CHAPTER

4 Principles of Inheritance and Variation

4.1. Mendel's Laws of Inheritance

1. Given below are two statements:

Statement I: Mendel studied seven pairs of contrasting traits in pea plants and proposed the Laws of Inheritance.

Statement II: Seven characters examined by Mendel in his experiment on pea plants were seed shape and colour, flower colour, pod shape and colour, flower position and stem height.

In the light of the above statements, choose the correct answer from the options given below:

(A) Both Statement I and Statement II are incorrect.

(B) Statement I is correct but Statement II is incorrect.

(C) Statement I is incorrect but Statement II is correct.

(D) Both Statement I and Statement II are correct.

[NEET 2022]

2. The number of contrasting characters studied by Mendel for his experiments was:

(A) 14 (B) 4

(C) 2 (D) 7

[NEET Oct. 2020, AIPMT 2015]

3. How many true breeding pea plant varieties did Mendel select as pairs, which were similar except in one character with contrasting traits?

(A) 2 (B) 14

(C) 8 (D) 4 **[NEET Sept. 2020]**

4. Which one from those given below is the period of Mendel's hybridisation experiments?

(A) 1856-1863 (B) 1840-1850

(C) 1857-1869 (D) 1870-1877 **[NEET 2017]**

5. Among the following characters, which one was not considered by Mendel in his experiments on pea?

(A) Stem- Tall or Dwarf

(B) Trichomes- Glandular or Non-glandular

(C) Seed- Green or Yellow

(D) Pod- Inflated or Constricted **[NEET 2017]**

6. In his classic experiments on pea plants, Mendel did not use:

(A) seed colour (B) pod length

(C) seed shape (D) flower position.

[AIPMT Latest July 2015]

7. Which one of the following traits of garden pea studied by Mendel was a recessive feature?

(A) Axial flower position

(B) Green seed colour

(C) Green pod colour

(D) Round seed shape **[AIPMT 2003]**

8. Which of the following character studied by Mendel in garden pea was found to be dominant?

(A) Green seed colour (B) Terminal flower position

(C) Green pod colour (D) Wrinkled seed

[AIPMT 2000]

9. The allele which is unable to express its effect in the presence of another is called:

(A) Co-dominant (B) Supplementary

(C) Complementary (D) Recessive **[AIPMT 1991]**

10. First genetist/Father of genetics is:

(A) De Vries (B) Mendel

(C) Darwin (D) Morgan **[AIPMT 1991]**

11. What is the reason for Mendel's success?

(A) Qualitative analysis of data

(B) Observation of distinct inherited traits

(C) His knowledge of Biology

(D) Consideration of one character at one time

[AIPMT 1988]

4.2. Inheritance of One Gene

12. Match List-I with List-II:

List-I (Type of Inheritance)	List-II (Example)
(a) Incomplete dominance	(i) Blood groups in human
(b) Co-dominance	(ii) Flower colour in *Antirrhinum*
(c) Pleiotropy	(iii) Skin colour in human
(d) Polygenic inheritance	(iv) Phenylketonuria

Choose the correct answer from the options given below:

	(a)	(b)	(c)	(d)
(A)	(iii)	(iv)	(ii)	(i)
(B)	(ii)	(i)	(iv)	(iii)
(C)	(ii)	(iii)	(i)	(iv)
(D)	(iv)	(i)	(iii)	(ii)

[Re-NEET 2024]

13. The mother has A+ blood group, the father has B+ and the child is A+. What can be the possible genotypes of all three respectively?

(I) $I^AI^A|I^Bi|I^Bi$ (II) $I^AI^A|I^Bi|I^Ai$

(III) $I^Bi|I^AI^A|I^AI^B$ (IV) $I^AI^B|I^BI^B|I^Ai$

(V) $I^Bi|I^Bi|I^Ai$

Choose the correct answer from the options given below:

(A) (III) and (IV) (B) (IV) and (I)

(C) (I) and (II) (D) (II) and (V)

[Re-NEET 2024]

14. Match List I with List II:

List I	List II
(a) Two or more alternative forms of a gene	(i) Back cross
(b) Cross of F_1 progeny with homozygous recessive parent	(ii) Ploidy
(c) Cross of F_1 progency with any of the parents	(iii) Allele
(d) Number of chromosome sets in plant	(iv) Test cross

Choose the correct answer from the options given below:

	(a)	(b)	(c)	(d)
(A)	(ii)	(i)	(iii)	(iv)
(B)	(iii)	(iv)	(i)	(ii)
(C)	(iv)	(iii)	(ii)	(i)
(D)	(i)	(ii)	(iii)	(iv)

[NEET 2024]

15. A pink flowered Snapdragon plant was cross with a red flowered Snapdragon plant. What type of phenotype/s is/ are expected in the progeny?

