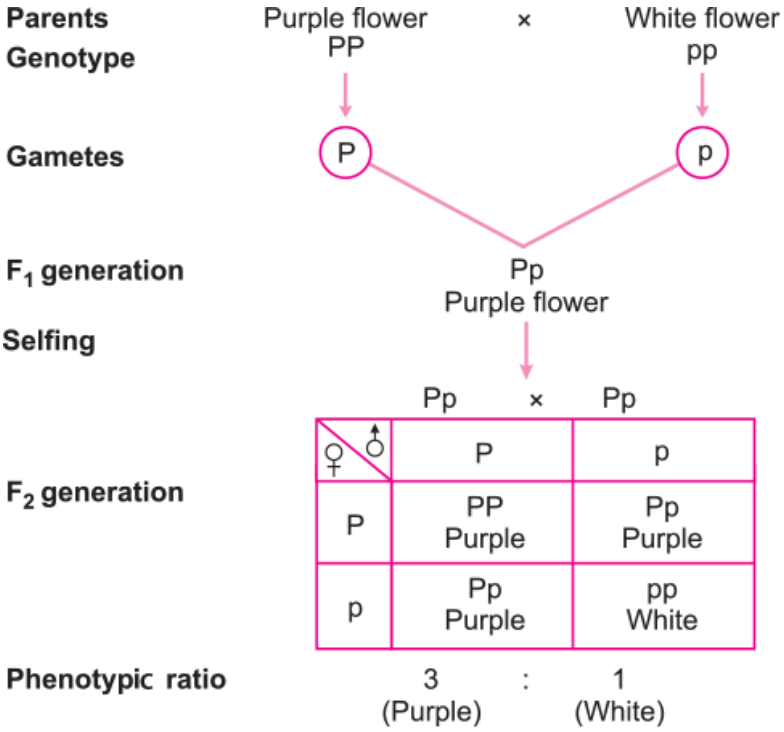
Short Answer Questions-II (PYQ)

[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.

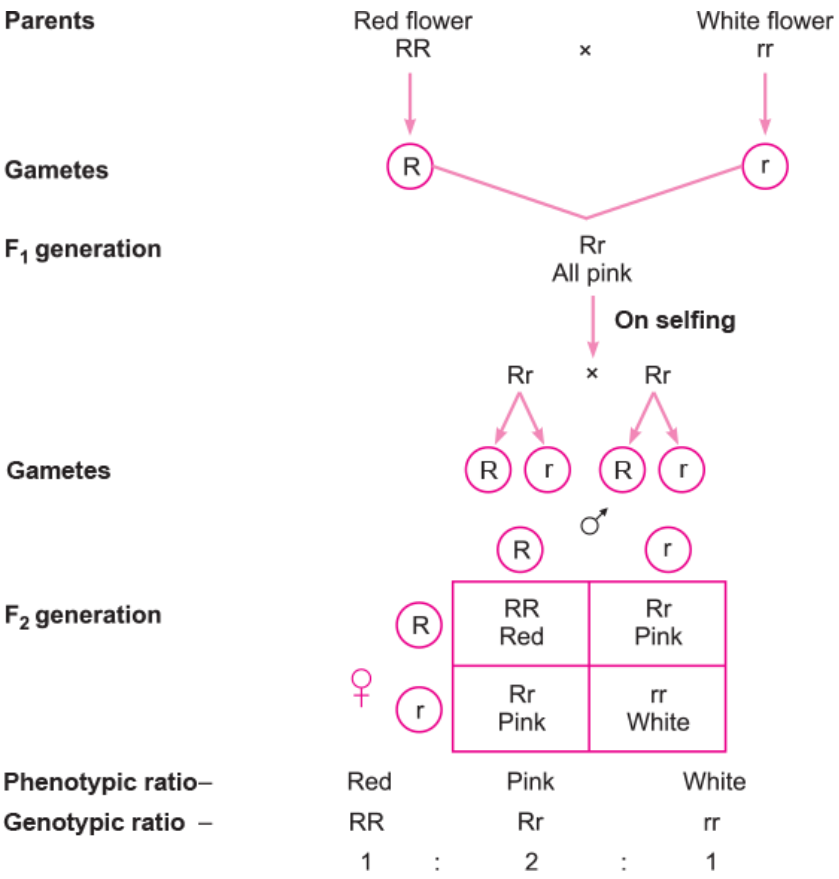
Ans. The gene for purple flowers is dominant over that of white flowers. So, when two pure varieties are crossed, the F1 generation has only purple flowers and on selfing, the flowers are produced in a 3 : 1 ratio.



