THE VILLAGE INTERNATIONAL SCHOOL
"We Nurture Dreams"

Grade 12 Biology

Chapter 5: Principles of inheritance and variation

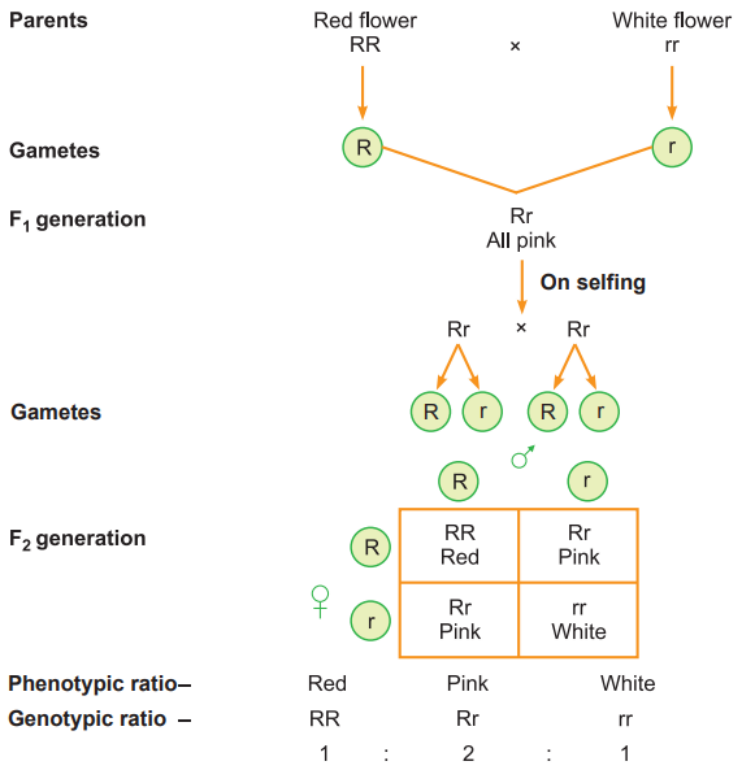
Question bank part 3

Long Answer Questions

Q. 1. The F2 progeny of a monohybrid cross showed phenotypic and genotypic ratio as 1 : 2 : 1, unlike that of Mendel's monohybrid F2 ratio. With the help of a suitable example, work out a cross and explain how it is possible.

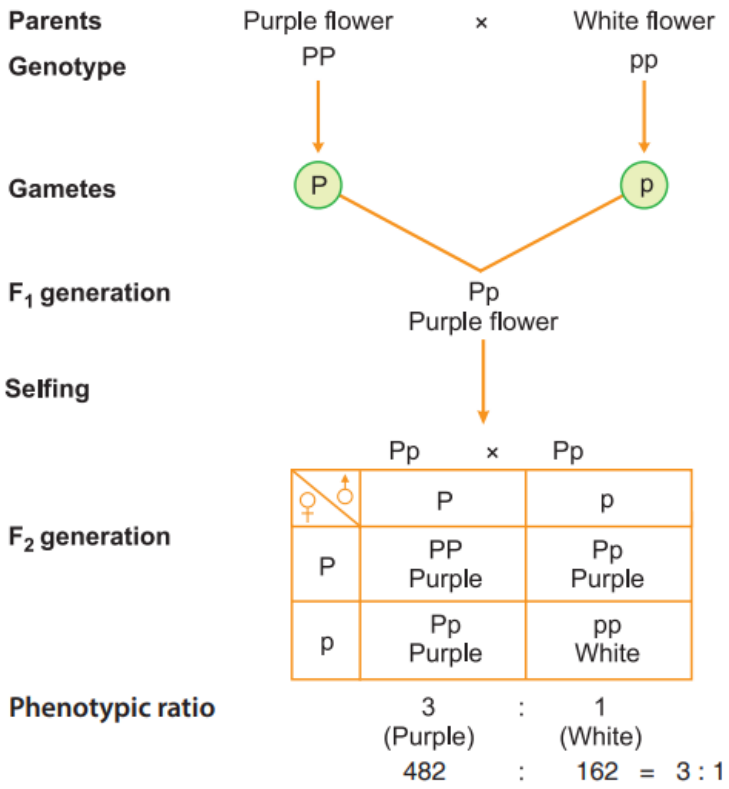
Ans. This kind of cross is observed in Mirabilis jalapa/Four o'clock plant/Antirrhinum majus.