(A) Red flowered as well as pink flowered plants

(B) Only pink flowered plants

(C) Red, Pink as well as white flowered plants

(D) Only red flowered plants **[NEET 2024]**

16. Which one of the following can be explained on the basis of Mendel's Law of Dominance?

(I) Out of one pair of factors one is dominant and the other is recessive.

(II) Alleles do not show any expression and both the characters appear as such in F_2 generation.

(III) Factors occur in pairs in normal diploid plants.

(IV) The discrete unit controlling a particular character is called factor.

(V) The expression of only one of the parental characters in found in a monohybrid cross.

Choose the correct answer from the options given below:

(A) (I), (III), (IV) and (V) only

(B) (II), (III) and (IV) only

(C) (I), (II), (III), (IV) and (V)

(D) (I), (II) and (III) only **[NEET 2024]**

17. As per ABO blood grouping system, the blood group of father is B^+, mother is A^+ and child is O^+. Their respective genotype can be:

(I) $I^Bi / I^Ai / ii$ (II) $I^BI^B / I^AI^A / ii$

(III) $I^AI^B / iI^A / I^Bi$ (IV) $I^Ai / I^Bi / I^Ai$

(V) $iI^B / iI^A / I^AI^B$

Choose the most appropriate answer from options given below:

(A) (II) only (B) (III) and (II) only

(C) (IV) and (V) only (D) (I) only **[NEET 2024]**

18. In a plant, black seed color (BB/Bb) is dominant over white seed color (bb). In order to find the genotype of the black seed plant, with which of the following genotype will you cross it?

(A) bb (B) Bb

(C) BB/Bb (D) BB **[NEET 2024]**

19. Persons with 'AB' blood group are called as "Universal recipients". This is due to:

(A) absence of antigens A and B on the surface of RBCs

(B) absence of antigens A and B in plasma

(C) presence of antibodies, anti-A and anti-B, on RBCs

(D) absence of antibodies, anti-A and anti-B in plasma.

[NEET 2021, AIPMT 2014]

20. Identify the wrong statement with reference to the gene "I" that controls ABO blood groups.

(A) A person will have only two of the three alleles.

(B) Allele 'I' does not produce any sugar.

(C) The gene 'I' has three alleles.

(D) When I^A and I^B are present together, they express same type of sugar. **[NEET Sept. 2020]**

21. In *Antirrhinum* (snapdragon), a red flower was crossed with a white flower and F_2 generation showed white, red and pink flowers.

Choose the incorrect statement from the following.

(A) Pink colour in F_1 is due to incomplete dominance.

(B) Ratio of F_2 is $\frac{1}{4}$ (Red) : $\frac{2}{4}$ (Pink) : $\frac{1}{4}$ (White).

(C) Law of segregation does not apply in this experiment.

(D) This experiment does not follow the principle of dominance. **[NEET National 2019, AIPMT 1991]**

22. Which one of the following pair is wrongly matched?

(A) XO type sex-determination — Grasshopper

(B) ABO blood grouping — Co-dominance

(C) Starch synthesis in pea — Multiple alleles

(D) T.H. Morgan — Linkage

[NEET 2018]

23. Select the correct statement.

(A) Franklin Stahl coined the term 'linkage'.

(B) Spliceosomes take part in translation.

(C) Punnett square was developed by a British scientist.

(D) Transduction was discovered by S. Altman.