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

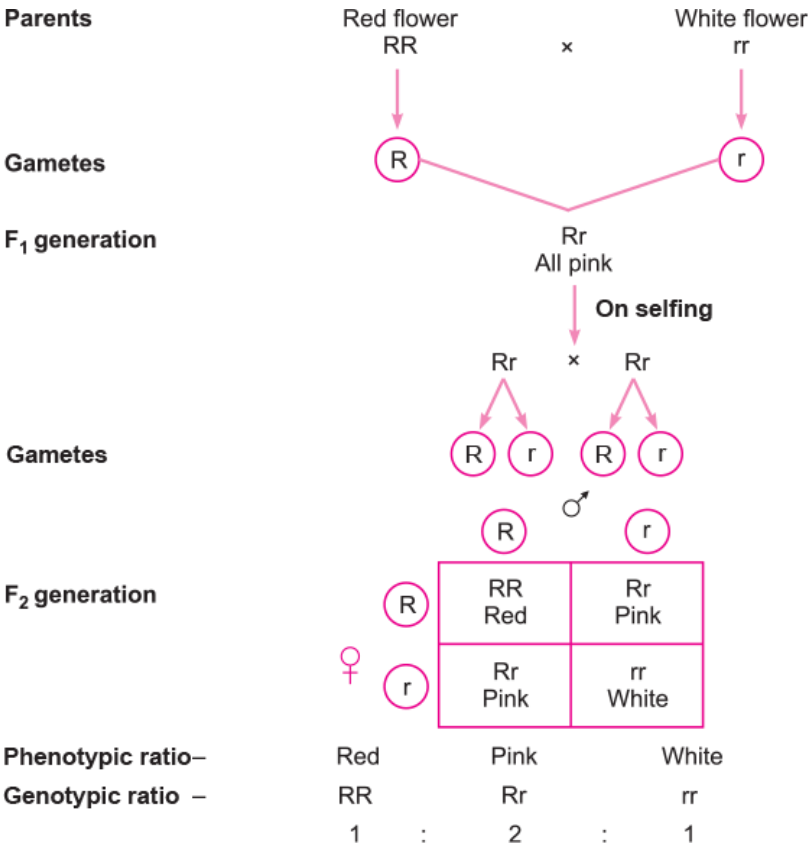
In heterozygous condition a single dominant gene is not sufficient to produce red colour therefore it is a case of incomplete dominance.

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.

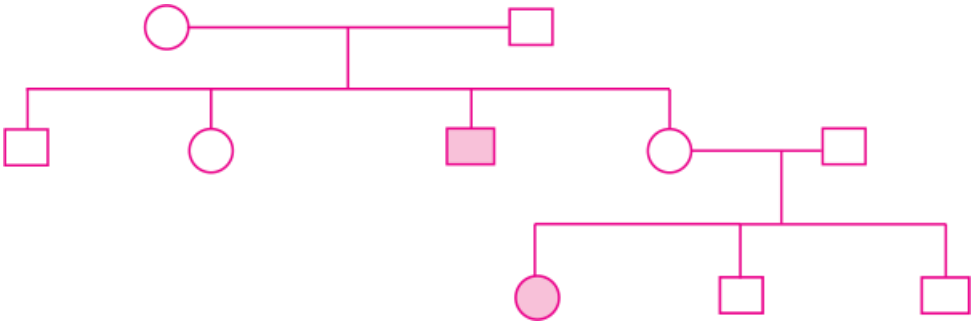
Ans.

(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.

