Principles of Inheritance and Variation

1. Select the incorrect match from the following : (2024)

	Human Karyotype		Characters
(A)	45 + XX	-	Broad palm with characteristic palm crease
(B)	44 + XXY	-	Overall feminine development
(C)	44 + XO	-	Sterile females as ovaries are rudimentary
(D)	44 + XY	-	Normal male

Ans. (B) 44 + XXY - Overall feminine development

2. two statements are given one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below. (2024)

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

Assertion (A) : Linked genes do not show dihybrid F2 ratio 9 : 3 : 3 : 1.

Reason (R) : Linked genes do not undergo independent assortment.

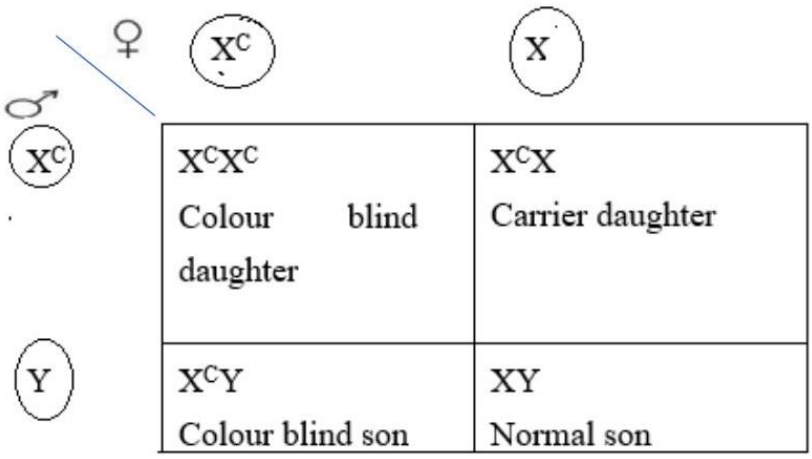
Ans. (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

3. In a family, the father, the daughter and the son are colour blind, whereas the mother has normal vision. Do you think the son and the daughter have inherited the disease from their father ? Work out a cross to justify your answer. (2024)

Ans. No,

Son inherited disease from the mother and daughter inherited disease from both mother and father.

Mother		Father
X^CX (1/2 Mark)	X	X^CY (1/2 Mark)
Normal (Carrier)		Colour blind



4. Stability, as one of the properties of genetic material, was very evident in one of the very early experiments in genetics. Name the scientist and describe his experiment. State the conclusion he arrived at. (2024)

Ans.

- Frederick Griffith

Took two strains of Streptococcus pneumoniae bacteria and inject them into mice

- R strain – Rough and Non–virulent

- S strain – Smooth and virulent (with mucous coat)

S strain ⟶ Inject into mice ⟶ Mice die

R strain ⟶ Inject into mice ⟶ Mice live

S strain (heat-killed) ⟶ Inject into mice ⟶ Mice live

S strain (heat-killed) + R strain (live) ⟶ Inject into mice ⟶ Mice die

Conclusion :

• R–strain bacteria had been transformed by heat killed S – strain.

• 'Transforming principle' transferred from heat killed S - Strain and enabled R – strain to synthesise a smooth polysaccharide coat. This must be due to the transfer of the genetic material.

• Heat which killed bacteria did not destroy some of the properties of genetic material which shows stability of genetic material.

5. A tall pea plant bearing violet flowers with unknown genotype is given. Find the genotype by working out different crosses only by selfing the plants. Write the genotypic and phenotypic ratios of each cross shown by you. (2024)

Ans. Tall Pea plant with violet flowers can have 4 types of genotypes

TTVV , TtVV , TtVv , TTVv

Case I- TTVV X TTVV

↓

Genotype TTVV

Phenotype All will be tall and violet.

Case II-

Tt VV X Tt VV

↓

Gametes	TV	tV
TV	TTVV Tall Violet	TtVV Tall Violet
tV	TtVV Tall Violet	ttVV Dwarf Violet

Phenotypic ratio Tall Violet : Dwarf Violet

3 : 1

Genotypic ratio TTVV:TtVV : ttVV

1 : 2 : 1

Case III-

Tt Vv X Tt Vv

↓

Gametes	TV	Tv	tV	tv
TV	TTVV Tall violet	TTVv Tall Violet	TtVV Tall Violet	TtVv Tall Violet
Tv	TTVv Tall Violet	TTvv Tall white	TtVv Tall Violet	Ttvv Tall white

tV	TtVV Tall violet	TtVv Tall Violet	ttVV dwarf violet	ttVv dwarf Violet
Tv	TtVv Tall violet	Ttvv Tall white	ttVv dwarf violet	ttvv dwarf white

Phenotypic ratio - Tall Violet : Dwarf violet:Tall white: dwarf white

9 : 3 : 3 : 1

Genotypic ratio - TTVV: TTVv:TtVV:TtVv:TTvv:ttVV: ttVv: Ttvv: ttvv

1 : 2 : 2 : 4 : 1 : 1 : 2 : 2 : 1

Case IV

TTVv X TTVv

↓

Gametes	TV	Tv
TV	TTVV Tall Violet	TTVv Tall Violet
Tv	TTVv Tall Violet	TTvv Tall White

Phenotypic ratio - Tall violet Tall white

3 : 1

Genotypic ratio - TTVV : TTVv : TTvv

1 : 2 : 1

Previous Years' CBSE Board Questions

4.1 Mendel's Laws of Inheritance

VSA (1 mark)

1. 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. **(Delhi 2015)**

2. Mention any two contrasting traits with respect to seeds in pea plant that were studied by Mendel.
(AI 2014)

4.2 Inheritance of One Gene

MCQ

3. Assertion (A): In a monohybrid cross between tall plants and dwarf plants, the F_2 generation showed tall and dwarf plants in the ratio of 3: 1.

Reason (R): There is no blending of traits/characters in the F_2 generation.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).

(b) Both (A) and (R) are true and (R) is not the correct explanation of (A).

(c) (A) is true, but (R) is false.

(d) (A) is false, but (R) is true.
(2023)

4. The number of different types of gametes that would develop in an organism with genotype AABBCCDd.

(a) 1 (b) 2

(c) 3 (d) 4
(Term 1, 2021-22)

5. In Pisum sativum, the pod colour may be green (G) or yellow (g). What percentage of offsprings with green pod colour trait would be obtained in a cross of Ggx Gg?

(a) 25% (b) 50%

(c) 75% (d) 90% **(Term I, 2021-22)**

6. A child with blood group O has father with blood group A and mother with blood group B. What would be the possible genotypes of parents and the child? Choose the correct option.

	Character	Dominant	Recessive
(a)	Flower colour	Violet	White
(b)	Pod shape	Inflated	Constricted
(c)	Stem height	Tall	Dwarf
(d)	Flower position	Terminal	Axial

(Term I, 2021-22)

7. Given below are the pairs of contrasting traits in Pisum sativum as studied by Mendel. Select the incorrectly mentioned option from the table given below.

	Mother	Father	Child
(a)	PP	pp	Pp
(b)	Pp	pp	pp
(c)	Pp	Pp	pp
(d)	pp	PP	Pp

8. How many types of gametes can be produced in a diploid organism which is heterozygous for 3 loci?

(a) 4 (b) 8

(c) 16 (d) 32 **(NCERT, Term I, 2021-22)**

9. Polydactyly (six-fingered hands) is a genetic condition due to a dominant allele (P) over recessive allele (p). If a six-fingered woman and a five-fingered man have a five-fingered child, the genotype of the parents and the child would be

	Father	Mother	Child
(a)	I^Bi	I^Ai	I^Ai
(b)	I^Ai	I^Bi	ii
(c)	I^AI^A	I^BI^B	ii
(d)	I^BI^B	I^AI^A	I^Bi

(Term I, 2021-22)

VSA (1 mark)

10. British geneticist R.C. Punnett developed a graphical representation of a genetic cross called "Punnett Square". Mention the possible result this representation predicts of the genetic cross carried.
(Delhi 2019)

11. Name the pattern of inheritance where F_1 phenotype:

(a) resembles only one of the two parents. *(NCERT Exemplar, Term I, 2021-22)*

(b) does not resemble either of the two parents and is in between the two.
(AI 2019)

12. Name the type of cross that would help to find the genotype of a pea plant bearing violet flowers.
(AI 2017)

13. State a difference between a gene and an allele.
(Delhi 2016)

14. How many kinds of phenotypes would you expect in F_2 generation in a monohybrid cross exhibiting co-dominance?
(Delhi 2014C)

SA I (2 marks)

15. By using Punnett square depict the genotypes and phenotypes of test crosses (where green pod colour (G) is dominant over yellow pod colour (g) in garden pea with unknown genotype. **(2023)**

16. Two children one with blood group 'AB' and other with blood group 'O' are born to parents where the father has blood group 'A' and the mother has blood group 'B'. Work out a cross to show how is it possible?
(NCERT, 2020)

17. Mendel did not explain the expression of incomplete dominance in plants. Give an example of flower exhibiting incomplete dominance.

Name and state the Law of Mendel the genes which exhibit incomplete dominance follow. **(2020 C)**

18. When does a geneticist need to carry a test cross? How is it carried? (Foreign 2015)

19. State and explain the law of segregation as proposed by Mendel in a monohybrid cross. **(2/5, Foreign 2015)**

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

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

(b) Name the type of the cross carried out.
(Delhi 2014)

21. How does the gene 'I' control ABO blood groups in humans? Write the effect the gene has on the structure of red blood cells.
(Delhi 2014)

22. 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?
(Al 2014)

23. With the help of one example, explain the phenomena of co-dominance and multiple allelism in human population.
(AI 2014)

SA II (3 marks)

24. Explain Mendel's "Law of segregation" in a typical monohybrid cross with the help of a suitable example.
(2020)

25. Differentiate between dominance, incomplete dominance and co-dominance with the help of a suitable example of each.
(2020)

26. Explain the phenomena of dominance, multiple allelism and co-dominance taking human ABO blood group as an example.
(AI 2019)

27. What is a test cross? How can it decipher the heterozygosity of a plant?
(AI 2016)

28. 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. **(Delhi 2015)**

29. 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. **(AI 2015)**

30. 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.
(AI 2015)

31. (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. **(Foreign 2014)**

LA (5 marks)

32. It is sometimes observed that the F_1 progeny has a phenotype that does not resemble either of the two parents and has intermediate phenotype. Explain by taking a suitable example and working out the cross upto F_2 progeny.
(2023)

33. Differentiate between incomplete dominance and co-dominance. Substantiate your answer with one example of each.
(NCERT Exemplar, Delhi 2019)

34. (a) How would you find out whether a given tall garden pea plant is homozygous or heterozygous?

Substantiate your answer with the help of Punnett squares.

(b) Given below are the F_2 phenotypic ratios of two independently carried monohybrid crosses:

(i) 1:2:1

(ii) 3:1

Mention what does each ratio suggest.
(2019)

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

(b) 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.
(NCERT, Foreign 2015)

36. (a) A couple with blood groups 'A' and 'B' respectively have a child with blood group 'O: Work out a cross to show how it is possible and the probable blood groups that can be expected in their other offspring.

(b) Explain the genetic basis of blood groups in human population.
(AI 2015C)

37. Work out a monohybrid cross upto F_2 generation between two pea plants and two Antirrhinum plants both having contrasting traits with respect to colour of flower. Comment on the pattern of inheritance in the crosses carried above.
(AI 2014C)

4.3 Inheritance of Two Genes

MCQ

38. The chromosomal theory of inheritance was put forth by

(a) Gregor Mendel and Tschermak

(b) Walter Sutton and Theodore Boveri

(c) Thomas Hunt Morgan and Alfred Sturtevant

(d) De Vries and Correns. **(NCERT, Term I, 2021-22)**

39. In chick pea assume that there is no linkage and allele of large seed (L) is dominant over small seed (1) and green colour seed (G) is dominant over yellow colour seed (g).

Two chick pea parent plants when crossed resulted in progeny having seeds with phenotypes small seeds and green colour, and large seeds with yellow colour besides other phenotypic progenies. Select the genotype of these two parents plants.

(a) LLGG x ligg

(b) ligg x LLgg

(c) IIGG x IIGg

(d) IlGgx Ligg

(Term I, 2021-22)

40. In a dihybrid Mendelian cross, garden pea plants heterozygous for yellow flowers and round seeds are crossed with homozygous white flowers and wrinkled seeds. The genotypic and phenotypic ratio of F_1 progeny would be

(a) 9:3:3:1

(b) 1:2:2:1

(c) 1:1:1:1

(d) 3:1.

(Term I, 2021-22)

41. Morgan hybridised Drosophila white eyed and yellow bodied female with red eyed and brown bodied male (wild type) and intercrossed their F_1 progeny. He observed that the two genes

(a) did not segregate independent of each other

(b) may be located on two different chromosomes

(c) segregated independently of each other

(d) showed very high percentage of recombinants.

(Term I, 2021-22)

VSA (1 mark)

42. Name the stage of cell division where segregation of an independent pair of chromosome occurs.

(AI 2014)

SA I (2 marks)

43. 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.

(Delhi 2016)

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

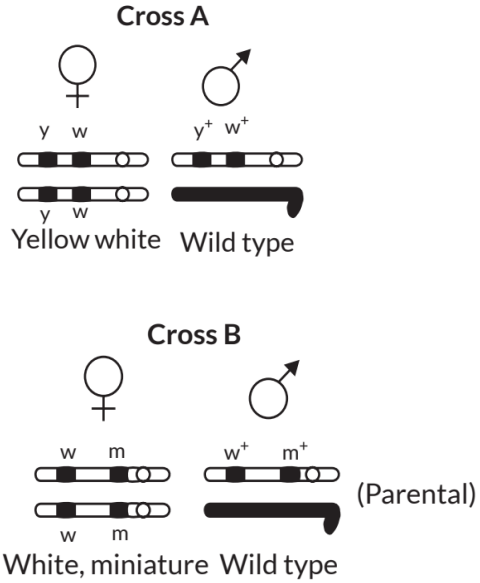
(NCERT Exemplar, Foreign 2015)

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

(AI 2014)

46. Linkage and crossing over of genes are alternative of each other. Justify with the help of an example.
(AI 2014)

47. Study the figures given below and answer the question.



Identify in which of the given crosses, the strength of linkage between the genes is higher? Give reasons in support of your answer.
(Foreign 2014)

SA II (3 marks)

48. Compare in any three ways the chromosomal theory of inheritance as proposed by Sutton and Boveri with that of experimental results on pea plant presented by Mendel. **(Delhi 2019)**

49. (a) Explain linkage and recombination as put forth by T.H. Morgan based on his observations with Drosophila melanogaster crossing experiment.

(b) Write the basis on which Alfred Sturtevant explained gene mapping.
(Delhi 2019)

50. 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? **(3/5, Foreign 2015)**

51. Mendel published his work on inheritance of characters in 1865, but it remained unrecognised till 1900. Give three reasons for the delay in accepting his work. **(Delhi 2014)**

52. Explain with the help of a suitable example the inheritance of a trait where two different dominant alleles of a trait express themselves simultaneously in the progeny. Name this kind of inheritance pattern.
(AI 2014)

53. Morgan carried out several dihybrid crosses in Drosophila and found F_2-ratios deviated very significantly from the expected Mendelian ratio. Explain his findings with the help of one example.

(Delhi 2014C)

LA (5 marks)

54. You are given a tall pea plant with green seeds. The genotype of this plant is unknown. You are allowed to do only 'selfing' of these plants to find out the genotype of the given plant.

Work out all possible crosses and show how you would determine the genotype of the given plant.

(2023)

55. (a) Why did T.H. Morgan select Drosophila melanogaster for his experiments?

(b) How did he disprove Mendelian dihybrid F_2 phenotypic ratio 9:3:3: 1? Explain giving reasons.

(2020)

56. Mendel crossed a homozygous pea plant having yellow and round seeds with another pea plant bearing green and wrinkled seeds. He found that in some of the F_2 population new combination of parental characters were observed.

How will you explain the appearance of a new combination of parental characters in F_2-offsprings? Support your answer with the help of Punnett square.
(2019)

57. (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?

(NCERT, 2018)

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

(Delhi 2017)

OR

Work out a typical Mendelian dihybrid cross and state the law that he derived from it. **(AI 2014)**

59. Give a genetic explanation for the following cross. When a tall pea plant with round seeds was crossed with a dwarf pea plant with wrinkled seeds then all the individual of F_1 populations were tall with round seeds. However, selfing among F_1 population led to a 9:3:3:1 phenotypic ratio. **(AI 2016)**

60. (a) Dihybrid cross between two garden pea plant one homozygous tall with round seeds and the other dwarf with wrinkled seeds was carried.

(i) Write the genotype and phenotype of the F_1 progeny obtained from this cross.

(ii) Give the different types of gametes of the F_1 progeny.

(iii) Write the phenotypes and its ratios of the F_2 generation obtained in this cross along with the explanation provided by Mendel.

(b) How were the observations of F_2 progeny of dihybrid crosses in Drosophila by Morgan different from that of Mendel carried in pea plants? Explain giving reasons.