[NEET 2018]

24. Which of the following characteristics represent 'Inheritance of blood groups' in humans?

(I) Dominance

(II) Co-dominance

(III) Multiple allele

(IV) Incomplete dominance

(V) Polygenic inheritance

Choose the correct option:

(A) (II), (IV) and (V) (B) (I), (II) and (III)

(C) (II), (III) and (V) (D) (I), (III) and (V)

[NEET 2018]

25. The genotypes of a husband and wife are I^AI^B and I^Ai. Among the blood types of their children, how many different genotypes and phenotypes are possible?

(A) 3 genotypes ; 3 phenotypes

(B) 3 genotypes ; 4 phenotypes

(C) 4 genotypes ; 3 phenotypes

(D) 4 genotypes ; 4 phenotypes **[NEET 2017]**

26. A tall true breeding garden pea plant is crossed with a dwarf true breeding garden pea plant. When the F_1 plants were selfed the resulting genotypes were in the ratio of:

(A) 1 : 2 : 1 :: Tall heterozygous: Tall homozygous : Dwarf

(B) 3 : 1 :: Tall : Dwarf

(C) 3 :1 :: Dwarf : Tall

(D) 1 : 2 : 1 :: Tall homozygous :Tall heterozygous : Dwarf **[NEET Phase-I 2016]**

27. Match the terms in Column I with their description in Column II and choose the correct option.

Column I	Column II
(a) Dominance	(i) Many genes govern a single character
(b) Co-dominance	(ii) In a heterozygous organism only one allele expresses itself
(c) Pleiotropy	(iii) In a heterozygous organism both alleles express themselves fully
(d) Polygenic inheritance	(iv) A single gene influences many characters

Select the correct option from the following.

	(a)	(b)	(c)	(d)
(A)	(ii)	(iii)	(iv)	(i)
(B)	(iv)	(i)	(ii)	(iii)
(C)	(iv)	(iii)	(i)	(ii)
(D)	(ii)	(i)	(iv)	(iii)

[NEET Phase-I 2016]

28. Alleles are:

(A) different phenotype

(B) true breeding homozygotes

(C) different molecular forms of a gene

(D) heterozygotes. **[AIPMT Cancelled 2015]**

29. A gene showing co-dominance has:

(A) one allele dominant on the other

(B) alleles tightly linked on the same chromosome

(C) alleles that are recessive to each other

(D) both alleles independently expressed in the heterozygote. **[AIPMT Latest July 2015]**

30. If two persons with 'AB' blood group marry and have sufficiently large number of children, these children could be classified as 'A' blood group : 'AB' blood group : 'B' blood group in 1 : 2 : 1 ratio. Modern technique of protein electrophoresis reveals presence of both 'A' and 'B' type proteins in 'AB' blood group individuals. This is an example of:

(A) co-dominance (B) incomplete dominance

(C) partial dominance (D) complete dominance.

[NEET 2013]

31. Which Mendelian idea is depicted by a cross in which the F_1 generation resembles both the parents?

(A) Incomplete dominance

(B) Law of dominance

(C) Inheritance of one gene

(D) Co-dominance

[NEET 2013]

32. A certain road accident patient with unknown blood group needs immediate blood transfusion. His one doctor friend at once offers his blood. What was the blood group of the donor?

(A) Blood group B (B) Blood group AB

(C) Blood group O (D) Blood group A

[AIPMT Screening 2012, 11]

33. F_2 generation in a Mendelian cross showed that both genotypic and phenotypic ratios are same as 1 : 2 : 1. It represents a case of:

(A) codominance

(B) dihybrid cross

(C) monohybrid cross with complete dominance

(D) monohybrid cross with incomplete dominance.

[AIPMT Screening 2012]

34. A test cross is carried out to:

(A) determine the genotype of a plant at F_2

(B) predict whether two traits are linked

(C) assess the number of alleles of a gene

(D) determine whether two species or varieties will breed successfully **[AIPMT Mains 2012]**

35. Test cross in plants or in *Drosophila* involves crossing:

(A) between two genotypes with recessive trait

(B) between two F_1 hybrids

(C) the F_1 hybrid with a double recessive genotype

(D) between two genotypes with dominant trait.

[AIPMT Mains 2011]

36. In *Antirrhinum*, two plants with pink flowers were hybridized. The F_1 plants produced red, pink and white flowers in the proportion of 1 red, 2 pink and 1 white. What could be the genotype of the two plants used for hybridization? Red flower colour is determined by RR, and white by rr genes.