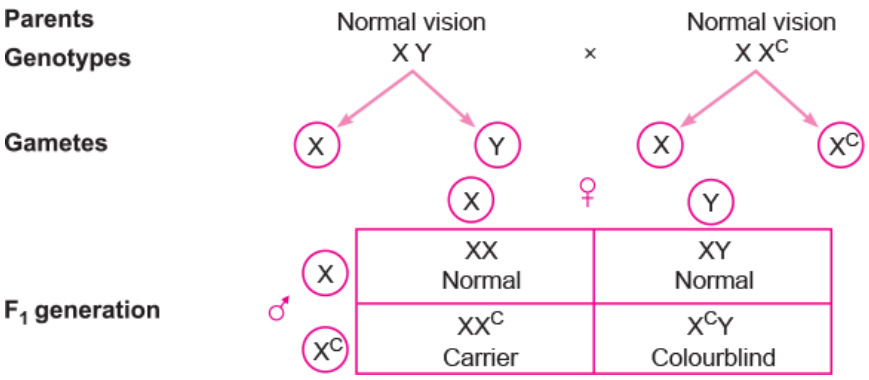
(ii) Partially open mouth with protruding furrowed tongue.

(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.



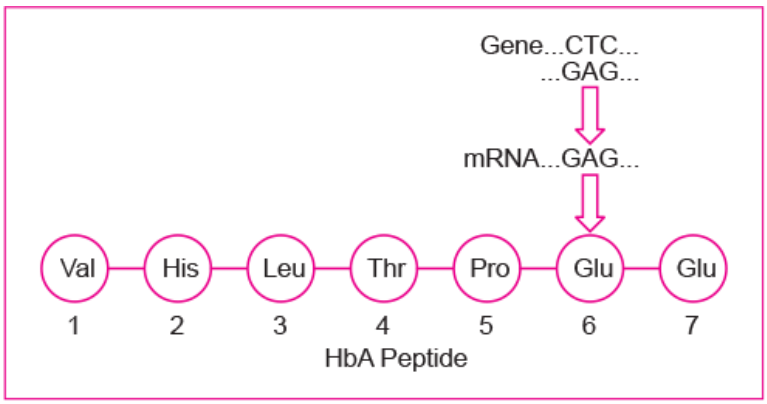
It is possible when the mother is carrier of colourblindness gene. She will have normal vision but will pass on the gene to her children. Another possibility is that there is a mutation on the X-chromosome of one of the twins.

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).

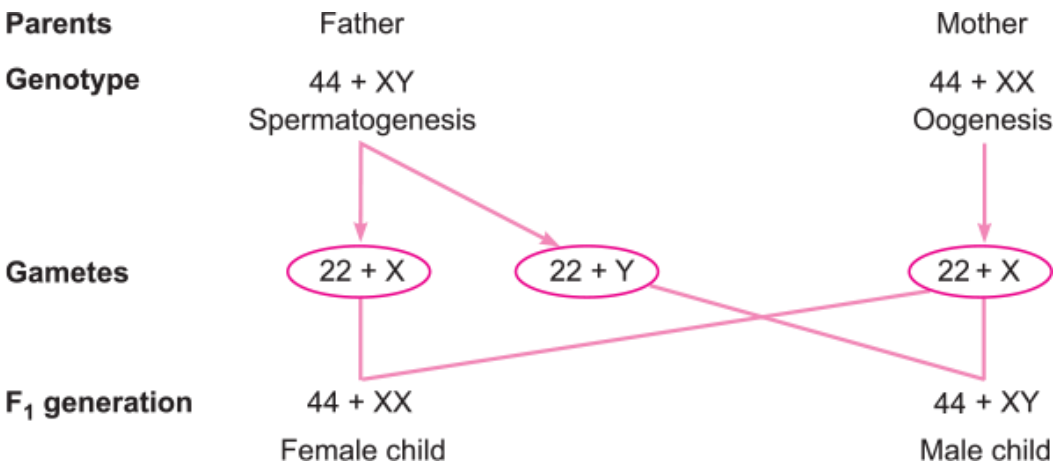
***** Females have a pair of X-chromosomes.