(Delhi 2015C)

61. A tall pea plant bearing violet flowers is given with its unknown genotypes. Explain by working out the crosses how would you find the correct genotypes with respect to the two traits mentioned only by "selfing" the given plants.

(AI 2015C)

62. A pea plant producing yellow coloured and round seeds is given with unknown genotypes. Explain how you would find the correct genotypes of the plants with respect to the two traits mentioned. Work out the cross and name it.

(AI 2015C)

63. 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.

(Foreign 2014)

64. (a) Work out cross between a tall pea plant bearing violet flowers (heterozygous for both) with a dwarf pea plant having white flowers. Write the genotypes and phenotypes of the progeny along with their ratios.

(b) Name such a cross and state its importance.

(Delhi 2014C)

4.4 Polygenic Inheritance

VSA (1 mark)

65. On what basis is the skin colour in humans considered polygenic?

(AI 2015)

SA I (2 marks)

66. Explain polygenic inheritance with the help of a suitable example.

(Delhi 2014C)

LA (5 marks)

67. (a) During a cross involving true breeding red flowered and true breeding white flowered snapdragon plants the F_1 progeny did not show any of the parental traits, while they reappeared in F_2 progenies. Explain the mechanism using Punnett square.

(b) Explain polygenic inheritance with the help of an example.

(Foreign 2015)

4.5 Pleiotropy

MCQ

68. Select the pair-that is not correct.

(a) Pleiotropy: Sickle cell anaemia

(b) Linkage: Drosophila

(c) Incomplete dominance: Antirrhinum

(d) Co-dominance: ABO blood group

(Term I, 2021-22)

SA I (2 marks)

69. 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.

(Foreign 2015)

70. Explain pleiotropy with the help of an example.

(Foreign 2014)

LA (5 marks)

71. (a) What is polygenic inheritance? Explain with the help of a suitable example.

(b) How are pleiotropic inheritance different from polygenic pattern of inheritance? **(Al 2015)**

72. (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.

(AI 2015)

73. How do "pleiotropy", "incomplete dominance", "co-dominance" and "polygenic inheritance" deviate from the observation made by Mendel? Explain with the help of one example for each.

(Delhi 2015C)

4.6 Sex Determination

MCQ

74. Which of the following are true about males in a colony of honeybees?

(i) They have 16 chromosomes per cell.

(ii) They produce sperms by meiosis.

(iii) They have a grandfather but no father.

(iv) All males in the colony are haploid except one.

(a) (i) and (iii) only (b) (ii) and (iii) only

(c) (iii) and (iv) only (d) (ii) and (iv) only

(2023)

VSA (1 mark)

75. State the fate of a pair of autosomes during gamete formation.

(Delhi 2017)

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

(AI 2016)

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

(Al 2015)

78. Identify and write the correct statement:

(a) Drosophila male has one X and one Y chromosome.

(b) Drosophila male has two X chromosomes.

(AI 2014)

79. Identify the correct statement.

(a) Female of many birds has a pair of dissimilar ZW chromosomes, while the males possess a pair of similar ZZ chromosomes.

(b) Female of many birds has a pair of similar ZZ chromosomes, while the males possess a pair of dissimilar ZW chromosomes.

(AI 2014C)

SA I (2 marks)

80. Differentiate between male and female heterogamety.

(Delhi 2015)

81. Explain mechanism of sex-determination in birds.

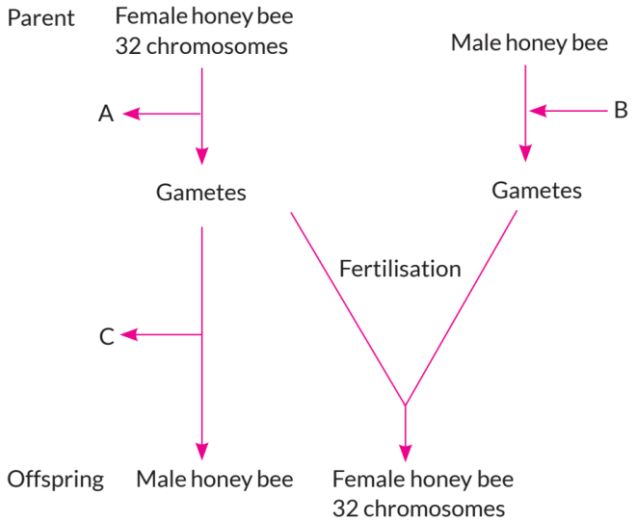
(Delhi 2015)

82. Differentiate between 'ZZ' and 'XY' type of sex-determination mechanisms.

(Delhi 2015)

SA II (3 marks)

83. The cytological observations made in a number of insects led to the development of the concept of genetic/chromosomal basis of sex-determination mechanism. Honey bee is an interesting example to study the mechanism of sex-determination. Study the schematic cross between the male and the female honey bees given below and answer the questions that follow:



(a) Identify the cell divisions 'A' and 'B' that lead to gamete formation in female and male honey bees respectively.

(b) Name the process 'C' that leads to the development of male honey bee (drone). **(2020)**

84. (a) Compare the mechanism of sex determination in humans with that of honey bees, with respect to chromosome number.

(b) How is the gamete formation comparable in the above two cases?
(2020)

85. Explain the mechanism of 'sex determination' in birds. How does it differ from that of human beings?
(2018)

LA (5 marks)

86. (a) How is sex determined in humans?

(b) How does it differ from sex determination in birds and honey bees?
(NCERT, Delhi 2014C)

4.8 Genetic Disorders

MCQ

87. Assertion (A): In thalassemia, an abnormal myoglobin chain is synthesised due to a gene defect.

Reason (R): α-thalassemia is controlled by genes HBA1 and HBA2 on chromosome 16.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).

(b) Both (A) and (R) true, but (R) is not the correct explanation of (A).

(c) (A) is true, but (R) is false.

(d) (A) is false, but (R) is true.
(2023)

88. The cause for Klinefelter's syndrome in humans is because of

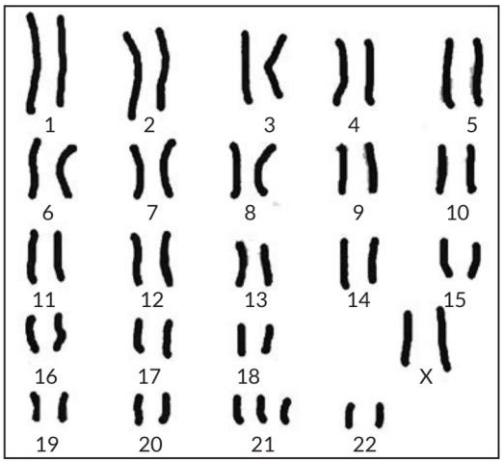
(a) an extra copy of autosome

(b) an extra copy of X chromosome

(c) absence of one X chromosome

(d) absence of one Y chromosome.
(Term I, 2021-22)

89. Given diagram depicts a karyotype obtained after analysis of fetal cells for probable genetic disorder.



Based on the karyotype, the chromosomal disorder detected in unborn fetus and the consequent symptoms the child may suffer from are

(a) Down's syndrome: Gynaecomastia, overall masculine, development.

(b) Down's syndrome: Furrowed tongue, short stature.

(c) Turner's syndrome: Rudimentary ovaries, sterile individual.

(d) Turner's syndrome: Gynaecomastia, masculine development.
(Term I, 2021-22)

90. The autosomal disorder/disease in humans is

(a) colour blindness

(b) thalassemia

(c) haemophilia

(d) Turner's syndrome.
(2020)

VSA (1 mark)

91. Name a human genetic disorder due to the following:

(a) An additional X-chromosome in a male

(b) Deletion of one X-chromosome in a female
(2019)

92. State the chromosomal defect in individuals with Turner's syndrome.
(Delhi 2015C)

93. Write the chromosomal defect in individuals affected with Klinefelter's syndrome. **(AI 2015C)**

SA I (2 marks)

94. State what are Mendelian disorders. Both thalassemia and colour blindness are categorised as Mendelian disorders. Justify.
(2020)

95. (a) Explain the cause responsible in a human to have sex chromosomes as XXY instead of 'XX' or 'XY.

(b) List any two ways such individuals are different from the normal being.
(2020)

96. Why is the frequency of red-green colour blindness more in human males than in females? Explain.
(2019 C)

97. Name a disorder a human suffers from as a result of monosomy of the sex chromosome. Give the karyotype and write the symptoms.
(AI 2019)

98. Differentiate between Turner's syndrome and Down's syndrome.
(2019)

99. Why is the possibility of a human female suffering from haemophilia rare? Explain.

(Foreign 2014)

SA II (3 marks)

100. Differentiate between the pattern of inheritance in humans of the blood diseases haemophilia and thalassemia.
(2020)

101. A normal couple has their first child who is haemophilic. Work out a cross to show how it is possible. State the possibility of the normal and haemophilic children, along with their sexes, that can be born to them.
(2020)

102. Generally, it is observed that human males suffer from hemophilia more than human females, who rarely suffer from it. Explain giving reason.
(2020)

103. A doctor after conducting certain tests on a pregnant woman advised her to undergo M.T.P., as the foetus she was carrying showed trisomy of 21^{st} chromosome.

(a) State the cause of trisomy of the 21^{st} chromosome.

(b) Why was the pregnant woman advised to undergo M.T.P. and not to complete the full term of her pregnancy? Explain.
(2019 C)

104. During a medical investigation, an infant was found to possess an extra chromosome 21. Describe the symptoms the child is likely to develop later in the life. (Delhi 2017)

105. 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.

(Al 2017)

106. 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.
(Delhi 2016)

OR

A colourblind child is born to a normal couple. Work out a cross to show how it is possible. Mention the sex of this child.
(Delhi 2014)

107. Which chromosomes carry the mutant genes causing thalassemia in humans? What are the problems caused by these mutant genes?
(Delhi 2015C)

108. If there is a history of haemophilia in the family, the chances of male members becoming haemophilic are more than that of the female.

(a) Why is it so?

(b) Write the symptoms of the disease.
(AI 2015C)

109. Identify 'a', 'b', 'c', 'd', 'e' and 'f' in the given table.

No.	Syndrome	Cause	Characteristics of affected individuals	Sex male/ female/ both
1.	Down's	Trisomy of 21	**'a' (i) (ii)**	**'b'**
2.	**'c'**	XXY	Overall masculine development	**'d'**
3.	Turner's	45 with XO	**'e' (i), (ii)**	**'f'**

(AI 2014)

110. Why is haemophilia rare in human females? Mention a clinical symptom for the disease.

(AI 2014)

LA (4 or 5 marks)

111. The chromosome number is fixed for all normal organisms leading to species specification whereas any abnormality in the chromosome number of an organism results into abnormal individuals. For example, in humans 46 is the fixed number of chromosomes both in male and female. In male it is '44 + XY' and in female it is '44 + XX'. Thus, the human male is heterogametic, in other words produces two different types of gametes one with '22 + X' chromosomes and other with '22 + Y' chromosomes respectively. Human female, on the other hand is homogametic, i.e., produces only one type of gamete with '22 + X' chromosomes only.

Sometimes an error may occur during meiosis of cell cycle, where the sister chromatids fail to segregate called nondisjunction, leading to the production of abnormal gametes with altered chromosome number. On fertilisation such gametes develop into abnormal individuals.

(a) State what is aneuploidy.

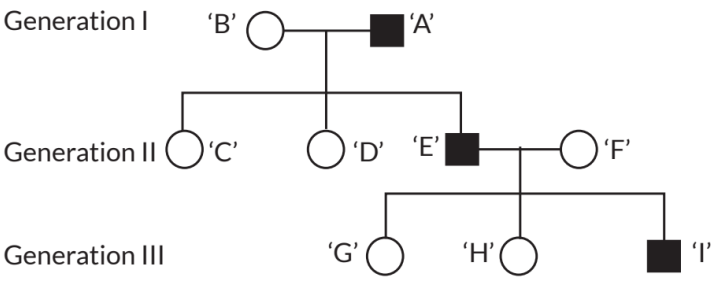
(b) If during spermatogenesis, the chromatids of sex chromosomes fail to segregate during meiosis, write only the different types of gametes with altered chromosome number that could possibly be produced.

(c) A normal human sperm (22 + Y) fertilises an ovum with karyotype '22 + XX. Name the disorder the offspring thus produced would suffer from and write any two symptoms of the disorder.

OR

(c) Name a best known and most common autosomal aneuploid abnormality in human and write any two symptoms.
(2023)

112. The following pedigree chart shows the inheritance of a genetic disorder up to three generations of a family. Observe the chart and answer the questions that follow.



(i) Is the disease sex-linked or autosomal as per the chart? Give reasons in support of your answer.

(ii) Is it a recessive or a dominant disorder?

(iii) Write the genotypes of the individuals 'C', 'D', and 'H'.

(iv) (a) If the female 'D' marries a normal man, what will be the probability of their daughter being a sufferer of this disease?

OR

(iv) (b) If the mother 'B' is a carrier of the disease, what will be the probability of their daughter being a sufferer of this disease?
(2023)

113. (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 colour blindness whereas only about 0.4% of human female population suffers from this disease. Write an explanation to show how it is possible. **(AI 2015)**

CBSE Sample Questions

4.2 Inheritance of One Gene

MCQ

1. How many types of gametes would be produced if the genotype of a parent is AaBB?

(a) 1 (b) 2

(c) 3 (d) 4 **(Term I, 2021-22)**

2. In Antirrhinum, RR is phenotypically red flowers, rr is white and Rr is pink.

Select the correct phenotypic ratio in F_1 generation when a cross is performed between RRX Rr.

(a) 1 red: 2 pink: 1 white (b) 2 pink: 1 white

(c) 2 red: 2 pink (d) All pink **(Term I, 2021-22)**

3. What would be the genotype of the parents if the offspring have the phenotypes in 1:1 proportion?

(a) Aa X Aa (b) AA X AA

(c) Aa X AA (d) Aa X aa **(Term I, 2021-22)**

4. Genotypic ratio of 1: 2: 1 is obtained in a cross between

(a) AB X AB (b) Ab X Ab

(c) Ab X ab (d) ab X ab. **(Term I, 2021-22)**

5. The gene that controls the ABO blood group system in human beings has three alleles - IA, IB and i. A child has blood group O. His father has blood group A and mother has blood group B. Genotypes of other offsprings can be:

(i) lBlB (ii) lAi

(iii) lBi (iv) lAlB

(v) ii

(a) (i), (ii), (iii), (v)

(b) (ii), (iii), (iv), (v)

(c) (iii), (iv), (v)

(d) (iv), (iii), (i) **(Term I, 2021-22)**

VSA (1 mark)

6. A snapdragon plant with violet flowers was crossed with another such plant with white flowers. The F_1 progeny obtained had pink flowers. Explain, in brief, the inheritance pattern seen in offsprings of F_1 generation. **(2020-21)**

SA II (3 marks)

7. How would you find out the genotype of a pea plant with violet flowers? Explain with the help of Punnett's square showing crosses. **(2020-21)**

4.3 Inheritance of Two Genes

MCQ

8. Assertion (A): When white eyed, yellow bodied Drosophila females were hybridised with red eyed, brown-bodied males; and F_1 progeny was intercrossed, F, ratio deviated from 9:3:3:1.

Reason (R): When two genes in a dihybrid are on the same chromosome, the proportion of parental gene combinations is much higher than the non-parental type.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).

(b) Both (A) and (R) are true and (R) is not the correct explanation of (A).

(c) (A) is true but (R) is false.

(d) (A) is false but (R) is true. **(2022-23)**

9. Which of the following statements indicates parallelism in genes and chromosomes?

(i) They occur in pairs.

(ii) They segregate during gamete formation.

(iii) They show linkage.

(iv) Independent pairs segregate independently.

(a) (i) and (iii) (b) (ii) and (iii)

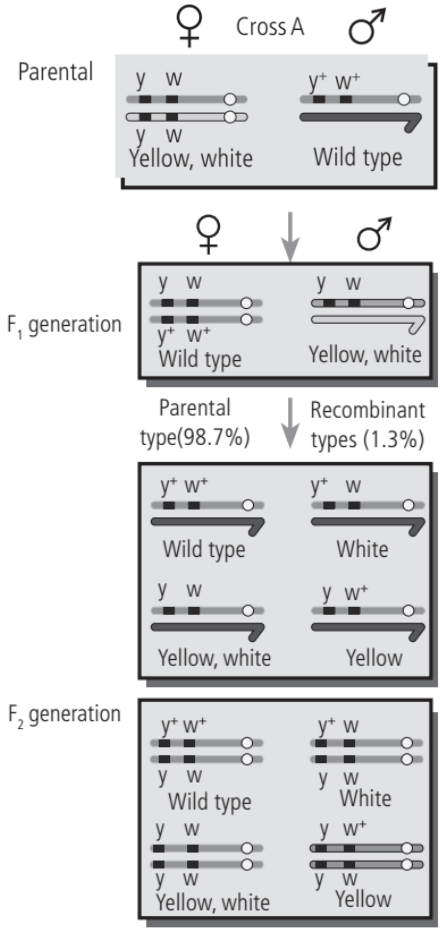
(c) (i), (ii) and (iii) (d) (i), (ii) and (iv)

(Term I, 2021-22)

10. A cross is made between tall pea plants having green pods and dwarf pea plants having yellow pods. In the F_2 generation, out of 80 plants how many are likely to be tall plants?