(A) rrrr (B) RR

(C) Rr (D) rr **[AIPMT Mains 2011]**

37. A cross in which an organism showing a dominant phenotype is crossed with the recessive parent in order to know its genotype is called:

(A) monohybrid cross (B) back cross

(C) test cross (D) dihybrid cross.

[AIPMT Mains 2011]

38. ABO blood grouping is controlled by gene I, which has three alleles and show co-dominance. There are six genotypes. How many phenotypes in all are possible?

(A) Six (B) Three

(C) Four (D) Five

[AIPMT Mains 2011, 10]

39. The most popularly known blood grouping is the ABO grouping. It is named ABO and not ABC, because 'O' in it refers to having:

(A) other antigens besides A and B on RBCs

(B) over dominance of this type on the genes for A and B types

(C) one antibody only-either anti-A or anti-B on the RBCs

(D) no antigens A and B on RBCs.

[AIPMT Screening 2009]

40. Read the following statement, if incorrect, correct it by changing only underlined words.

In garden pea, dwarf plants are hybrid and when they are crossed with each other, they produce 50% dwarf plants.

(A) Tall, 25% (B) Tall, 50%

(C) Dwarf 100% (D) It is correct

[AIPMT Mains 2009 (Mod.)]

41. A common test to find the genotype of a hybrid is by:

(A) crossing of one F_2 progeny with female parent

(B) studying the sexual behaviour of F_1 progenies

(C) crossing of one F_1 progeny with male parent

(D) crossing of one F_2 progeny with male parent.

[AIPMT 2007]

42. In pea plants, yellow seeds are dominant to green. If heterozygous yellow seeded plant is crossed with a green seeded plant, what ratio of yellow and green seeded plants would you expect in F_1 generation?

(A) 9 : 1 (B) 1 : 3

(C) 3 : 1 (D) 50 : 50. **[AIPMT 2007]**

43. Test cross involves:

(A) crossing between two genotypes with dominant trait

(B) crossing between two genotypes with recessive trait

(C) crossing between two F_1 hybrids

(D) crossing the F_1 hybrid with a double recessive genotype. **[AIPMT 2006]**

44. A gene is said to be dominant if:

(A) it expresses its effect only in the homozygous stage

(B) it expresses its effect only under heterozygous condition

(C) it expresses its effect both under homozygous and heterozygous conditions

(D) it never expresses its effect under any condition.

[AIPMT 2002, 92]

45. When dominant and recessive alleles express itself together it is called:

(A) Dominance (B) Co-dominance

(C) Amphidominance (D) Pseudodominance

[AIPMT 2001]

46. Hybridisation between Tt × tt gives rise to the progeny of ratio:

(A) 1:1 (B) 1:2:1

(C) 1:2 (D) 4:1 **[AIPMT 1999]**

47. With respect to the ABO group, there are four major blood types because this blood group is determined by:

(A) three alleles, all of which are recessive

(B) three alleles, of which, two are recessive and third is dominant

(C) three alleles, of which, two are co-dominant and third is recessive

(D) three alleles, all of which are co-dominant

[AIPMT 1998]

48. A child of blood group O cannot have parents of blood groups:

(A) AB and AB/O (B) A and B

(C) B and B (D) O and O **[AIPMT 1994]**

49. Which type of progeny indicates that the man is not homozygous, if a man with blood group A marries AB blood group woman?

(A) AB (B) B

(C) A (D) O **[AIPMT 1993, 91]**

50. An allele is dominant if it is expressed in:

(A) both homozygous and heterozygous states

(B) second generation

(C) heterozygous combination

(D) homozygous combination **[AIPMT 1992]**

51. What will be the genotype of the father, if a child of blood group O has B-group father?

(A) I^OI^O (B) I^BI^B

(C) I^AI^B (D) I^BI^O **[AIPMT 1992]**

52. An organism with two identical alleles is:

(A) dominant (B) hybrid

(C) heterozygous (D) homozygous

[AIPMT 1992]