***** 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.

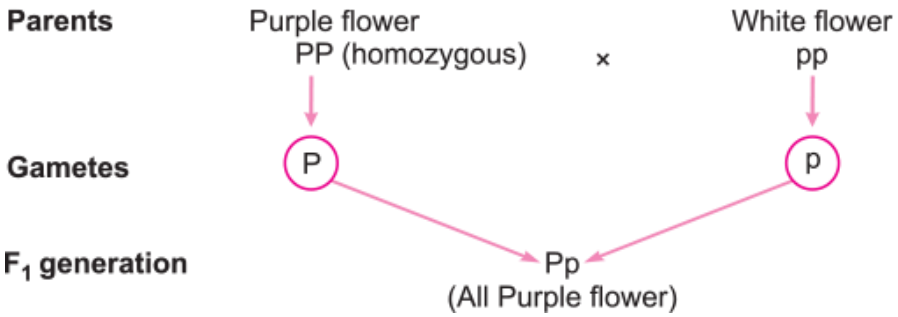
Short Answer Questions-II (OIQ)

[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?

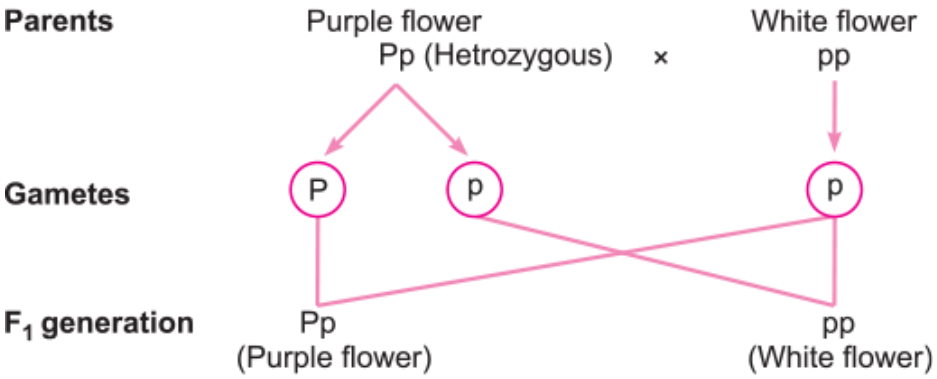
Ans. The genotype of a purple flowered plant can be determined by conducting a test cross i.e., crossing the purple flowered plant with homozygous recessive individual i.e., pp.

