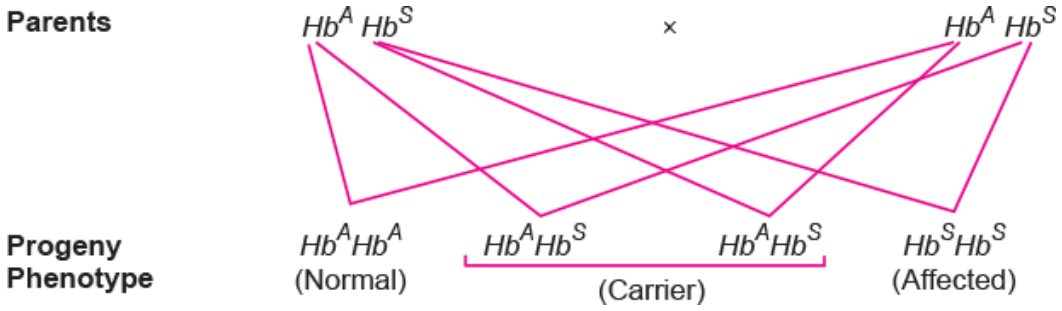
XY type is seen in human beings The males are heterogametic (XY) and females homogametic (XX). Sex is determined by the type of sperm fertilising the ovum.

Q.28. Why is pedigree analysis done in the study of human genetics? State the conclusions that can be drawn from it.

Ans. Pedigree analysis is done to control crosses which are not possible in case of humans beings. This can be useful analysis of traits in several generations of a family, to trace pattern of inheritance to check whether the trait is dominant or recessive or sex-linked or not.

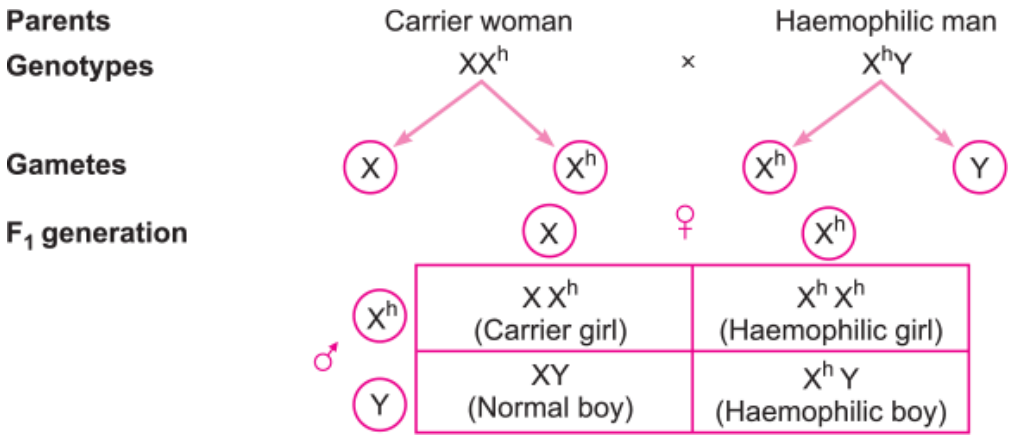
Q.29. Give an example of an autosomal recessive trait in humans. Explain its pattern of inheritance with the help of a cross.

Ans. Sickle cell anaemia is an autosomal recessive trait in humans. The disease is controlled by a single pair of allele HbA and HbS . Only the homozygous individuals HbS HbS show the diseased phenotype. The heterozygous individuals (Hb^AHb^S) are carriers.



Q.30. Recently a baby girl has been reported to suffer from haemophilia. How is it possible? Explain with the help of a cross.

Ans. It is possible to have a haemophilic girl when the cross is between a carrier woman and a haemophilic man as shown below:



Q.31. Why are human females rarely haemophilic? Explain. How do haemophilic patients suffer?

Ans. Haemophilia is a sex-linked recessive disorder. The females haves XX chromosomes and the males have XY chromosomes. If one of the two X chromosomes is normal, she remains a carrier and not diseased. Females will haemophilic only when both the X chromosomes carry the haemophilia gene and this is possible only when the

mother is a carrier and father is haemophilic. Haemophillic patients suffer from non-stop bleeding and no clotting.

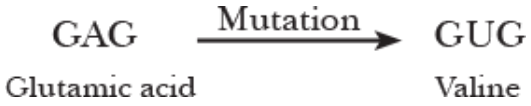
Q.32.

(a) Sickle celled anaemia in humans is a result of point mutation. Explain.

(b) Write the genotypes of both the parents who have produced a sickle celled anaemic offspring.

Ans.

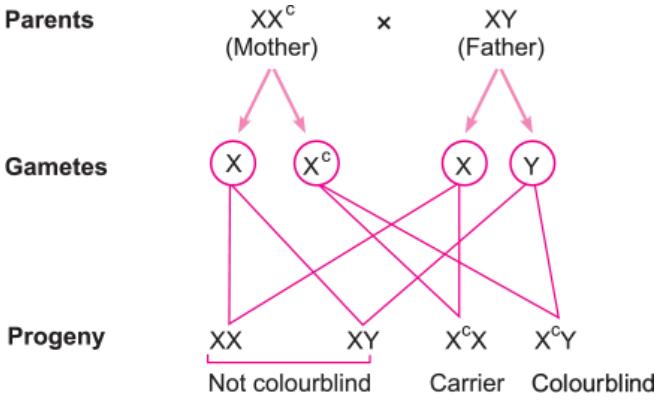
(a) In sickle cell anaemia, due to point mutation there is a substitution of a single nitrogen base at the sixth codon of the β-globin chain of haemoglobin that leads to substitution of value in place of glutamic acid.



(b) The genotypes of both the parents would be Hb^AHb^S and Hb^AHb^S.

Q.33. A couple with normal vision bear a colourblind child. Work out a cross to show how it is possible and mention the sex of the affected child.

Ans.



The colourblind child will be a male.

Q.34. Name a disorder, give the karyotype and write the symptoms a human suffers from as a result of monosomy of the sex chromosome.

Ans. Turner's syndrome is a disorder caused by the absence of one of the X-chromosomes. Its karyotype will be 45 + XO. Symptoms are:

(i) Sterile females

(ii) Rudimentary ovaries

(iii) Lack of secondary sexual characters.

Q.35. Name a disorder, give the karyotype and write the symptoms where a human male suffers as a result of an additional X-chromosome.

Ans. Klinefelter's syndrome. The karyotype is 44 + XXY. Symptoms are:

(i) Sex of the individual is masculine but possesses feminine characters.

(ii) Gynaecomastia, i.e., development of breasts.

(iii) Poor beard growth and often sterile.

(iv) Feminine pitched voice.

Q.36. Name the phenomenon that leads to situations like 'XO' abnormality in humans. How do humans with 'XO' abnormality suffer? Explain.

Ans. Absence of one X chromosome leads to XO abnormality. These are sterile female with rudimentary ovaries. They have shield-shaped thorax, webbed neck, poor development of breasts, short stature, small uterus and puffy fingers.

Q.37. Which chromosome carries the mutated gene causing β-thalassemia? What are the problems caused by the mutation?

Ans. Chromosome number 11 carries the mutant gene causing β-thalassemia. It causes formation of abnormal haemoglobin molecules, resulting into anaemia.

Q.38. Both haemophilia and thalassemia are blood related disorders in humans. Write their causes and the difference between the two. Name the category of genetic disorder they both come under.

Ans.

Haemophilia	**Thalassemia**
Single protein involved in the clotting of blood isaffected.	Defects in the synthesis of globin leading to formation of abnormal hemoglobin.
Sex-linked recessive disorder.	Autosomal recessive disorder.
Blood does not clot.	Results in anaemia.

Q.39. A relevant portion of β-chain of haemoglobin of a normal human is given below:

The codon for the sixth amino acid is GAG. The sixth codon GAG mutates to GAA as a result of mutation 'A' and into GUG as a result of mutation 'B'. Haemoglobin structure did not change as a result of mutation 'A' whereas haemoglobin

structure changed because of mutation 'B' leading to sickle shaped RBCs. Explain giving reasons how could mutation 'B' change the haemoglobin structure and not mutation 'A'.

Ans. Due to mutation 'A', GAG mutates to GAA. But both GAG and GAA code for glutamic acid and hence there is no change in RBCs. Whereas GUG formed due to mutation 'B' codes for valine and so the RBCs become sickle-shaped.

Q.40. In snapdragon, a cross between true-breeding red flowered (RR) plants and true-breeding white flowered (rr) plants showed a progeny of plants with all pink flowers.

(a) The appearance of pink flowers is not known as blending. Why?

(b) What is this phenomenon known as?

Ans.

(a) R (dominant allele red colour) is not completely dominant over r (recessive allele white colour). r maintains its originality and reappears in F_2 generation. Therefore, it is not blending.

(b) Incomplete dominance.

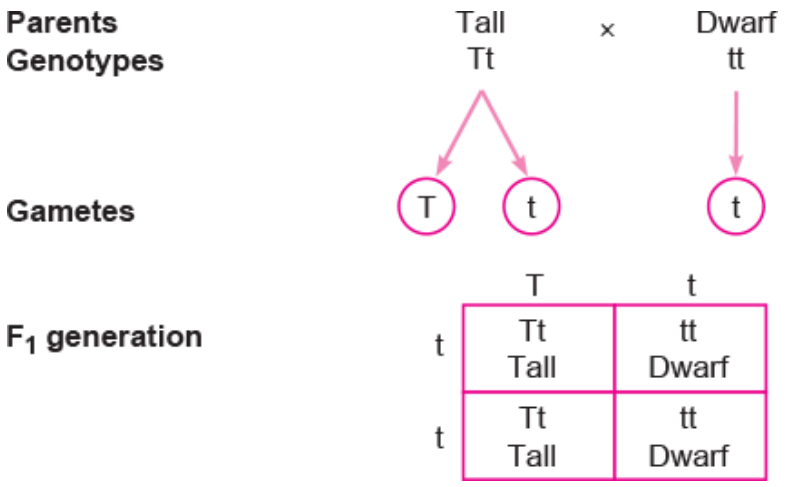
Q.41. A cross was carried out between two pea plants showing the contrasting traits of height of the plant. The result of the cross showed 50% of parental characters.

(i) Work out the cross with the help of a Punnett square.

(ii) Name the type of the cross carried out.

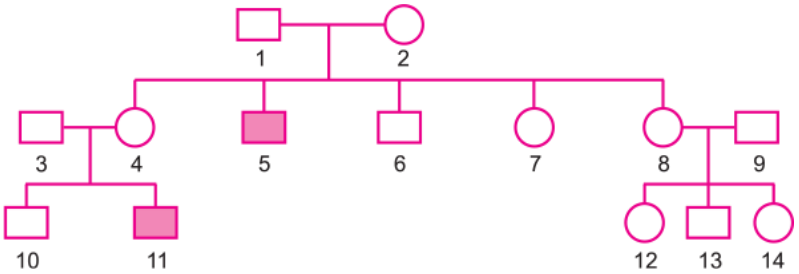
Ans.

(i)



(ii) Test cross

Q.42. Haemophilia is a sex-linked inheritance condition in humans where a simple cut causes non-stop bleeding. Study the pedigree chart showing the inheritance of haemophilia in a family. Answer the questions that follow:



Give reasons which explain that haemophilia is

(i) sex-linked, and

(ii) caused by 'X'-linked gene.

Ans.

(i) Haemophilia is sex-linked because it shows transmission from unaffected carrier female to some of the male progeny.

(ii) Haemophilia is caused by 'X'-linked gene because the heterozygous female for haemophilia may transmit the disease to sons. It appears more in males because of only one X chromosome.

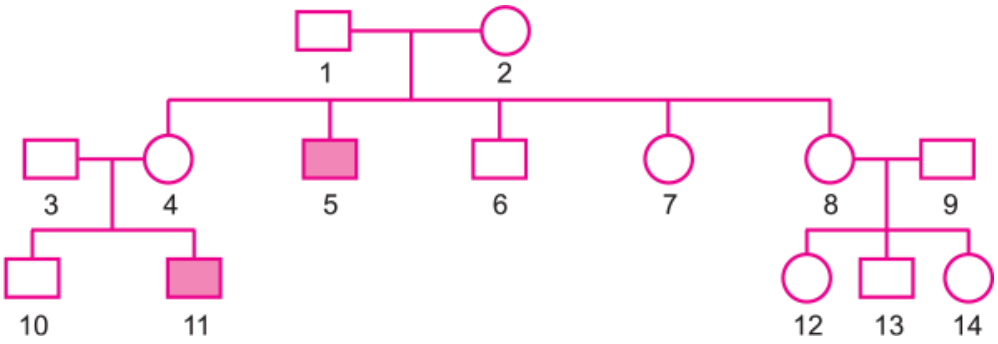
Q.43. A cross between a normal couple resulted in a son who was haemophilic and a normal daughter. In course of time, when the daughter was married to a normal man, to their surprise, the grandson was also haemophilic.

(i) Represent this cross in the form of a pedigree chart. Give the genotypes of the daughter and her husband.

(ii) Write the conclusion you draw of the inheritance pattern of this disease.

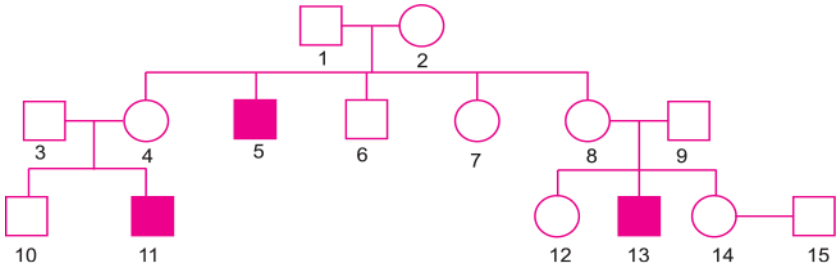
Ans.

(a)



(b) Sex-linked recessive inheritance pattern.

Q.44. Haemophilia is a sex-linked recessive disorder of humans. The pedigree chart given below shows the inheritance of haemophilia in one family. Study the pattern of inheritance and answer the questions given.



(i) Give all the possible genotypes of the members 4, 5 and 6 in the pedigree chart.

(ii) A blood test shows that the individual 14 is a carrier of haemophilia. The member numbered 15 has recently married the member numbered 14. What is the probability that their first child will be a haemophilic male?

Ans.

(i) Genotypes of member 4— XX or XX^h Genotype of member 5— X^hY and Genotype of member 6— XY

(ii) The probability of first child to be a haemophilic male is 25%.

Short Answer Questions-I (OIQ)

[2 Mark]

Q.1. What are the characteristic features of a true-breeding line?

Ans. A true-breeding line for a trait is one that has undergone continuous self-pollination, showing a stability in the inheritance of the trait for several generations.

Q.2. Differentiate between back cross and test cross.

Ans. If a cross is done between the F1 hybrid organism and any one of the parent, it is called back cross. If a cross is done between F1 hybrid organism and the homozygous recessive individual, it is called test cross.

Q.3. Explain two situations when independent assortment of genes occur, resulting in 50% recombination?

Ans.

i. When the genes of different traits are located on the same chromosome, and must be distantly located to enhance the recombination frequency they are so far apart that there is 100% chance of crossing over between them.

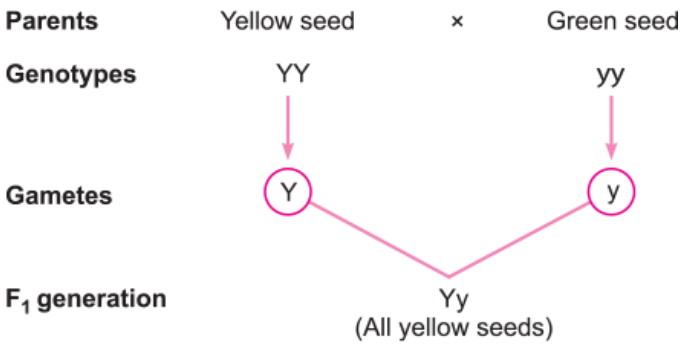
ii. When the genes of different traits may be located on different chromosomes.

Q.4. In order to obtain the F_1 generation, Mendel pollinated a true-breeding, say, tall plant with a true-breeding dwarf plant. But for getting the F2 generation, he simply self-pollinated the tall F_1 plants. Why?

Ans. All the F_1 off springs of the cross are heterozygous so allowing self-pollination is sufficient to raise F_2 offspring. Also, he intended to understand the inheritance of the selected trait over generations.

Q.5. Mendel crossed plants that bred true for yellow seeds with plants that bred true for green seeds. All seeds in the F1 generation were yellow. Work out the inheritance involved in this cross by using symbols for the trait. Which trait was dominant?

Ans.



Conclusion: The yellow seed colour is dominant over green as it is expressed in the F_1 generation.

Q.6. In a particular plant species, majority of the plants bear purple flowers. Very few plants bear white flowers. No intermediate colours are observed. If you are given a plant bearing purple flowers, how would you ascertain that it is a pure breed for that trait? Explain.

Ans. By test cross. Cross purple flower plant with a (homozygous) recessive plant with white flowers, if all the flowers of the progeny of the above are purple, the plant is homozygous dominant, i.e. pure breed.

Q.7. In snapdragon (Antirrhinum majus), a cross between varieties with red and white flowers produces an all pink progeny. Explain how it is a case of incomplete dominance and not of blending inheritance.

Ans. In incomplete dominance the genes of an allelomorphic pair are not expressed as dominant and recessive but express themselves partially when present together in a

hybrid and is an intermediate between the two genes. As a result an intermediate character is obtained. e.g., Two types of flowers occur in Mirabilis jalapa (4 o' clock plant) and Antirrhinum majus (snapdragon/dog flower). The red flower colour is due to gene RR, white flower colour is due to gene rr but pink flower colour appears in case of genotype Rr..

It is not a case of blending inheritance because the parental characters reappear in the F_2 generation without any modification.

Q.8. In peas, tallness is dominant over dwarfness, and red colour of flowers is dominant over the white colour. When a tall plant bearing red flowers was pollinated by a dwarf plant bearing white flowers, the different phenotypic groups were obtained in the progeny in numbers mentioned against them.

Tall, Red = 138 Tall, White = 132

Dwarf, Red = 136 Dwarf, White= 128

Mention the genotypes of the two parents and of the types of four off springs.

Ans. The result shows that the four types of offspring are in a ratio of 1 : 1 : 1 : 1. Such a result is observed in a test cross progeny of a dihybrid cross.

The cross can be represented as:

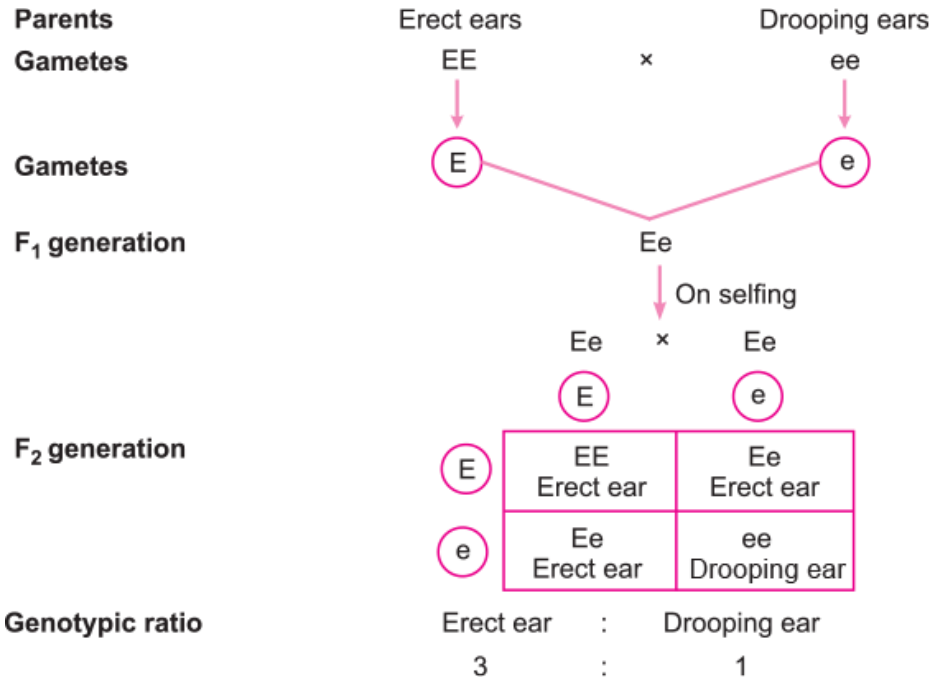
Parents: Tall and red (TtRr) × Dwarf and white (ttrr)

Offsprings:

♀ ♂	**TR**	**Tr**	**tR**	**tr**
tr	TtRr Tall and red	Ttrr Tall and white	ttRR Dwarf and red	ttrr Dwarf and white

Q.9. In a certain mammal, erect ears are dominant over drooping ears. In a cross between the two types, out of the four offsprings produced in F_2 generation, three had erect ears and one had drooping ears. What were the genotypes of the parent? (You may represent the dominant gene as E.)

Ans.



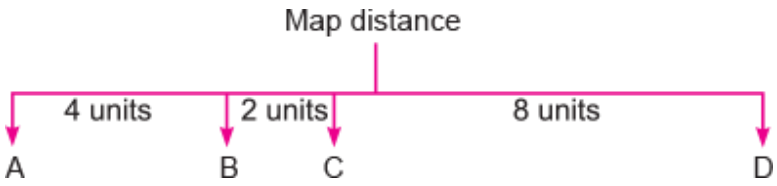
Thus, the genotypes of parents were EE and ee.

Q.10. The phenotypic and genotypic ratio in F2 generation are same in a certain kind of inheritance. Name an organism in which it occurs and mention the kind of inheritance involved.

Ans. This kind of inheritance occurs in Mirabilis jalapa (4 o'clock plant) and the type of inheritance is called incomplete dominance.

Q.11. The map distance in certain organisms between gene A and B is 4 units, B and C is 2 units and between C and D is 8 units which one of these gene pairs will show more recombination frequency? Give reasons in support of your answer.

Ans.



The recombination frequency is directly proportional to the distance between the genes. The distance between C and D is more, i.e., 8 units in the above condition, so recombination frequency will be more between them.

Q.12. What are linked genes? How can a pair of linked genes be identified?

Ans. The genes which tend to transmit together as a single unit, as they are located very close on the same chromosome, from one generation to the next are called linked

genes. The linked genes modify the Mendelian dihybrid ratio from 9 : 3 : 3 : 1 to 3 : 1 and modify dihybrid test ratio from 1 : 1 : 1 : 1 to 1 : 1.