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



Q. 2. 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 in F2 generation.



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.

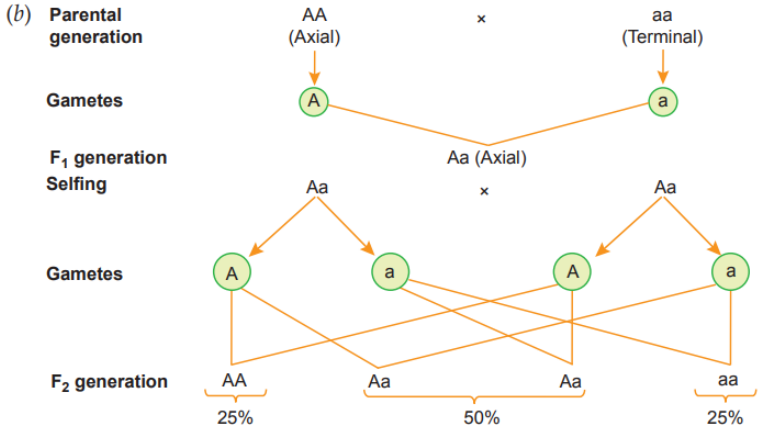
Q. 3. A cross is made between different homozygous pea plants for contrasting flower positions.

(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?

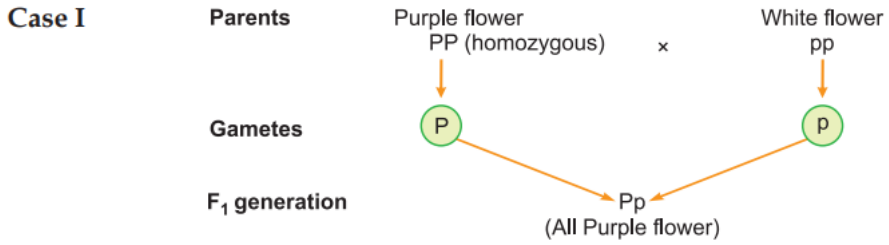
Ans. (a) Axial position



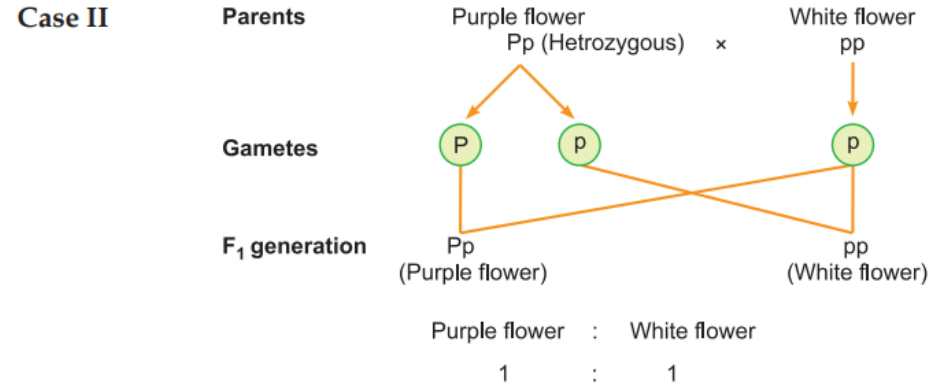
(c) $AA = \frac{25}{100} = \frac{1}{4}$, $Aa = \frac{50}{100} = \frac{1}{2}$, $aa = \frac{25}{100} = \frac{1}{4}$

Q4. 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.



If the F1 generation produces all purple flowers, the parent would be homozygous dominant, i.e., PP.



If the F1 generation produces purple and white flowers in 1:1 ratio, the parent would be heterozygous, i.e., Pp.

Q. 5. 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 e.g., Tt – 'T' is dominant over t (dwarfness).

Co-dominance: It is a phenomenon in which when two contrasting alleles are present together, both the alleles express themselves e.g., IA IB genotype gives blood group AB.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.,

$$\text{Red flower} \times \text{White flower} \longrightarrow \text{Pink flower colour}$$
$$RR \times rr \longrightarrow Rr$$

Q. 6. (a) Explain the phenomena of dominance, multiple allelism and co-dominance taking ABO blood group as an example.

(b) What is the phenotype of the following?

(i) IAi (ii) ii

Ans. (a) Dominance: The alleles IA and IB both are dominant over allele i as IA and IB form antigens A and B, respectively, but i does not form any antigen.

Multiple allelism: It 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 IA, IB and IO/i.