(a) 15 (b) 20 (c) 45 (d) 60 **(Term I, 2021-22)**

11. Given below is a dihybrid cross performed on Drosophila.



Which of the following conclusions can be drawn on the basis of this cross?

When yellow bodied (y), white eyed (w) Drosophila females were hybridized with brown bodied (y+), red eyed males (w+) and F_1 progenies were intercrossed, F_2 generation would have shown the following ratio.

(a) 1: 2: 1 because of linkage of genes.

(b) 9: 3: 3: 1 because of recombination of genes.

(c) Deviation from 9: 3: 3: 1 ratio because of segregation of genes.

(d) Deviation from 9: 3: 3: 1 ratio because of linkage of genes.

(Term I, 2021-22)

12. Assertion (A): When the two genes in a dihybrid cross are situated on the same chromosome, the proportion of parental gene combinations is much higher than non-parental type.

Reason (R): Higher parental gene combinations can be attributed to crossing over between two genes.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A)

(b) Both (A) and (R) are true and (R) is not the correct explanation of (A)

(c) (A) is true but (R) is false

(d) (A) is false but (R) is true **(Term I, 2021-22)**

SA I (2 marks)

13. A true breeding pea plant, homozygous dominant for inflated green pods is crossed with another pea plant with constricted yellow pods (ffgg). With the help of Punnett square show the above cross and mention the results obtained phenotypically and genotypically in F_1 generation. **(2022-23)**

4.4 Polygenic Inheritance

MCQ

14. In human beings, where genotype AABBCC represents dark skin colour, aabbcc represents light skin colour and AaBbCc represents intermediate skin colour; the pattern of genetic inheritance can be termed as

(a) pleiotropy and co-dominance

(b) pleiotropy and incomplete dominance

(c) polygenic and qualitative inheritance

(d) polygenic and quantitative inheritance.

(Term I, 2021-22)

4.6 Sex Determination

MCQ

15. Which of the following combination of chromosome numbers represents the correct sex determination pattern in honey bees?

(a) Male 32, Female 16

(b) Male 16, Female 32

(c) Male 31, Female 32

(d) Female 32, Male 31

(Term I, 2021-22)

16. A couple has two daughters. What is the probability that the third child will also be a female?

(a) 25%

(b) 50%

(c) 75%

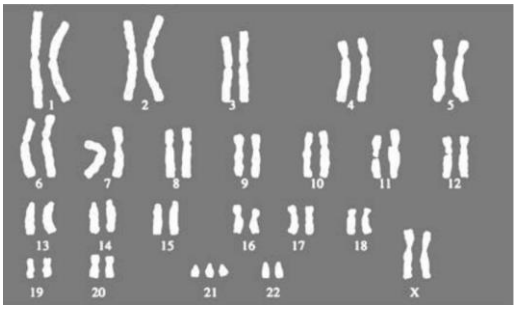
(d) 100%

(Term I, 2021-22)

4.8 Genetic Disorders

MCQ

17. Placed below is a karyotype of a human being.



On the basis of this karyotype, which of the following conclusions can be drawn?

(a) Normal human female

(b) Person is suffering from colour blindness

(c) Affected individual is a female with Down's syndrome

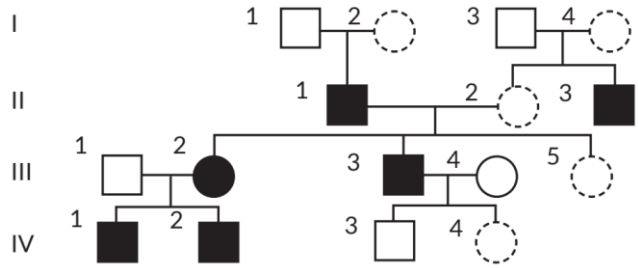
(d) Affected individual is a female with Turner's syndrome.
(Term I, 2021-22)

SA I (2 marks)

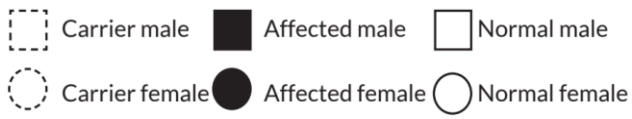
18. Karyotype of a child shows trisomy of chromosome number 21. Identify the disorder and state the symptoms which are likely to be exhibited in this case.
(2020-21)

LA (4 marks)

19. Study the Pedigree chart given below and answer the questions that follow:



Symbols used in the given pedigree chart are as follows:



[Note: There is a mistake in CBSE SQP. Rectified pedigree is given above.]

(a) On the basis of the inheritance pattern exhibited in this pedigree chart, what conclusion can you draw about the pattern of inheritance?

(b) If the female is homozygous for the affected trait in this pedigree chart, then what percentage of her sons will be affected?

(c) Give the genotype of offsprings 1,2,3 and 4 in III generation.

OR

(c) In this type of inheritance pattern, out of male and female children which one has less probability of receiving the trait from the parents? Give a reason.
(2022-23)

Detailed SOLUTIONS

Previous Years' CBSE Board Questions

1. Living beings with shorter life cycles are preferred by geneticists for studying variations and patterns of inheritance because such organisms complete their life cycle in short duration and produce large number of progenies in less time span, e.g., pea plant used in Mendel's experiments.

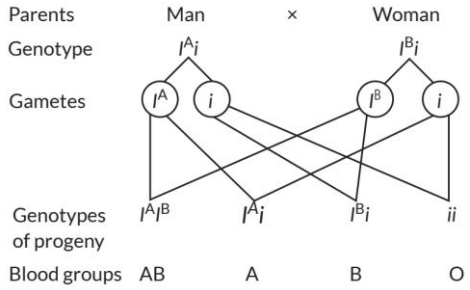
2. Seed traits studied by Mendel in pea plant were:

(i)	Seed shape	–	Smooth/Round (R) Wrinkled (r)
(ii)	Seed (cotyledon) colour	–	Yellow (Y) Green (y)

3. (a) : In a monohybrid cross between tall and dwarf plants, a 3: 1 ratio is showed in F_2 generation suggest that contrasting characters of alleles do not show any blending.

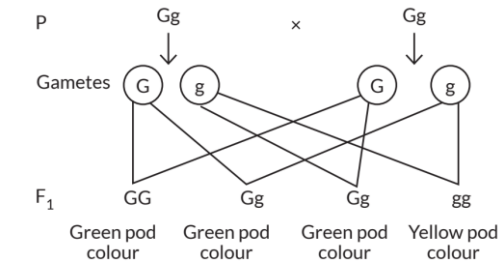
4. (b) : Organism with genotype AABBCCDd will produce 2^1 i.e., 2 types of gametes.

5. (c) : In Pisum sativum, green pod colour is dominant over yellow. Thus, the cross between Gg × Gg will be



Thus, 75% of offsprings will produce green pod colour.

6. (b) : If father has blood group 'A', mother has blood group 'B', and the child with blood group 'O' appears in progeny, this means that the parents are heterozygous.



Genotype : GG : Gg : gg
1 : 2 : 1
Phenotype : Green pod colour : Yellow pod colour
3 : 1

7. (d): Flower position is one of the characters studied by Mendel in Pisum sativum, in which axial position is dominant over terminal position.

8. (b): Types of gametes formed $= 2^n$

where, n is the no. of heterozygous loci $= 3$

Therefore, types of gametes $= 2^3 = 8$

9. (b): In polydactyly (six fingered hands), the allele for polydactyly (P) is dominant over recessive allele (p) for five-fingered hands. Thus, the child with five fingered (pp) must have a mother with genotype (Pp) and father with genotype (pp).

10. Punnett square is a graphical representation to calculate the probability of all possible genotypes of offspring in a genetic cross. Thus, various types of phenotypes and genotypes are obtained.

11. (a) Complete dominance is the condition in which the F_1 phenotype resembles the dominant parent i.e., one of the two parents.

(b) Incomplete dominance is the condition in which the F_1 phenotype does not resemble both the parents and is in between the two.

12. To find the genotype of a pea plant bearing violet flowers, test cross must be performed.

13. Difference between a gene and an allele are as follows:

Gene	Allele
A gene is the unit of DNA responsible for the appearance and inheritance of a character.	An allele is one of the forms in which a gene can exist. Normally there are two alleles for a given gene that are located at the same locus in the homologous chromosomes.

14. Three types of phenotypes are obtained in a monohybrid cross exhibiting co-dominance. E.g., coat colour in cattle. In F_2 generation, three types of phenotypes were obtained – red, roan and white coat colour.

15. In test cross, an individual with unknown genotype is crossed with homozygous recessive parent for the trait being investigated.

Green pod colour (G) is dominant over yellow pod colour (g) in garden pea.

Green pod plant could have two possible genotypes: GG and Gg.

Case I: If green (homozygous) pod (GG) plant is crossed with yellow pod (gg) plant.

Parent : GG × gg

Gametes : G G g g

Progeny

♀ \ ♂	g	g
G	Gg Green	Gg Green
G	Gg Green	Gg Green

If the plant produced all green plants as offspring, then the genotype of plant is GG i.e., homozygous green pod plant.

Case II: If green (heterozygous) pod (Gg) plant is crossed with yellow pod (gg) plant.

Parent : Gg × gg

Gametes : G g g g

Progeny

♀ \ ♂	g	g
G	Gg Green	Gg Green
g	gg Yellow	gg Yellow

If the plant produced 1 (green): 1 (yellow), then the genotype of plant is Gg, i.e., heterozygous green pod plant.

16. Father has blood group A and mother has blood group B, whereas their children have blood groups AB and O. This indicates that the parents are heterozygous.

∴ Genotype of father = I^AI^O and genotype of mother = I^BI^O

Parent: I^AI^O × I^BI^O

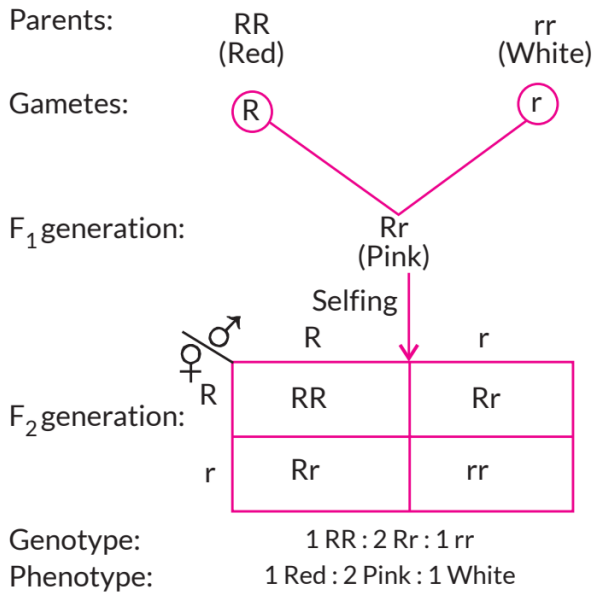
Gametes: I^A I^O I^B I^O

Progenies: I^AI^B I^AI^O I^BI^O I^OI^O

Blood groups: AB A B O

Hence, all the four types of blood groups viz. AB, A, B and O are possible in their offspring.

17. Antirrhinum flowers exhibit incomplete dominance in which neither of the two alleles of a gene is completely dominant over the other. It can be explained with the help of cross shown:



Incomplete dominance is due to law of segregation which states that the members of the allelic pair that remained together in the parent, segregate during gamete formation and only one factor enters a gamete.

18. To determine the genotype of a plant i.e., whether the individual is exhibiting dominant character is homozygous or heterozygous, a test cross is carried out by a geneticist. The individual having dominant phenotype is crossed with its homozygous recessive parent. If heterozygous tall is crossed with homozygous recessive parent, tall and dwarf will be produced, in equal proportion while if homozygous tall is crossed with homozygous recessive, the upcoming progenies will contain all tall plants.

19. Principle of segregation states that, "when a pair of contrasting factor or gene are brought together in a hybrid; these factors do not blend or mix up but simply associate themselves and remain together and separate at the time of gamete formation", i.e, allele pairs segregate during gamete formation and the paired condition is restored by random fusion of gametes during fertilisation.

20. Two contrasting characters of height are tall and dwarf. In the given cross, if 50% of the progeny shows parental characters, then it must be a cross between a heterozygous tall and a homozygous recessive dwarf parent.

(a) Parent : Tall Dwarf

Genotype : Tt × tt

Gametes : (T) (t) (t) (t)

F_1 generation :

♀ \ ♂	T	t
t	Tt Tall	tt Dwarf
t	Tt Tall	tt Dwarf

Phenotypic ratio ⇒ Tall : Dwarf = 1 : 1

(b) This type of cross is known as test cross.

21. ABO blood groups are controlled by the gene I. The plasma membrane of the red blood cells has sugar polymers that protrude from its surface and the kind of sugar is controlled by the gene I. The gene I has three alleles I^A, I^B and i. The alleles I^A and I^B produce a slightly different form of the sugar while allele i does not produce any sugar. Each person possesses any two of the three I gene alleles. IA and IB are completely dominant over i. When I^A and I^B are present together they both express their own types of sugar because of co-dominance. Hence, red blood cells have both A and B types of sugars. Since there are three different alleles, there are six different combinations of these three alleles that are possible, and therefore, a total of six different genotypes are there in human ABO blood group.

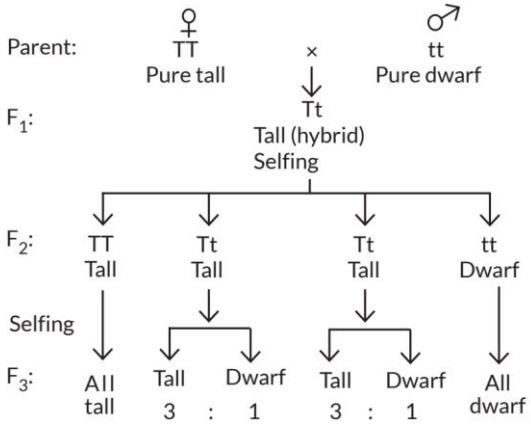
22. (a) When a cross is made between a red flowered (RR) plant with a white flowered (rr) plant of snapdragon, the F_1 hybrid has pink flowers (Rr). When the F, individual was self-pollinated F_2 individuals were obtained bearing red (RR), pink (Rr) and white (rr) flowers in the ratio 1:2:1. It is not a case of blending inheritance because the parental characters appear in the F_2 generation without any change. It is due to law of segregation which states that the members of the allelic pair that remained together in the parent, segregate during gamete formation and only one factor enters a gamete.

(b) In this, neither of the two alleles of a gene is completely dominant over the other, hence the phenomenon is known as incomplete dominance.

23. In the ABO system, there are four blood groups A, B, AB and O. ABO blood groups are controlled by gene I. The gene I has three alleles I^A, I^B and i. This phenomenon is known as multiple allelism. I^A and I^B are completely dominant over i. When I^A and I^B are present together they both express themselves and produce blood group AB. This phenomenon is known as co-dominance.

24. Mendel performed a monohybrid cross wherein he crossed pure tall pea plants (TT) with pure dwarf (tt) pea plants. He obtained all tall hybrid pea plants

in F_1 generation. He selfed the plants of F_1 generation and obtained tall and dwarf plants in the ratio 3: 1 in F_2 generation. Then he selfed all F_2 plants and found that dwarf plants were pure breeding but of tall plants of F_2 generation only about 1/3 were pure breeding for tallness while remaining 2/3 produced both tall and dwarf plants in the ratio 3: 1.



In F_3 generation, two third of tall plants produced both tall and dwarf plants. This is possible only when the two factors of a character segregated during gamete formation and come together in offspring at random according to law of probability. This is called law of segregation.

25. In dominance, F_1 is similar to the dominant parent, phenotypic ratio is different from genotypic ratio. For example, tall pea plant is dominant to dwarf pea plant.

In incomplete dominance, F_1 is different from either of the two parents. Phenotypic and genotypic ratios are the same. In Antirrhinum, red flower is incompletely dominant over white flower.

In co-dominance, the effect of both the alleles are equally conspicuous. Both the alleles produce their effect independently, e.g., roan coat colour in cattle.

26. In humans, ABO system of blood group is a case of dominance, multiple allelism and co-dominance. In the ABO blood group system, there are four blood groups: A, B, AB and O.

ABO blood groups are controlled by the gene I. The plasma membrane of the red blood cells has sugar polymers that protrude from its surface. The kind of sugar is controlled by the gene I. The gene I has three alleles: I^A, I^B and i. The alleles I^A and I^B produce a slightly different form of the sugar while allele i does not produce any sugar. Each person possesses any two of the three I gene alleles. The alleles I^A and I^B are completely dominant over i, as I^A and I^B form antigen A and antigen B respectively but i does not form any antigen and are not dominant over each other. This shows dominance.