53. RR (red) *Antirrhinum* is crossed with WW (white) one. Offsprings RW are pink. This is an example of:

(A) Dominant-recessive (B) Incomplete dominance

(C) Hybrid (D) Supplementary genes

[AIPMT 1991]

54. In Mendelian crosses, the contrasting pairs of factors are called:

(A) Alloloci (B) Paramorphs

(C) Multiple alleles (D) Allelomorphs

[AIPMT 1991]

55. Blue colour eye is recessive to brown eye colour. A brown eyed man whose mother was blue eyed marries a blue eyed woman. The children shall be:

(A) all brown eyed

(B) all blue eyed

(C) blue eyed and brown eyed 3:1

(D) both blue eyed and brown eyed 1:1 **[AIPMT 1991]**

56. Multiple alleles control inheritance of:

(A) phenylketonuria (B) colour blindness

(C) sickle-cell aneamia (D) blood groups.

[AIPMT 1991]

57. ABO blood group system is due to:

(A) Incomplete dominance

(B) Multiple allelism

(C) Epistasis

(D) Multifactor inheritance **[AIPMT 1990]**

58. Haploids are able to express both recessive and dominant alleles/mutations because there is/are:

(A) only one allele in a gene

(B) two alleles for each gene

(C) many alleles for each gene

(D) only one allele for each gene in the individual

[AIPMT 1988]

4.3. Inheritance of Two Genes

59. When a tall pea plant with round seeds was selfed, it produced the progeny of:

(I) tall plants with round seeds and

(II) tall plants with wrinkled seeds.

Identify the genotype of the parent plant.

(A) TtRr (B) TtRR

(C) TTRR (D) TTRr **[Re-NEET 2024]**

60. Frequency of recombination between gene pairs on same chromosome as a measure of the distance between genes to map their position on chromosome, was used for the first time by:

(A) Alfred Sturtevant

(B) Henking

(C) Thomas Hunt Morgan

(D) Sutton and Boveri **[NEET 2023]**

61. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Mendel's law of independent assortment does not hold good for the genes that are located closely on the same chromosome.

Reason (R): Closely located genes assort independently.

In the light of the above statements, choose the correct answer from the options given below.

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

(B) (A) is correct, but (R) is not correct.

(C) (A) is not correct, but (R) is correct.

(D) Both (A) and (R) are correct and (R) is the correct explanation of (A). **[NEET 2022]**

62. Chromosomal theory of inheritance was proposed by:

(A) Sutton and Boveri (B) Bateson and Punnett

(C) T.H. Morgan (D) Watson and Crick.

[NEET Oct. 2020]

63. Experimental verification of the chromosomal theory of inheritance was done by:

(A) Sutton (B) Boveri

(C) Morgan (D) Mendel.

[NEET Sep. 2020]

64. What map unit (Centimorgan) is adopted in the construction of genetic maps?

(A) A unit of distance between two expressed genes representing 100% cross over.

(B) A unit of distance between genes on chromosomes representing 1% cross over.

(C) A unit of distance between genes on chromosomes representing 50% cross over.

(D) A unit of distance between two expressed genes representing 10% cross over.

[NEET National 2019]

65. A woman has an X-linked condition on one of her X chromosomes. This chromosome can be inherited by:

(A) only grand children (B) only sons

(C) only daughters (D) both (B) and (C).

[NEET 2018]

66. In a test cross involving F_1 dihybrid flies, more parental-type offspring were produced than the recombinant type offspring. This indicates:

(A) chromosomes failed to separate during meiosis.

(B) the two genes are linked and present on the same chromosome.

(C) both of the characters are controlled by more than one gene.

(D) the two genes are located on two different chromosomes. **[NEET Phase-I 2016]**

67. Multiple alleles are present:

(A) on different chromosomes

(B) at different loci on the same chromosome

(C) at the same locus of the chromosome

(D) on non-sister chromatids. **[AIPMT Cancelled 2015]**

68. Which of the following statement is not true of two genes that show 50% recombination frequency?

(A) The genes may be on different chromosomes.

(B) The genes are tightly linked.

(C) The genes show independent assortment.