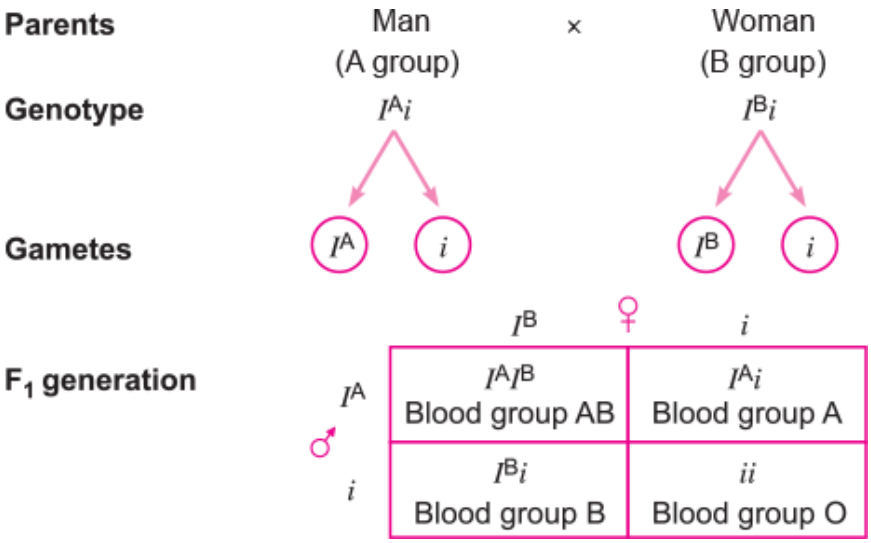
Q.13. The male fruit fly and female fowl are heterogametic while the female fruit fly and the male fowl are homogametic. Why are they called so?

Ans. The male fruit fly has XY sex chromosomes and produces two types of gametes, hence it is called heterogametic while female fowl has ZW sex chromosomes thereby producing two types of gametes, thus it is called heterogametic.

Female fruit fly has two X chromosomes, i.e., XX and produces similar gametes, hence it is called homogametic. Also, male fowl has two Z chromosomes and produces similar gametes, thus it is called homogametic.

Q.14. A man with blood group A married a woman with B group. They have a son with AB blood group and a daughter with blood group O. Work out the cross and show the possibility of such inheritance.

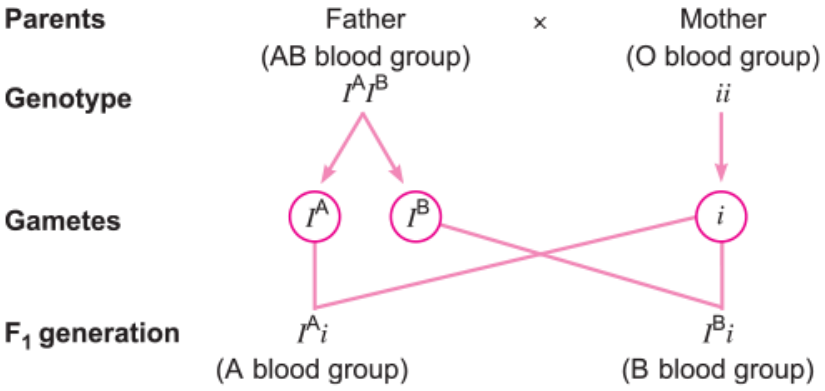
Ans.



Thus, the F1 progeny can have all the four possible blood groups, i.e., A, B, AB and O.

Q.15. A woman with blood group O married a man with AB group. Show the possible blood groups of the progeny. List the alleles involved in this inheritance.

Ans.



The alleles involved in this inheritance are: I^A, I^B and i.

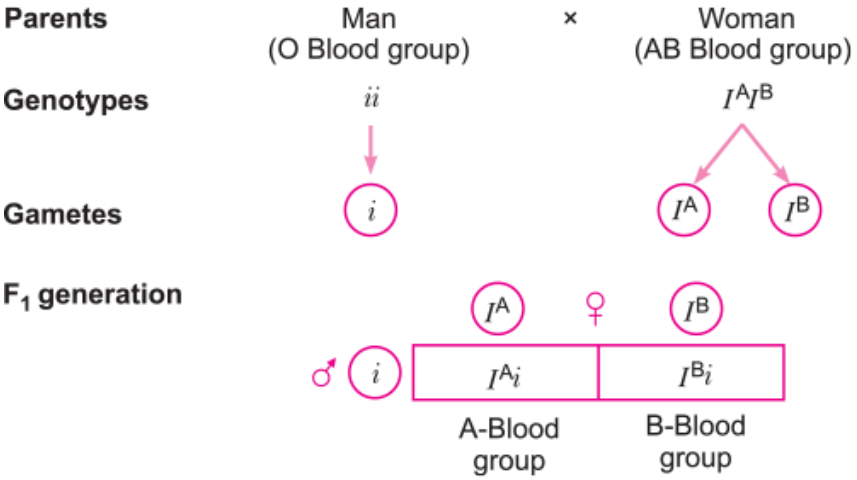
Q.16. What is trisomy? Give an example.

Ans. When a particular chromosome is present in three copies in a cell, it is called trisomy.

For example, Down's syndrome is because of trisomy of 21st chromosome.

Q.17. A man with blood group O and his wife with blood group AB claim a child with blood group AB as their son. With Punnett square justify their statement.

Ans.



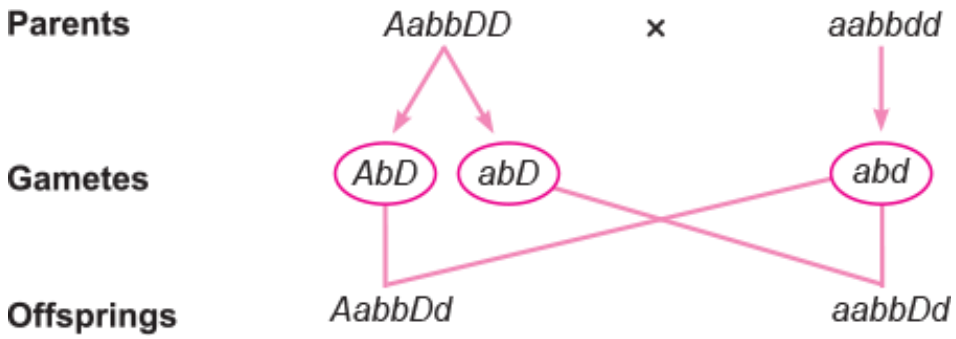
Hence, the progeny can only have blood group A or B but can never have blood group 'AB'. Thus, the statement given by the couple is false.

Q.18. Even if character shows multiple allelism an individual will have only two alleles for that character, why?

Ans. Diploid individual has only two sets of homologous chromosomes hence only two alleles of a gene can be present on homologous pair of chromosome.

Q.19. A, B and D are three independently assorting genes with their recessive alleles a, b and d, respectively. A cross was made between individuals of AabbDD genotype and aabbdd. Explain the type of genotypes of the offspring produced.

Ans.



Q.20. Explain why the term 'homozygous' and 'heterozygous' with respect to an X-linked trait are applicable to human females but not to human males?

Ans. Females have two X chromosomes. Therefore, two alleles of a gene are present on the homologous chromosomes which can be either in a heterozygous or homozygous condition. Whereas males have only one X chromosome and one Y chromosome. Since, these do not have homologous chromosomes, so a single form of gene is present.

Q.21. Why do the sons of a haemophilic father never suffer from this trait?

Ans. Haemophilia is X-linked recessive disorder. The father passes only the Y chromosome to the son and not the haemophilic X chromosome. Therefore, sons of haemophilic father never suffer from haemophilia.

Q.22. How is the child affected if it has grown from the zygote formed by an XX-egg fertilised by a Y-carrying sperm? What do you call this abnormality?

Ans. The zygote will be XXY, i.e., the zygote is male but with feminine characters. This disorder is called Klinefelter's syndrome.

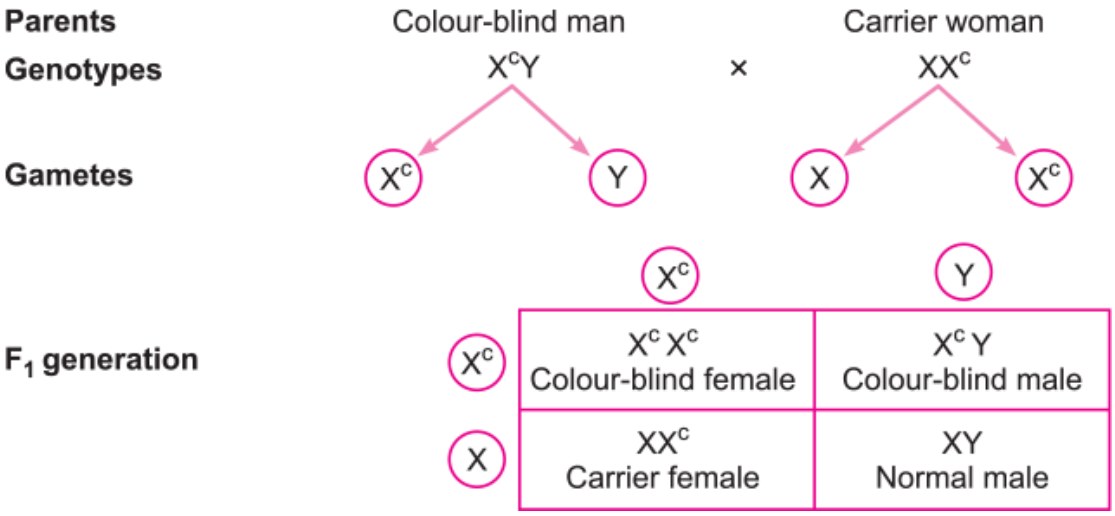
Q.23. Sometimes a gene which carries a major disadvantage in homozygous state confers an advantage in heterozygous condition. Explain by giving suitable example.

Ans. The individual with homozygous condition $(\mathrm{HB}^{\mathrm{S}}\ \mathrm{Hb}^{\mathrm{S}})$ for sickle-cell anaemia dies before reaching 20 years of age. The individual with normal gene (HbHb) does not have sickle-cell anaemia but they are sensitive towards malaria.

The individual with heterozygous condition $(\mathrm{HbHb}^{\mathrm{S}})$ for sickle-cell anaemia do not develop sickle-cell anaemia and are resistant to malaria. Due to abnormal haemoglobin, the malarial parasite will not affect the person. So, the heterozygous condition has more survival advantage with respect to the homozygous individuals.

Q.24. A colour-blind man marries a woman with normal vision whose father was colour-blind. Work out a cross to show the genotype of the couple and their respective sons.

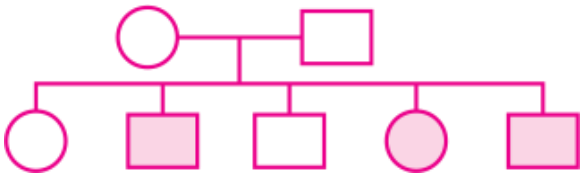
Ans. The father of normal woman is colour-blind, so the woman will be carrier, i.e., XX^c .



50% sons will be colour-blind and rest 50% will be normal.

50% daughters will be colour-blind and rest 50% will be carriers.

Q.25. A pedigree chart given below, present a particular generation which shows a trait irrespective of sexes (i.e., present in both male and female). Neither of the parents of the particular generation shows the trait. Draw your conclusion on the basis of the pedigree.



Ans. The trait is autosome linked and recessive in nature. Both the parents are carriers (i.e., heterozygous). Hence, among the offsprings only few show the trait irrespective of sex. The other offsprings are either normal or carrier.

Q.26. A woman of 47 years, delivered an abnormal child with flattened nasal bridge and mouth usually open with a large protruding tongue. Name this genetic abnormality. What causes this condition?

Ans. The genetic disorder is known as Down's syndrome. It is caused due to trisomy of 21st chromosome.

Q.27. Give the chromosomal constitution and the resulting sex in each of the following syndromes:

Q. Turner's syndrome

Ans. XO, female

Q. Klinefelter's syndrome

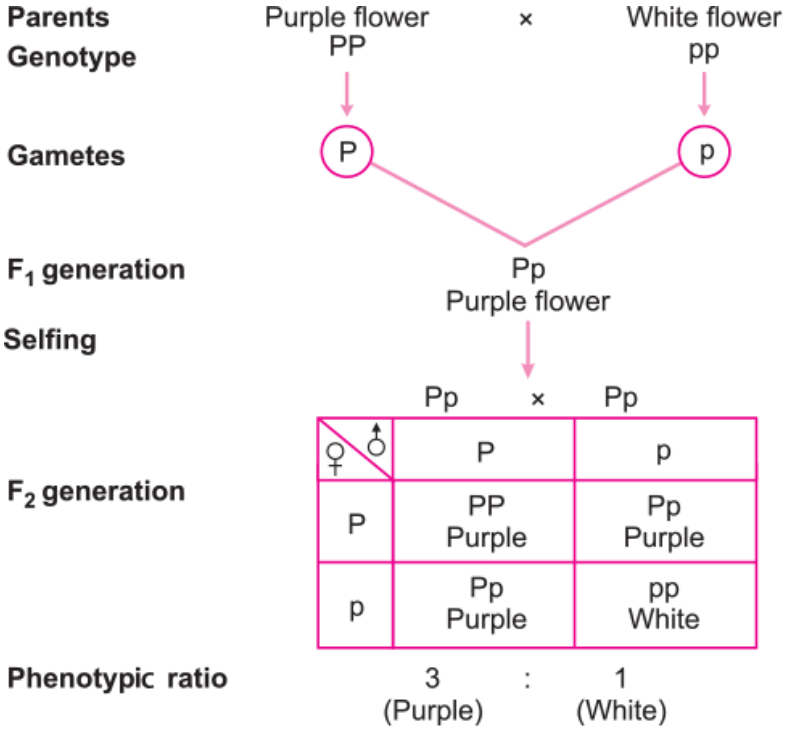
Ans. XXY, male with female characters.

Short Answer Questions-II (PYQ)

[3 Marks]

Q.1. A pea plant with purple flowers was crossed with white flowers producing 50 plants with only purple flowers. On selfing, these plants produced 482 plants with purple flowers and 162 with white flowers. What genetic mechanism accounts for these results? Explain.

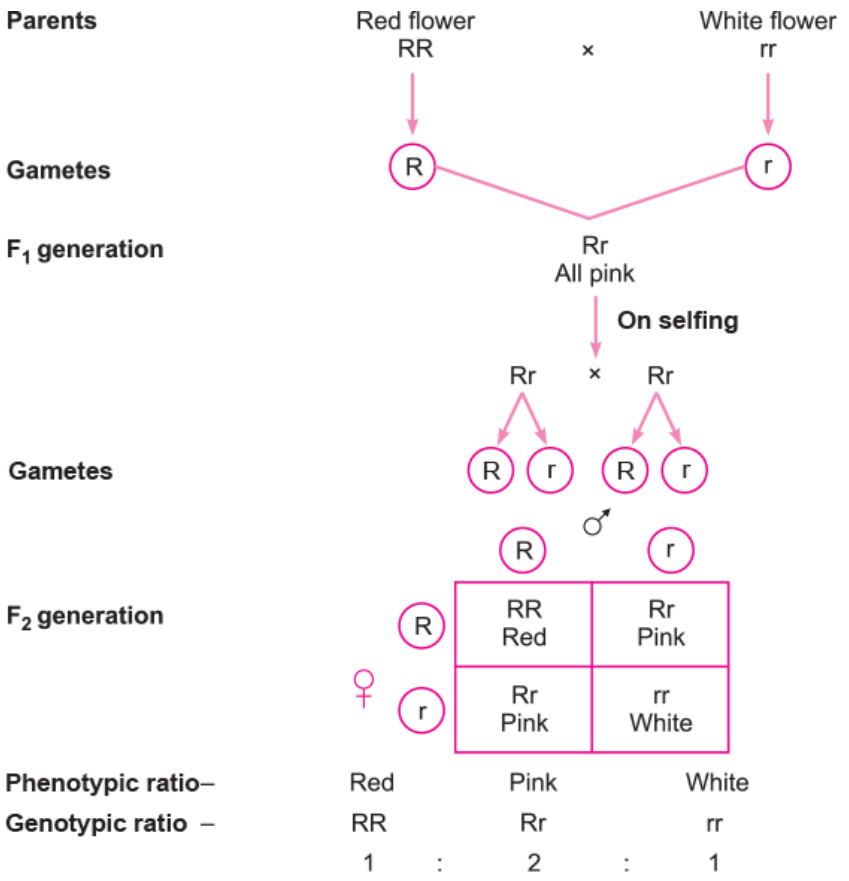
Ans. The gene for purple flowers is dominant over that of white flowers. So, when two pure varieties are crossed, the F1 generation has only purple flowers and on selfing, the flowers are produced in a 3 : 1 ratio.



This result is obtained due to segregation of the alleles at the time of gametogenesis. The alleles remain together in a zygote but during gamete formation, they segregate such that the gametes carry only one allele.

Q.2. The F_2 progeny of a monohybrid cross showed phenotypic and genotypic ratio as 1 : 2 : 1, unlike that of Mendel's monohybrid F_2 ratio. With the help of a suitable example, work out a cross and explain how it is possible.

Ans. This kind of cross is observed in Mirabilis jalapa/Four o'clock plant/Antirrhinum majus.



Monohybrid cross in snapdragon, where one allele is incompletely dominant over the other allele

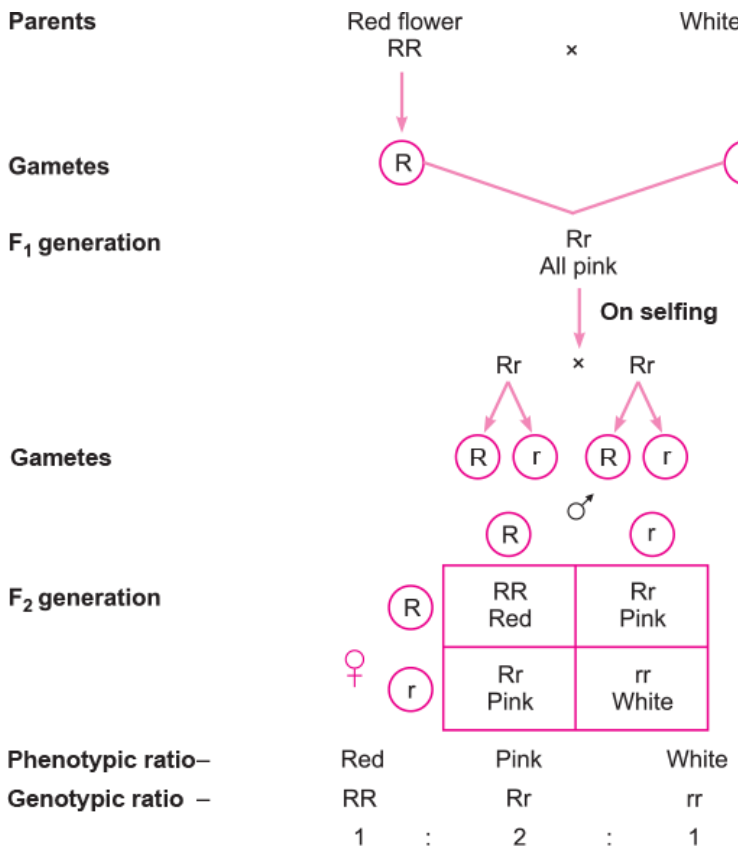
In heterozygous condition a single dominant gene is not sufficient to produce red colour therefore it is a case of incomplete dominance.

Q.3. Snapdragon shows incomplete dominance for flower colour. Work out a cross and explain the phenomenon. How is this inheritance different from Mendelian pattern of inheritance? Explain.

OR

In snapdragon (Antirrhinum majus), a plant with red flowers was crossed with a plant with white flowers. Work out all the possible genotypes and phenotypes of F_1 and F_2 generations. Comment on the pattern of inheritance in this case.

Ans.



Monohybrid cross in snapdragon, where one allele is incompletely dominant over the other allele

Q.4. How are dominance, co-dominance and incomplete dominance patterns of inheritance different from each other?

Ans. Dominance: It is a phenomenon in which when two contrasting alleles are present together, only one expresses itself and is called dominant whereas the other which does not express itself is called recessive.

Co-dominance: It is a phenomenon in which when two contrasting alleles are present together, both of the alleles express themselves.

Incomplete dominance: It is a phenomenon in which when two contrasting alleles are present together neither of the alleles is dominant over other and the phenotype formed is intermediate of the two alleles. *e.g.,*

Red flower × White flower → Pink flower colour

Q.5. Why did T.H. Morgan select Drosophila melanogaster to study sex linked genes for his lab experiments?

Ans. T.H. Morgan selected Drosophila melanogaster for his study because:

(i) it can be grown in a simple synthetic medium in laboratory.

(ii) it completes its life cycle in only two weeks.

(iii) large number of progeny are produced at a time.

(iv) there is differentiation of sexes.

(v) many hereditary variations can be observed.

Q.6. During his studies on genes in Drosophila that were sex-linked. T.H. Morgan found population phenotypic ratios deviated from expected 9 : 3 : 3 : 1. Explain the conclusion he arrived at.

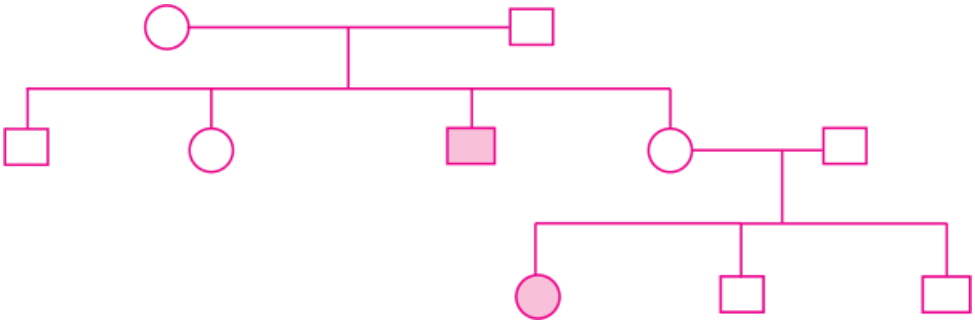
Ans.

(i) He observed that when the two genes in a dihybrid cross are located on the same chromosome, the proportion of parental gene combinations in the progeny was much higher than the non-parental or recombination of genes.

(ii) Morgan and his group found that when genes were grouped on the same chromosome, some genes are tightly linked and show less recombination.

(iii) When the genes are loosely linked they show higher recombination.

Q.7. Study the given pedigree chart and answer the questions that follow:



Q. Is the trait recessive or dominant?

Ans. Recessive trait.

Q. Is the trait sex-linked or autosomal?

Ans. Autosomal trait.

Q. Give the genotypes of the parents in generation I and of their third and fourth child in generation II.

Ans. Genotypes of the parents in generation I is ‘Aa’ and ‘Aa’. Genotypes in generation II of third child is ‘aa’ and fourth child is ‘Aa’.

Q.8. Explain the sex determination mechanism in humans. How is it different in birds?