Multiple allelism is the presence of more than two alleles of a gene. They occur on the same gene locus of the same chromosome or its homologue and are responsible for multiple phenotypic expression. The ABO system of blood groups in humans are determined by three different allelic forms I^A, I^B and i showing multiple allelism. When I^A and I^B are present together they both express themselves and produce blood group AB (I^AI^B) by forming antigens A and B. This phenomenon is known as codominance.

27. Test cross is a cross used to identify whether an individual is homozygous or heterozygous for dominant character. The individual is crossed with homozygous recessive parent for the trait being investigated. Tall plant could have two possible genotypes: TT and Tt

Case I: Tall (homozygous) pea plant crossed with dwarf pea plant:

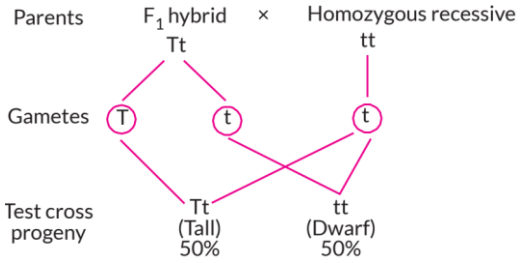
Parent : TT × tt

Gametes : (T) (T) (t) (t)

Progeny :

♀ \ ♂	t	t
T	Tt Tall	Tt Tall
T	Tt Tall	Tt Tall

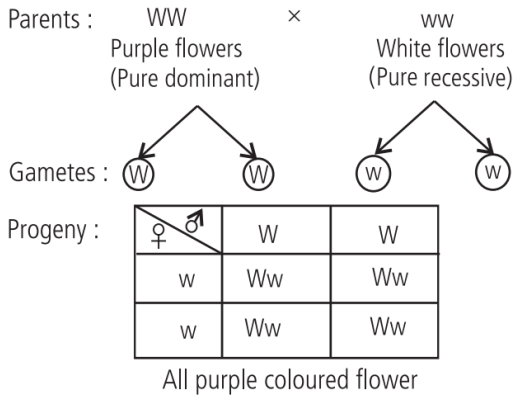
If plant produces tall plants as offspring, then the genotype of plant is TT i.e., homozygous tall plant. Case II: Tall (heterozygous) pea plant is crossed with dwarf pea plant.



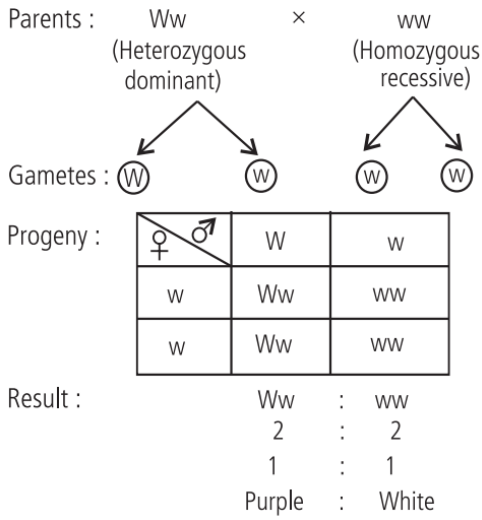
If plant produces both tall and dwarf plants in the ratio of 1: 1, then genotype of plant is Tt, i.e., heterozygous tall pea plant.

28. Purple coloured flowers in pea plant is a dominant trait. The genotype of pea plant that whether an individual for purple-coloured flowers is homozygous or heterozygous, can be determined by test cross. If the individual is homozygous dominant, then all offspring will be 100% dominant. In case of heterozygous individual, offspring will be 50% dominant and 50% recessive. This can be explained as follows:

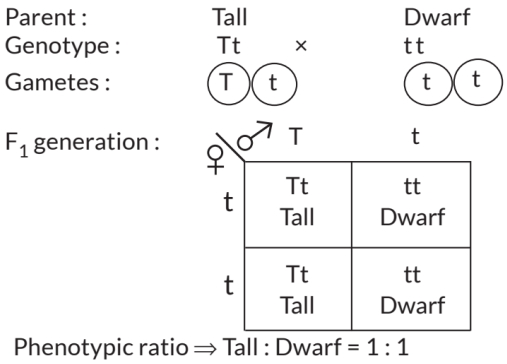
When plant is homozygous dominant,



When plant is heterozygous dominant,



29. Two contrasting characters of height are tall and dwarf. In the given cross, if 50% of the progeny shows parental characters, then it must be a cross between a heterozygous tall and a homozygous recessive dwarf parent.



30. The phenotypic and genotypic ratio of 1: 2: 1 in F_2 progeny of a monohybrid cross is seen in incomplete dominance.

This phenomenon has been observed in flower colour of Mirabilis jalapa or four O' clock plant. The phenotypic as well as genotypic monohybrid ratio in F_2 generation in incomplete dominance is 1: 2: 1 i.e., pure dominant : hybrid: pure

recessive. F_1 generation expresses a phenotype which is intermediate between those of the parent.

When a cross is made between a red flowered plant and a white flowered plant of Mirabilis jalapa, the F_1 hybrid has pink flowers. When the F_1 individual was self-pollinated, F_2 individuals were obtained bearing red, pink and white flowers in the ratio 1: 2: 1.

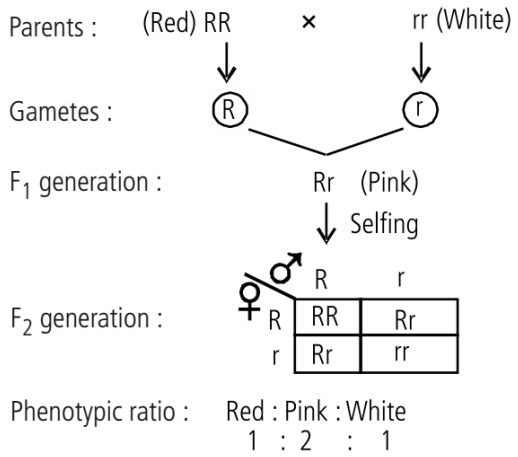


Fig.: Incomplete dominance in *Mirabilis jalapa*

31. (a) Whenever Mendel carried out a cross between plants for a contrasting trait, he found that only one trait out of the two appears in the F_1 generation. He concluded that the trait which is expressed in F_1 is dominant while the one which remains hidden is recessive. He also said that characters are controlled by discrete unit called factors which occur in pair.

(b) In a diploid organism, there are two copies of each gene, i.e., pair of alleles. These two alleles are not always identical, as in a heterozygote. One of them may be modified due to mutation.

The unmodified functional allele that represents the original phenotype behaves as dominant allele and codes for functional protein. The mutated non-functional allele behaves as recessive allele and codes for mutant or non-functional protein.

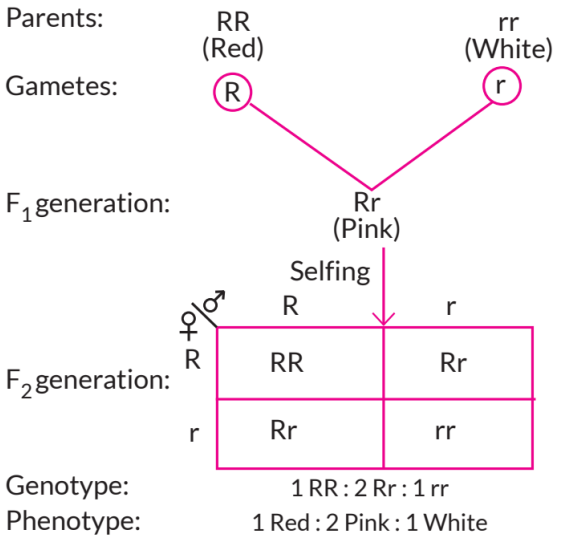
The phenotype of the organism will only be dependent on the functioning of the unmodified allele. Hence, in a heterozygote, the dominant allele will express itself whereas recessive allele will remain hidden.

32. When a cross is made between a red flowered plant with a white flowered plant of snapdragon, the F_1 hybrid has pink flowers.

When the F_1 individual was self pollinated F_2 individuals were obtained bearing red, pink and white flowers in the ratio 1: 2: 1. It is not a case of blending inheritance because the parental characters appear in the F_2 generation without any change.

It is due to law of segregation which states that the members of the allelic pair that remained together in the parent, segregate during gamete formation and only one factor enters a gamete.

In this neither of the two alleles of a gene is completely dominant over the other, hence the phenomenon is known as incomplete dominance. Incomplete dominance in snapdragon (Antirrhinum) is explained below:



33. Differences between incomplete dominance and codominance are as follows:

	Incomplete dominance	Co-dominance
(i)	Effect of one of the two alleles is more conspicuous.	The effect of both the alleles is equally conspicuous.
(ii)	The effect in hybrid is intermediate of the expression of the two alleles.	Both the alleles produce their effect independently, *e.g.*, I^A and I^B
(iii)	The expressed new phenotype has no allele of its own.	The expressed phenotype is combination of two phenotypes and their alleles.
(iv)	The incomplete dominance is the result of quantitative effect of alleles.	A quantitative effect is absent.
(v)	Example : In *Mirabilis jalapa*, when two types of plants having flower colour in pure state red and white are crossed, the F_1 generation have pink flowers.	Example : When red cattle are crossed with white cattle, the hybrid of F_1 generation are of roan colour *i.e.*, having a dark coat interspersed with white hair.

34. (a) Tall height is a dominant trait in pea plant. The genotype of a plant for a trait to be heterozygous or homozygous can be determined by performing test cross. In test cross, the individual is crossed with homozygous recessive parent for the trait being investigated.

Tall plant could have two possible genotypes: TT and Tt

Case I: Tall (homozygous) pea plant crossed with dwarf pea plant:

Parent : Tt × tt

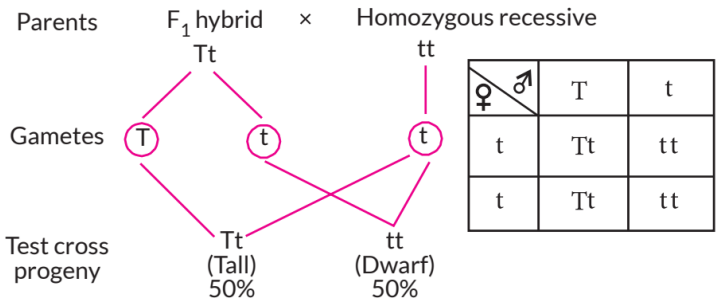
Gametes : T T t t

Progeny :

♀ \ ♂	t	t
T	Tt Tall	Tt Tall
T	Tt Tall	Tt Tall

If plant produces tall plants as offspring, then the genotype of plant is TT i.e., homozygous tall plant.

Case II: Tall (heterozygous) pea plant is crossed with dwarf pea plant.



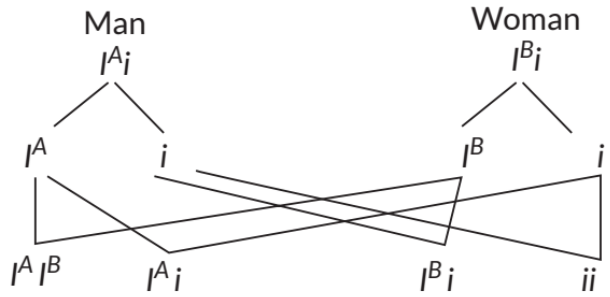
♀ \ ♂	T	t
t	Tt	tt
t	Tt	tt

If plant produces both tall and dwarf plants in the ratio of 1: 1, then genotype of plant is TT, i.e., heterozygous tall pea plant.

(b) (i) When the phenotypic ratio is 1:2:1, this means there are three different phenotypes. This can be due to incomplete dominance or codominance. In both cases, the heterozygotes have a phenotype that is a mixture of the individual dominant and recessive phenotypes. Here, the genotypic ratios were exactly as we would expect in any Mendelian monohybrid cross, but the phenotypic ratios had changed from the 3:1 (dominant: recessive) ratio to 1: 2: 1 ratio.

(ii) The ratio 3:1 suggest the typical monohybrid cross between the true-breeding homozygous dominant and a homozygous recessive parent. The F_1 generation when self-crossed gives this ratio.

35. (a) Law of dominance states that characters are controlled by discrete units called factors, which occur in pairs with one membssser of the pair dominating over the other dissimilar pair. This law explains expression of only one of the parental character in F_1 generation. This can be explained by the following cross:

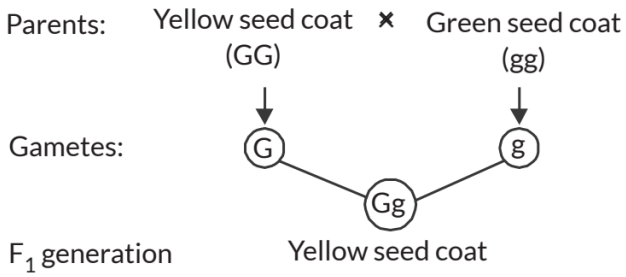


In the given cross, the trait producing yellow seeds is dominant over the trait producing green seeds. In F_1 generation, all offspring showed yellow colour of seed (dominant character) and no green seeds plants were obtained.

(b)

	Incomplete dominance	Co-dominance	Mendelian inheritance
F_1	Dominant trait is incompletely expressed.	Expressed phenotype is combination of two phenotypes and their alleles.	Dominant trait is completely expressed.
F_2	The F_2 generation of snapdragon flower consists of three types of flowers - red, pink and white in the ratio of 1:2:1.	The F_2 generation in human blood group may have upto four phenotypes – 'A', 'B', 'AB' and 'O' with blood group AB showing co-dominance.	F_2 progeny has 3:1 ratio *i.e.*, dominant trait : recessive trait.

36. (a)

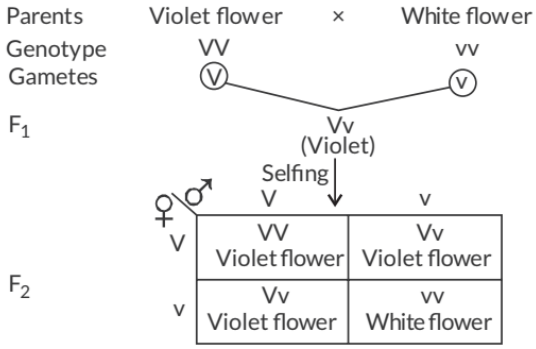


Parents must be heterozygous since blood group O appears in progeny. The progeny can have all the four blood groups A, B, AB and O. There are three alleles of the gene controlling blood group character, i.e., I^A, I^B and i. I^A and I^B are dominant over i and together they are codominant to each other.

(b) ABO blood groups are controlled by gene I. The gene I has three alleles I^A, I^B and i. This phenomenon is known as multiple allelism. The blood groups and their possible genotypes are given below in the table:

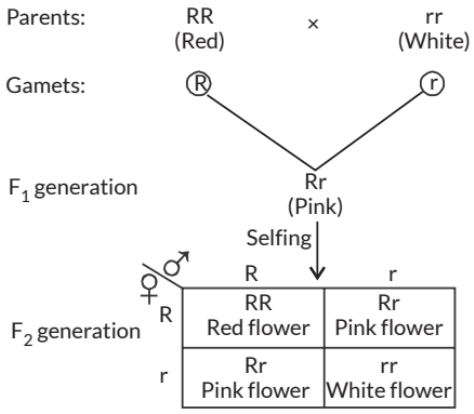
Blood group	Genotypes (possible)
A	I^AI^A or I^Ai
B	I^BI^B or I^Bi
AB	I^A I^B
O	*ii*

37. In case of pea plant:



Genotype : VV : Vv : vv
1 : 2 : 1
Phenotype : Violet : White
3 : 1

In case of Antirrhinum plant:

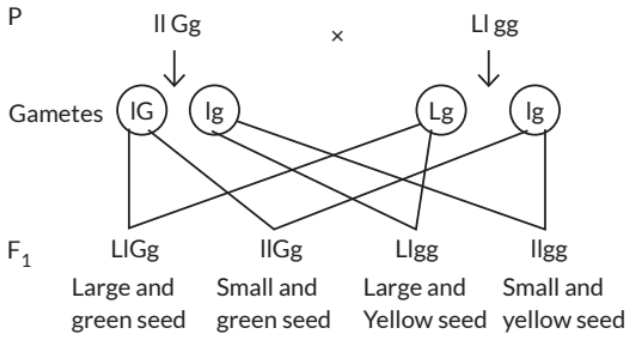


Genotype : RR : Rr : rr
1 : 2 : 1
Phenotype : Red : Pink : White
1 : 2 : 1

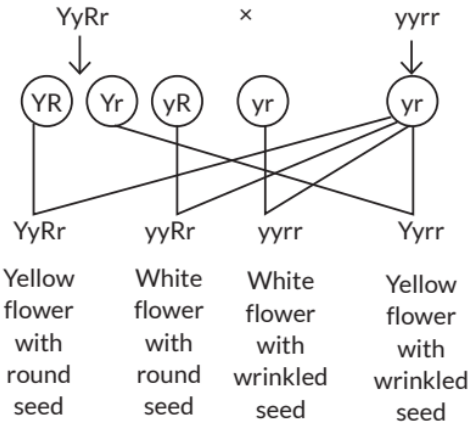
The inheritance pattern of flower colour in garden pea plant is an example of complete dominance whereas inheritance pattern of flower colour in Antirrhinum is an example of incomplete dominance.