(D) If the genes are present on the same chromosome, they undergo more than one crossovers in every meiosis. **[NEET 2013]**

69. The fruit fly, *Drosophila melanogaster* was found to be very suitable for experimental verification of chromosomal theory of inheritance by Morgan and his colleagues because:

(A) it reproduces parthenogenetically

(B) a single mating produces two young flies

(C) smaller female is easily recognisable from larger male

(D) it completes life cycle in about two weeks.

[AIPMT Mains 2011]

70. Select the correct statement from the ones given below with respect to dihybrid cross.

(A) Tightly linked genes on the same chromosome show higher recombinations.

(B) Genes far apart on the same chromosome show very few recombinations.

(C) Genes loosely linked on the same chromosome show similar recombinations as the tightly linked ones.

(D) Tightly linked genes on the same chromosome show very few recombinations. **[AIPMT Screening 2010]**

71. Select the incorrect statement from the following.

(A) Linkage is an exception to the principle of independent assortment in heredity.

(B) Galactosemia is an inborn error of metabolism.

(C) Small population size results in random genetic drift in a population.

(D) Baldness is a sex limited trait.

[AIPMT Screening 2009]

72. Two genes R and Y are located very close on the chromosomal linkage map of maize plant. When RRYY and rryy genotypes are hybridized, the F_2 segregation will show:

(A) segregation in the expected 9 : 3 : 3 : 1 ratio

(B) segregation in 3 : 1 ratio

(C) higher number of the parental types

(D) higher number of the recombinant types.

[AIPMT 2007]

73. A human male produces sperms with the genotype AB, Ab, aB, and ab pertaining to two diallelic characters in equal proportions. What is the corresponding genotype of this person?

(A) AaBB (B) AABb

(C) AABB (D) AaBb **[AIPMT 2007]**

74. Phenotype of an organism is the result of:

(A) genotype and environment interactions

(B) mutations and linkages

(C) cytoplasmic effects and nutrition

(D) environmental changes and sexual dimorphism.

[AIPMT 2006]

75. Which one of the following is the most suitable medium for culture of *Drosophila melanogaster*?

(A) Cow dung (B) Moist bread

(C) Agar agar (D) Ripe banana

[AIPMT 2006]

76. How many different kinds of gametes will be produced by a plant having the genotype AABbCC?

(A) Two (B) Three

(C) Four (D) Nine

[AIPMT 2006, 98]

77. In Mendel's experiments with garden pea, round seed shape (RR) was dominant over wrinkled seeds (rr), yellow cotyledon (YY) was dominant over green cotyledon (yy). What are the expected phenotypes in the F_2 generation between cross RRYY × rryy?

(A) Round seeds with yellow cotyledons, and wrinkled seeds with greeen cotyledons.

(B) Only round seeds with green cotyledons.

(C) Only wrinkled seeds with yellow cotyledons.

(D) Only wrinkled seeds with green cotyledons.

[AIPMT 2006]

78. In order to find out the different types of gametes produced by a pea plant having the genotype AaBb it should be crossed to a plant with the genotype:

(A) AABB (B) AaBb

(C) aabb (D) aaBB. **[AIPMT 2005]**

79. Lack of independent assortment of two genes A and B in fruit fly, *Drosophila* is due to:

(A) repulsion (B) recombination

(C) linkage (D) crossing over.

[AIPMT 2004]

80. Recombination crossing over that results in genetic recombination in higher organisms occurs between:

(A) sister chromatids of a bivalent

(B) non-sister chromatids of a bivalent

(C) two daughter nuclei

(D) two different bivalents. **[AIPMT 2004]**

81. In a plant, red fruit (R) is dominant over yellow fruit (r) and tallness (T) is dominant over shortness (t). If a plant with RRTt genotype is crossed with a plant that is *rrtt*,

(A) 25% will be tall with red fruit

(B) 50% will be tall with red fruit

(C) 75% will be tall with red fruit

(D) all the offspring will be tall with red fruit.

[AIPMT 2004]

82. The linkage map of X-chromosome of fruitfly has 66 units, with yellow body gene (y) at one end and bobbed hair (b) gene at the other end. The recombination frequency between these two genes (y and b) should be:

(A) 66 % (B) > 50 %

(C) ≤ 50 % (D) 100% **[AIPMT 2003]**

83. The genes controlling the seven pea characters studied by Mendel are now known to be located on how many different chromosomes?