Ans. For sex determination in humans refer to Basic Concepts Point 13.

In birds, female heterogamety is observed. They exhibit ZW type of sex determination. Both males and females have equal number of chromosomes. Female birds have one Z and one W chromosome whereas males have a pair of Z chromosomes.

Q.9. Explain how does trisomy of 21st chromosome occur in humans. List any four characteristic features in an individual suffering from it.

Ans. Down's syndrome

Cause: Additional copy of chromosome number 21 or trisomy of chromosome 21.

Symptoms:

(i) Short statured with small round head.

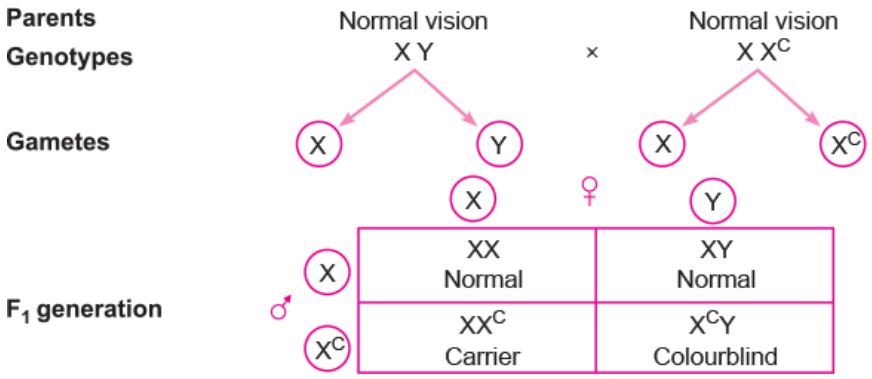
(ii) Partially open mouth with protruding furrowed tongue.

(iii) Palm is broad with characteristic palm crease.

(iv) Slow mental development.

Q.10. One of the twins born to parents having normal colour vision was colour blind whereas the other twin had normal vision. Work out the cross. Give two reasons how it is possible.

Ans.



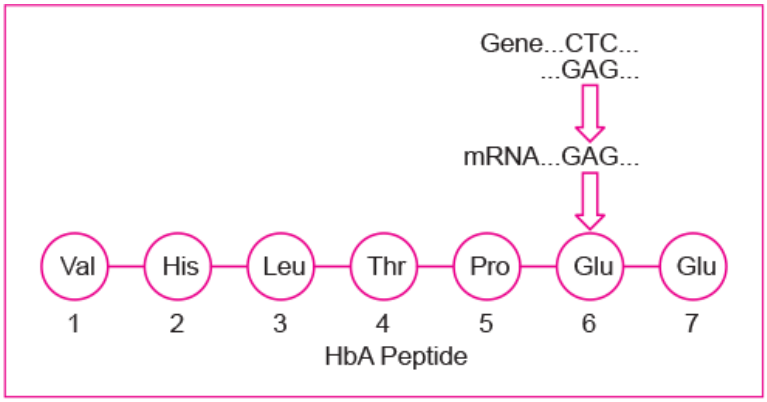
It is possible when the mother is carrier of colourblindness gene. She will have normal vision but will pass on the gene to her children. Another possibility is that there is a mutation on the X-chromosome of one of the twins.

Q.11. Explain the pattern of inheritance of haemophilia in humans. Why is the possibility of a human female becoming a haemophilic extremely rare? Explain.

Ans. Haemophilia is a sex-linked (X-chromosome linked) recessive disorder which shows its transmission from unaffected carrier female to some of the male progeny. If the female is a carrier (heterozygous XX^h), it transmits the disease only to some of her sons but a sufferer (homozygous $X^h X^h$) female transmits the disease to all her sons.

The possibility of a female becoming haemophilic is extremely rare because to be diseased she has to be homozygous (X^h X^h) recessive for that trait. As females have 2X chromosomes so there is rare chance of being homozygous recessive.

Q.12. Given below is the representation of amino acid composition of the relevant translated portion of b-chain of haemoglobin, related to the shape of human red blood cells.



Q. Is this representation indicating a normal human or a sufferer from certain related genetic disease? Give reason in support of your answer.

Ans. This representation (HbA peptide) indicates a normal human because glutamic acid in the sixth position is not substituted by valine.

Q. What difference would be noticed in the phenotype of the normal and the sufferer related to this gene?

Ans. The sufferer's RBC become elongated and sickle shaped whereas the normal person will have biconcave RBCs.

Q. Who are likely to suffer more from the defect related to the gene represented the males, the females or both males and females equally? And why?

Ans. Both males and females are likely to suffer from the disease equally because this is not a sexlinked disease. It is an autosomal-linked recessive trait.

Q.13. (a) Name the kind of diseases/disorders that are likely to occur in humans if

(i) mutation in the gene that codes for an enzyme phenyl alanine hydrolase occurs,

(ii) there is an extra copy of chromosome 21,

(iii) the karyotype is XXY.

(b) Mention any one symptom of the diseases/disorders named above.

Ans.

	Disease/disorder	**Symptoms**

(*i*)	Phenylketonuria	Mental retardation
(*ii*)	Down's syndrome	Short stature/furrowed tongue
(*iii*)	Klinefelter's syndrome	Overall masculine development with feminine features (enlarged breast)

Q.14. Explain the causes, inheritance pattern and symptoms of any two Mendelian genetic disorders.

Ans.

(a) Haemophilia

(i) It is a sex-linked recessive disorder.

(ii) Patient continues to bleed even with a minor cut because of a defect in blood coagulation.

(iii) The gene for haemophilia is located on X chromosome.

(iv) More males suffer from haemophilia than females because in males single gene for the defect is able to express as males have only one X chromosome.

(v) The defective alleles produce non-functional proteins which later form a non-functional cascade of proteins involved in blood clotting.

(vi) Females suffer from this disease only in homozygous condition, i.e., Xc Xc .

(vii) Queen Victoria was a carrier of this disease and produced haemophilic offsprings.

(b) Sickle-cell anaemia

(i) It is an autosome-linked recessive trait.

(ii) The disease is controlled by a single pair of allele HbA and HbS .

(iii) Only the homozygous individuals for HbS , i.e., HbS HbS show the diseased phenotype.

(iv) The heterozygous individuals are carriers (HbAHbS).

(v) Due to point mutation, glutamic acid (Glu) is replaced by valine (Val) at the sixth position of β-globin chain of haemoglobin molecule.

(vi) HbS behaves as normal haemoglobin except under oxygen stress where erythrocytes lose their circular shape and become sickle-shaped. As a result, the cells cannot pass through narrow capillaries. Blood capillaries are clogged and thus affect blood supply to different organs.

Q.15. Write the symptoms of haemophilia and sickle-cell anaemia in humans. Explain how the inheritance pattern of the two diseases differs from each other.

Ans. Symptoms of Haemophilia: Patient continues to bleed even on a minor cut as the patient does not possess natural phenomenon of blood clotting.

Symptoms of Sickle-cell Anaemia: Hb behaves as normal haemoglobin except under oxygen stress where erythrocytes lose their circular shape and become sickle-shaped. As a result, the cells cannot pass through narrow capillaries. Blood capillaries are clogged and thus affects blood supply to different organs.

Q.16. Answer the following questions:

Q. Explain the phenomena of dominance, multiple allelism and co-dominance taking ABO blood group as an example.

Ans. Dominance: The alleles I^A and I^B both are dominant over allele i as I^A and I^B form antigens A and B, respectively, but i does not form any antigen.

Multiple allelism is the phenomenon of occurrence of a gene in more than two allelic forms on the same locus. In ABO blood group in humans, one gene I has three alleles I^A, I^B and IO/i.

Co-dominance is the phenomena in which both alleles express themselves when present together. We inherit any two alleles for the blood group. When the genotype is I^AI^B the individual has AB blood group since both I^A and I^B equally influence the formation of antigens A and B.

Q.17. Answer the following questions:

Q. Explain sex determination in humans.

Ans. Sex Determination in Humans

***** Humans show XY type of sex determining mechanism.

***** Out of 23 pair of chromosomes, 22 are autosomes (same in both males and females).

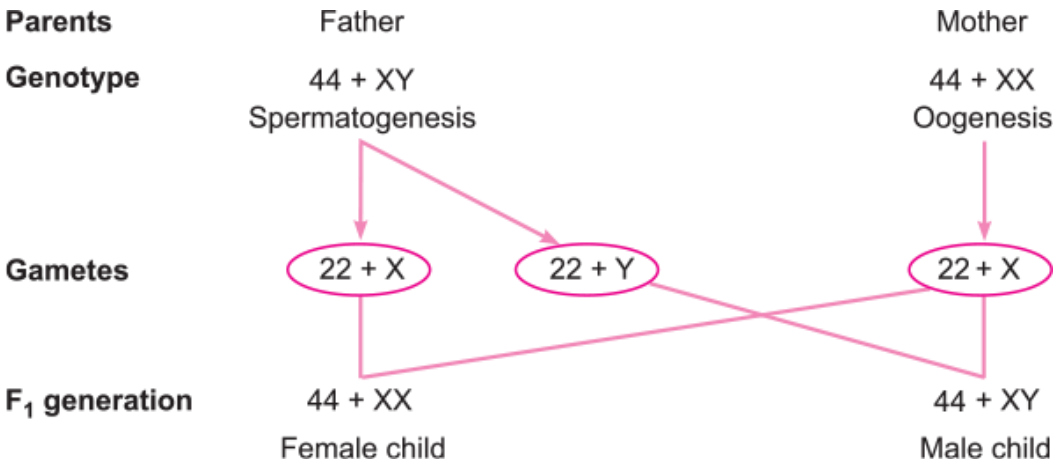
***** Females have a pair of X-chromosomes.

***** Males have an X and a Y chromosome.

***** During spermatogenesis males produce two types of gametes with equal probability – sperm carrying either X or Y chromosome.

***** During oogenesis females produce only one types of gamete – having X chromosome.

***** An ovum fertilised by the sperm carrying X-chromosome develops into a female (XX) and an ovum fertilised by the sperm carrying Y-chromosome develops into a male (XY).



Q. How do human males with 'XXY' abnormality suffer?

Ans. The XXY individual suffers from Klinefelter's syndrome.

Q.18. Answer the following questions:

Q. Why are grasshopper and Drosophila said to show male heterogamety? Explain.

Ans. Drosophila exhibits XY type of sex determination. Males produce two types of sperms, one having X chromosome and one having Y chromosome whereas females have only X-type of chromosomes. Grasshoppers exhibit XO type of sex determination. Males produce two types of gametes, one with X chromosome and other with no sex chromosome. Thus, both show male heterogamety.

Q. Explain female heterogamety with the help of an example.

Ans. Female heterogamety can be seen in female birds. In these, the females have one Z and one W chromosome whereas males have a pair of Z chromosomes besides the autosomes.

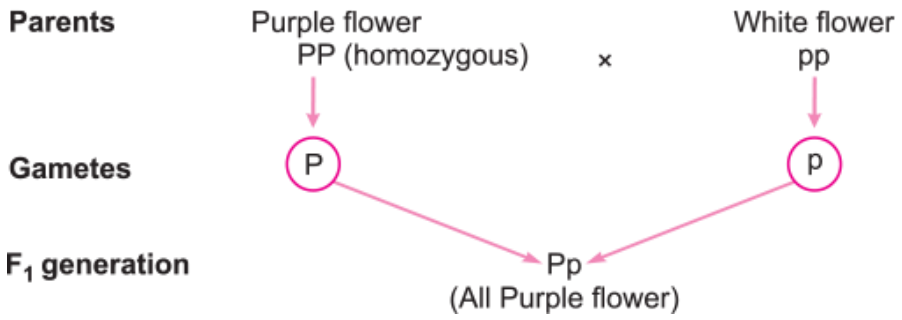
Short Answer Questions-II (OIQ)

[3 Marks]

Q.1. For flower colour in pea, the allele for purple flower (P) is dominant to the allele for white flower (p). A purple flowered plant therefore could be of genotype PP or Pp. What genetic cross would you make to determine the genotype of a purple flowered plant? Explain how your cross gives you the correct genotype of the purple flowered plant?

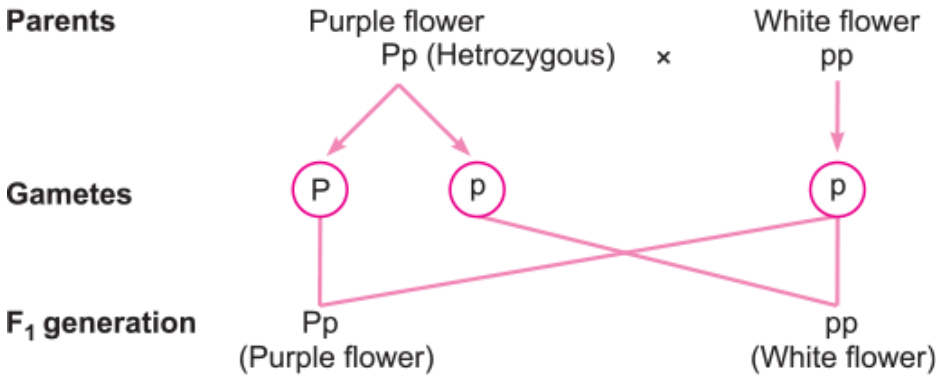
Ans. The genotype of a purple flowered plant can be determined by conducting a test cross i.e., crossing the purple flowered plant with homozygous recessive individual i.e., pp.

Case I



If the F_1 generation produces all purple flowers, the parent would be homozygous dominant, *i.e.*, PP.

Case II



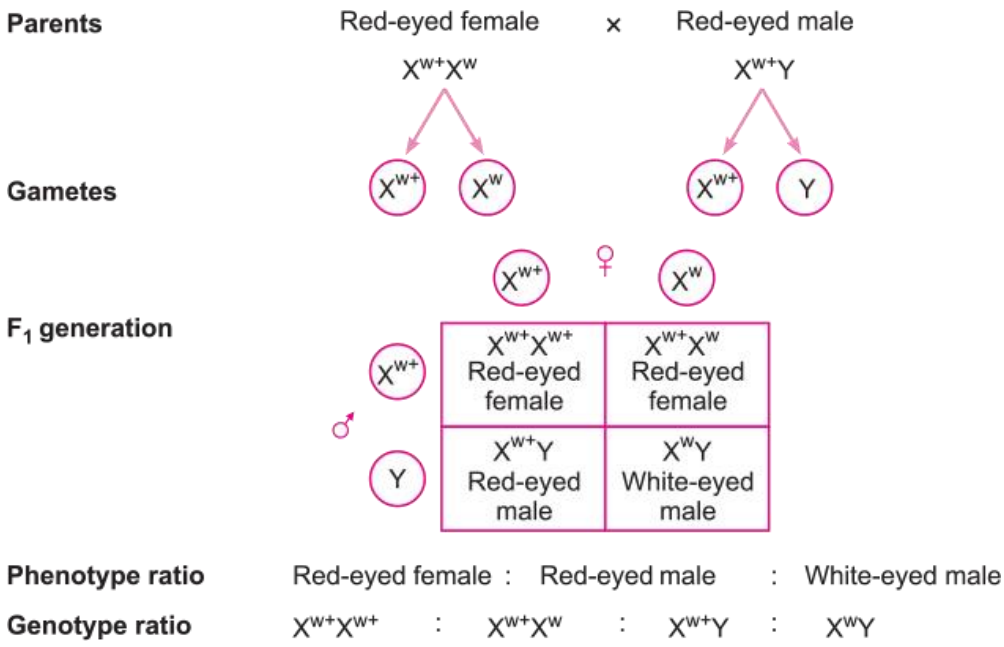
Purple flower	:	White flower
1	:	1

If the F_1 generation produces purple and white flowers in 1:1 ratio, the parent would be heterozygous, i.e., Pp.

Q.2. A red-eyed heterozygous female fruit fly is crossed with a red-eyed male. Work out all possible genotypes and phenotypes of the progeny. Comment on the pattern of inheritance of eye colour in fruit flies.

Ans.

(i)



(ii)

***** The gene for eye colour is sex-linked and is present on X chromosome.

***** The character passes into the male from female and the male passes it to the female in the next generation. Male has only one X-chromosome and one Y-chromosome with no corresponding allele.

Q.3. What is the chromosomal basis of Turner's syndrome? Mention the sex and any three symptoms of this disorder.

Ans. Turner's syndrome

Cause: Absence of one of the X chromosomes, resulting in the karyotype 44+XO.

Symptoms:

(i) Sterile female with rudimentary ovaries.

(ii) Shield-shaped thorax.

(iii) Webbed neck.

(iv) Poor development of breasts.

(v) Short stature, small uterus, puffy fingers.

Q.4. What is Down's syndrome? Give its symptoms and cause. Why is it that the chances of having a child with Down's syndrome increases if the age of the mother exceeds forty years?

Ans. Down's syndrome is a human genetic disorder caused due to trisomy of chromosome 21. Such individuals are aneuploid and have 47 chromosomes (2n + 1). The symptoms include mental retardation, growth abnormalities, constantly open mouth, dwarfness, etc. The reason for the disorder is the non-disjunction (failure to separate) of homologous chromosome of pair 21 during meiotic division in the ovum.

The chance of having a child with Down's syndrome increase with the age of the mother (40+) because ova are present in females since their birth and therefore older cells are more prone to chromosomal non-disjunction because of various physicochemical exposures during the mother's life-time.

Q.5. What is aneuploidy? Differentiate between trisomic and triploid condition? Name any one trisomic condition found in human.

Ans. Aneuploidy is a phenomenon which occurs due to non-disjunction resulting into gain or loss of one or more chromosomes during meiosis.

S. No.	Trisomic condition	Triploid condition
(i)	This occurs when a chromosome occurs in three copies in a diploid cell.	This occurs when a cell contains three sets of chromosomes.

Trisomic condition in human: Down's syndrome.

Q.6. List any four symptoms shown by Klinefelter's syndrome sufferer. Explain the cause of this disease.

Ans. Klinefelter's syndrome

Cause: Presence of an additional copy of X chromosome resulting in the karyotype 44+XXY.

Symptoms:

(i) Sex of the individual is masculine but possess feminine characters.

(ii) Gynaecomastia, i.e., development of breasts.

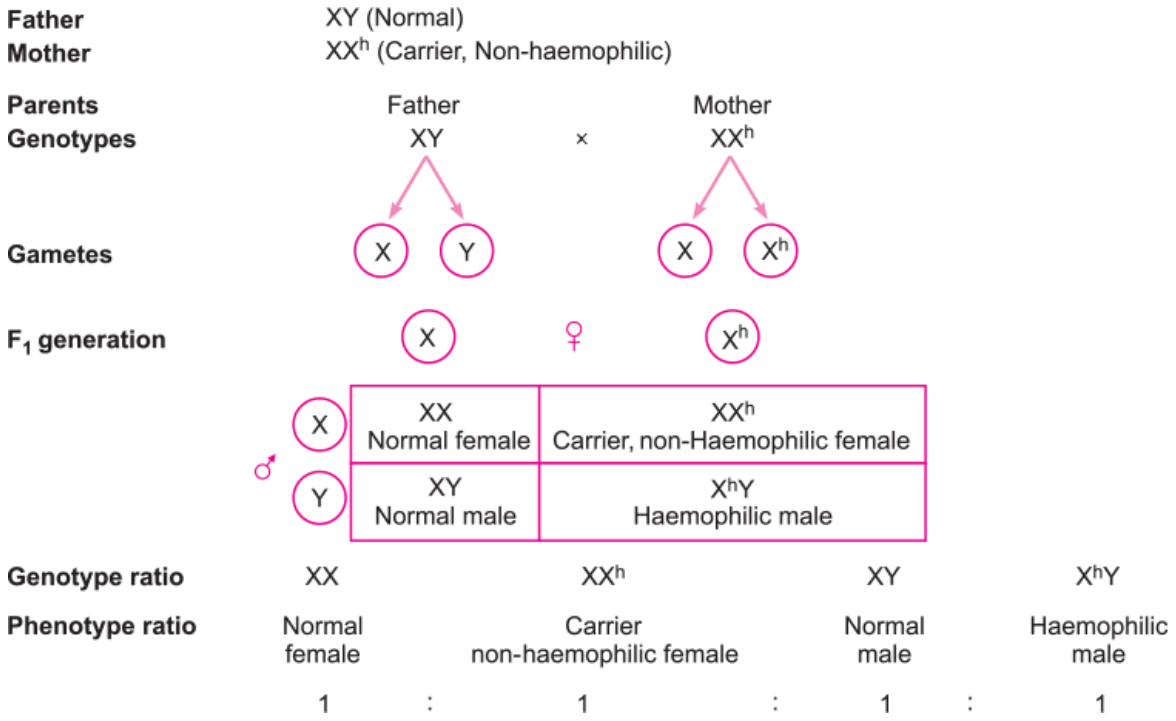
(iii) Poor beard growth and often sterile.

(iv) Feminine pitched voice.

Q.7. A non-haemophilic couple was informed by their doctor that there is possibility of a haemophilic child be born to them. Explain the basis on which the doctor conveyed this information. Give the genotypes and the phenotypes of all the possible children who could be born to them.

Ans. On the basis of pedigree analysis, the doctor conveyed this information. Pedigree analysis is a strong tool, which is utilised to trace the inheritance of a specific trait,

abnormality or disease. Since, both the parents are non-haemophilic, their genotypes will be:



Q.8. Both Down's syndrome and Turner's syndrome are examples of chromosomal disorders. Cite the differences between the two.

Ans.

S.No.	Down's syndrome	Turner's syndrome
(i)	It is a trisomy of chromosome number 21.	It is a monosomy of the X-chromosome.
(ii)	It can occur in either males or females.	It can occur only in females.
(iii)	The total number of chromosomes in the genome is 47.	The total number of chromosomes in the genome is 45.

Q.9. Answer the following questions:

Q. Give two reasons why Mendel selected garden pea for his experiments. Give the biological name of this plant.

Ans. Mendel's Experimental Plant

It is an annual plant with a short life-cycle. So, several generations can be studied within a short period.