38. (b) : The chromosomal theory of inheritance was proposed by Walter Sutton and Theodore Boveri in 1902. They noted that the behaviour of chromosomes was parallel to the behaviour of genes and used chromosome movement to explain Mendel's law.

39. (d): The cross between llGg X Llgg will produce small seeds with green colour and large seeds with yellow colour besides other phenotypic progenies.



40. (c) : A cross between a heterozygous yellow flowers and round seed (YyRr) with homozygous white flowers and wrinkled seed (yyrr) will produce



Genotype : YyRr : Yyrr : yyRr : yyrr
1 : 1 : 1 : 1

Phenotype : Yellow flower with round seed 1 : Yellow flower with wrinkled seed 1 : White flower with round seed 1 : White flower with wrinkled seed 1

So, the genotypic and phenotypic ratio of F_1 generation will be 1: 1: 1: 1.

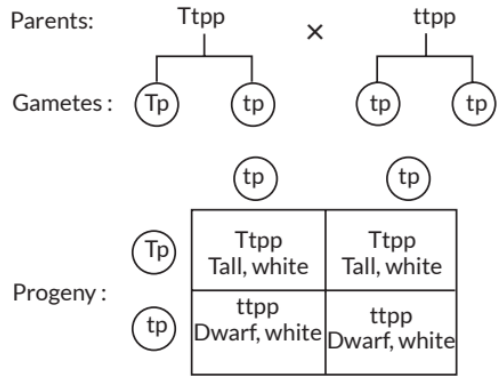
41. (a) : In Drosophila, crossing of yellow bodied (y) and white eyed (w) female with brown bodied (y^+) and red eyed (w^+) male produced F_1 to be brown bodied and red eyed. On intercrossing of F_1 progeny, Morgan observed that the two genes did not segregate independently of each other and therefore, the F_2 ratio deviated significantly from expected 9: 3: 3: 1 ratio.

42. During anaphase of meiosis I, segregation of an independent pairs of chromosomes occur.

43. Test cross is a cross used to identify whether an individual is homozygous or heterozygous for dominant character. The individual is crossed with homozygous recessive parent for the trait being investigated.

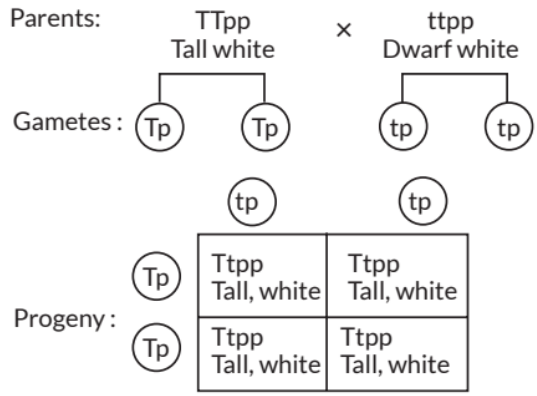
Tall plant with white flowers could have two possible genotypes: TTpp and Ttpp (white colour of flower in pea is a recessive trait, so it will be 'pp' in pea plant).

Case I: Tall (homozygous) pea plant with white flowers crossed with dwarf pea plant with white flowers.



If plant produces all tall plants with white flowers as offspring, then genotype of plant is TTpp i.e., homozygous tall plant with white flowers.

Case II: Tall (heterozygous) pea plant with white flowers is crossed with dwarf pea plant with white flowers.



If plant produces both tall plant with white flowers and dwarf plant with white flowers, then genotype of plant is Ttpp i.e., heterozygous tall pea plant with white flowers.

44. T.H. Morgan select Drosophila melanogaster to study sex-linked genes because of following reasons:

(i) They could be grown on simple synthetic medium in the laboratory.

(ii) They complete their life cycle in about two weeks.

(iii) A single mating could produce a large number of progeny flies.

(iv) There was a clear differentiation of sexes - the male and female flies are easily distinguishable. (v) They have many types of hereditary variations that can be seen with lower microscope.

45. Drosophila melanogaster is fruit fly. T.H. Morgan selected Drosophila melanogaster to study sex-linked genes because of following reasons:

(i) They could be grown on simple synthetic medium in the laboratory.

(ii) They complete their life cycle in about two weeks.

(iii) A single mating could produce a large number of progeny flies.

46. Linkage is the tendency of two different genes on the same chromosome to remain together during the separation of homologous chromosomes at meiosis. Linked genes do not exhibit the dihybrid ratio of 9:3:3:1. It produces offspring with parental characters. Crossing over is the exchange of genes occurring during meiotic prophase I to break old linkage and establish new ones. It produces recombination resulting in new varieties. Thus, they are alternative of one another, i.e., if linkage is present in between genes, no crossing over occurs between them and if crossing over occurs between the two genes, they are not linked. Example: In Drosophila a yellow bodied white eyed female was crossed with brown bodied red eyed male, F_1 progeny produced and intercrossed. The F_2 phenotypic ratio of Drosophila deviate significantly from Mendel's 9:3:3:1.

This signifies that the genes for eye colour and body colour are closely located on the 'X' chromosome and are linked. Therefore, inherited together. Recombinants were formed due to crossing over but at low percentage.

47. In cross A, the strength of linkage between the genes is higher. The distance between the linked genes in the chromosome determines the strength of linkage. The closely located genes show stronger linkage than the distant genes, because the latter are more likely to undergo crossing over than the former.

48. The chromosomal theory of inheritance proposed by Sutton and Boveri can be compared with the experimental results on pea plant presented by Mendel (genes) by the given three ways:

(i) In diploid cells, chromosomes occur in homologous pairs. Genes also occur in allelic pairs.

(ii) Both chromosome and gene segregate during gamete formation (meiosis) so that a gamete receives only one chromosome and one allele of each pair.

(iii) Both genes and chromosomes show law of independent assortment. But, it is important to note that only those gene pairs show independent assortment which occur on different chromosomes.

49. (a) The organism that was used by Thomas Hunt Morgan and his colleagues for their experiments on linkage was Drosophila melanogaster. They found that the genes located on same chromosome remain linked together in passing from one generation to other due to phenomenon of linkage. Linked genes tend to transmit together in a single unit. The Mendelian dihybrid ratio of 9: 3: 3: 1 is modified as the two genes fail to assort independently due to linkage. Morgan carried out several dihybrid crosses in Drosophila to study genes that were sex linked. He hybridised yellow-bodied, white eyed females to brown bodied, red-eyed males and intercrossed their F_1 progeny. The F_2 generation deviated significantly from the Mendelian ratio.

Morgan and his colleagues knew that the genes were located on the X chromosome and deduced that when 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 due to linkage. They coined the term recombination to describe the generation of non-parental gene combinations. They also discovered that even when genes were grouped on the same chromosome, some genes were very tightly linked and showed very low recombination. They found that the genes white and yellow were tightly linked with 1.3% recombination while white and miniature wing showed 37.2% recombination.

(b) Sturtevant used the frequency of recombination between the gene pairs on the same chromosome as a measure of the distance between genes and mapped their position on the chromosome. This resulted in a chromosome map which was a linear graphic representation of the sequence and relative distances of the various genes present in that chromosome. This relative distance between genes was indicated by the percentage of their recombination or crossing over. A 100% cross over was termed as Morgan (M), 10% as Deci Morgan (dM) and 1% as Centi Morgan (cM) or 1 map unit. Today genetic maps are extensively used as a starting point in the sequencing of whole genomes.

$$\text{Recombination frequency} = \frac{\text{Total number of recombinants}}{\text{Total number of progeny}}$$

50. Mendelian F_2 phenotypic ratio in a dihybrid cross is 9:3:3:1. Law proposed by Mendel on the basis of this ratio is law of independent assortment. It states that in the inheritance of two pairs of contrasting characters, the factors of each pair of characters segregate independently of the factors of the other pair of characters. It is different from law of segregation as law of segregation states that

the members of the allelic pair that remained together in the parent, segregate during gamete formation and only one factor enters a gamete.

51. The following are the three reasons that led to the delay in acceptance of Mendel's work:

(i) Lack of communication and publicity in those days.

(ii) His concept of factors (genes) as stable and discrete units that controlled expression of traits and, of the pair of alleles that did not blend with each other was not accepted in the light of variations occurring continuously in nature.

(iii) Mendel's approach to explain biological phenomenon with the help of mathematics was also not accepted.

52. Two different contrasting traits i.e., (inflated/ constricted) and (Green/yellow) were chosen. The cross between two dominant traits is shown as follows:

Parents: Inflated green pods × Constricted yellow pods

Genotype: FFGG × ffgg

Gametes: FG, fg

F_1: FfGg, Inflated green

Selfing

F_2:

♀ \ ♂	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

Phenotypic ratio: Inflated green pods : Inflated yellow pods : Constricted green pods : Constricted yellow pod

9 : 3 : 3 : 1

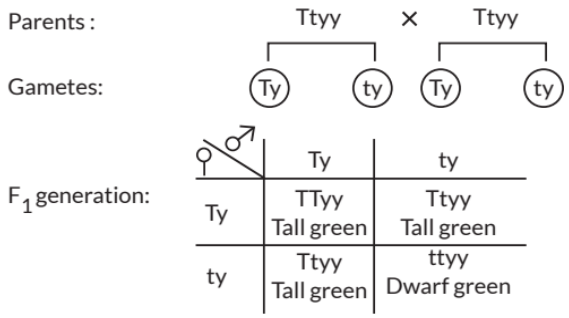
This kind of inheritance is known as two gene inheritance represented by a dihybrid cross. In two gene inheritance both the traits express themselves simultaneously in the progeny.

53. Morgan observed that the F_2 ratio obtained in the cross deviates significantly from 9: 3: 3: 1 ratio i.e., Mendelian ratio. Example: In Drosophila, a yellow bodied white eyed female was crossed with brown bodied red eyed male, F_1 progeny produced and intercrossed. The F_2 phenotypic ratio of Drosophila deviate significantly from Mendel's 9:3:3:1. This signifies that the genes for eye colour and body colour are closely located on the 'X' chromosome and are linked. Therefore, inherited together. Recombinants were formed due to crossing over

but at low percentage. Linkage was not observed by Mendel as the characters he chose were unlinked genes.

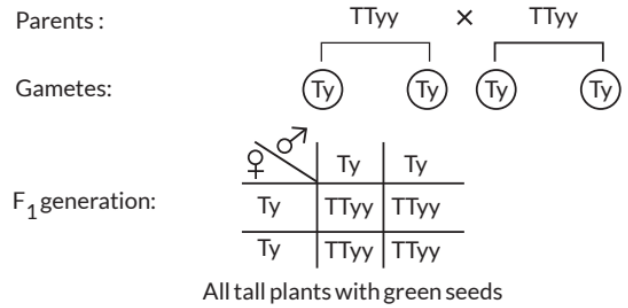
54. Tall plant with green seeds could have two possible genotypes: TTyy, Ttyy.

Case I: Tall and green seed pea plant having TTyy genotype is selfed.



If plant produce all tall plants with green seeds as offspring, then genotype of plant is TTyy i.e,. homozygous for both traits.

Case II: Heterozygous tall plant with green seeds (Ttyy) is selfed.

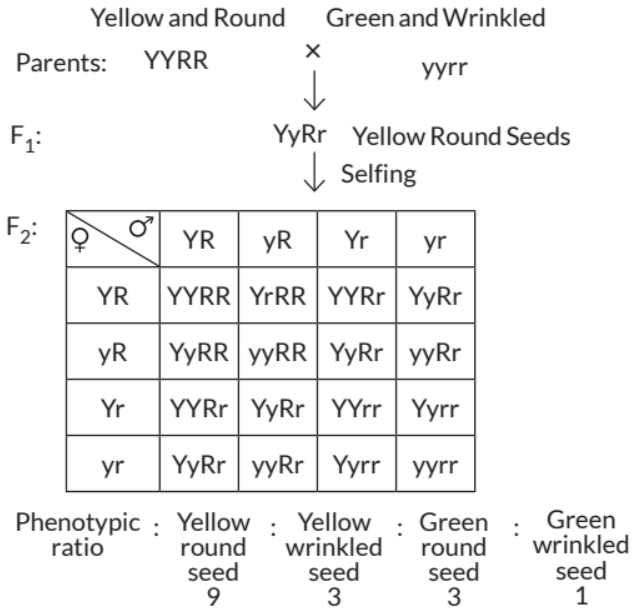


If plant produces tall plant with green seeds and dwarf plant with green seeds in the ratio of 3:1, then the genotype of the plant is Ttyy.

55. (a) Refer to answer 44.

(b) Morgan observed that the F_2 ratio obtained in the cross deviates significantly from 9: 3: 3: 1 ratio i.e., Mendelian ratio. This is because the genes are linked. They are carried on the same chromosome and are inherited together. Linkage was not observed by Mendel as the characters he chose were unlinked genes.

56. According to the law of independent assortment as proposed by Mendel, the genes of different characters located in different pairs of chromosomes are independent of one another in their segregation during gamete formation. This results in the appearance of a new combination of parental characters in F_2 offspring. Cross between parents having yellow round seed and green wrinkled seeds in Pisum sativum (Pea plant) is as follows:



57. (a) The organism that was used by Thomas Hunt Morgan and his colleagues for their experiments on linkage was Drosophila melanogaster. They found that the genes located on same chromosome remain linked together in passing from one generation to other due to phenomenon of linkage. Linked genes tend to transmit together in a single unit.

The Mendelian dihybrid ratio of 9:3:3:1 is modified as the two genes fail to assort independently due to linkage. Morgan carried out several dihybrid crosses in Drosophila to study genes that were sex linked. He hybridised yellow-bodied, white eyed females to brown bodied, red-eyed males and intercrossed their F_1 progeny. The F_2 generation deviated significantly from the Mendelian ratio.

Morgan and his colleagues knew that the genes were located on the X chromosome and deduced that when 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 due to linkage. They coined the term recombination to describe the generation of non-parental gene combinations.

They also discovered that even when genes were grouped on the same chromosome, some genes were very tightly linked and showed very low recombination. They found that the genes white and yellow were tightly linked with 1.3% recombination while white and miniature wing showed 37.2% recombination.

(b) Sturtevant used the frequency of recombination between the gene pairs on the same chromosome as a measure of the distance between genes and mapped their position on the chromosome. This resulted in a chromosome map which was a linear graphic representation of the sequence and relative distances of the various genes present in that chromosome.

This relative distance between genes was indicated by the percentage of their recombination or crossing over. A 100% cross over was termed as Morgan (M), 10% as deciMorgan (dM) and 1% as centiMorgan (cM) or 1 map unit. Today genetic maps are extensively used as a starting point in the sequencing of whole genomes.

$$\text{Recombination frequency} = \frac{\text{Total number of recombinants}}{\text{Total number of progeny}}$$

58. Law of independent assortment states that the allele of two pairs of a trait separate independently of each other during gamete or spore formation and get randomly rearranged in the offspring at the time of fertilisation producing both parental and new combination of traits. This can be explained by the following typical example of Mendelian dihybrid cross.

Mendel performed crosses involving two characters. They are called dihybrid crosses that made to study inheritance of two pairs of genes. The classical example of dihybrid cross given below is the use of two pairs of characters namely the seed colour and seed shape.