(A) Seven (B) Six

(C) Five (D) Four **[AIPMT 2003]**

84. When a cluster of genes show linkage behaviour they:

(A) do not show a chromosome map

(B) show recombination during meiosis

(C) do not show independent assortment

(D) induce cell division. **[AIPMT 2003]**

85. Pattern baldness, moustaches and beard in human males are examples of:

(A) sex limited traits

(B) sex linked traits

(C) sex determining traits

(D) sex differentiating traits **[AIPMT 2003]**

86. Genetic map is one that:

(A) shows the stages during the cell division

(B) shows the distribution of various species in a region

(C) establishes sites of the genes on a chromosome

(D) establishes the various stages in gene evolution

[AIPMT 2003]

87. A plant is of F_1 generation with genotype AABbCC. On selfing of this plant, what is the phenotypic ratio in F_2 generation?

(A) 3 : 1 (B) 1 : 1

(C) 9 : 3 : 3 : 1 (D) 27 : 9 : 9 : 9 : 3 : 3 : 3 : 1

[AIPMT 2002]

88. There are three genes a, b and c. The percentage of crossing over between a and b is 20%, b and c is 28% and a and c is 8%. What is the sequence of genes on chromosome?

(A) b, a, c (B) a, b, c

(C) a, c, b (D) None **[AIPMT 2002]**

89. Which of these do not follow independent assortment?

(A) Linked genes on same chromosome.

(B) Unlinked gene on same chromosome.

(C) Genes on non-homologous chromosomes and absence of linkage.

(D) Genes on homologous chromosomes.

[AIPMT 2001]

90. What shall be the genotype of progeny in a cross between AB/ab and ab/ab, if A and B genes are linked?

(A) AAbb and aabb (B) AaBb and aabb

(C) AABB and aabb (D) None of these

[AIPMT 2001]

91. If Mendel had studied the seven traits using a plant with 12 chromosomes instead of 14, in what way would his interpretation have been different?

(A) He would have discovered sex-linkage.

(B) He would have mapped the chromosomes.

(C) He would not have discovered the law of independent assortment.

(D) He would have discovered blending or incomplete dominance. **[AIPMT 1998]**

92. Crossing over in diploid organism is responsible for:

(A) Dominance of genes

(B) Linkage between genes

(C) Segregation of alleles

(D) Recombination of linked alleles **[AIPMT 1998]**

93. In a dihybrid cross AABB x aabb, F_2 progeny of AABB, AABb, AaBB and AaBb occurs in the ratio of:

(A) 1:1:1:1 (B) 9:3:3:1

(C) 1:2:2:1 (D) 1:2:2:4 **[AIPMT 1994]**

94. Which of the following is suitable for experiment on linkage?

(A) aaBB × aaBB (B) AABB × aabb

(C) AaBb × AaBb (D) AAbb × AaBB

[AIPMT 1993]

95. Mendel studied inheritance of seven pairs of traits in pea which can have 21 possible combinations. If in one of these combinations, independent assortment is not observed in later studies, what will be your reaction?

(A) Independent assortment principle may be wrong.

(B) It is impossible.

(C) Mendel might not have studied all the combinations.

(D) Later studies may be wrong. **[AIPMT 1993]**

96. Two dominant non-allelic genes are 50 map units apart. The linkage is:

(A) *cis* type (B) *trans* type

(C) complete (D) absent/incomplete

[AIPMT 1993]

97. Segregation of Mendelian factors (no linkage, no crossing over) occurs during:

(A) Anaphase-I (B) Anaphase-II

(C) Diplotene (D) Metaphase-I

[AIPMT 1992]

98. In a cross between AABB x aabb, the ratio of F_2 genotypes between AABB, AaBB, Aabb and aabb would be:

(A) 9:3:3:1 (B) 2:1:1:2

(C) 1:2:2:1 (D) 7:5:3:1 **[AIPMT 1992]**

99. Mendel's last law is:

(A) segregation

(B) dominance

(C) independent assortment

(D) polygenic inheritance. **[AIPMT 1991]**

100. A dihybrid condition is:

(A) ttRr (B) Ttrr

(C) ttrr (D) TtRr **[AIPMT 1991]**

4.4. Polygenic Inheritance

101. Given below are two statements:

Statement I: When many alleles of a single gene govern a character, it is called polygenic inheritance.