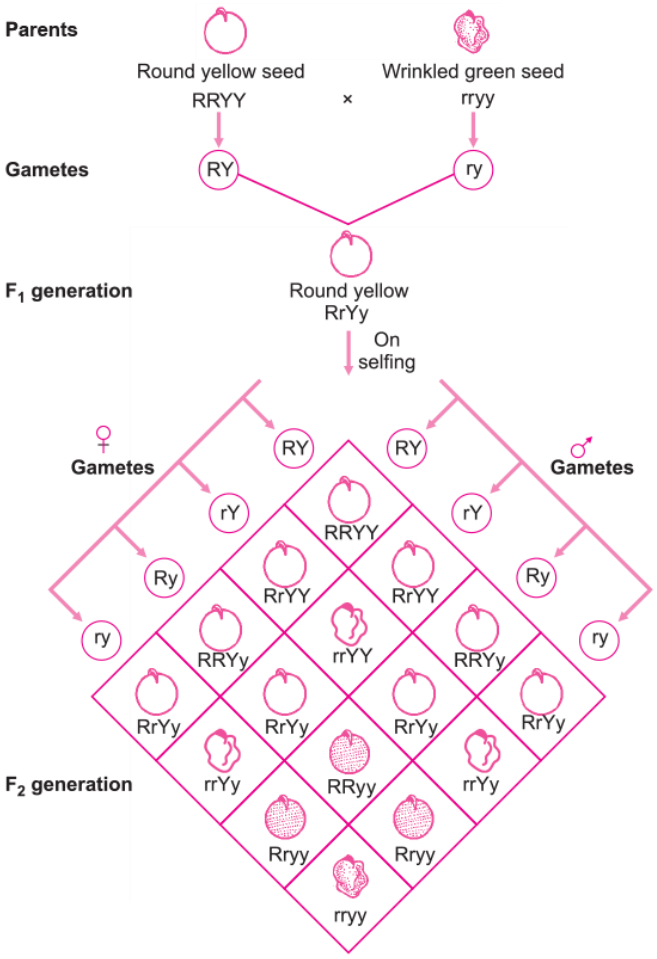
It has perfect bisexual flowers containing both male and female parts.

Biological name of pea plant is Pisum sativum.

Q. State Mendel's principle of segregation.

Ans. Law of segregation.

This law states that the factors or alleles of a pair segregate from each other during gamete formation, such that a gamete receives only one of the two factors. They do not show any blending.



Phenotypic ratio–	Round yellow			:	Round green			:	Wrinkled yellow			:	Wrinkled green			
		9		:		3		:		3		:		1		
Genotypic ratio–	1	:	2	:	2	:	4	:	1	:	2	:	1	:	2	: 1

Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits: seed colour and seed shape

Q.10. Answer the following questions:

Q. State the principle of independent assortment.

Ans. According to the principle of independent assortment the two factors of each character assort or separate out independently of the factors of other characters ,at the

time of gamete formation and get randomly rearranged in the offsprings producing both parental and new combinations of characters.

Q. How would the following affect the phenomenon of independent assortment?

a. Crossing over

b. Linkage.

Ans.

a. Crossing over: Crossing over influences linked genes as a result of which 50% recombination is obtained in the test cross progeny.

b. Linkage: It influences recombination which is less than 50%.

Q.11. A cross is made between different homozygous pea plants for contrasting flower positions.

a. Find out the position of flowers in F1 generation on the basis of genotypes.

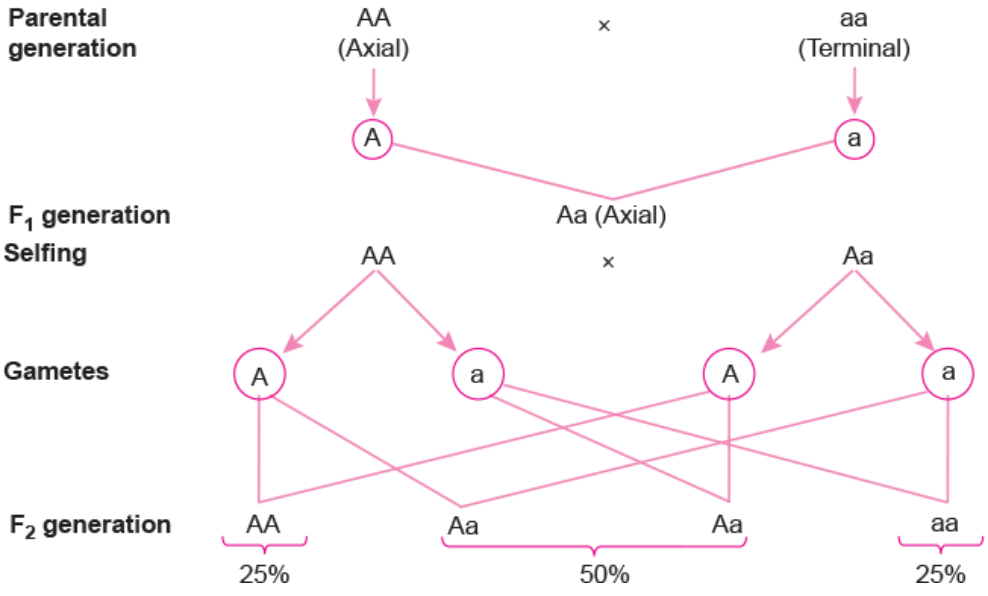
b. Work out the cross upto F2 generation.

c. Compute the relative fraction of various genotypes in the F2 generation?

Ans.

(a) Axial position

(b)



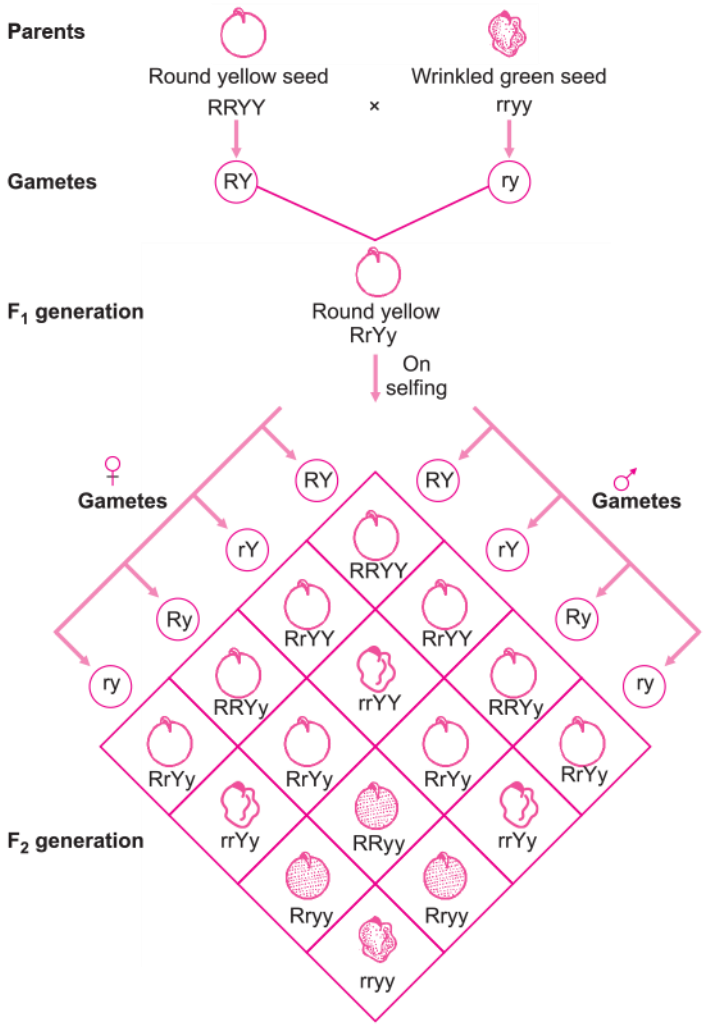
(c) $\mathrm{AA} = \frac{25}{100} = \frac{1}{4}, Aa = \frac{50}{100} = \frac{1}{2}, \mathrm{aa} = \frac{25}{100} = \frac{1}{4}$

Long Answer Questions (PYQ)

[5 Marks]

Q.1. Work out a typical Mendelian dihybrid cross and state the law that he derived from it.

Ans.



Phenotypic ratio–	Round yellow			:	Round green			:	Wrinkled yellow			:	Wrinkled green			
		9		:		3		:		3		:		1		
Genotypic ratio–	1	:	2	:	2	:	4	:	1	:	2	:	1	:	2	: 1

Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits: seed colour and seed shape For the dihybrid cross Mendel derived the law of Independent Assortment: It states that when two pairs of traits are combined in a hybrid, segregation of one pair of character is independent of the other pair of characters.

Q.2.

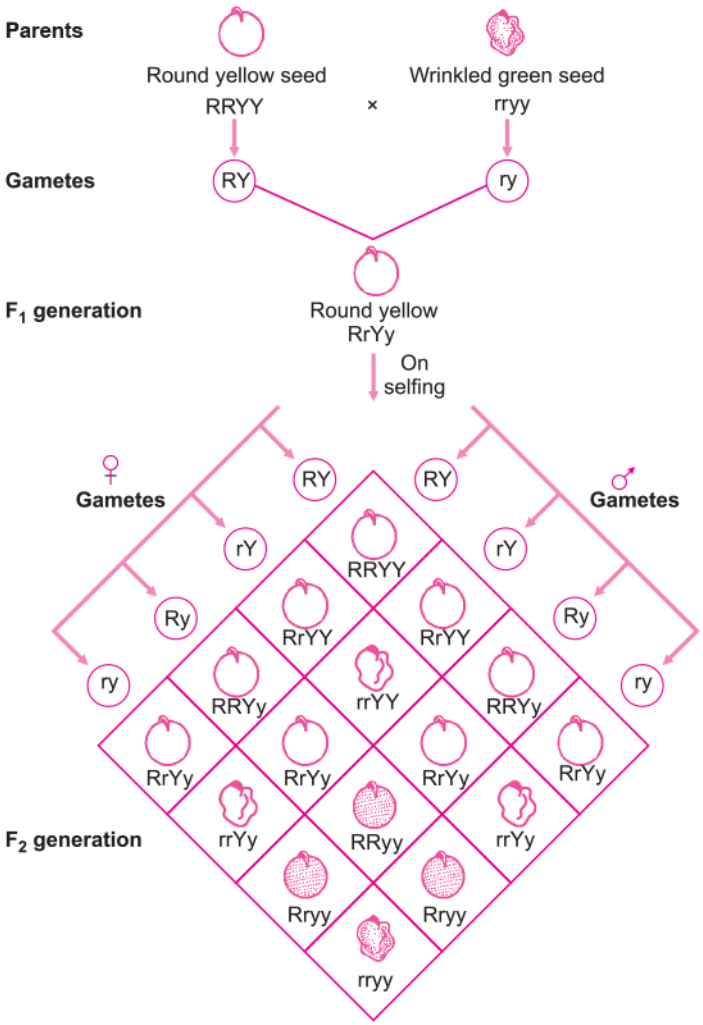
(a) State the law of independent assortment.

(b) Using Punnett square demonstrate the law of independent assortment in a dihybrid cross involving two heterozygous parents.

Ans.

a. According to this law the two factors of each character assort or separate out independent of the factors of other characters, at the time of gamete formation and get randomly rearranged in the offsprings, producing both parental and new combinations of characters.

b.



Phenotypic ratio–	Round yellow			:	Round green			:	Wrinkled yellow			:	Wrinkled green		
		9		:		3		:		3		:		1	
Genotypic ratio–	1	:	2	:	2	:	4	:	1	:	2	:	1	:	2	:	1

Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits: seed colour and seed shape

Q.3.

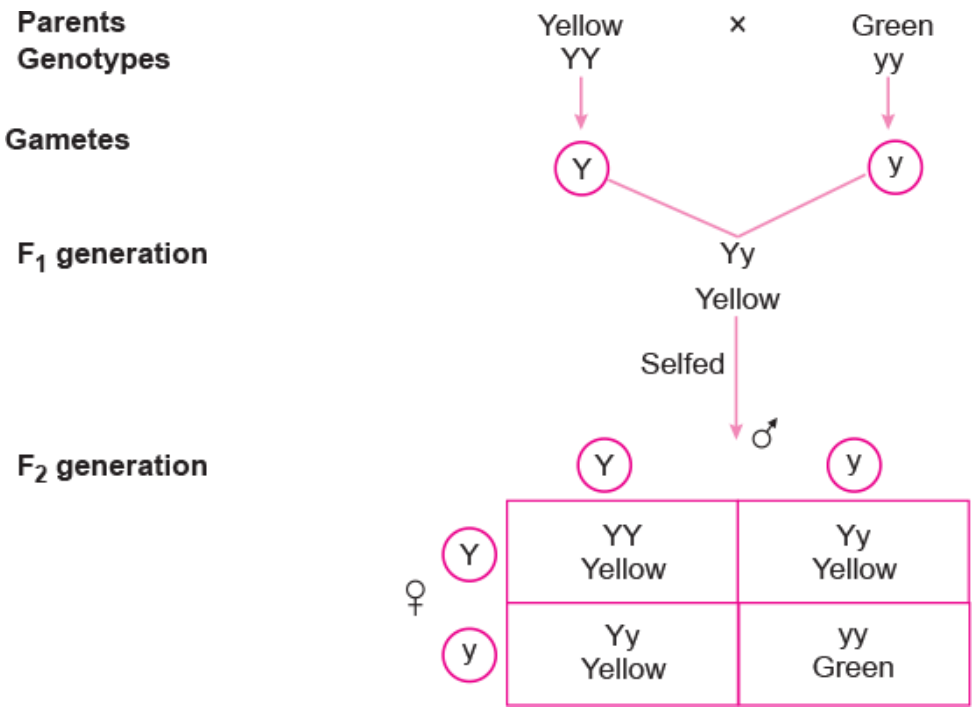
a. Explain a monohybrid cross taking seed coat colour as a trait in Pisum sativum. Work out the cross up to F2 generation.

b. State the laws of inheritance that can be derived from such a cross.

c. How is the phenotypic ratio of F2 generation different in a dihybrid cross?

Ans.

(a)



F2 Phenotypic ratio = 3 : 1; F2 Genotypic ratio = 1 : 2 : 1

(b)

* Law of Dominance: In a contrasting pair of factors, one member of the pair dominates (dominant) the other (recessive).

* Law of Segregation: Factors or allele of pair separate from each other such that gamete receives only one of the two factors.

(c) Phenotypic ratio of F2 in monohybrid cross is 3 : 1 whereas in a dihybrid cross the phenotypic ratio is 9 : 3 : 3 : 1.

Q.4.

(a) A true breeding homozygous pea plant with green pods and axial flowers as dominant characters, is crossed with a recessive homozygous pea plant with

yellow pods and terminal flowers. Work out the cross up to F2 generation giving the phenotypic ratios of F1 and F2 generation respectively.

(b) State the Mendelian principle which can be derived from such a cross and not from monohybrid cross.

Ans.

(a)

Parents — Green axial GGAA × Yellow terminal ggaa

Gametes — GA, Ga

F_1 generation — GgAa × GgAa—(Hybrid) green axial

Selfing

F_2 generation

	GA	Ga	gA	ga
GA	GGAA Green axial	GGAa Green axial	GgAA Green axial	GgAa Green axial
Ga	GGAa Green axial	GGaa Green terminal	GgAa Green axial	Ggaa Green terminal
gA	GgAA Green axial	GgAa Green axial	ggAA Yellow axial	ggAa Yellow axial
ga	GgAa Green axial	Ggaa Green terminal	ggAa Yellow axial	ggaa Yellow terminal

Phenotypic ratio

Green axial	:	Green terminal	:	Yellow axial	:	Yellow terminal
9	:	3	:	3	:	1

(b) From the above cross law of independent assortment can be derived which states that when two pairs of traits are combined in a hybrid, segregation of one pair of character is independent of the other pair of characters.

Q.5.

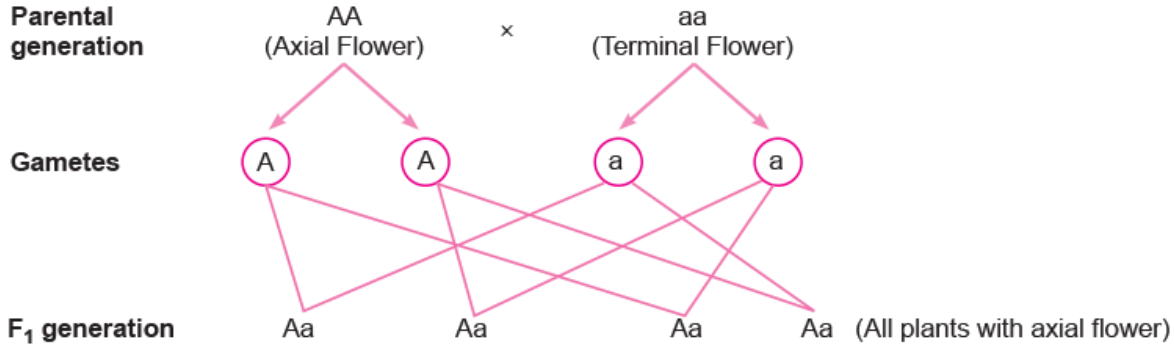
(a) A pea plant bearing axial flowers is crossed with a pea plant bearing terminal flowers. The cross is carried out to find the genotype of the pea plant bearing axial flowers. Work out the cross to show the conclusions you arrive at.

(b) State the Mendel's law of inheritance that is universally acceptable.

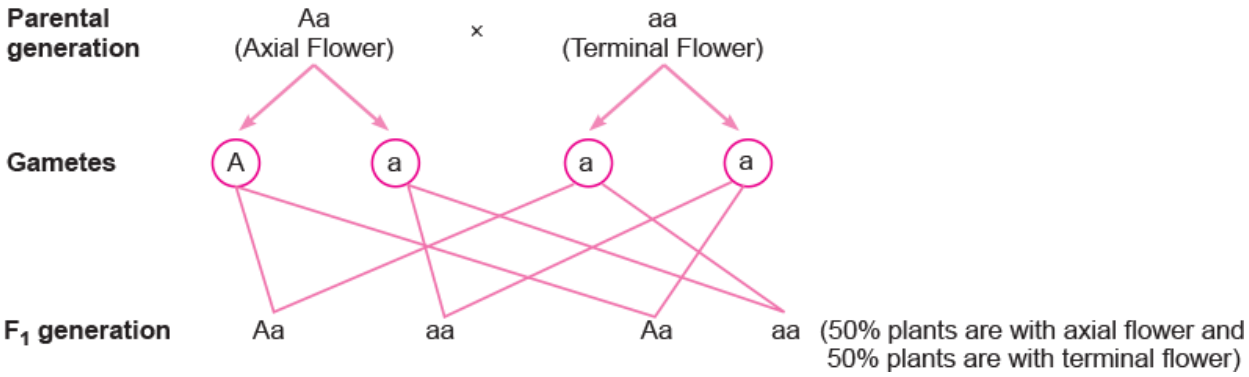
Ans.

(a) If the plant is homozygous for the dominant trait.

(*i*) If the plant is homozygous for the dominant trait.



(*ii*) If the plant is heterozygous for the dominant trait.



Conclusion: If all progeny show axial flowers (dominant) the plant is homozygous (AA), If 50% of progeny show axial flower (Dominant) and 50% terminal flower (Recessive) the plant is heterozygous.

(b) Law of Segregation is universally accepted. It states that allelic pair segregate (separates) during gamete formation.

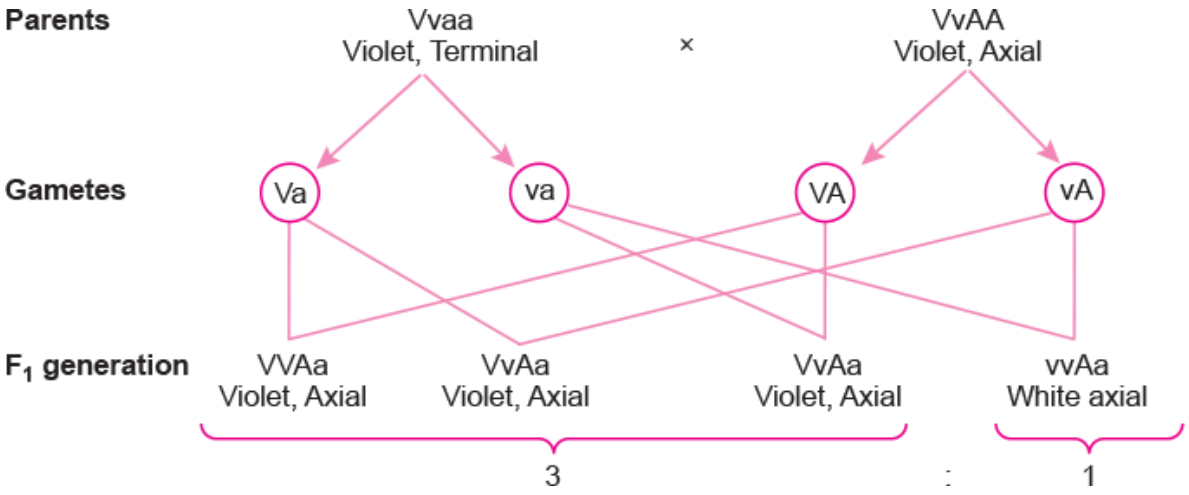
Q.6.

(a) A garden pea plant bearing terminal, violet flowers, when crossed with another pea plant bearing axial, violet flowers, produced axial, violet flower and axial, white flowers in the ratio of 3 : 1. Work out the cross showing the genotypes of the parent pea plants and their progeny.

(b) Name and state the law that can be derived from this cross and not from a monohybrid cross.

Ans.

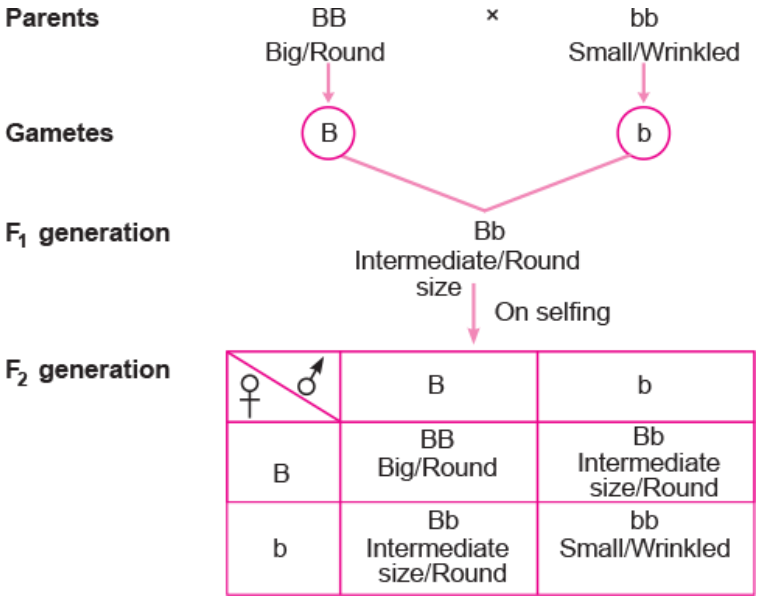
(a)



(b) Law of Independent Assortment: When two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of character.

Q.7. What is the inheritance pattern observed in the size of starch grains and seed shape of Pisum sativum? Workout the monohybrid cross showing the above traits. How does this pattern of inheritance deviate from that of Mendelian law of dominance?

Ans. A single gene controls the size of the starch grains and seed shape of Pisum sativum.