Co-dominance: It 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 IAIB the individual has AB blood group since both IA and IB equally influence the formation of antigens A and B.

(b) (i) IAi — A blood group.

(ii) ii — O blood group.

Q. 7. 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.

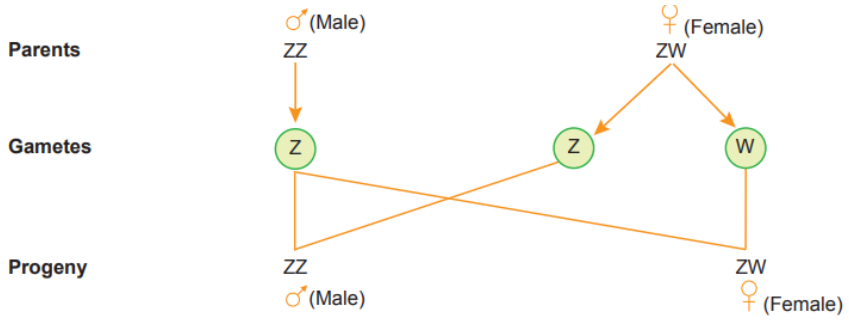
(ii) Morgan and his group found that when genes were grouped on the same chromosome, some genes are tightly linked and show less recombination.

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

Q. 8. Explain the mechanism of 'sex determination' in birds. How does it differ from that of human beings?

Ans. In birds, female heterogamety is observed. They exhibit ZW type of sex determination.

In humans, male heterogamety is observed. They exhibit XY type of sex determination.



Q. 9. (a) How does mutation occur?

(b) Differentiate between point mutation and frameshift mutation.

Ans. (a) Mutation occurs due to loss by deletion or gain by insertion/duplication/addition or change in position of DNA segments or chromosomes.

(b) Mutation due to change in a single base pair of DNA is point mutation. Insertion or deletion of one or two bases change the reading frame from the point of insertion or deletion. This is called as frameshift mutation.

Q. 10. (i) Why are grasshopper and Drosophila said to show male heterogamety? Explain.

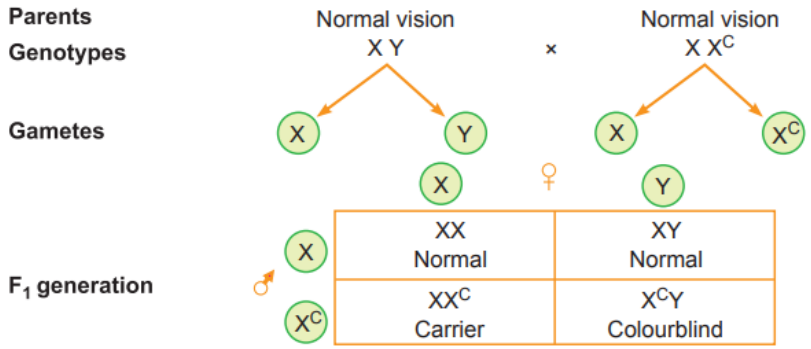
(ii) Explain female heterogamety with the help of an example.

Ans. (i) Drosophila exhibits XY type of sex determination. Males produce two types of sperms, one having X chromosome and the other 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 without any sex chromosome. Thus, both show male heterogamety.

(ii) 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.

Q. 11. One of the twins born to parents having normal colour vision was Down's blind whereas the other twin had normal vision. Work out the cross. Give two reasons how it is possible.

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



Q. 12. (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 phenylalanine 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.

	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)