The plants with yellow and round seeds (pure) were crossed with those having green and wrinkled seeds (pure). The F_1 seeds were yellow and round. F_1 plants were selfed and F_2 seeds obtained which showed all the four possible combinations, i.e., (i) yellow and round seeds, (ii) yellow and wrinkled seeds, (iii) green and round seeds and (iv) green and wrinkled seeds in 9: 3: 3: 1 ratio. It can be shown by the following cross:

Parents: Yellow round YYRR × Green wrinked yyrr

Gametes: YR, yr

F_1 Generation: YyRr (Yellow round)

Gametes of F_1: Selfing

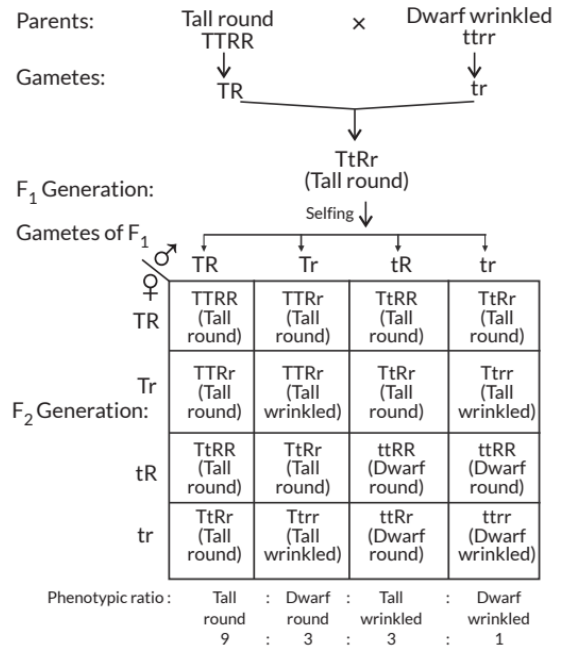
♀ \ ♂	YR	Yr	yR	yr
YR	YYRR (Yellow round)	YYRr (Yellow round)	YyRR (Yellow round)	YyRr (Yellow round)
Yr	YYRr (Yellow round)	YYrr (Yellow wrinkled)	YyRr (Yellow round)	Yyrr (Yellow wrinkled)
yR	YyRr (Yellow round)	YyRr (Yellow round)	yyRR (Green round)	yyRr (Green round)
yr	YyRr (Yellow round)	Yyrr (Yellow wrinkled)	yyRr (Green round)	yyrr (Green wrinkled)

F_2 Generation:

Phenotypic ratio : Yellow round : Green round : Yellow wrinkled : Green wrinkled

9 : 3 : 3 : 1

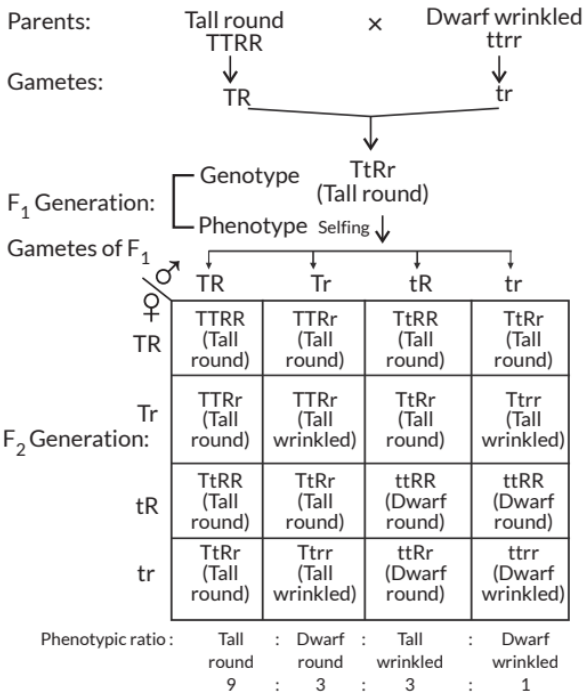
59. Cross between parents with two different contrasting traits is as follows:



When F_1 seeds were grown into plants, F_2 seeds were obtained which showed all the four possible combinations, i.e., (i) tall and round seeds (ii) tall and wrinkled seeds, (iii) dwarf and round seeds and (iv) dwarf and wrinkled seeds in 9: 3: 3: 1 ratio.

Genetic explanation: The genes of different characters located in different pairs of chromosomes are independent of one another in their segregation during gamete formation.

60. (a) Cross between parents with two different contrasting traits is as follows:



(i) Genotype and phenotype of F_1 progeny are TtRr and Tall and round seeded plant respectively.

(ii) Gametes produced of F_1 progeny are TR, Tr, tR, tr.

(iii) When F_1 seeds were grown into plants, F_2 seeds were obtained which showed all the four possible combinations, i.e., tall and round seeds, tall and wrinkled seeds, dwarf and round seeds and dwarf and wrinkled seeds in 9: 3: 3: 1 ratio. Based upon such observations Mendel proposed law of independent assortment which states that the allele of two pairs of a trait separate independently of each other during gamete or spore formation and get randomly rearranged in the offspring at the time of fertilisation producing both parental and new combination of traits.

(b) Morgan observed that the F_2 ratio obtained in the cross deviates significantly from 9: 3: 3: 1 ratio i.e., Mendelian ratio. This is because the genes are linked. They are carried on the same chromosome and are inherited together. Linkage was not observed by Mendel as the characters he chose were unlinked genes.

61. Tall pea plant with violet coloured flower could have four possible genotypes: TTVV, TtVV, TTVv and TtVv. Case I: Homozygous tall plant with violet colour (homozygous) flower is selfed.

Parents: TTVV × TTVV

Gametes: TV TV TV TV

F_1:

♀ \ ♂	TV	TV
TV	TTVV	TTVV
TV	TTVV	TTVV

If plant produce all tall plants with violet flowers as offspring, then genotype of plant is TTVV.

Case II: Heterozygous tall plant with homozygous violet coloured flower is selfed.

Parents: TtVV × TtVV

Gametes: TV tV TV tV

F_1:

♀ \ ♂	TV	tV
TV	TTVV Tall violet	TtVV Tall violet
tV	TtVV Tall violet	ttVV Dwarf violet

If plant produces tall plants with violet flowers and dwarf plants with violet flowers in the ratio of 3:1 as offspring, then the genotype of parent is TtVV.

Case III: Homozygous tall plant with violet heterozygous flower is selfed.

Parents: TTVv × TTVv

Gametes: TV Tv TV Tv

Progeny:

♀ / ♂	TV	Tv
TV	TTVV Tall violet	TTVv Tall violet
Tv	TTVv Tall violet	TTvv Tall white

If the plant produces tall plant with violet flower and tall plant with white flower in the ratio of 3: 1 as offspring then the genotype of parent is TTVv.

Case IV: Tall plant with violet flower (heterozygous for both the trait) is selfed.

Parents : TtVv × TtVv

Gametes : TV, Tv, tV, tv TV, Tv, tV, tv

Progenies :

♀ / ♂	TV	Tv	tV	tv
TV	TTVV Tall Violet	TTVv Tall Violet	TtVV Tall Violet	TtVv Tall White
Tv	TTVv Tall Violet	TTvv Tall White	TtVv Tall Violet	Ttvv Tall White
tV	TtVv Tall Violet	Ttvv Tall violet	ttVV Dwarf Violet	ttVv Dwarf violet
tv	TtVv Tall Violet	Ttvv Tall white	ttVv Dwarf Violet	ttvv Dwarf white

Tall violet : Tall white : Dwarf violet : Dwarf white

9 : 3 : 3 : 1

If the above given ratio is obtained, then the genotype is TtVv.

62. Test cross is used to identify whether an individual is homozygous or heterozygous for dominant character. The individual is crossed with homozygous recessive parent for the trait being investigated. Yellow coloured round seed pea plant could have four possible genotypes: YYRR, YyRR, YYRr and YyRr.

Case I: Yellow coloured round seed (homozygous) pea plant is crossed with green coloured wrinkled seed pea plant.

Parents : YYRR × yyrr

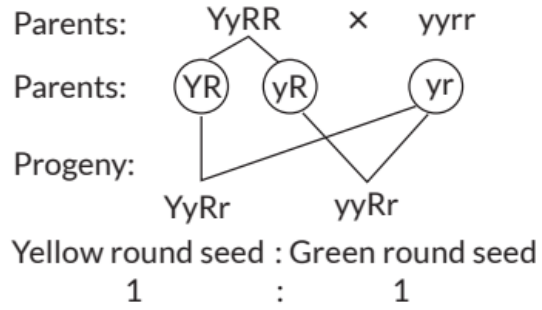
Gametes : YR yr

Progeny : YyRr

All yellow and round seeds.

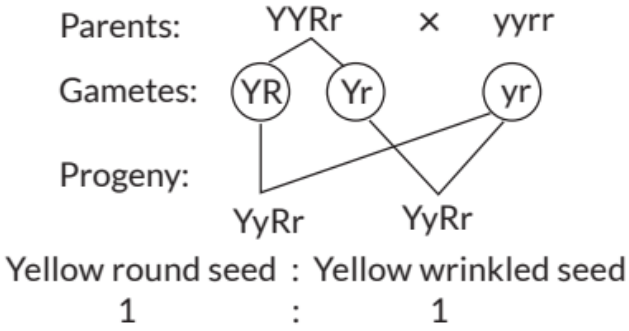
If plant produced all yellow coloured round seeds as offspring, then genotype of parent is YYRR.

Case II: Yellow (heterozygous) coloured round (homozygous) seed pea plants is crossed with green coloured wrinkled seed pea plant.



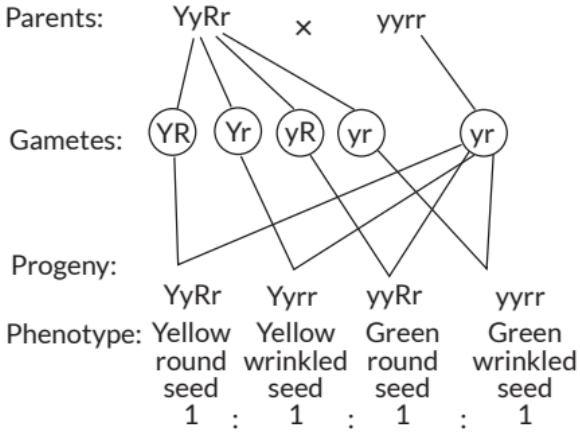
If above mentioned ratio is obtained in the progeny, then the genotype is YyRR.

Case III: Homozygous yellow coloured round (heterozygous) seed pea plant is crossed with green coloured wrinkled seed pea plant.



If above mentioned ratio is obtained in the progeny, then the genotype is YYRr.

Case IV: Heterozygous pea plant for yellow and round seed is crossed with pea plant having green and wrinkled seed.



If above mentioned ratio is obtained in the progeny, then the genotype is YyRr.

63. (a)

Parents : RrYy (Round yellow) × rryy (Wrinkled green)

Gametes : (RY) (rY) (Ry) (ry)

F_1 :

	(RY)	(rY)	(Ry)	(ry)
(ry)	RrYy	rrYy	Rryy	rryy

(b) Phenotype of the progeny of this cross is:

(i) Round and yellow

(ii) Wrinkled and yellow

(iii) Round and green

(iv) Wrinkled and green

(c) This dihybrid cross is known as test cross. A test cross is performed to find out genotype of the unknown plant.

64. (a) When a tall pea plant bearing violet flowers (heterozygous for both) is crossed with a dwarf pea plant having white flowers, progenies produced in 1: 1: 1: 1 ratio. The cross is shown as follows:

Parents: Tall violet TtVv × Dwarf white ttvv

Gametes: (TV) (Tv) (tv) (tV) (tv)

Progeny :

♀ \ ♂	TV	Tv	tV	tv
tv	TtVv Tall violet	Ttvv Tall white	ttVv Dwarf violet	ttvv Dwarf white

Phenotype : Tall violet : Tall white : Dwarf violet : Dwarf white

1 : 1 : 1 : 1

Genotype: TtVv : Ttvv : ttVv : ttvv

1 : 1 : 1 : 1

(b) This dihybrid cross is known as test cross. A test cross is performed to find out genotype of the unknown plant.

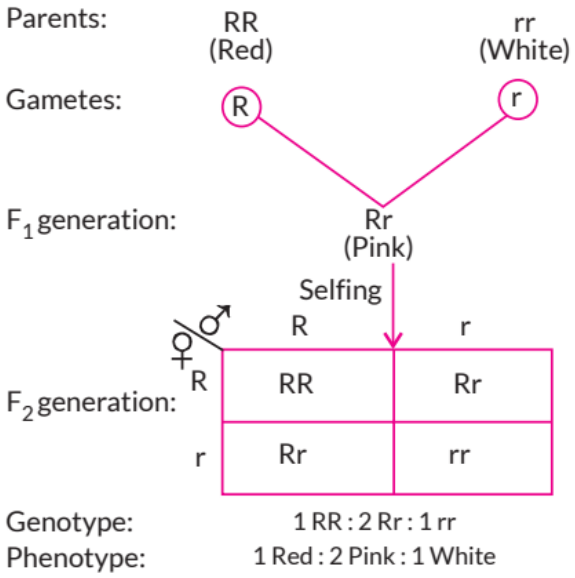
65. The skin colour of human is controlled by three genes where the dominant alleles have cumulative effect. Each dominant allele expresses a part or unit of the trait (skin colour). Such type of genes is called polygenes and their inheritance is called as polygenic inheritance. So, the skin colour of human is a polygenic trait.

66. Polygenic inheritance is a type of inheritance controlled by one or more genes in which the dominant alleles have cumulative effect with each dominant allele

expressing a part or unit of the trait, the full trait being shown only when all the dominant alleles are present. Human skin colour is an example of polygenic inheritance. Human skin colour is caused by pigment melanin. The quantity of melanin is due to three pairs of genes (A, B and C). If black or very dark (AABBCC) and white or very light (aabbcc) individuals marry, the offsprings or individuals of F_1 generation show intermediate colour often called mulatto (AaBbCc). When two such individuals of intermediate colour marry, the skin colour of the children will vary from very dark or black to very light or white. A total of eight allele combinations is possible in the gametes forming 27 distinct genotypes distributed into 7 phenotypes-1 very dark, 6 dark, 15 fairly dark, 20 intermediate, 15 fairly light, 6 light and 1 very light.

67. (a) When a cross is made between a red flowered plant with a white flowered plant of snapdragon, the F_1 hybrid has pink flowers. When the F_1 individual was self pollinated F_2 individuals were obtained bearing red, pink and white flowers in the ratio 1: 2: 1. It is not a case of blending inheritance because the parental characters appear in the F_2 generation without any change. It is due to law of segregation which states that the members of the allelic pair that remained together in the parent, segregate during gamete formation and only one factor enters a gamete.

In this neither of the two alleles of a gene is completely dominant over the other, hence the phenomenon is known as incomplete dominance. Incomplete dominance in snapdragon (Antirrhinum) is explained below:



(b) Refer to answer 66.

68. None of the options is correct.

In human beings, pleiotropy is exhibited by sickle cell anemia in which genes causing this disorder alter the type of haemoglobin and also change the form of RBCs. Morgan defined linkage on basis of his breeding experiments in fruit fly (Drosophila). Inheritance of flower colour in snapdragon (Antirrhinum) is an example of incomplete dominance. ABO blood grouping is an example of codominance.

69. 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.

70. The ability of a gene to have multiple phenotypic effect because it influences a number of characters simultaneously is known as pleiotropy. The gene having a multiple phenotypic effect because of its ability to control expression of two or more characters is called pleiotropic gene. For example, in cotton a gene for the lint also influences the height of plant, size of the boll, number of ovules and viability of seeds.

71. (a) Refer to answer 66.

(b) Pleiotropy is the ability of a gene to have multiple phenotypic effect because it influences a number of characters simultaneously. Pleiotropy is due to effect of the gene on two or more inter-related metabolic pathways that contribute to formation of different phenotypes. It is not essential that all the traits are equally influenced. Sometimes the effect of a pleiotropic gene is more evident in case of one trait (major effect) and less evident in case of others (secondary effect). E.g., in cotton a gene for the lint also influences the height of the plant, size of the boll, number of ovules and viability of seeds.

72. (a) Mendelian Inheritance: Mendelian inheritance is a type of inheritance controlled by one or more genes in which only dominant trait was expressed in the F_1 generation while at the F_2 stage both the traits were expressed. The contrasting traits did not show any blending at either F_1 or F_2 stage on the basis of this Mendel proposed three laws: (i) Law of Dominance, (ii) Law of Segregation and (iii) Law of Independent Assortment.

Polygenic Inheritance: Polygenic inheritance is a type of inheritance controlled by one or more genes in which the dominant alleles have cumulative effect with each dominant allele expressing a part or unit of the trait, the full trait being shown only when all the dominant alleles are present.

Pleiotropy: The ability of a gene to have multiple phenotypic effect because it influences a number of characters simultaneously is known as pleiotropy. Pleiotropy is due to effect of the gene on two or more inter-related metabolic pathways that contribute to formation of different phenotypes.

(b) Refer to answer 66.

73. According to Mendel's law of dominance, when two individuals of a species, differing in a pair of contrasting forms of a trait are crossed, the form of the trait that appears in the F_1 hybrid is dominant and the alternate form that remains hidden, is called recessive. Incomplete dominance and co-dominance are exception to this law. According to Mendel, one gene controls the expression of one character only. Pleiotropy is exception to this. The ability of a gene to have multiple phenotypic effect because it influences a number of characters simultaneously is known as pleiotropy. The gene having a multiple phenotypic effect because of its ability to control expression of two or more characters is called pleiotropic gene. For example, in cotton a gene for the lint also influences the height of plant, size of the boll, number of ovules and viability of seeds.

Incomplete dominance is the phenomenon where none of the two contrasting alleles or factors is dominant. The expression of the character in a hybrid or F_1 individual is intermediate or a fine mixture of the expression of the two factors. As seen in Mirabilis jalapa where when two types of plants having flower colour in pure state red and white are crossed, the hybrid or F_1 generation have pink flowers.

Co-dominance is the phenomenon of expression of both the alleles in a heterozygote, i.e., both alleles are able to express themselves independently when present together. E.g., hair colour in cattle. When red cattle are crossed with white cattle, the hybrid of F_1 generation are of roan colour i.e., having a dark coat interspered with white hair.