♀ \ ♂	B	b
B	BB Big/Round	Bb Intermediate size/Round
b	Bb Intermediate size/Round	bb Small/Wrinkled

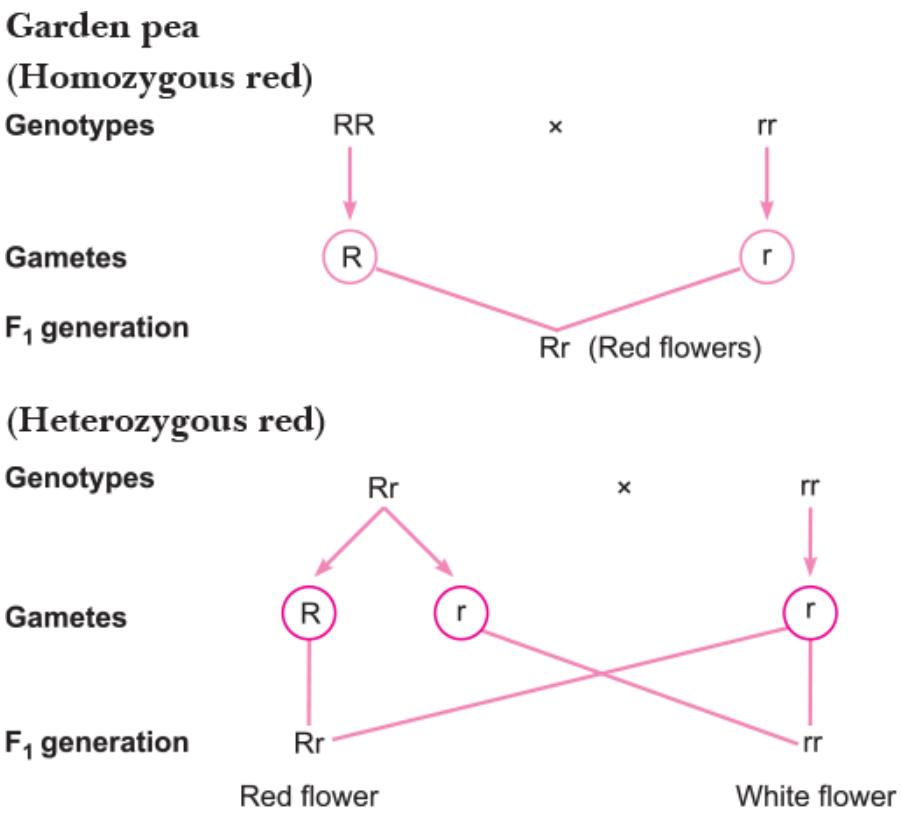
With respect to size of starch grains it shows 3 forms-big, Intermediate and small as in incomplete dominance but with respect to seed shape it follows Mendelian law of Dominance showing either round or wrinkled.

Q.8. You are given a red flower-bearing pea plant and a red flower-bearing snapdragon plant. How would you find the genotypes of these two plants with

respect to the colour of the flower? Explain with the help of crosses. Comment upon the pattern of inheritance seen in these two plants.

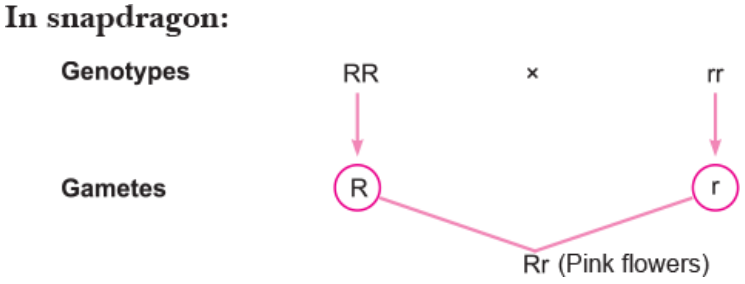
Ans. A test cross is required to find out the genotype of both the plants.

(a)



If the F_1 generation plants have all red flowers, the genotype of the parent plant will be homozygous dominant and if the F_1 generation plants have red and white flowers in the ratio of 1 : 1, then the genotype of the parent plant is heterozygous dominant. This inheritance follows the Mendelian law of dominance.

(b)



The parent plant will be homozygous for flower colour because a heterozygous plant will have pink flowers due to the phenomenon of incomplete inheritance.

Q.9. With the help of one example each, provide genetic explanation for the following observations:

Q. F_1-generation resembles both the parents.

Ans.

F_1 generation resembles both the parents: This happens in the case of co-dominance where both alleles express themselves fully in heterozygous condition. For example: different types of red blood cells determine ABO blood grouping in human beings.

Co-dominance

* The alleles which are able to express themselves independently, even when present together are called co-dominant alleles and this biological phenomenon is called co-dominance.For example, ABO blood grouping in humans.

* ABO blood groups are controlled by gene I. Gene I has three alleles IA, IB and IO/i.

* IA and IB produce RBC surface antigens sugar polymer A and B, respectively, whereas i does not produce any antigen.

* IA and IB are dominant over i hence IA and IB are dominant alleles and i is recessive allele as in IAi and IBi.

* When IA and IB are present together, both express equally and produce the surface antigens A and B, hence show co-dominance.

* Since humans are diploid, each person possesses any two of the three 'I' gene alleles, resulting into six different genotypic combinations and four phenotypic expressions.

Table showing the genetic basis of blood groups in human population

Allele fromParent 1	Allele fromParent 2	Genotype ofoffspring	Blood groups ofoffspring
I^A	I^A	$I^A I^A$	A
I^A	I^B	$I^A I^B$	AB
I^A	i	$I^A i$	A
I^B	I^B	$I^B I^B$	B
I^B	i	$I^B i$	B
i	i	$i\ i$	O

Q. F1-generation does not resemble either of the parents.

Ans.

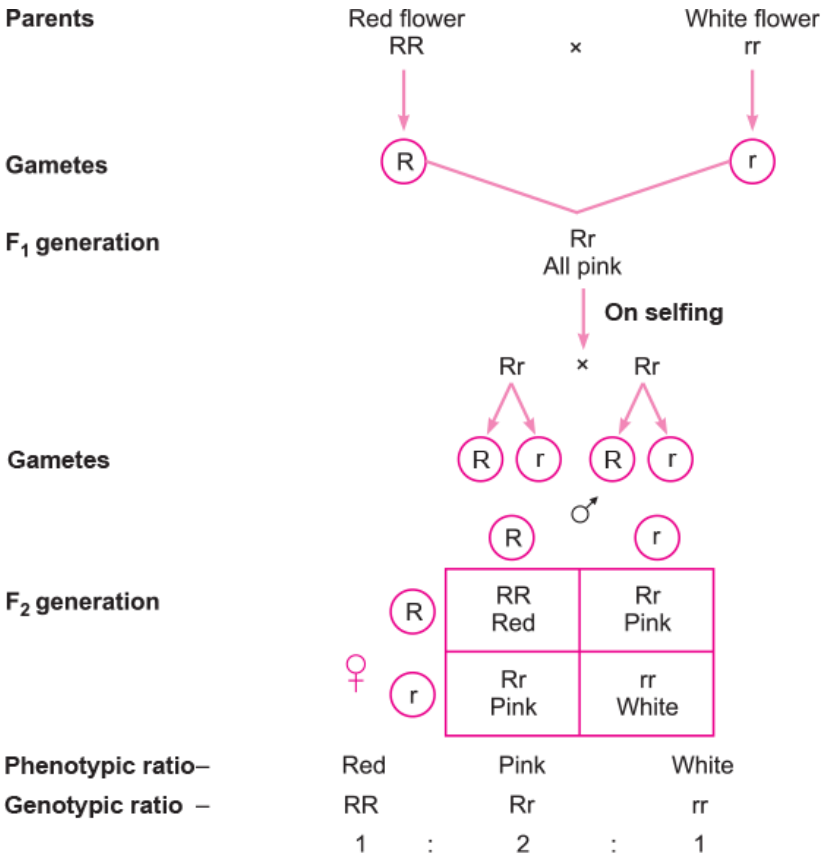
F_1 generation does not resemble either of the parents: In incomplete dominance, a heterozygous organism carrying two alleles wherein one is dominant and the other one is recessive, (e.g., Rr). Hence, the heterozygote (Rr) will have an intermediate phenotype and will not resemble any parent.

Incomplete Dominance

It is a phenomenon in which the F_1 hybrid exhibits characters intermediate of the parental genes.

Here, the phenotypic ratio deviates from the Mendel's monohybrid ratio.

It is seen in flower colours of Mirabilis jalapa (4 o' clock plant) and Antirrhinum majus (snapdragon), where red colour is due to gene RR, white colour is due to gene rr and pink colour is due to gene Rr.



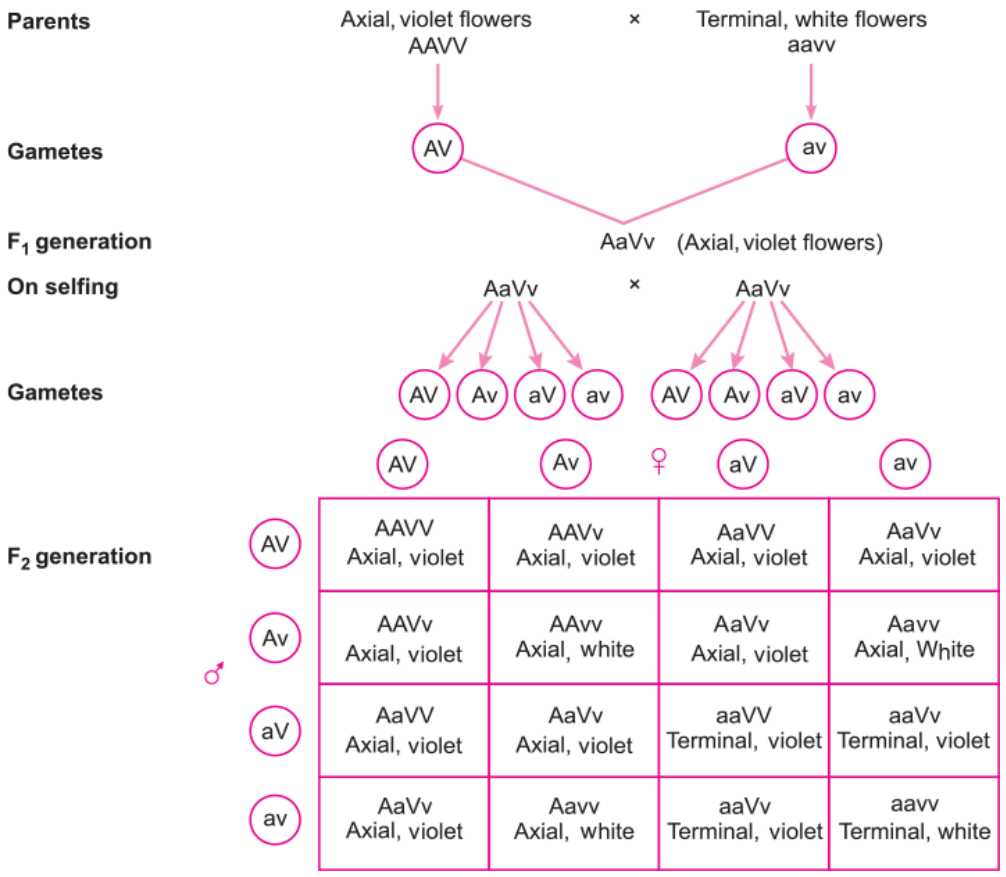
Q.10. A true breeding pea plant homozygous for axial violet flowers is crossed with another pea plant with terminal white flowers (aavv).

a. What would be the phenotype and genotype of F1 and F2 generations?

b. Give the phenotypic ratio of F2 generation.

c. List the Mendel's generalisations that can be derived from the above cross

Ans.



(a) Phenotype of F_1 generation—All axial, violet flowers.

Genotype of F_1 generation—AaVv.

(b) Phenotypic ratio of F_2 generation:

Axial violet flowers	:	Axial white flowers	:	Terminal violet flowers	:	Terminal white flowers
9		3		3		1

(c) Law of Independent Assortment: This law states that the different factors or allelomorphic pair in gametes and zygotes assort themselves and segregate independently of one another.

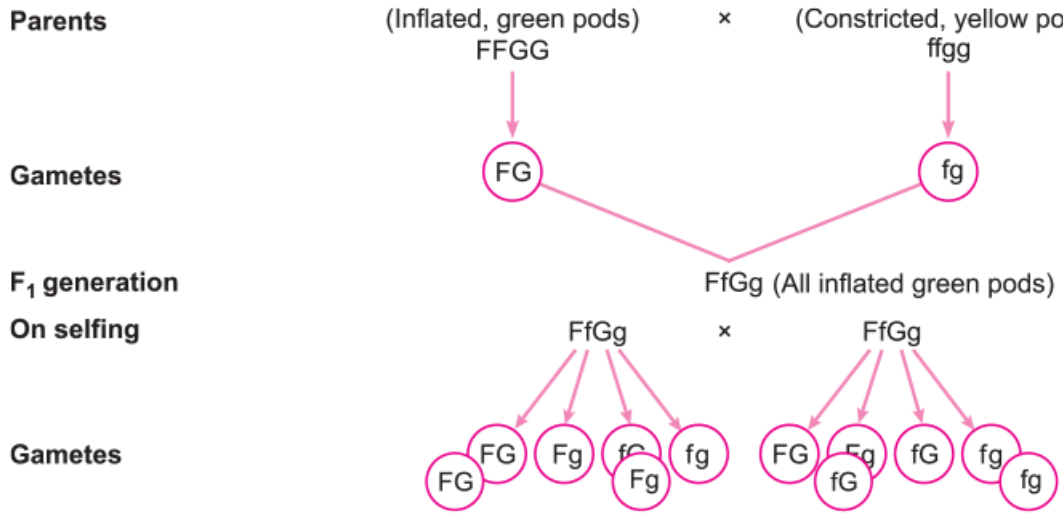
Q.11.

(a) A true breeding pea plant, homozygous for inflated green pods is crossed with another pea plant with constricted yellow pods (ffgg). What would be the phenotype and genotype of F1 and F2 generations? Give the phenotype ratio of generation.

(b) State the generalisation proposed by Mendel on the basis of the above-mentioned cross.

Ans.

(a)



F_2 generation

	FG	Fg	fG	fg
FG	FFGG Inflated, green	FFGg Inflated, green	FfGG Inflated, green	FfGg Inflated, green
Fg	FFGg Inflated, green	FFgg Inflated, yellow	FfGg Inflated, green	Ffgg Inflated, yellow
fG	FfGG Inflated, green	FfGg Inflated, green	ffGG Constricted, green	ffGg Constricted, green
fg	FfGg Inflated, green	Ffgg Inflated, yellow	ffGg Constricted, green	ffgg Constricted, yellow

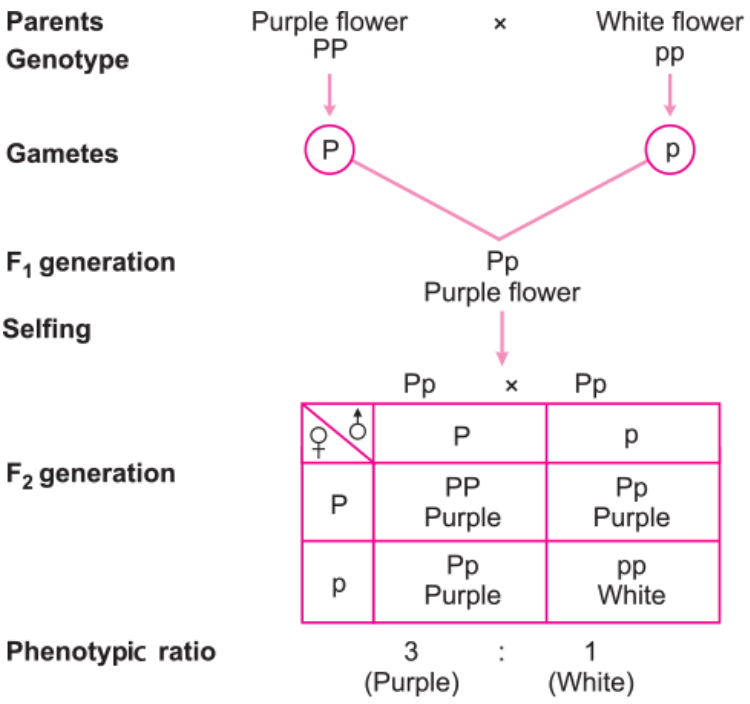
F_2 Phenotypic ratio

Inflated Green Pods	:	Inflated yellow Pods	:	Constricted Green Pods	:	Constricted yellow Pods
9	:	3	:	3	:	1

(b) Mendel's Law of Independent Assortment: This law states that the different factors or allelomorphic pair in gametes assort themselves and segregate independently of one another.

Q.12. Inheritance pattern of flower colour in garden pea plant and snapdragon differs. Why is this difference observed? Explain showing the crosses up to F_2 generation.

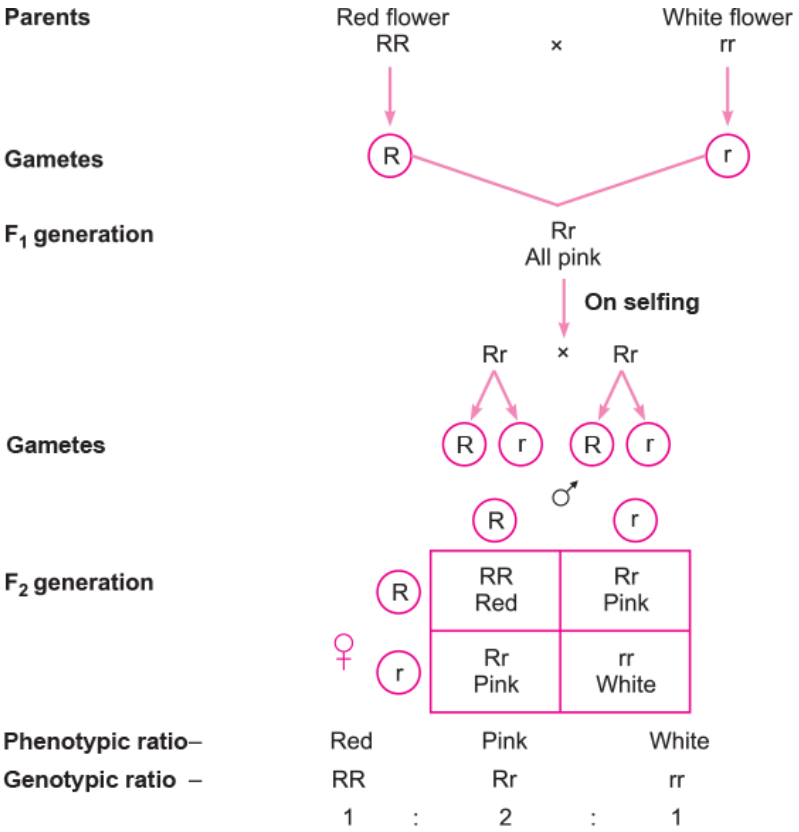
Ans. Inheritance pattern of flower colour in garden pea follows principle of dominance whereas inheritance in snapdragon shows incomplete dominance.



Phenotypic ratio—3 : 1

Genotypic ratio—1 : 2 : 1.

Inheritance of flower colour in snapdragon:



Phenotypic ratio—1 : 2 : 1

Genotypic ratio—1 : 2 : 1.

Q.13.

(a) Write the conclusions Mendel arrived at on dominance of traits on the basis of monohybrid crosses that he carried out in pea plants.

(b) Explain why a recessive allele is unable to express itself in a heterozygous state.

Ans.

(a) Mendel concluded that:

(i) Characters are controlled by discrete units called factors.

(ii) Factors occur in pair.

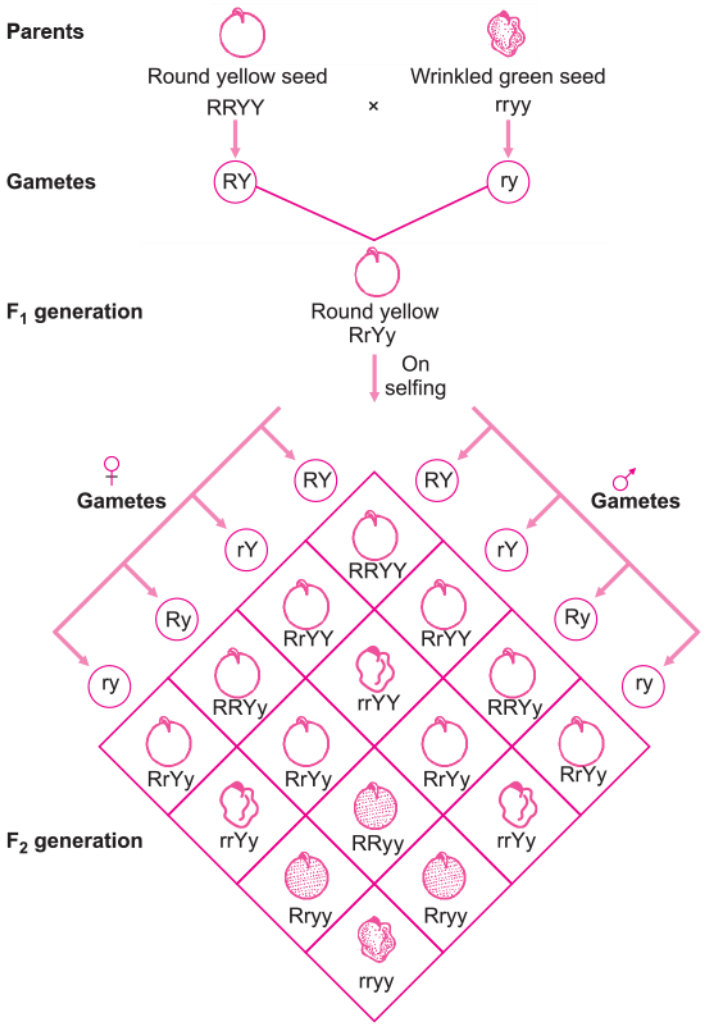
(iii) In a dissimilar pair of factors one member of the pair dominates/only one of the parental character is expressed in a monohybrid cross in the F1 and both are expressed in the F2.

(b) The alleles are present on homologous chromosomes. The recessive allele does not code for its product or codes for a defective product. The other allele remains normal and thus expresses itself.

Q.14. State and explain the "law of independent assortment" in a typical Mendelian dihybrid cross.

Ans. Law of independent assortment

According to this law the two factors of each character assort or separate out independent of the factors of other characters at the time of gamete formation and get randomly rearranged in the off springs producing both parental and new combinations of characters.