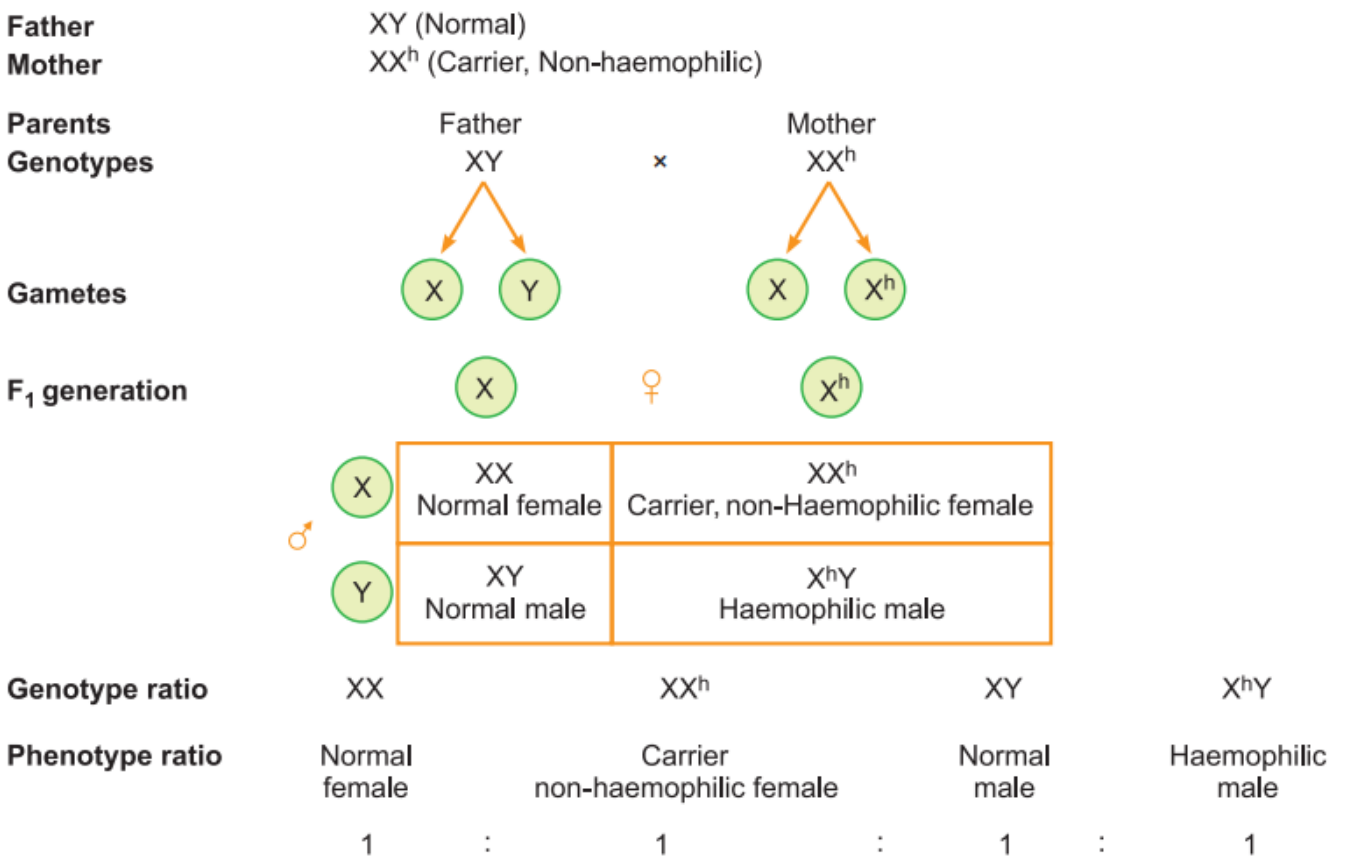
Q. 13. Write the symptoms of haemophilia and sickle-cell anaemia in humans. Explain how the inheritance pattern of the two diseases differs from each other.

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

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. 16. (a) State and explain the law of dominance as proposed by Mendel.

(b) How would phenotypes of monohybrid F1 and F2 progeny showing incomplete dominance in snapdragon and co-dominance in human blood group be different from Mendelian monohybrid F1 and F2 progeny? Explain.

Ans. (a) 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 F1 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.

(*b*)

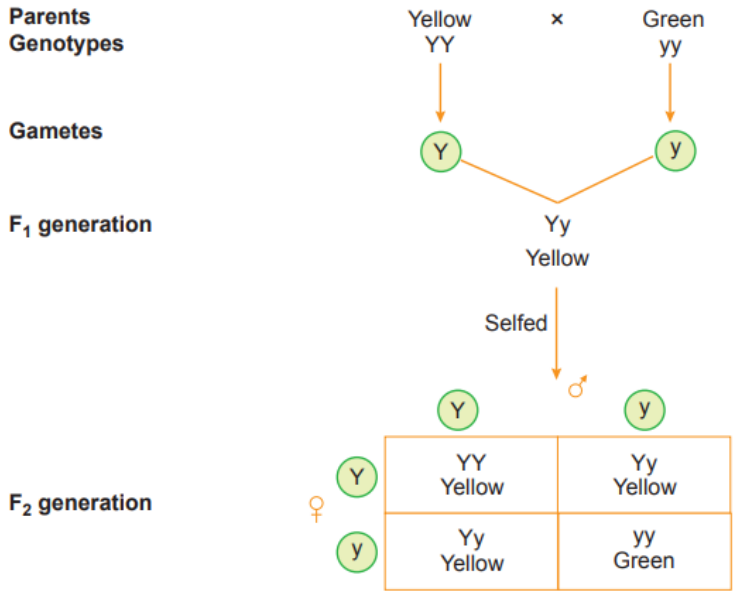
Progeny	Mendelian monohybrid cross	Incomplete dominance	Co-dominance
F_1	All members resemble the parent with dominant trait.	All members do not resemble either of the two parents but show an intermediate trait.	Blood groups of all members resemble combination of dominant traits of both the parents.
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. 17. (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?