Case I



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

Case II



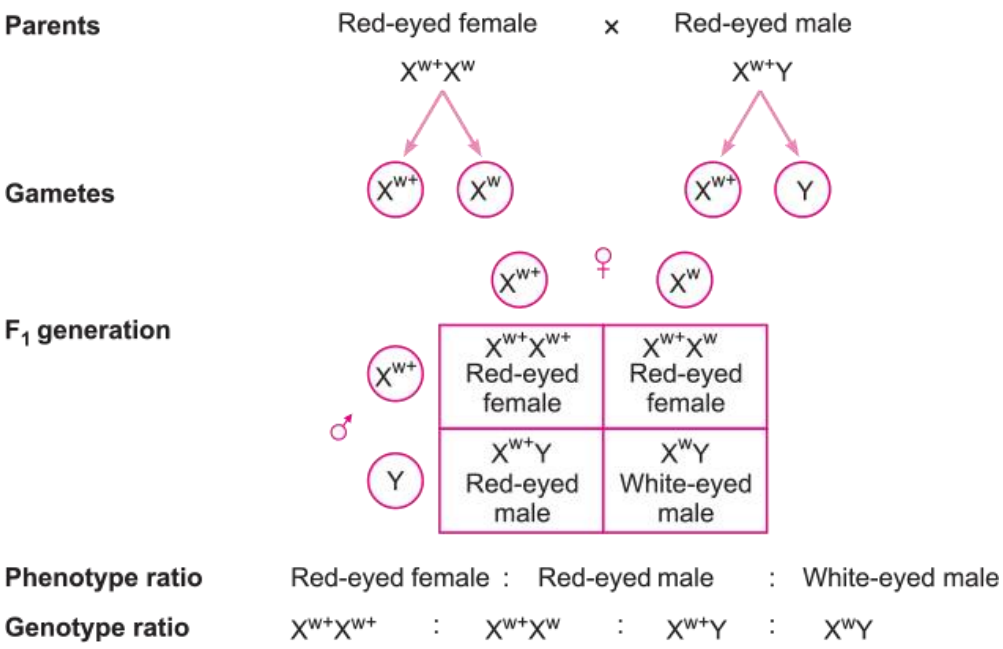
Purple flower	:	White flower
1	:	1

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)



Phenotype ratio Red-eyed female : Red-eyed male : White-eyed male

Genotype ratio $X^{w+}X^{w+}$: $X^{w+}X^{w}$: $X^{w+}Y$: $X^{w}Y$

(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.

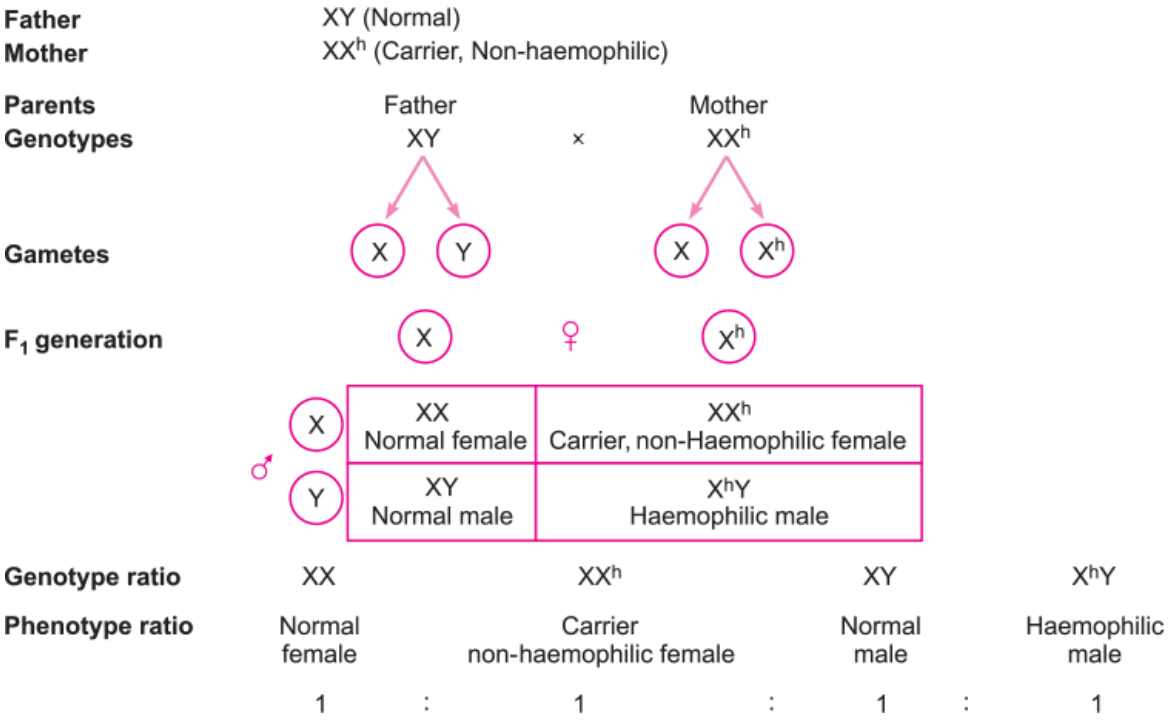
(iii) Poor beard growth and often sterile.

(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.