Phenotypic ratio–	Round yellow			:	Round green			:	Wrinkled yellow			:	Wrinkled green			
	9			:	3			:	3			:	1			
Genotypic ratio–	1	:	2	:	2	:	4	:	1	:	2	:	1	:	2	: 1

Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits: seed colour and seed shape

Q.15. Let us assume in a given plant the genotype symbol "Y" stands for dominant yellow seed colour and "y" for recessive green seed colour; symbol "R" for round seed shape and "r" for wrinkled seeds. Two homozygous parents (plants) with genotypes "RRYY" and "rryy" are crossed and their F1-generation progeny is then selfed. What shall be the

a. Phenotype of F1-progeny

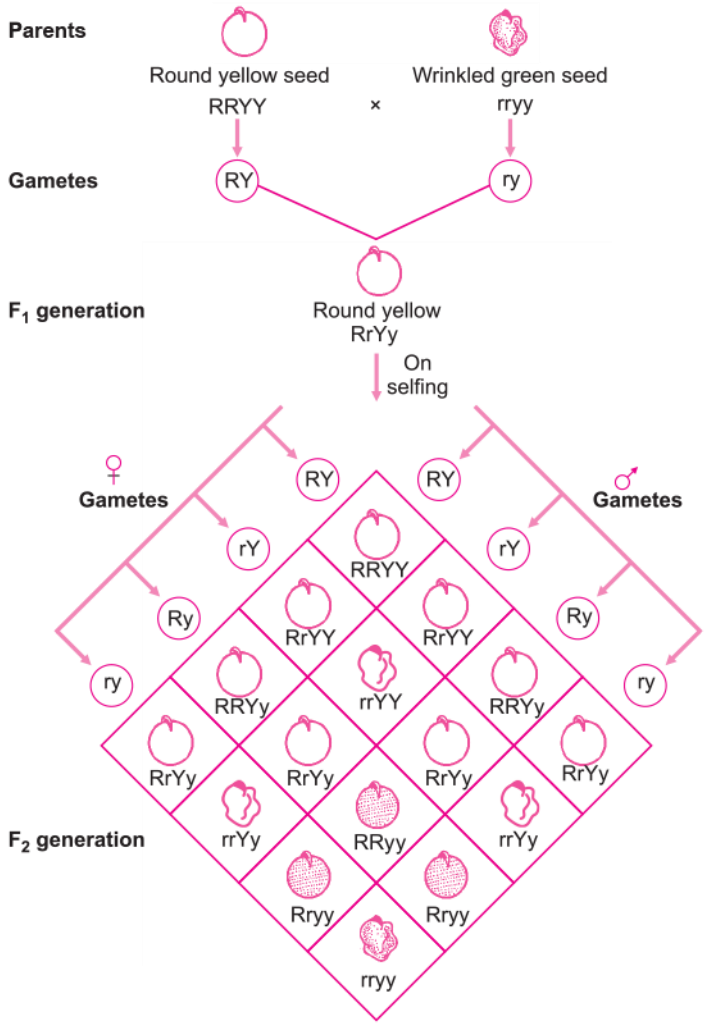
b. Genotype of F1-progeny

c. Gamete genotypes of F1-progeny

d. Phenotypic ratio of F2 population

e. Phenotypic ratio of yellow seed to green seed and round seed to wrinkled seed in F2 population.

Ans.



Phenotypic ratio–	Round yellow			:	Round green			:	Wrinkled yellow			:	Wrinkled green			
	9			:	3			:	3			:	1			
Genotypic ratio–	1	:	2	:	2	:	4	:	1	:	2	:	1	:	2	: 1

Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits: seed colour and seed shape

a. Phenotype of F1-progeny: Round seeds that are yellow in colour

b. Genotype of F1-progeny: RrYy

c. Gamete genotypes of F1-progeny: RY, Ry, rY and ry

d. Phenotypic ratio of F2 population: 9 : 3 : 3 : 1.

Nine round-yellow seeds; three round-green seeds; three wrinkled-yellow seeds; one wrinkled-green seed.

e. Phenotypic ratio of yellow seed to green seed and round seed to wrinkled seed in F2 population:

Yellow seed to green seed = 3 : 1

Round seed to wrinkled seed = 3 : 1

Q.16.

a. Provide genetic explanation for the observation in which the flower colour in F_1 generation of snapdragon did not resemble either of the two parents. However, the parental characters reappeared when F_1 progenies were selfed.

b. State the three principles of Mendel's law of inheritance.

Ans.

(a) This is an exception to Mendel's principle of dominance and can be explained by the phenomenon of **'Incomplete dominance'**. It is a phenomenon where none of the two contrasting alleles or factors are dominant. The expression of the character in a hybrid or F1 individual is intermediate or a fine mixture of expression of the two factors (pink flowers in this case from two parents with red and white flowers). This may be considered as an example of quantitative inheritance where only a single gene pair is involved. F_2 phenotypic ratio is 1 : 2 : 1, similar to the genotypic ratio, in which the parental characters also reappear.

(b) Mendel's Laws of Inheritance

- Based on his hybridisation experiments, Mendel proposed the laws of inheritance.
- His theory was rediscovered by Hugo de Vries of Holland, Carl Correns of Germany and Eric von Tschermak of Austria in 1901.

(i)Law of dominance

- This law states that when two alternative forms of a trait or character (genes or alleles) are present in an organism, only one factor expresses itself in F_1 progeny and is called dominant while the other that remains masked is called recessive.

(ii) Law of segregation.

- This law states that the factors or alleles of a pair segregate from each other during gamete formation, such that a gamete receives only one of the two factors. They do not show any blending.

Q.17.

(a) Differentiate between dominance and co-dominance.

(b) Explain co-dominance taking an example of human blood groups in the population.

Ans.

(a) Dominance: It is a phenomenon in which when two contrasting alleles are present together, only one expresses itself and is called dominant whereas the other which does not express itself is called recessive.
Co-dominance: It is a phenomenon in which when two contrasting alleles are present together, both of the alleles express themselves.

(b) Co-dominance

- The alleles which are able to express themselves independently, even when present together are called co-dominant alleles and this biological phenomenon is called co-dominance.**For example,** ABO blood grouping in humans.
- ABO blood groups are controlled by gene *I*. Gene *I* has three alleles I^A, I^B and I^O/*i*.
- I^A and I^B produce RBC surface antigens sugar polymer A and B, respectively, whereas *i* does not produce any antigen.
- I^A and I^B are dominant over *i* hence I^A and *I*B are dominant alleles and *i* is recessive allele as in $I^A i$and I^Bi.
- When I^A and I^B are present together, both express equally and produce the surface antigens A and B, hence show co-dominance.
- Since humans are diploid, each person possesses any two of the three '*I*' gene alleles, resulting into six different genotypic combinations and four phenotypic expressions.**Table showing the genetic basis of blood groups in human population**

Allele fromParent 1	Allele fromParent 2	Genotype ofoffspring	Blood groups ofoffspring
I^A	I^A	$I^A I^A$	A
I^A	I^B	$I^A I^B$	AB
I^A	*i*	$I^A i$	A
I^B	I^B	$I^B I^B$	B
I^B	*i*	$I^B i$	B
i	*i*	*i i*	O

Q.18. Describe the mechanism of inheritance of the ABO system of blood group, highlighting the principle of genetics involved in it.

OR

Explain the genetic basis of blood grouping in human population.

Ans.

Co-dominance

- The alleles which are able to express themselves independently, even when present together are called co-dominant alleles and this biological phenomenon is called co-dominance.**For example,** ABO blood grouping in humans.
- ABO blood groups are controlled by gene *I*. Gene *I* has three alleles I^A, I^B and I^O/i.
- I^A and I^B produce RBC surface antigens sugar polymer A and B, respectively, whereas *i* does not produce any antigen.
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- When I^A and I^B are present together, both express equally and produce the surface antigens A and B, hence show co-dominance.
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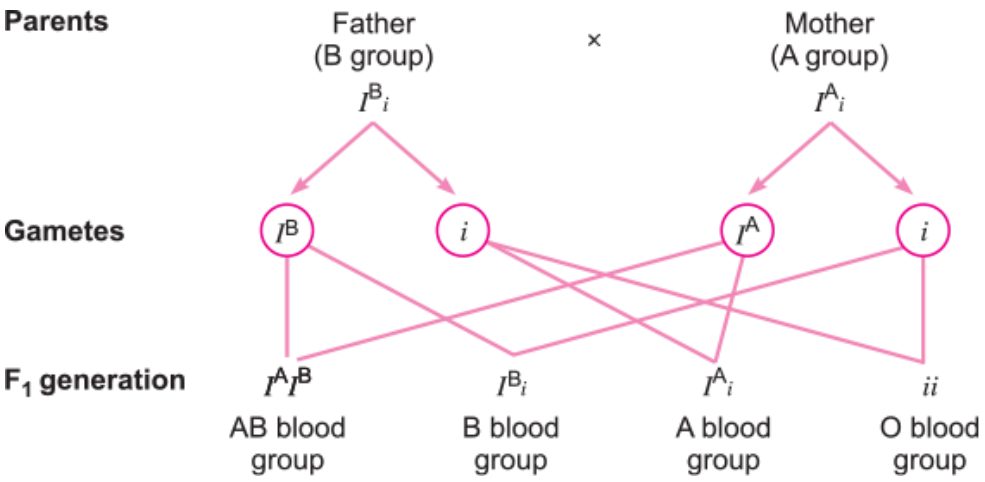
I^A	I^B	I^AI^B	AB
I^A	*i*	I^Ai	A
I^B	I^B	I^BI^B	B
I^B	*i*	I^Bi	B
i	*i*	*i i*	O

Q.19.

a. **Write the blood group of people with genotype I^AI^B. Give reasons in support of your answer.**
b. **In one family, the four children each have a different blood group. Their mother has blood group A and their father has blood group B. Work out a cross to explain how it is possible.**

Ans.

a. Blood group AB. Both the alleles I^A and I^B are co-dominant and express themselves completely.
b. A cross is carried out between heterozygous father (for blood group B) and heterozygous mother (of blood group A) to get four children with different blood groups.



All the four blood groups are controlled by three allelic genes I^A, I^B, i and thus it shows phenomena of multiple allelism. Both I^A and I^B are dominant over *i*. However, when together, both are dominant and show the phenomena of co-dominance forming the blood group AB. Six genotypes are possible with combination of these three alleles.

Q.20.

a. List the three different allelic forms of gene "I" in humans. Explain the different phenotypic expressions, controlled by these three forms.

b. A woman with blood group "A" marries a man with blood group "O". Discuss the possibilities of the inheritance of the blood groups in the following starting with "yes" or "no" for each:

i. They produce children with blood group "A" only.

ii. They produce children some with "O" blood group and some with "A" blood group.

Ans.

The three different allelic forms are: I^A, I^B, I^O/i.

Co-dominance

- The alleles which are able to express themselves independently, even when present together are called co-dominant alleles and this biological phenomenon is called co-dominance.**For example,** ABO blood grouping in humans.
- ABO blood groups are controlled by gene *I*. Gene *I* has three alleles I^A, I^B and I^O/i.
- I^A and I^B produce RBC surface antigens sugar polymer A and B, respectively, whereas *i* does not produce any antigen.
- I^A and I^B are dominant over *i* hence I^A and *I*B are dominant alleles and *i* is recessive allele as in $I^Ai$and I^Bi.
- When I^A and I^B are present together, both express equally and produce the surface antigens A and B, hence show co-dominance.

- Since humans are diploid, each person possesses any two of the three '*I*' gene alleles, resulting into six different genotypic combinations and four phenotypic expressions.

Table showing the genetic basis of blood groups in human population

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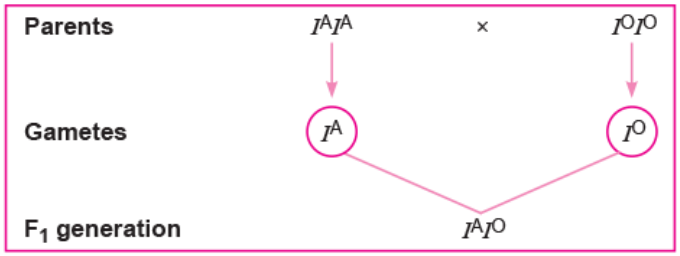
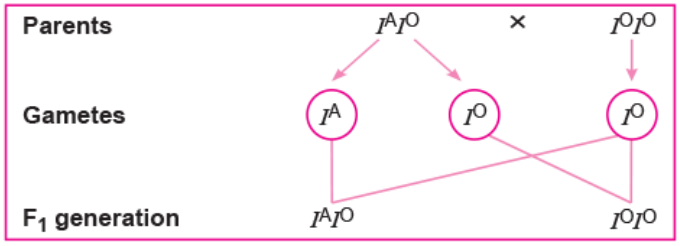
I^A	I^B	I^AI^B	AB
I^A	i	I^Ai	A
I^B	I^B	I^BI^B	B
I^B	i	I^Bi	B
i	i	$i\,i$	O

(b)

(*i*) Yes; when both the parent are homozygous.



(*ii*) Yes; when the woman is heterozygous.



Q.21.

a. How are Mendelian inheritance, polygenic inheritance and pleiotropy different from each other?
b. Explain polygenic inheritance pattern with the help of a suitable example.

Ans.

(a)

Mendelian Inheritance	Polygenic inheritance	Pleiotropy

One gene controls one trait/ character/phenotype	Two or more genes influence the expression of one trait/ character/phenotype	One genes controls the expression of more than one trait/character/phenotype

(b) Human height or skin colour are examples of polygenic inheritance. Height trait is controlled by at least three gene pairs. Additive effect allele contributes to the phenotypic expression of the trait. The dominant alleles more are, more pronounced is the phenotypic expression or more in other word. The recessive alleles less pronounced is the phenotypic expression.

Q.22.

i. How does a chromosomal disorder differ from a Mendelian disorder?
ii. Name any two chromosomal aberration associated disorders.
iii. List the characteristics of the disorders mentioned above that help in their diagnosis.

Ans.

i.

S. No.	Mendelian disorder	Chromosomal disorder
(*i*)	This disorder is mainly due to alteration or mutation in the single gene.	This disorder is caused due to absence or excess or abnormal arrangement of one or more chromosomes.
(*ii*)	This follows Mendel's principles of inheritance.	This does not follow Mendel's principles ofinheritance.
(*iii*)	This may be recessive or dominant in nature	This is always dominant in nature.
(*iv*)	For example, haemophilia, sickle-cell anaemia.	For example, Turner's syndrome.

ii. Two chromosomal aberration-associated disorders are Down's syndrome and Klinefelter's syndrome.

iii.

a. **Down's syndrome:** The individuals have overall masculine development but they express feminine development like development of east, *i.e.*, gynaecomastia. They are sterile.
b. **Klinefelter's syndrome:** The females are sterile as ovaries are rudimentary. Other secondary sexual characters are also lacking.

Q.23. Thalassemia and haemophilia are both Mendelian disorders related to blood. Write the symptoms of the diseases. Explain with the help of crosses the difference in the inheritance pattern of the two diseases.

OR

Why are thalassemia and hemophilia categorised as Mendelian disorders? Write the symptoms of these diseases. Explain their pattern of inheritance in humans. Write the genotypes of the normal parents producing a haemophilic son.

Ans. Both are caused due to alteration or mutation, in a single gene and follow Mendelian pattern of inheritance.

Symptoms:

Thalassemia: anaemia (caused due to defective/abnormal Hb)

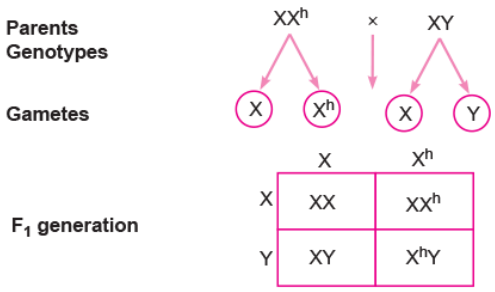
Haemophilia: non-stop bleeding even in minor injury.

Pattern of inheritance:

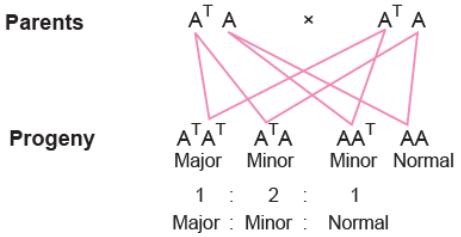
Thalassemia: autosomal recessive inheritance pattern inherited from eterozygous/parent carrier.

Haemophilia: X-linked recessive inheritance inherited from a haemophilic father/carrier mother (females are rarely haemophilic).

Cross for haemophilia:



Cross for thalassemia:



Thalassemia is an autosome-linked recessive blood disease. Its inheritance is like Mendelian inheritance pattern.

Q.24. Write the symptoms of haemophilia and sickle-cell anaemia in humans. Explain how the inheritance pattern of the two diseases differs from each other.

Ans. Symptoms of haemophilia: Patient continues to bleed through a minor cut as the patient does not possess natural phenomenon of blood clotting.

Symptoms of sickle-cell anaemia: Erythrocytes lose their circular shape and become sickleshaped. As a result, the cells cannot pass through narrow capillaries. Blood capillaries are clogged and thus affects blood supply to different organs.

S. No.	Haemophilia	Sickle-cell anaemia
(*i*)	It is a sex-linked recessive disorder.	It is an autosomal linked recessive trait.
(*ii*)	The gene for haemophilia is located onX-chromosome.	The disease is controlled by a single pair of allele Hb^A and Hb^S.
(*iii*)	More males suffer from haemophilia than females because in males single gene for the defect is able to express. Females suffer from this disease only in homozygous condition,*i.e.*, X^c X^c.	Only the homozygous individuals for Hb^S , *i.e.*, Hb^S Hb^Sshow the diseased phenotype.
(*iv*)	The defective alleles produce non-functional protein which later form a non-functional cascade of proteins involved in blood clotting.	Due to point mutation Glutamic acid (Glu) is replaced by Valine (Val) at sixth positions of beta globin chain of haemoglobin molecule.

Q.25.

a. Why are colour blindness and thalassemia categorised as Mendelian disorders? Write the symptoms of these diseases seen in people suffering from them.

b. About 8% of human male population suffers from colourblindness whereas only about 0.4% of human female population suffers from this disease. Write an explanation to show how it is possible.

Ans.

a. Both are caused due to mutation or alteration in a single gene, and follow Mendelian inheritance, therefore, they are called Mendelian disorders.
Symptoms of colour blindness: unable to discriminate between red and green colours.
Symptoms of thalassemia: formation of abnormal haemoglobin resulting in Anaemia.

b.

- **Thalassemia**

a. It is an autosome-linked recessive disease.
b. It occurs due to either mutation or deletion resulting in reduced rate of synthesis of one of globin chains of haemoglobin.
c. Anaemia is the characteristic of this disease.
d. Thalassemia is classified into two types:
    a. α-thalassemia—Production of α-globin chain is affected. It is controlled by the closely linked genes *HbA1* and *HbA2* on chromosome 16. It occurs due to mutation or deletion of one or more of the four genes.
    b. β-thalassemia—Production of β-globin chain is affected. It occurs due to mutation of one or both *HbB* genes on chromosome 11.

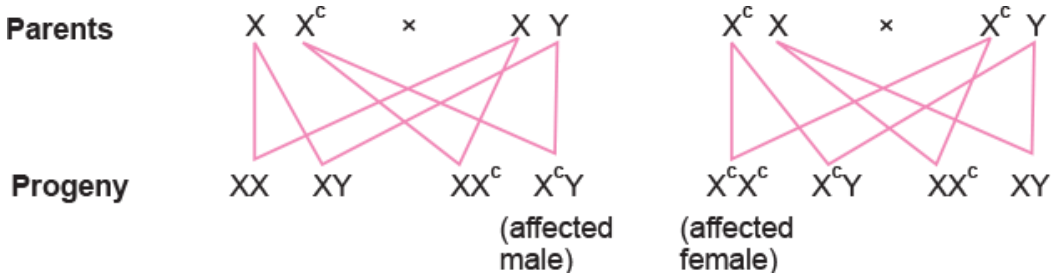
- **Colour blindness**
    a. It is a sex-linked recessive disorder.
    b. It results in defect in either red or/and green cone of eye, resulting in failure to discriminate between red and green colour.
    c. The gene for colour blindness is present on X chromosome.
    d. It is observed more in males (X^cY) because of presence of only one X chromosome as compared to two chromosomes of females.

Q.26.

a. State the cause and symptoms of colour-blindness in humans.
b. Statistical data has shown that 8% of the human males are colour-blind whereas only 0.4% of females are colour-blind. Explain giving reasons how is it so.

Ans.

a. Colour-blindness is a sex-linked recessive disorder.
Its symptoms are failure to discriminate between red and green colour.
b. Since males have only one X chromosome gene for colour blindness, if present in any one parent will always be expressed, whereas in female it will be expressed only if it is present on both the X chromosome or when both parents are carrying gene for colour blindness.



Q.27. Write the type and location of the gene causing thalassemia in humans. State the cause and symptoms of the disease. How is sickle cell anaemia different from this disease?

Ans.

Sickle-cell anaemia

i. It is an autosome-linked recessive trait.
ii. The disease is controlled by a single pair of allele Hb^A and Hb^S.
iii. Only the homozygous individuals for Hb^S, *i.e.*, Hb^SHb^S show the diseased phenotype.
iv. The heterozygous individuals are carriers (Hb^AHb^S).
v. Due to point mutation, glutamic acid (Glu) is replaced by valine (Val) at the sixth position of β-globin chain of haemoglobin molecule.
vi. HbS behaves as normal haemoglobin except under oxygen stress where erythrocytes lose their circular shape and become sickle-shaped. As a result, the cells cannot pass through narrow capillaries. Blood capillaries are clogged and thus affect blood supply to different organs.

Thalassemia

i. It is an autosome-linked recessive disease.
ii. It occurs due to either mutation or deletion resulting in reduced rate of synthesis of one of globin chains of haemoglobin.
iii. Anaemia is the characteristic of this disease.
iv. Thalassemia is classified into two types:
- α-thalassemia—Production of α-globin chain is affected. It is controlled by the closely linked genes HbA1 and HbA2 on chromosome 16. It occurs due to mutation or deletion of one or more of the four genes.
- β-thalassemia—Production of β-globin chain is affected. It occurs due to mutation of one or both HbB genes on chromosome 11.

Q.28. Identify '*a*', '*b*', '*c*', '*d*', '*e*' and '*f*' in the table given below:

Ans.

S. No.	**Syndrome**	**Cause**	**Characteristics ofaffected individuals**	**SexMale/Female/Both**
1.	Down's	Trisomy of 21	'a' (*i*) (*ii*)	'*b*'
2.	'*c*'	XXY	Overall masculinedevelopment	'*d*'
3.	Turner's	45 with XO	'e' (*i*) (*ii*)	'*f*'

Ans.