(*a*)



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

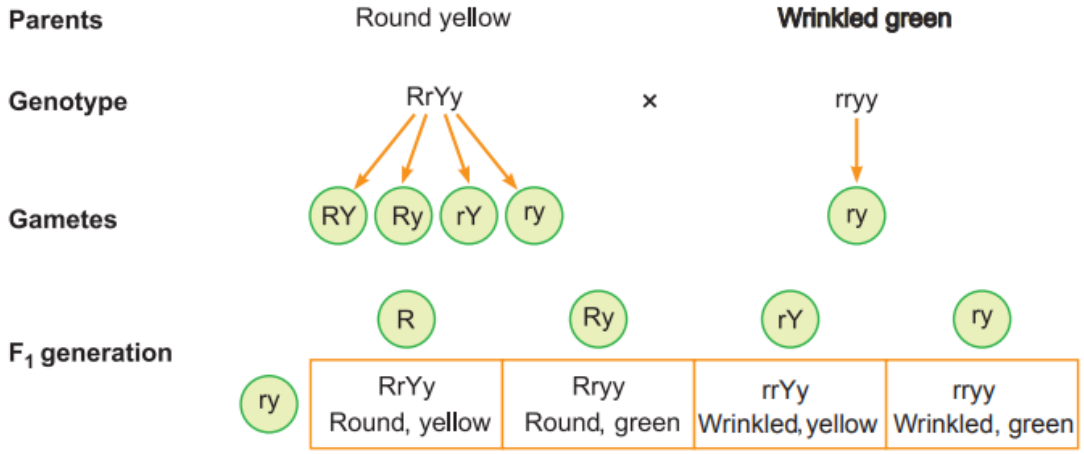
Q. 18. A cross was carried out between a pea plant heterozygous for round and yellow seeds with a pea plant having wrinkled and green seeds.

(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.

(a)

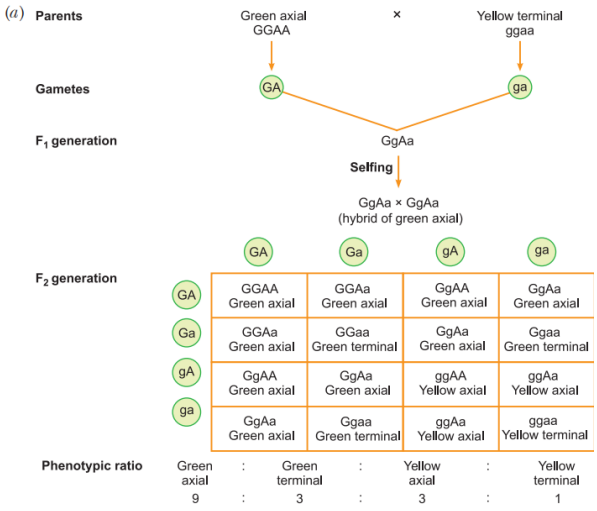


(b) Both the phenotypic and genotypic ratio are same, i.e., 1: 1 : 1 : 1.

(c) This cross is known as test cross.