Polygenic inheritance is a type of inheritance controlled by one or more genes in which the dominant alleles have cumulative effect with each dominant allele expressing a part or unit of the trait, the full trait being shown only when all the dominant alleles are present. The genes involved in quantitative inheritance are called polygenes and inheritance called as polygenic inheritance. E.g., human skin

colour. Human skin colour is an example of polygenic inheritance. Human skin colour is caused by pigment melanin. The quantity of melanin is due to three pairs of polygenes (A, B and C).

74. (a) : In honeybees, all males are haploid having 16 chromosomes. The males produce sperms by mitosis.

75. During gamete formation a diploid germinal cell changes to a haploid germ cell. Hence, a pair of autosomes get segregated by means of meiotic division to produce haploid gametes.

76. In honeybees, an unfertilised egg develops into a male and a fertilised egg develops into a female. Therefore, the female is diploid (2n), and the male is haploid (n).

77. Drones of honeybees are haploid and possess 16 chromosomes. Mitosis is involved in the production of sperms.

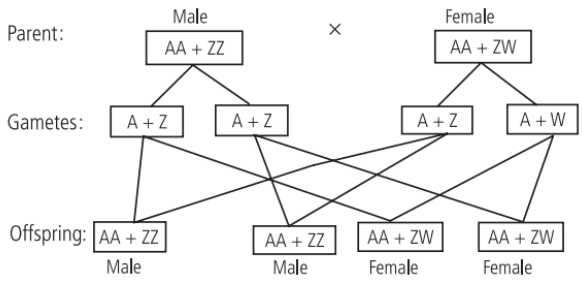
78. Statement (a) is correct. Drosophila male has one X and one Y chromosome.

79. Statement (a) is correct. In birds, the male has two homomorphic sex chromosomes (ZZ) and is homogametic, and the female has two heteromorphic sex chromosomes (ZW) and is heterogametic.

80. The type of sex determination mechanism shown in female XX with male XY is called male heterogamete because male produces two different types of gametes, e.g., Drosophila.

The type of sex determination mechanism shown in female ZW with male ZZ is female heterogamety because female produces two different types of gametes, e.g., birds.

81. Birds have ZW - ZZ type of sex determination mechanism. In this type the male has two homomorphic sex chromosomes (ZZ) and is homogametic, and the female has two heteromorphic sex chromosomes (ZW) and is heterogametic. There are, thus, two types of eggs: with Z and with W, and only one type of sperms, i.e., each with Z. Fertilisation of an egg with Z chromosome by a sperm with Z chromosome gives a zygote with ZZ chromosomes (male). Fertilisation of an egg with W chromosome by a sperm with Z chromosome yields a zygote with ZW chromosomes (female). ZW-ZZ type of sex determination is as follows:



82. Differences between ZZ and XY sex determination mechanisms are as follows:

	ZZ-sex determination	XY-sex determination
(i)	This is chromosomal sex determination where females are heterogametic, *i.e*, they produce two type of gametes, (ZW)while the male are homogametic *i.e*, they produce similar type of gamete (ZZ).	This is chromosomal sex determination where male are heterogametic, *i.e*, they produce two types of gametes (XY), while the females are homogametic *i.e*,. they possess similar type of gamete (XX).

(ii)	The females produce two type of eggs (A + Z) and (A + W), while the males produce only one type of sperm (A + Z).	The females produce one type of egg (X) while the males produce two types of sperms (X) and (Y).
(iii)	Organisms that have the ZZ type sex-determination mechanism are birds, fish, some reptiles, etc.	Organisms that have XY type of sex-determination mechanism are humans and *Drosophila*.

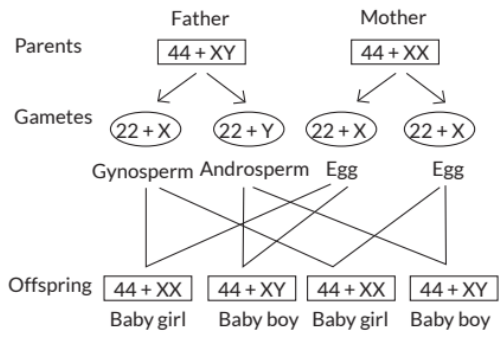
83. (a) Female honeybee produces eggs through meiosis (A) and male honey bee produces sperms through mitosis(B).

(b) Male honeybee (drone) develop through arrhenotokous or haploid parthenogenesis (C) i.e., direct development of the haploid egg without fertilisation.

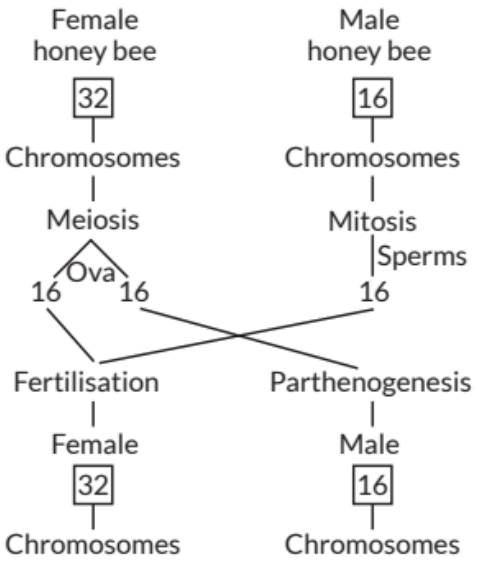
84. (a) Chromosomal determination of sex in human beings is of XX-XY type. Human beings have 22 pairs of autosomes and one pair of sex chromosomes. The females possess two homomorphic (= isomorphic) sex chromosomes, named XX. The males contain two heteromorphic sex chromosomes, i.e., XY. All the ova formed by female are similar in their chromosome type (22+ X). Therefore, females are homogametic. The male gametes or sperms produced by human males are of two types, gynosperms (22 + X) and androsperms (22 + Y). Human males are therefore, heterogametic. Sex of the offspring is determined at the time of fertilisation. Fertilisation of the egg (22 + X) with a gynosperm (22 + X) will produce a female child (44 + XX) while fertilisation with an androsperm (22 + Y) gives rise to male child (44 + XY). As the two types of sperms are produced in equal proportions, there are equal chances of getting a male or female child in a particular mating. As Y-chromosomes determines the male sex of the individual, it is also called androsome.

In honeybees, haploid-diploid mechanism of sex determination has been found. It is a unique phenomenon in which an unfertilised egg develops into a male and a fertilised egg develops into a female. Therefore, the female is diploid (2n), and the male is haploid (n).

(b) Gamete formation in case of humans:



Gamete formation in case of honeybees:



Humans, gamete is formed by meiotic division only whereas in honeybee male gamete is formed by mitotic division and female gamete is formed by meiotic division.

85. In case of birds, the type of sex determination is ZW-ZZ type. Female has two different sex chromosomes (ZW) whereas male has a pair of same sex chromosomes (ZZ). As the female has heteromorphic sex chromosomes, the female is heterogametic and produces two types of eggs, (A + Z) and (A+W). The male gametes or sperms are of one type (A + Z). Therefore, in birds, sex is determined by female. Chromosomal determination of sex in human beings is of XX-XY type.

Human beings have 22 pairs of autosomes and one pair of sex chromosomes. The females possess two homomorphic sex chromosomes, named XX while. The males have two heteromorphic sex chromosomes, i.e., XY. All the ova formed by female are similar in their chromosome type (22 + X). Therefore, females are homogametic.

The male gametes or sperms produced by human males are of two types, gynosperms (22 + X) and androsperms (22+ Y). Human males are therefore, heterogametic. Thus, the genetic makeup of the sperm determines the sex of the child in case of humans.

86. (a) Chromosomal determination of sex in human beings is of XX-XY type. Human beings have 22 pairs of autosomes and one pair of sex chromosomes. The females possess two homomorphic (= isomorphic) sex chromosomes, named XX.

The males contain two heteromorphic sex chromosomes, i.e., XY. All the ova formed by female are similar in their chromosome type (22+ X). Therefore, females are homogametic.

The male gametes or sperms produced by human males are of two types, gynosperms (22 + X) and androsperms (22 + Y). Human males are therefore, heterogametic.

Sex of the offspring is determined at the time of fertilisation. Fertilisation of the egg (22 + X) with a gynosperm (22 + X) will produce a female child (44 + XX) while fertilisation with an androsperm (22 + Y) gives rise to male child (44 + XY). As the two types of sperms are produced in equal proportions, there are equal chances of getting a male or female child in a particular mating. As Y-chromosomes determines the male sex of the individual, it is also called androsome.

(b) In case of birds, the type of sex determination is ZWZZ type. Female has two different sex chromosomes (Z and W) whereas male has a pair of same chromosomes (ZZ), therefore, in birds, sex is determined by female.

In honeybee's haploid-diploid mechanism of sex determination has been found. It is a unique phenomenon in which an unfertilised egg develops into a male and a fertilised egg develops into a female. Therefore, the female is diploid (2n), and the male is haploid(n).

87. (d)

88. (b) : Klinefelter's syndrome in humans is a genetic disorder which is caused due to the presence of an additional copy of chromosome resulting into a karyotype of 47 (44 +XXY).

89. (b): The given karyotype is of Down syndrome. It is an autosomal aneuploidy, caused by presence of an extra chromosome number 21, i.e., 21-trisomy. It is characterised by round face, broad forehead, permanently open mouth protruding tongue, furrowed tongue, etc.

90. (b): Thalassemia is an autosomal disorder in humans.

91. (a) Klinefelter's syndrome

(b) Turner's syndrome

92. Turner's syndrome is due to monosomy. It occurs due to union of an allosome free egg (22 + 0) and a normal X sperm or a normal egg and an allosome free sperm (22+ 0). The individual has 2n = 45 chromosomes (44 + XO) instead of 46.

93. Klinefelter's syndrome is caused by union of an abnormal XX egg and a normal Y sperm or normal X and abnormal XY sperm. The individual has 47 (44 + XXY) chromosomes.

94. Mendelian disorders are gene related human disorders that are determined by mutations in single gene. They are transmitted to the offspring as per Mendelian principles.

The pattern of inheritance of such disorders can be traced in a family of pedigree analysis. Thalassemia is an autosomal recessive disorder caused due to mutation or deletion of genes controlling the formation of globin chains of haemoglobin.

This causes the formation of abnormal haemoglobin molecules resulting into anaemia. Colourblindness is a sex-linked recessive disorder in which the eye fails to distinguish between red and green colours.

The gene for normal vision is dominant whereas recessive allele causes colourblindness. Both these allelles are carried on X chromosome. As both disorders are gene related so can be categorised as Mendelian disorders.

95. (a) The individual having 47 chromosomes (44 +XXY) are males with Klinefelter's syndrome. It is due to the trisomy of sex (X) chromosome. It is formed by the union of an abnormal XX egg (formed due to non-disjunction at the time of gametogenesis) with a normal Y sperm.

(b) Such persons are called feminised males or sterile males with undeveloped testes, mental retardation, feminine pitched voice, enlarged breasts (gynaecomastia), etc.

96. The genes that can cause red-green colour blindness are passed down on the X-chromosomes. Since it is passed down on the X-chromosome, red green colour blindness is more common in human males than in females. This is because males have only one X-chromosome inherited from their mother while females have two X-chromosomes.

In case female to be colour blind, she must have allele for it on both of her X-chromosomes. If she possesses allele for colour blindness on X-chromosome only. She will act as a carrier and not diseased. On the other hand, males have only one X-chromosome, that means allele on the X-chromosome, will make them colourblind.

97. Turner's syndrome is a disorder caused due to the absence of one of X chromosomes (monosomy) where the individual has 22 pairs of autosomes and XO sex chromosomes i.e., 45 chromosomes. So, the karyotype will be 44 +X0.

Symptoms:

(i) Sterile females

(ii) Rudimentary ovaries

(iii) Lack of secondary sexual characters

(iv) Webbed neck and broad chest

(v) Underdeveloped breasts.

98. Difference between Turner's syndrome and down's syndrome are as follows:

Down's syndrome	Turner's syndrome
In this, there is the presence of an additional copy of chromosome number 21 i.e., trisomy of 21.	In this, there is the absence of one X chromosome, *i.e*, 45 with XO (Monosomy)
This involves autosomes.	This involves sex chromosomes.
The affected individual has short stature, partially opened mouth and broad palm.	The affected individual has short stature and underdeveloped feminine characters, i.e, lack of secondary sexual characters.
The affected individual is fertile.	The affected individual is sterile.

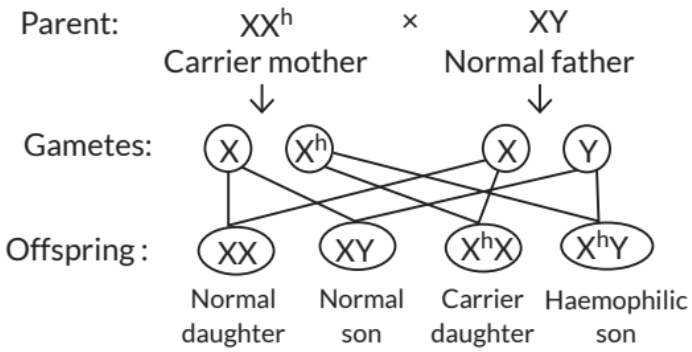
99. Haemophilia is genetic disorder caused due to the presence of a recessive sex-linked gene 'h', carried by X chromosome. It is generally observed in males as a single gene for the defect is able to express itself as the Y chromosome is devoid of any corresponding allele (X^hY).

Women will suffer from this disorder when a carrier woman (XX^h) marries with haemophilic man (X^hY). 50% girl babies will be carriers (XX^h) while the remaining 50% will be haemophilic (X^hX^h).

100. Differences between haemophilia and thalassemia are as follows:

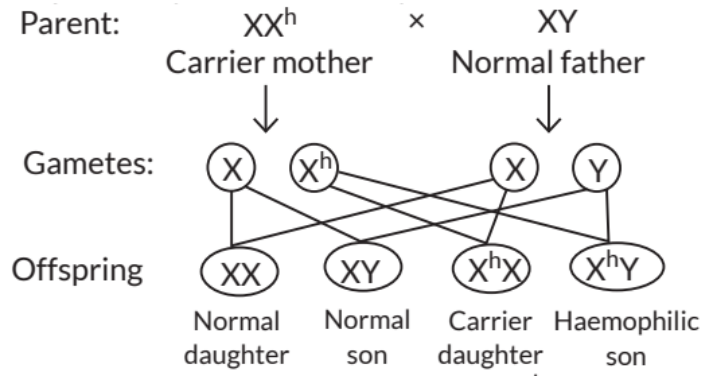
	Haemophilia	Thalassemia
(i)	Sex-linked recessive disorder.	Autosomal linked recessive disorder.
(ii)	Occurs due to presence of sex linked gene h carried by X-chromosome.	Occurs due to mutation or deletion of genes controlling formation of globin chains of haemoglobin.
(iii)	Follows criss-cross inheritance.	Inheritance is straight from both the parents to all the offspring.
(iv)	Due to absence of anti-haemophiliac globulin and plasma thromboplastin factor IX, the blood does not clot and patient continue to bleed even from a minor cut.	There is reduced synthesis of either α or β chains of haemoglobin which causes anaemia, jaundice, hepato-splenomegaly, cardiac enlargement and skeletal deformities.

101. Couple is normal but their child is haemophilic. It indicates that father is normal and mother is a carrier. Here is the cross given to explain this:



So, there is a probability that 50% of sons of this couple will be normal and 50% of sons will be haemophilic. Also 50% of daughters are normal and 50% are carriers.

102. Haemophilia is genetic disorder caused due to the presence of a recessive sex-linked gene 'h', carried by X chromosome. It is generally observed in males as a single gene for the defect is able to express itself as the Y chromosome is devoid of any corresponding allele (X^hY). Women will suffer from this disorder when a carrier woman (XX^h) marries with haemophilic man (X^hY). 50% girl babies will be carriers (XX^h) while the remaining 50% will be haemophilic (X^hX^h). A marriage between a haemophilic man (X^hY) and a carrier woman (XX^h) will produce haemophilic girl, carrier girl, haemophilic boy and normal boy in the ratio of 1: 1: 1: 1.



Marriage between a carrier woman (XX^h) and a normal man (XY) will produce normal girl, carrier girl, normal boy and haemophilic boy in the ratio of 1: 1: 1: 1.

103. (a) Trisomy of 21^{st} chromosome is caused when both the chromosomes of the 21^{st} pair pass into a single egg due to non-disjunction during oogenesis. Thus, the egg possess 24 chromosomes instead of 23 and offspring has 47 chromosomes (45 + XY in male, 45 + XX in female) instead of 46. It results in Down's syndrome.

(b) Since, fetus has trisomy of 21st chromosome, so it is an abnormal condition. Hence, the pregnant woman was advised to undergo MTP and not to complete the full term of her pregnancy. The person having trisomy of 21st chromosome is characterised by round face, broad forehead, partially open mouth, protruding tongue, projecting lower lip, short neck, flat hands and stubby (small) fingers, many 'loops' on finger tips, coarse and straight hair, furrowed tongue, broad palm with characteristic palmer crease, which runs all the way across the palm and monogolian type eye lid fold (epicanthus). Physical, psychomotor and mental development is retarded.