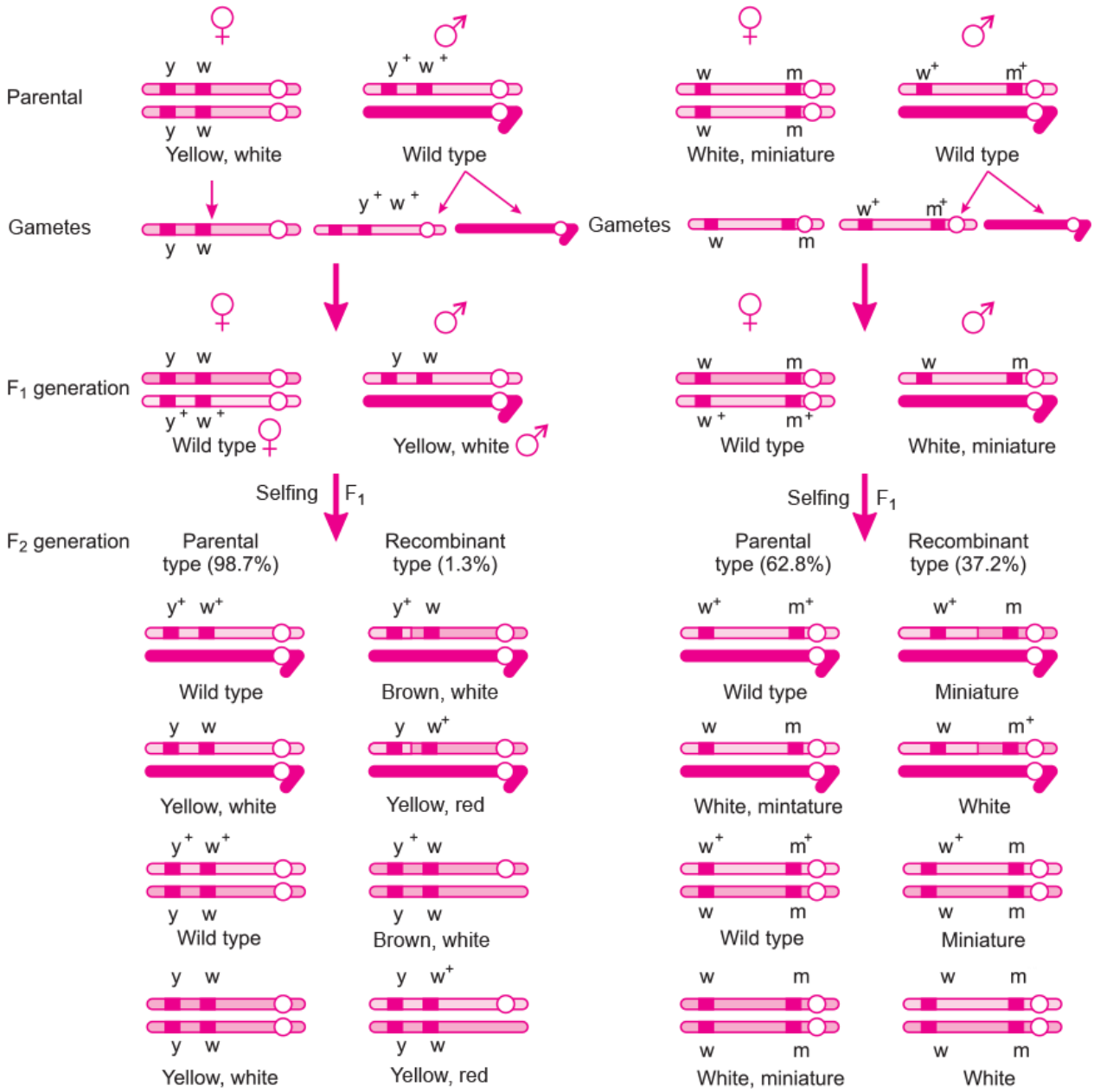
a. Short stature/small round head/furrowed tongue/partially open mouth/ mental development retarded.
b. Both.
c. Klinefelter's syndrome
d. Male
e.
    i. Sterile ovaries;
    ii. Lack of secondary sexual characters.
f. Female

Q.29. Describe the dihybrid cross carried on Drosophila melanogaster by Morgan and his group. How did they explain linkage, recombination and gene mapping on the basis of their observations?

Ans.

Linkage and Recombination

- **T. H. Morgan** carried out several dihybrid crosses in Drosophila to study the genes that are sex-linked. He observed that when the two genes in a dihybrid cross are located on the same chromosome, the proportion of parental gene combinations in the progeny was much higher than the non-parental or recombination of genes.
- Morgan and his group found that when genes are grouped on the same chromosome, some genes are tightly linked or associated and show little recombination.



- Results of two dihybrid crosses conducted by Morgan. Cross A shows crossing between genes y and w; Cross B shows crossing between genes w and m. Here dominant wild type alleles are represented with (+) sign in superscript.
- When the genes are loosely linked they show higher percentage of recombination.
- Morgan hybridised yellow bodied and white eyed females with brown bodied and red eyed males (wild type) (cross-A) and inter-crossed their F_1 progeny.
- Alfred Sturtevant determined that genes of *Drosophila* are arranged in a linear order. He measured the distance between genes and prepared **chromosome maps** with the position of genes on the chromosomes based on percentage of recombinants. These are also called **genetic maps**.

Q.30. Answer the following questions:

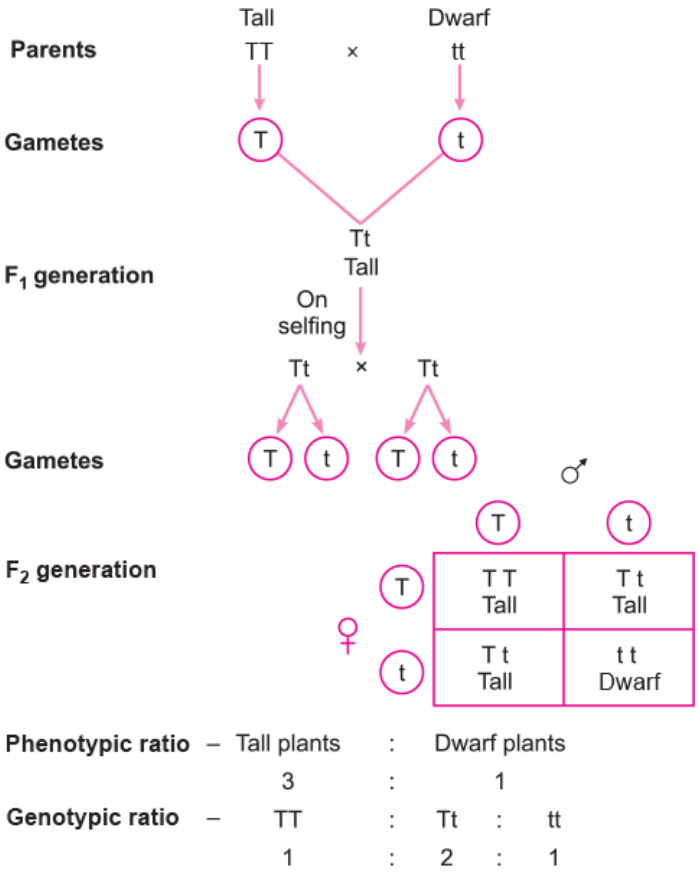
Q. State and explain the law of segregation as proposed by Mendel in a monohybrid cross.

Ans. Mendel's Observations

i. F_1 progenies always resembled one of the parents and trait of other parent was not seen.
ii. F_2 stage expressed both the parental traits in the proportion 3 : 1.
iii. The contrasting traits did not show any blending at either F_1 or F_2 stage.
iv. In dihybrid cross, he got identical results as in monohybrid cross.
v. He found that the phenotypes in F_2 generation appeared in the ratio 9 : 3 : 3 : 1.

Law of segregation.

- This law states that the factors or alleles of a pair segregate from each other during gamete formation, such that a gamete receives only one of the two factors. They do not show any blending.



Monohybrid cross of true-breeding pea plant

Q. Write the Mendelian F_2 phenotypic ratio in a dihybrid cross. State the law that he proposed on the basis of this ratio. How is this law different from the law of segregation?

Ans. The F_2 phenotypic ratio is 9:3:3:1. On the basis of this ratio Mendel proposed Law of Independent Assortment.

Law of independent assortment

- According to this law the two factors of each character assort or separate out independent of the factors of other characters at the time of gamete formation and get randomly rearranged in the offsprings producing both parental and new combinations of characters.

Q.31. Answer the following questions:

Q. State and explain the law of dominance as proposed by Mendel.

Ans. This law states that when two alternative forms of a trait or character (genes or alleles) are present in an organism, only one factor expresses itself in F_1 progeny and is called dominant while the other that remains masked is called recessive.
The characters are controlled by discrete units called factors. These factors occur in pairs.

Q. How would phenotypes of monohybrid F_1 and F_2 progeny showing incomplete dominance in Snapdragon and co-dominance in human blood group be different from Mendelian monohybrid F_1 and F_2 progeny? Explain.

Ans.

	Mendelian monohybrid cross	**Incomplete dominance**	**Co-dominance**
F_1	All members resemble the parent with dominant trait.	All members do not resemble either of the two parents but show an intermediate trait.	Blood groups of all members resemble combination of dominant traits of both the parents.
F_2	Both the parental traits reappear.	Both the parental traits and an intermediate trait appear.	Both the parental traits as well as the co-dominant trait appear.

Q.32. Answer the following questions:

Q. Explain Mendel's law of independent assortment by taking a suitable example.

Ans. According to this law, the two factors of each character assort or separate out independent of the factors of other characters at the time of gamete formation and get randomly rearranged in the offsprings producing both parental and new combinations of characters.

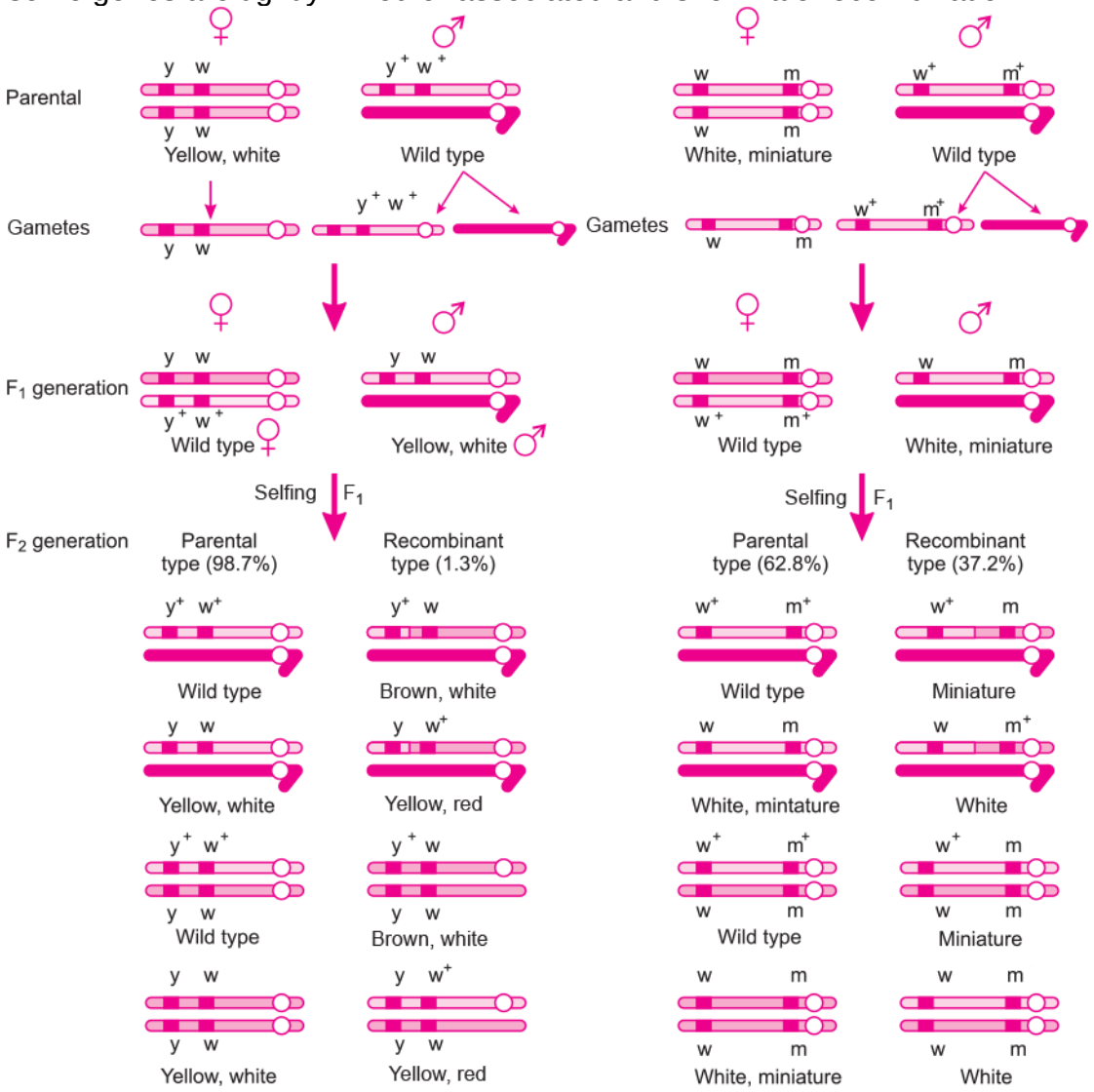
The Punnett square can be effectively used to understand the independent segregation of the two pairs of genes during meiosis and the production of eggs and pollen in the F_1 (RrYy) plant. Consider the segregation of one pair of genes R and r. Fifty per cent of the gametes have the gene R and the other 50 per cent have gene r. Now besides each gamete having either R or r, it should also have the allele Y or y. The important thing to remember here is that segregation of 50 per cent R and 50 per cent r is independent from the segregation of 50 per cent Y and 50 per cent y. Therefore, 50 per cent of the r bearing gamete has Y and the ther 50 per cent has y. Similarly, 50 per cent of the R bearing gamete has Y and the other 50 per cent has y.. Thus there are four genotypes of gametes (four types of pollen and four types of eggs). The four types are RY, Ry, rY and ry each with a frequency of 25 per cent of 1/4th of the total gametes produced.

Q. How did Morgan show the deviation in inheritance pattern in *Drosophila* with respect to this law?

Ans. Linkage and Recombination

- **T. H. Morgan** carried out several dihybrid crosses in Drosophila to study the genes that are sex-linked. He observed that when the two genes in a dihybrid cross are located on the same chromosome, the proportion of parental gene combinations in the progeny was much higher than the non-parental or recombination of genes.

- Morgan and his group found that when genes are grouped on the same chromosome, some genes are tightly linked or associated and show little recombination.



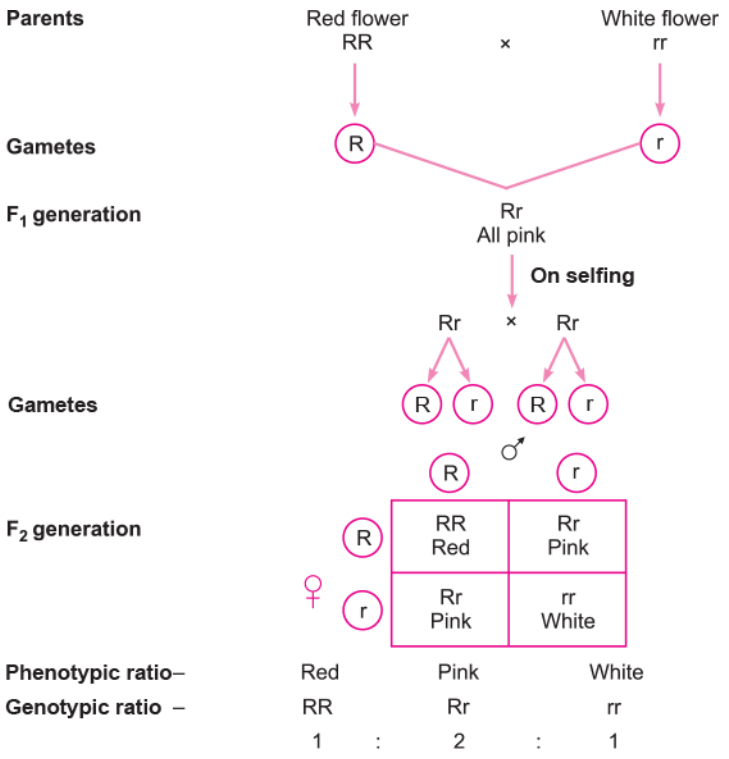
- Linkage: Results of two dihybrid crosses conducted by Morgan. Cross A shows crossing between genes y and w; Cross B shows crossing between genes w and m. Here dominant wild type alleles are represented with (+) sign in superscript.
- When the genes are loosely linked they show higher percentage of recombination.
- Morgan hybridised yellow bodied and white eyed females with brown bodied and red eyed males (wild type) (cross-A) and inter-crossed their F_1 progeny.
- Alfred Sturtevant determined that genes of *Drosophila* are arranged in a linear order. He measured the distance between genes and prepared **chromosome maps** with the position of genes on the chromosomes based on percentage of recombinants. These are also called **genetic maps**.

Q.33. Answer the following questions:

Q. During a cross involving true breeding red flowered and true breeding white flowered snapdragon plants, the F_1progeny did not show any of the parental traits, while they reappeared in F_2 progenies. Explain the mechanism using Punnett Square.

Ans. Incomplete Dominance

- It is a phenomenon in which the F_1 hybrid exhibits characters intermediate of the parental genes.
- Here, the phenotypic ratio deviates from the Mendel's monohybrid ratio.
- It is seen in flower colours of *Mirabilis jalapa* (4 o' clock plant) and *Antirrhinum majus* (snapdragon), where red colour is due to gene *RR*, white colour is due to gene *rr* and pink colour is due to gene *Rr*.



Monohybrid cross in snapdragon, where one allele is incompletely dominant over the other allele

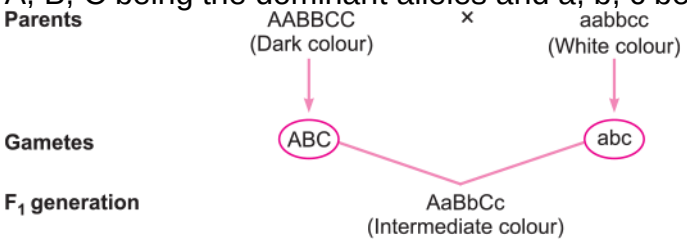
Q. Explain polygenic inheritance with the help of an example.

Ans.

Polygenic Inheritance

- It is a type of inheritance, in which traits are controlled by three or more genes. Such traits are called **polygenic traits**.

- The phenotype reflects contribution of each allele and is also influenced by the environment.
- For example, human skin colour. Suppose 3 genes A, B and C control skin colour with A, B, C being the dominant alleles and a, b, c being the recessive alleles. Then,



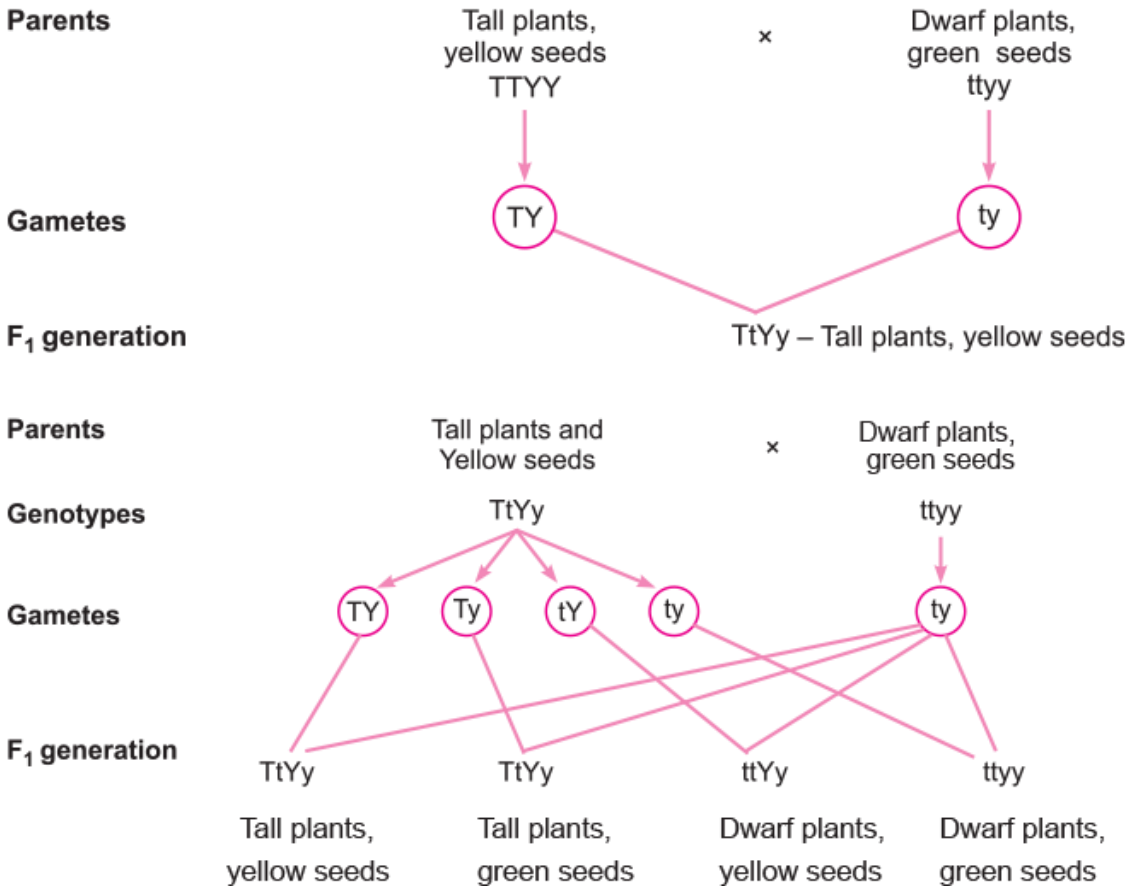
- The F_2 generation will have varied skin tones, with each type of allele in the genotype determining the darkness or lightness of the skin.

Q.34. Answer the following questions:

Q. You are given tall pea plants with yellow seeds whose genotypes are unknown. How would you find the genotype of these plants? Explain with the help of cross.

Ans.

Test cross will be performed to know the genotype of these plants.



If all the plants of F_1 generation are tall with yellow seeds, then the phenotype of the parent is homozygous dominant (case *i*). If the plants in F_1 generation are in the ratio of 1 : 1 : 1 : 1, then the parent plant is heterozygous dominant.

Q. Identify *a*, *b* and *c* in the table given below:

S. No.	Pattern of inheritance	Monohybrid F_1phenotypic expression
(*i*)	Co-dominance	*a*
(*ii*)	*b*	The progeny resembled only one of the parents
(*iii*)	Incomplete dominance	*c*

Ans.

a–Both the forms of a trait are equally expressed in F_1 generation.
b–Dominance.
c–Phenotypic expression of F_1 generation is somewhat intermediate between the two parental forms of a trait.