Q. 19. (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.

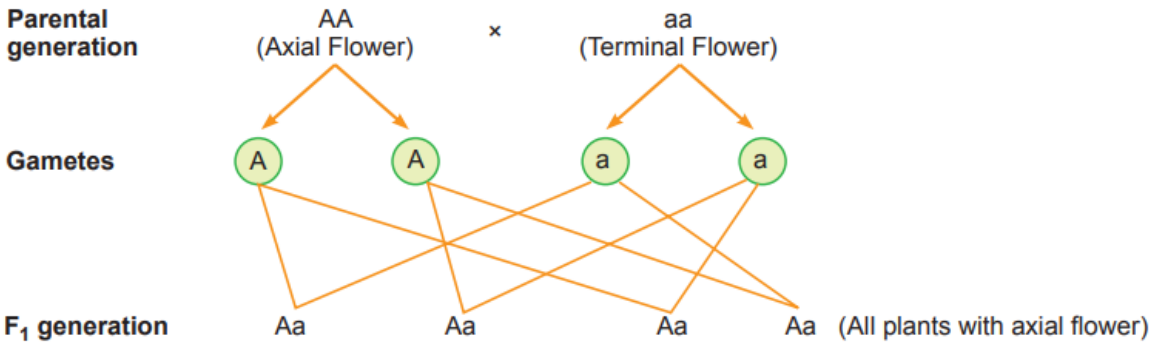


(b) From the above cross law of independent assortment can be derived which states that when two pairs of traits are combined in a hybrid, segregation of one pair of character is independent of the other pair of characters.

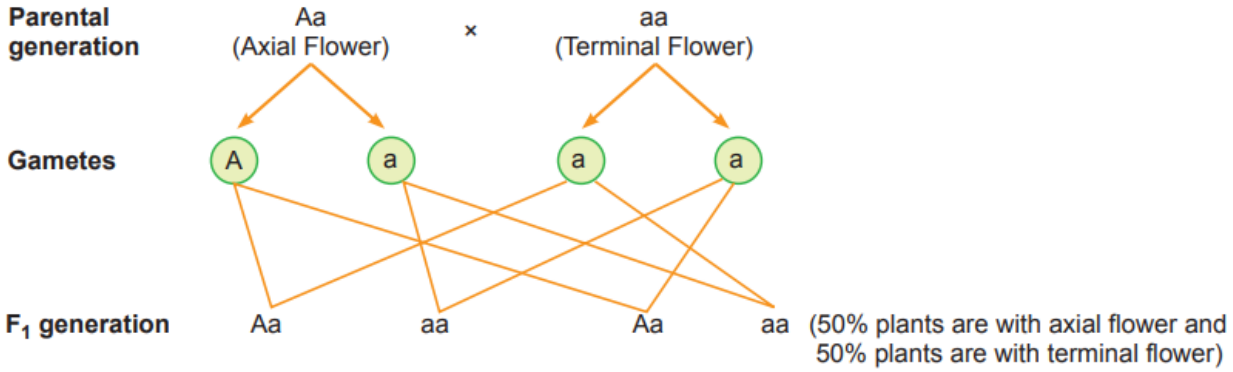
Q. 9. (a) A pea plant bearing axial flowers is crossed with a pea plant bearing terminal flowers. The cross is carried out to find the genotype of the pea plant bearing axial flowers. Work out the cross to show the conclusions you arrive at.

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

(*a*) (*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.

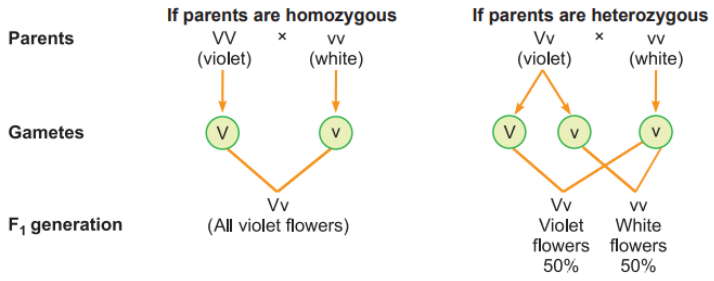
Q. 10. A particular garden pea plant produces only violet flowers.

(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.



Q. 11. Inheritance pattern of flower colour in garden pea plant and snapdragon differs. Why is this difference observed? Explain showing the crosses up to F2 generation.

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

Inheritance of flower colour in garden pea plant:

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. 12. (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. 13. (a) Write the scientific name of the organism Thomas Hunt Morgan and his colleagues worked with for their experiments. Explain the correlation between linkage and recombination with respect to genes as studied by them. (b) How did Sturtevant explain gene mapping while working with Morgan?

Ans. (a) Thomas Hunt Morgan and his colleagues worked on Drosophila melanogaster. They had the following observations.: (i) Two genes which are located closely on a chromosome did not segregate independently of each other. (ii) Tightly linked genes tend to show lesser recombinant frequency of parental traits. (iii) Loosely linked genes show higher percentage of recombinant frequency of parental traits. (iv) Genes present on same chromosome are said to be linked and the recombinant frequency depends on their relative distance on the chromosome.

(b) 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.