104. The infant is suffering from Down's syndrome that is caused by the presence of an extra chromosome number 21. It is an autosomal aneuploidy. Both the chromosomes of the pair 21 pass into a single egg due to non-disjunction during oogenesis. Thus, the egg possesses 24 chromosomes instead of 23. The child will have short stature and a small rounded head. Palms of the child will be broad with characteristic palmer crease and his physical and mental development will be retarded.

105. Haemophilia is genetic disorder caused due to the presence of a recessive sex linked gene 'h', carried by X chromosome. Thalassemia is caused due to mutation or deletion of gene controlling formation of globin chains of haemoglobin.

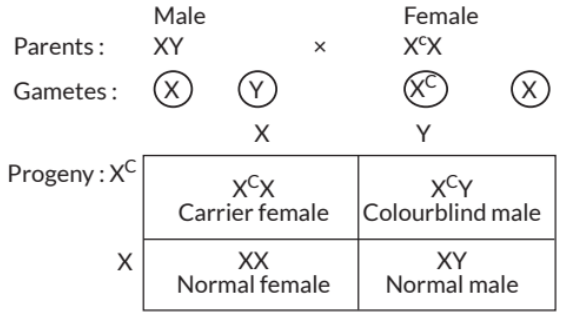
Differences between haemophilia and thalassemia are as follows:

	Haemophilia	Thalassemia
(i)	Sex-linked recessive disorder.	Autosomal linked recessive disorder.
(ii)	Occurs due to presence of sex linked gene h carried by X-chromosome.	Occurs due to mutation or deletion of genes controlling formation of globin chains of haemoglobin.
(iii)	Follows criss-cross inheritance.	Inheritance is straight from both the parents to all the offspring.
(iv)	Due to absence of anti-haemophiliac globulin and plasma thromboplastin factor IX, the blood does not clot and patient continue to bleed even from a minor cut.	There is reduced synthesis of either α or β chains of haemoglobin which causes anaemia, jaundice, hepatosp-lenomegaly, cardiac enlargement and skeletal deformities.

Haemophilia is a sex-linked recessive disorder and thalassemia is an autosomal linked recessive disease.

106. Colourblindness is an X-linked recessive disorder which shows transmission from carrier female to male progeny and hence, usually males are affected and females remain carriers.

If the given couple is normal with a colourblind child, their genotypes will be



Hence, a colourblind male child is born to the given couple.

107. Thalassemia is an autosomal, recessive inherited disorder. The defect can occur due to mutation or deletion of the genes controlling the formation of globin chains (commonly α and β) of haemoglobin. α thalassemia is caused by the defective formation of α-globin which is controlled by two genes HBA1 and HBA2 present on chromosome 16. The mutant gene cause anaemia, jaundice, hepatosplenomegaly and bone changes. All the defective alleles kill the fetus resulting in still birth or death soon after delivery. β thalassemia is caused due to decreased synthesis of β-globin. The defect is due to alleles of HBB gene present on chromosome 11. It results in severe haemolytic anaemia, hepatosplenomegaly, cardiac enlargement and skeletal deformities.

108. (a) Haemophilia is X linked recessive disease and female has homomorphic sex chromosomes (XX) and male has heteromorphic sex chromosomes (XY). Due to the presence of only one X-chromosome in males they are affected by Haemophilia when only one X-chromosome have mutant gene. So, they have higher chances of getting affected in comparison to females.

(b) Symptoms of haemophilia: A single protein involved in clotting of blood is affected. Due to this, blood does not so in a haemophilic individual, even a simple cut leads to non-stop bleeding. As a result, bruising is seen and increased bleeding in joints may occur leading to joint pain and swelling.

109. (a) (i) Partially opened mouth with furrowed tongue.

(ii) Broad palm with palm crease.

(b) Male or female

(c) Klinefelter's

(d) Male

(e) (i) Sterile female with poorly developed ovaries and underdeveloped breasts.

(ii) Webbed neck and broad chest

(f) Female

110. Haemophilia is genetic disorder caused due to the presence of a recessive sex linked gene 'h', carried by X chromosome. It is generally observed in males as a single gene for the defect is able to express itself as the Y chromosome is devoid of any corresponding allele (X^hY). Women will suffer from this disorder when a carrier woman (XX^h) marries with haemophilic man (X^hY). 50% girl babies will be carriers (XX^h) while the remaining 50% will be haemophilic (X^hX^h).

For clinical symptoms, Refer to answer 108(b).

111. (a) Aneuploidy is the failure of segregation of chromatids during cell division cycle resulting in the gain or loss of a chromosome(s).

(b) The gametes due to non-segregation of sex chromosomes during spermatogenesis produced will be 22+0 and 22 + XY.

(c) When a normal human sperm (22 + Y) fertilises an ovum with karyotype 22 + XX, the offspring produced would suffer from Klinefelter's syndrome.

Two symptoms of this disorder are:

(i) Overall masculine development but the feminine development (development of breast i.e., gynaecomastia) is also expressed.

(ii) Sterile male with undeveloped testes.

OR

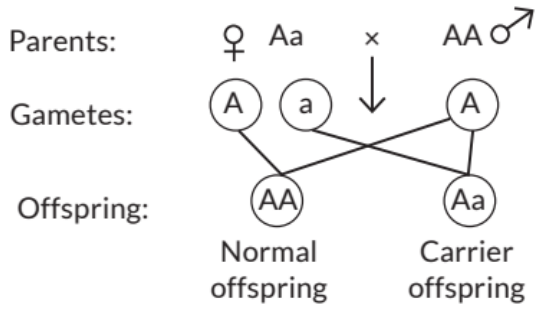
(c) Down's syndrome is an autosomal aneuploidy caused due to the presence of an additional copy of chromosome number 21. The symptoms are: (i) Short, broad palm with characteristic palmer crease, (ii) Mental retardation, small round head, partially open mouth with furrowed tongue.

112. (i) Since the given pedigree does not show criss cross inheritance, it represents autosomal disease.

(ii) It is an autosomal recessive disorder.

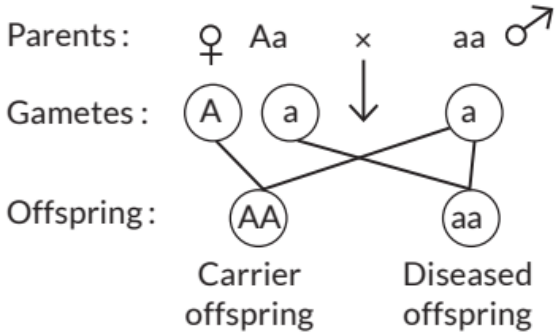
(iii) Genotype of C- Aa, D-Aa and H-Aa.

(iv) (a) Female D is carrier of disease with genotype Aa. If she marries a normal man (genotype AA), then neither of their daughter is diseased. Their daughter can be normal (genotype AA) or a carrier (genotype Aa). It can be represented as follows:



OR

(iv) (b) If mother B is a carrier of the disease, then the probability of their daughter being a sufferer of this disease is 50%. It can be illustrated as follows:



113. (a) Colourblindness and thalassemia are categorised as Mendelian disorders because of the following reasons:

(i) They are mainly due to alteration or mutation in a single gene.

(ii) These disorders are transmitted to the offspring in the same line as Mendelian principles of inheritance, i.e., by the parents who are carriers and are apparently normal.

(iii) The pattern of inheritance of these disorders can be traced in a family by pedigree analysis.

Symptoms of colourblindness: The person fails to discriminate between red and green colour due to the defect in either red or/and green cone cells of retina.

Symptoms of thalassemia: The person suffers from anaemia as the synthesis of either alpha globin chain(s) or beta globin chain (s) of haemoglobin is impaired.

(b) Colourblindness is a X-linked recessive disorder which shows transmission from carrier female to male progeny. In females, colour blindness appears only when both the sex chromosomes carry the recessive gene ($X^c X^c$). The females have normal vision but function as carrier if a single recessive gene for colourblindness is present (XX^c). However, in human males the defect appears in the presence of a single recessive gene ($X^c Y$) because Y-chromosome of male

does not carry any gene for colour vision. As a result, colour blindness is more common in males (8%) as compared to females (0.4%).

CBSE Sample Questions

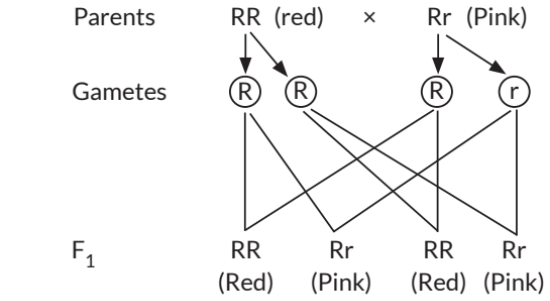
1. (b) : A parent having genotype AaBB is heterozygous for only one character A. Thus,

Total number of gametes $= 2^n = 2^1 = 2$,

where n = no. of heterozygous pair

So, the two types of gametes will be AB and aB.

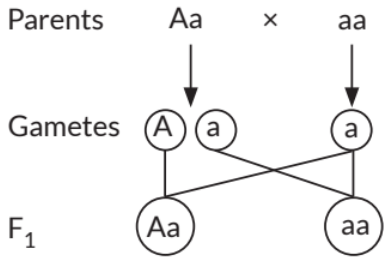
2. (c) : The cross between RR and Rr:



Genotypic ratio = RR : Rr
2 : 2

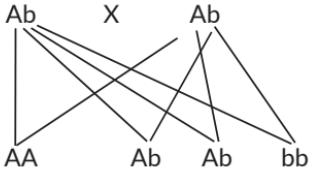
Phenotypic ratio = Red : Pink
2 : 2

3. (d) : The genotype of parent will be



Phenotypic ratio = 1: 1

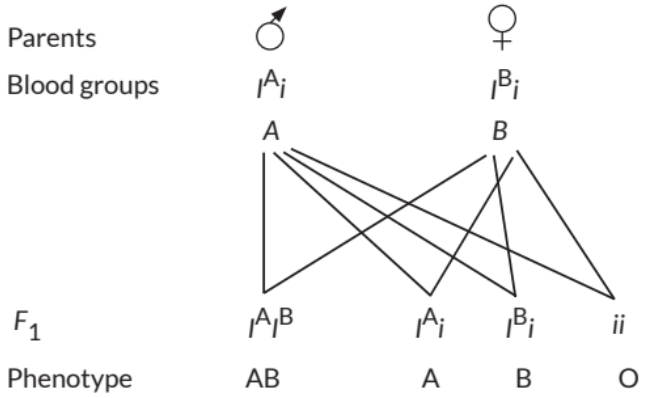
4. (b) : The selfing between Ab results in



Genotypic ratio – AA : Ab : bb
1 : 2 : 1

5. (b) : If a child has blood group O, that his/her parents would be heterozygous. Thus, mother with blood group B have genotype I^Bi and father with blood group A have genotype I^Ai.

Possible genotypes of other offsprings can be: I^AI^B, I^Ai, I^Bi or ii.



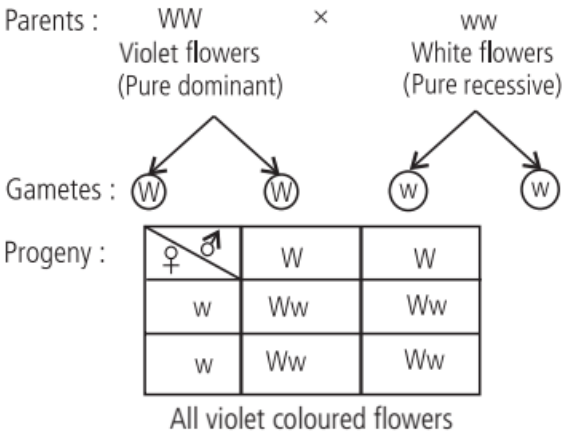
6. The given inheritance is incomplete dominance. In this, a new intermediate phenotype, i.e., pink, is obtained when two original phenotypes, i.e., violet and white flowers are crossed. One allele for a specific trait is not completely expressed over the other allele for the same trait.

7. The genotype of pea plant that whether an individual for violet-coloured flowers is homozygous or heterozygous, can be determined by test cross.

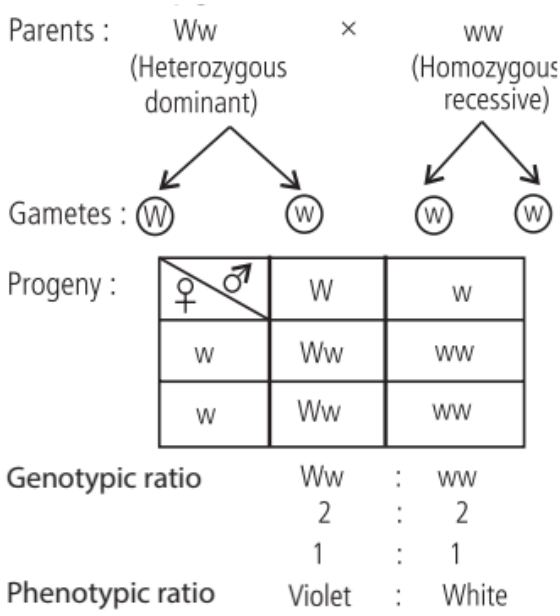
Violet coloured flowers in pea plant are a dominant trait. If the individual is homozygous dominant, then all offspring will be 100% dominant. In case of heterozygous individual, offspring will be 50% dominant and 50% recessive.

This can be explained as follows:

When plant is homozygous dominant,



When plant is heterozygous dominant,



8. (a)

9. (d): Both genes and chromosomes show independent assortment but linked genes do not show independent assortment rather they remain together in the same chromosomes.

10. (d): According to the dihybrid cross, if tall pea plant with green pods (TTGG) is crossed with dwarf pea plant with yellow pods (ttgg), in F_2 generation 16 plants are formed in which 9 are tall green, 3 are tall yellow, 3 are dwarf green and 1 dwarf yellow.

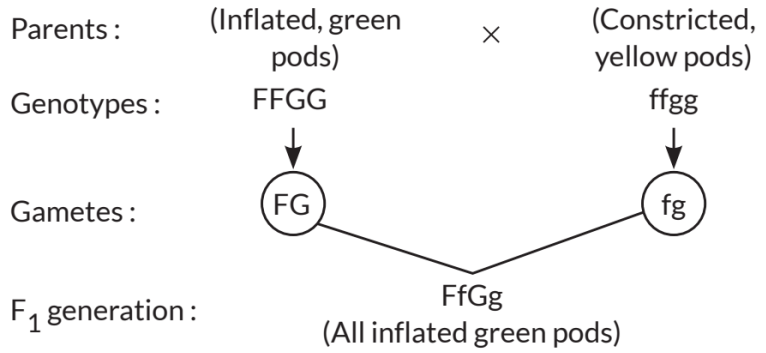
So, the number of tall plants (9+3) out of 80 plants is

$= \frac{12}{16} \text{ x } 80 = 60$

11. (d): In the dihybrid cross of Drosophila performed by Morgan in F_2 generation two genes did not segregate independently of each other and the F_2 ratio deviated very significantly from the 9:3:3:1 ratio (expected when the two genes are independent), because of linkage of genes.

12. (c): When the two genes are present on the same chromosome, at the time of gamete formation during meiosis, the tightly linked genes are unable to separate because there is no crossing over and the proportion of parental genotype is much higher than the non-parental type.

13.



Phenotype in F_1 generation – All Inflated green pods Genotype in F_1 generation – FfGg

14. (d): Human skin colour is an example of polygenic or quantitative inheritance, in which a single trait is controlled by two or more genes. The dominant allele has cumulative effect with each dominant allele expressing a part or unit of the trait and the full trait being shown only when all the dominant alleles are present.

15. (b): In honey bees, haplo-diploid mechanism of sex determination is present, in which male or drone is haploid having 16 chromosomes and female or queen is diploid having 32 chromosomes.

16. (b): Human sperm contains 50% X chromosome and 50% Y chromosome, so there is an equal probability of fertilisation of female X chromosome with either X or Y. XX results in female offspring and XY results in male offspring. Therefore, in each pregnancy there is always 50 percent probability of either a male or a female child.

17. (c): The given karyotype shows trisomy of 21 chromosome and two X chromosomes, thus, affected individual is a female with "Down's syndrome".

18. The given disorder is Down's Syndrome.

Symptoms: The affected individual is short statured with small round head; has furrowed tongue; partially open mouth; palm is broad with characteristic palm crease;

physical, psychomotor and mental development is retarded.

19. (a) X-linked, recessive trait

(b) 100%

(c) Genotype of offsprings 1, 2, 3 and 4 in III generation would be XY, X^aX^a, X^ay and XX respectively where 'a' represents the trait.

OR

(c) The possibility of the female getting the trait is less. The female will get the trait only if the mother is atleast a carrier and the father is affected.