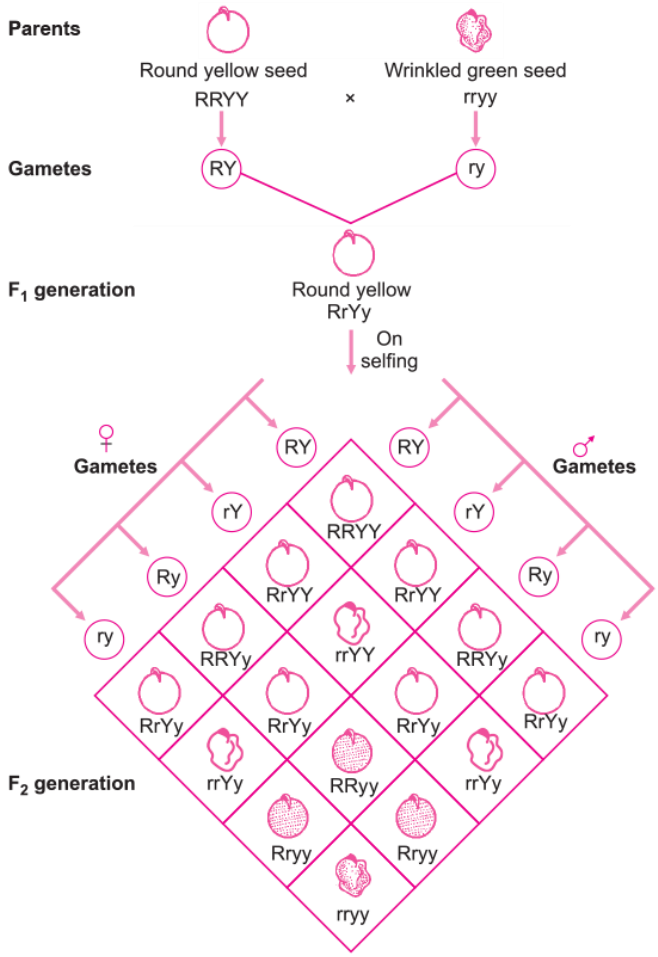
It has perfect bisexual flowers containing both male and female parts.

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.

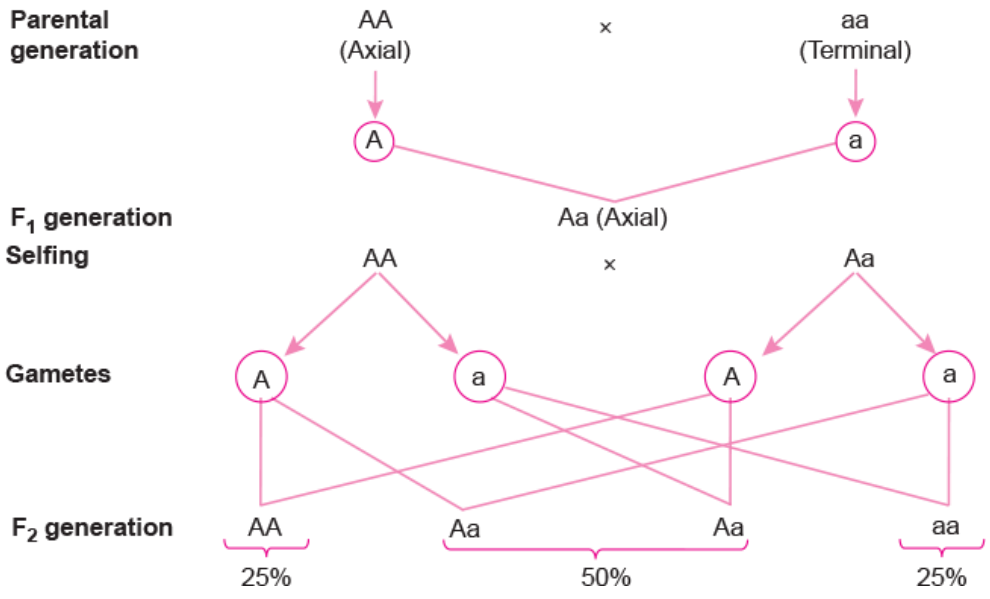
b. Work out the cross upto F2 generation.

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

Ans.

(a) Axial position

(b)



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