Q.35. Answer the following questions:

Q. Explain Polygenic inheritance and Multiple allelism with the help of suitable examples.

Ans. Co-dominance

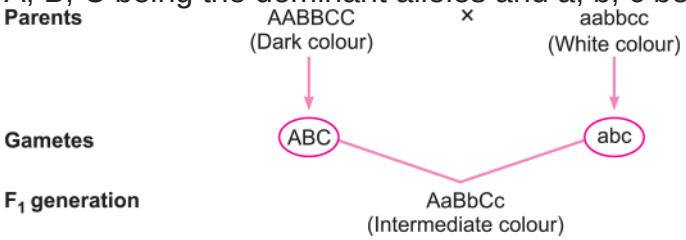
- The alleles which are able to express themselves independently, even when present together are called co-dominant alleles and this biological phenomenon is called co-dominance.**For example,** ABO blood grouping in humans.
- ABO blood groups are controlled by gene *I*. Gene *I* has three alleles I^A, I^B and I^O/*i*.
- I^A and I^B produce RBC surface antigens sugar polymer A and B, respectively, whereas *i* does not produce any antigen.
- I^A and I^B are dominant over *i* hence I^A and *I*B are dominant alleles and *i* is recessive allele as in I^Ai and I^Bi.
- When I^A and I^B are present together, both express equally and produce the surface antigens A and B, hence show co-dominance.
- Since humans are diploid, each person possesses any two of the three '*I*' gene alleles, resulting into six different genotypic combinations and four phenotypic expressions.**Table showing the genetic basis of blood groups in human population**

Allele fromParent 1	Allele fromParent 2	Genotype ofoffspring	Blood groups ofoffspring
I^A	I^A	I^AI^A	A
I^A	I^B	I^AI^B	AB
I^A	*i*	I^Ai	A
I^B	I^B	I^BI^B	B
I^B	*i*	I^Bi	B

i	*i*	*i i*	O

Polygenic Inheritance

- It is a type of inheritance, in which traits are controlled by three or more genes. Such traits are called **polygenic traits**.
- The phenotype reflects contribution of each allele and is also influenced by the environment.
- For example, human skin colour. Suppose 3 genes A, B and C control skin colour with A, B, C being the dominant alleles and a, b, c being the recessive alleles. Then,



- The F_2 generation will have varied skin tones, with each type of allele in the genotype determining the darkness or lightness of the skin.

Q. "Phenylketonuria is a good example that explains Pleiotropy." Justify.

Ans. In pleiotropy a single gene can exhibit multiple phenotypic expressions. In phenylketonuria single mutated gene express multiple phenotypic expression like mental retardation and reduction in hair and skin pigmentation.

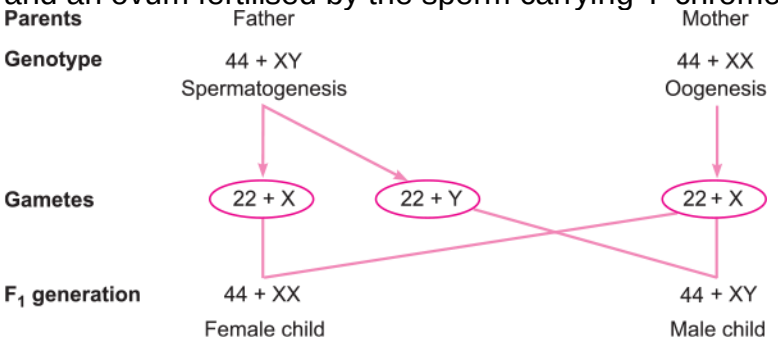
Q.36. Answer the following questions:

Q. Explain the mechanism of sex-determination in humans.

Ans. Sex Determination in Humans

- Humans show XY type of sex determining mechanism.
- Out of 23 pair of chromosomes, 22 are autosomes (same in both males and females).
- Females have a pair of X-chromosomes.
- Males have an X and a Y chromosome.
- During spermatogenesis males produce two types of gametes with equal probability – sperm carrying either X or Y chromosome.
- During oogenesis females produce only one types of gamete – having X chromosome.

- An ovum fertilised by the sperm carrying X-chromosome develops into a female (XX) and an ovum fertilised by the sperm carrying Y-chromosome develops into a male (XY).



Q. Differentiate between male heterogamety and female heterogamety with the help of an example of each.

Ans.

S. No.	Male heterogamety	Female heterogamety
(*i*)	Males produce two types of gametes.	Females produce two types of gametes.
(*ii*)	Example, male grasshopper produce gametes of two types—X and O.	Example, female birds produce gametes of two types—Z and W.

Q.37. Answer the following questions:

Q. Why is haemophilia generally observed in human males? Explain the conditions under which a human female can be haemophilic.

Ans. Haemophilia is caused due to the recessive gene on X chromosome. Y chromosome has no allele for this. If a male is X^hY, then he is haemophilic. If male inherits X^h from the mother, he will be haemophilic (with the genotype X^hY). If female inherits X^hX^h , one from the carrier mother and one from her haemophilic father, then she can be haemophilic.

Q. A pregnant human female was advised to undergo M.T.P. It was diagnosed by her doctor that the foetus she is carrying has developed from a zygote formed by an XX egg fertilised by Y-carrying sperms. Why was she advised to undergo M.T.P.?

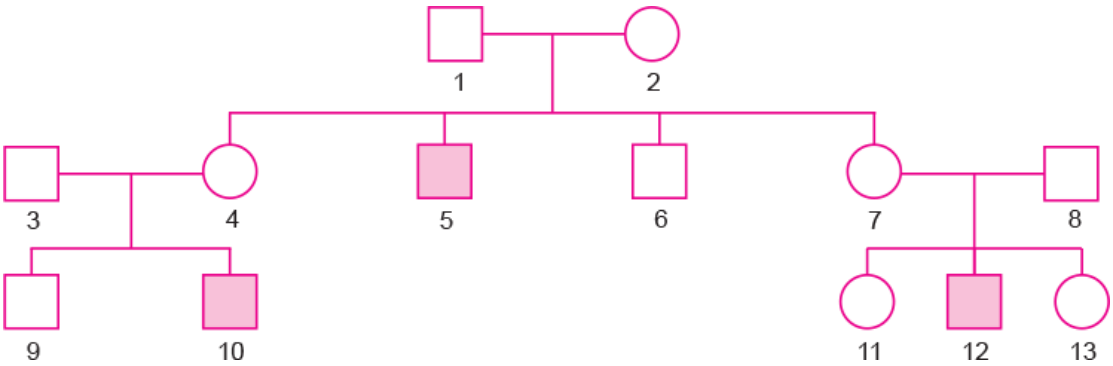
Ans. Embryo has (trisomy of sex chromosome) XXY karyotype or Klinefelter's syndrome.

She was advised to undergo MTP since the child will have the following problems:

i. male with feminine traits
ii. gynaecomastia
iii. underdeveloped testes
iv. sterile

Q.38. Answer the following questions:

Q. Haemophilia is a sex-linked recessive disease. Study the pedigree analysis given below showing the inheritance of the disease in a family and answer the questions that follow.



i. Give the evidence from the above analysis which suggests that the disease is
1. sex-linked and
2. caused by a recessive allele.
ii. Write the possible genotypes of the individuals '2' and '5'.

Ans.

i.
1. In all the generations, only the males are affected with the disease.
2. The parents of the affected individuals are not affected which implies that they are carriers and the gene is recessive.

ii. Possible genotype of '2': X^d X
Possible genotype of '5': X^d Y

Q. Why is thalassemia categorised as a Mendelian disorder? State the condition when an individual will suffer from the disease.

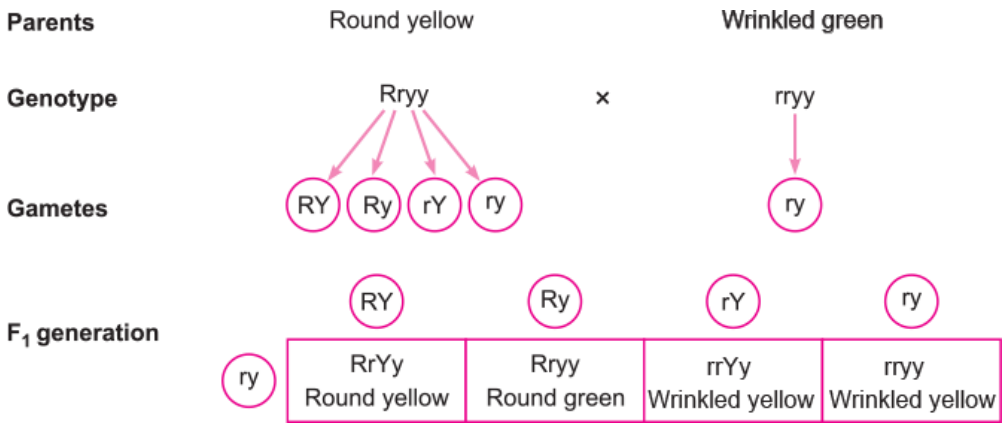
Ans. Thalassemia is categorised as Mendelian disorder because these are caused due to alteration or mutation in single gene and follow the Mendel's principles of inheritance. It occurs due to either mutation or deletion resulting in reduced rate of synthesis of one of globin chains of haemoglobin.

Q.39. A cross was carried out between a pea plant heterozygous for round and yellow seeds with a pea plant having wrinkled and green seeds.

a. **Show the cross in a Punnett square.**
b. **Write the phenotype of the progeny of this cross.**
c. **What is this cross known as? State the purpose of conducting such a cross.**

Ans.

(a)



(b) Both the phenotypic and genotypic ratio are same, i.e., 1: 1 : 1 : 1.

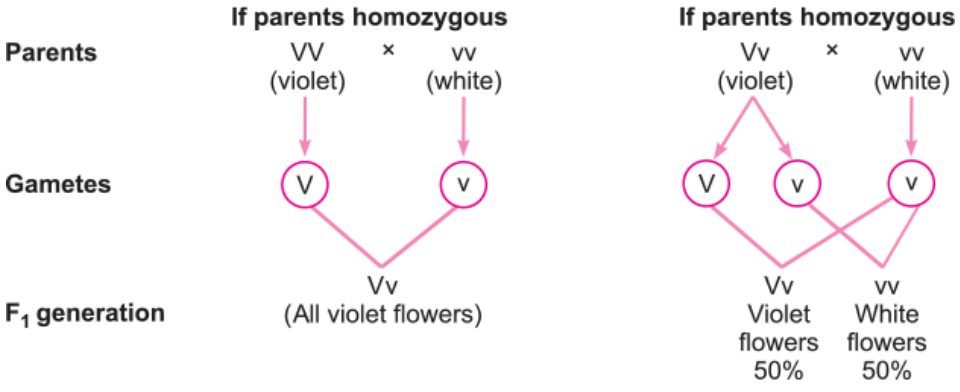
(c) This cross is known as test cross.

Q.40. A particular garden pea plant produces only violet flowers.

a. **Is it homozygous dominant for the trait or heterozygous?**
b. **How would you ensure its genotype? Explain with the help of crosses.**

Ans.

a. It could be homozygous dominant.
b. By performing test cross, genotype can be determined.



Long Answer Questions (OIQ)

[5 Marks]

Q.1. Describe the nature of inheritance of the ABO type of blood group in humans. In which ways does this inheritance differ from that of height of the plant in garden pea?

Ans. ABO blood group system in human:

Co-dominance

- The alleles which are able to express themselves independently, even when present together are called co-dominant alleles and this biological phenomenon is called co-dominance.**For example,** ABO blood grouping in humans.
- ABO blood groups are controlled by gene *I*. Gene *I* has three alleles I^A, I^B and I^O/i.
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- Since humans are diploid, each person possesses any two of the three '*I*' gene alleles, resulting into six different genotypic combinations and four phenotypic expressions.**Table showing the genetic basis of blood groups in human population**

Allele fromParent 1	Allele fromParent 2	Genotype ofoffspring	Blood groups ofoffspring
I^A	I^A	I^AI^A	A
I^A	I^B	I^AI^B	AB
I^A	*i*	I^Ai	A
I^B	I^B	I^BI^B	B
I^B	*i*	I^Bi	B
i	*i*	*i i*	O

S. No.	Blood group in man	Height of plant in garden pea
(*i*)	The gene *I* responsible for the blood group exists in three allelic alternative forms I^A, $I^B$and *i*.	The gene for this trait exists in two allelic forms T and t.

(*ii*)	I^A and I^B are dominant over *i* and I^A and $I^B$are co-dominant.	Allele T is dominant over t.
(*iii*)	They exhibit four phenotypes with six possible genotypes.	They exhibit two phenotypes with three possible genotype
(*iv*)	Blood group in man exhibit phenomena of multiple allelism.	Height in garden pea plant do not exhibit multiple allelism.

Q.2. Explain the chromosomal theory of inheritance.

Ans. Chromosomal Theory of Inheritance

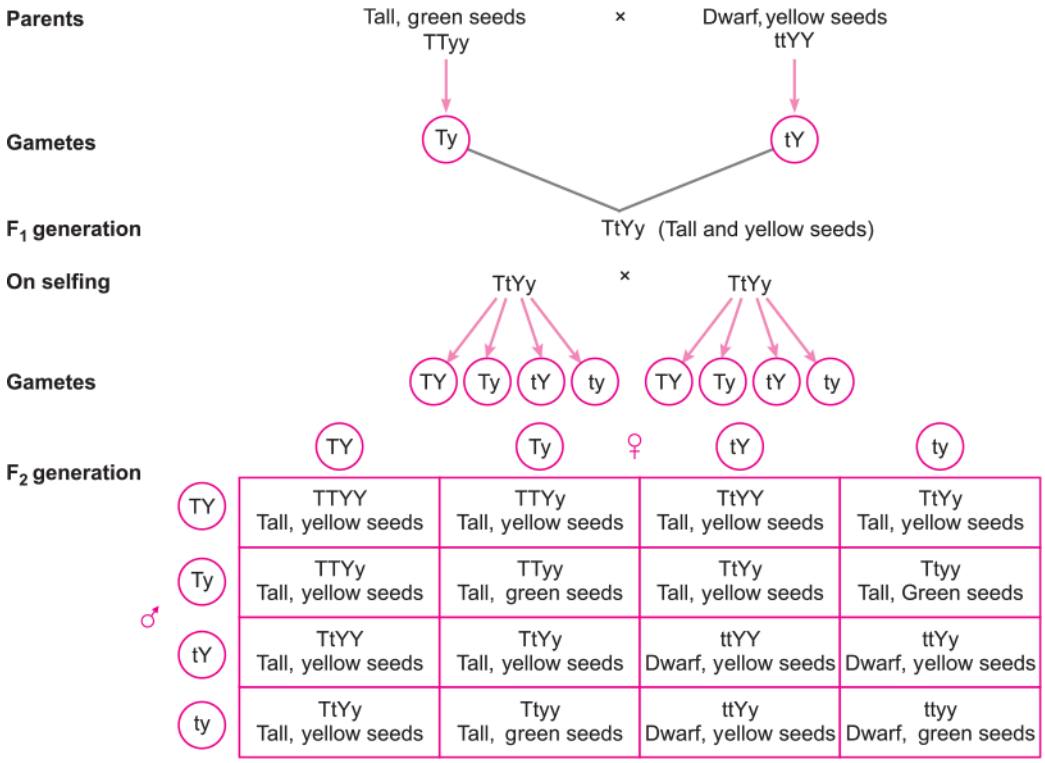
The chromosomal theory of inheritance was proposed independently by Walter Sutton and Theodore Boveri in 1902. According to this theory,

- **i.** Since the sperm and egg cells provide the only bridge from one generation to the other, all hereditary characters must be carried in them.
- **ii.** The hereditary factors are carried in the nucleus.
- **iii.** Like the Mendelian alleles, chromosomes are also found in pairs.
- **iv.** The sperm and egg having haploid sets of chromosomes fuse to re-establish the diploid state.
- **v.** The genes are located on the chromosomes in a linear order. As there are two chromosomes of each kind in somatic (diploid) cell there must be two genes of each kind, one in each of the two homologous chromosomes.
- **vi.** Homologous chromosomes synapse during meiosis and get separated to pass into different cells. This forms the basis for segregation and independent assortment. A gamete receives only one chromosome of each type and thus has only one gene for a trait. The paired condition is restored by fusion of gametes.

Q.3. A homozygous tall pea plant with green seeds is crossed with a dwarf pea plant with yellow seeds:

- **i. What would be the phenotype and genotype of F_1?**
- **ii. Work out the phenotypic ratio of F_2 generation with the help of a Punnett square.**

Ans.



i. Phenotype of F_1—Tall plants with yellow seeds.
Genotype of F_1—TtYy.

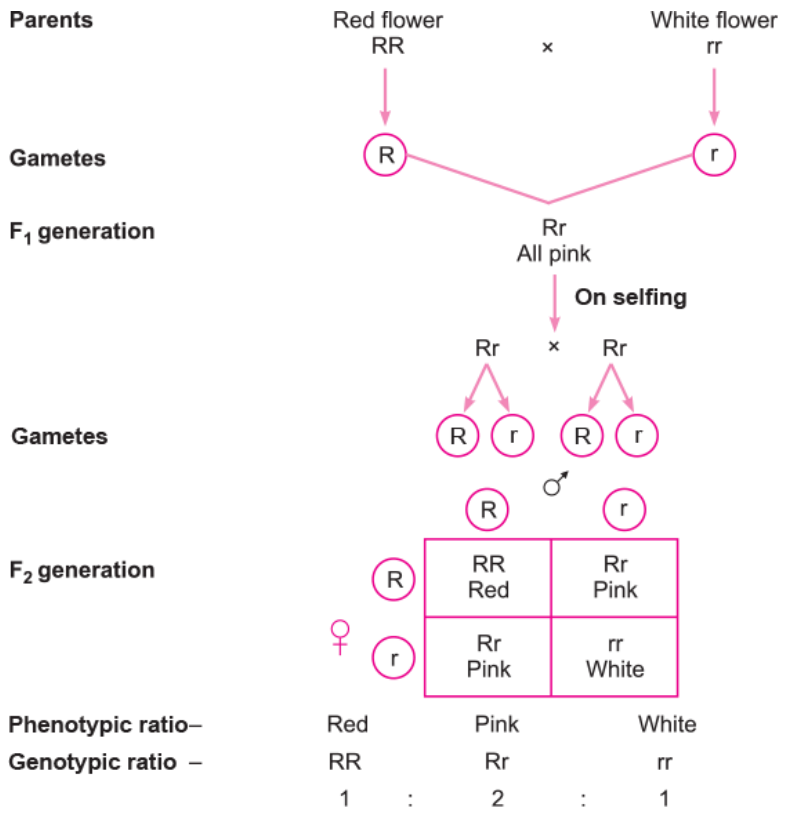
ii.

Phenotypic ratio of F_2 generation:

Tall, yellow seeds	:	Tall, green seeds	:	Dwarf, yellow seeds	:	Dwarf, green seeds
9	:	3	:	3	:	1

Q.4. In the case of snapdragon (*Antirrhinum majus*) a plant with red flowers was crossed with another plant with white flowers. Trace the inheritance of flower colour up to F_2 generation indicating the genotype and phenotype at each level. What special feature do you notice in the genotype and phenotype ratio in F_2 generation?

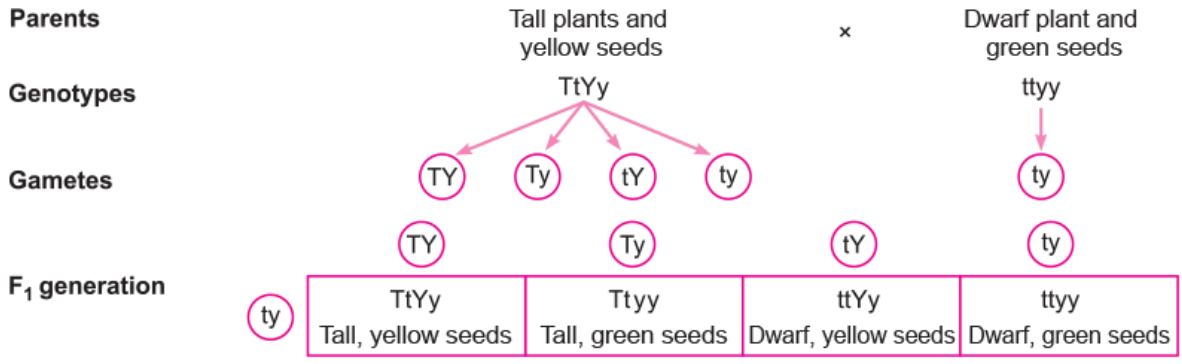
Ans.



Comment: This is a case of Mendelian deviation and that shows incomplete dominance as red and white both are not expressed but produce pink trait in F_1. Here, both the genotypic and phenotypic ratio are 1 : 2 : 1.

Q.5. A tall pea plant with yellow seeds (heterozygous for both the traits) is crossed with a dwarf pea plant with green seeds. Using a Punnett square work out the cross to show the phenotypes and the genotypes of F_1 generation.

Ans.



The phenotype and genotype of F_1 generation are

Tall, yellow seeds : Tall, green seeds : Dwarf, yellow seeds : Dwarf, green seeds

TtYy : Ttyy : ttYy : ttyy

1 : 1 : 1 : 1

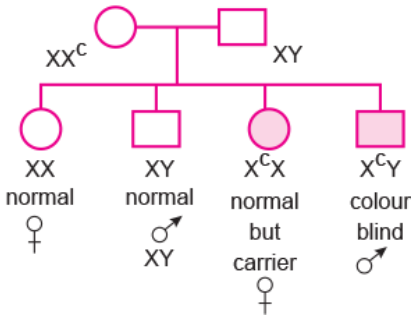
Q.6. A normal visioned woman, whose father is colour blind, marries a normal visioned man. What would be the probability of her (*a*) sons (*b*) daughters to be colour blind? Explain with the help of pedigree chart.

Ans.

The genotypes of parents are:

Father ⟶ XX^c as her father is colour blind.

Mother ⟶ XY



All daughters are normal visioned and 50% of sons are likely to be colour blind.

Q.7. Answer the following questions.

Q. Four children with four different blood groups are born to parents where the mother has blood group 'A' and the father has blood group 'B'. Work out the cross to show the genotypes of the parents and all four children.

Ans.

Parents I^AI^O × I^BI^O

Blood group A B

Gametes I^A I^O I^B I^O

F_1 generation

♀ \ ♂	I^A	I^O
I^B	I^AI^B Blood group AB	I^BI^O Blood group B
I^O	I^AI^O Blood group A	I^OI^O Blood group O

Q. Explain the contribution of Alfred Sturtevant in 'Chromosome mapping'.

Ans. Alfred Sturtevant used the frequency of recombination between gene pairs on the same chromosome as a measure of the distance between genes and mapped their position on the chromosome.