Statement II: In Polygenic inheritance, the effect of each allele is additive.

In the light of above statements, choose the correct answer from the options given below:

(A) Statement I is true but Statement II is false.

(B) Statement I is false but Statement II is true.

(C) Both Statement I and Statement II are true.

(D) Both Statement I and Statement II are false.

[Re-NEET 2024]

102. Inheritances of skin colour in humans is an example of:

(A) point mutation (B) polygenic inheritance

(C) codominance (D) chromosomal aberration.

[AIPMT 2007, 06, 1999, 93]

4.5. Pleiotropy

103. The phenomenon of pleiotropism refers to:

(A) A single gene affecting multiple phenotypic expression.

(B) More than two genes affecting a single character.

(C) Presence of several alleles of a single gene controlling a single crossover.

(D) Presence of two alleles, each of the two genes controlling a single trait. **[NEET 2023]**

104. The best example for pleiotropy is:
(A) skin colour (B) phenylketonuria
(C) colour blindness (D) ABO blood group.
[NEET Oct. 2020]

105. Which of the following is the example of pleiotropic gene?
(A) Haemophilia (B) Thalassemia
(C) Sickle cell anaemia (D) Colour blindness
[AIPMT 2002]

106. A single gene influences more than one traits. It is called:
(A) Epistasis (B) Pleiotropy
(C) Pseudodominance (D) None of these
[AIPMT 1998]

4.6. Sex-determination

107. XO type of sex-determination can be found in:
(A) Birds (B) Grasshoppers
(C) Monkeys (D) *Drosophila* **[NEET 2022]**

108. Match the items of Column I with Column II.

Column I	Column II
(a) XX-XO method of sex determination	(i) Turner's syndrome
(b) XX-XY method of sex determination	(ii) Female heterogamety
(c) Karyotype-45	(iii) Grasshopper
(d) ZW-ZZ method of sex-determination	(iv) Female homogamety

Select the correct option from the following.

	(a)	(b)	(c)	(d)
(A)	(ii)	(iv)	(i)	(iii)
(B)	(i)	(iv)	(ii)	(iii)
(C)	(iii)	(iv)	(i)	(ii)
(D)	(iv)	(ii)	(i)	(iii)

[NEET 2020, Odissa 2019]

109. In our society women are blamed for producing female children. Choose the correct answer for the sex-determination in humans.
(A) Due to some defect like aspermia in man
(B) Due to the genetic make up of the particular sperm which fertilizes the egg
(C) Due to the genetic make up of the egg
(D) Due to some defect in the women
[NEET Karnataka 2013]

110. Which one of the following conditions correctly describes the manner of determining the sex in the given example?
(A) XO type of sex chromosomes determine male sex in grasshopper.
(B) XO condition in humans as found in Turner's syndrome, detemines female sex.
(C) Homozygous sex chromosomes (XX) produce male in *Drosophila.*
(D) Homozygous sex chromosomes (ZZ) determine female sex in bird. **[AIPMT Screening 2011]**

111. Which one of the following conditions of the zygotic cell would lead to the birth of a normal human female child?
(A) Two X-chromosomes
(B) Only one Y-chromosome
(C) Only one X-chromosome
(D) One X and one Y-chromosome
[AIPMT Mains 2011]

112. The recessive genes located in X-chromosome humans are always:
(A) lethal (B) sub-lethal
(C) expressed in males (D) expressed in females.
[AIPMT 2004]

113. Two crosses between the same pair of genotypes or phenotypes in which the sources of the gametes are reversed in one cross, is known as:
(A) test cross (B) reciprocal cross
(C) dihybrid cross (D) reverse cross.
[AIPMT 2003]

114. In *Drosophila*, the sex is determined by:
(A) the ratio of number of X-chromosome to the sets of autosomes
(B) X and Y chromosomes
(C) the ratio of pairs of X-chromosomes to the pairs of autosomes
(D) whether the egg is fertilized or develops parthenogenetically. **[AIPMT 2003]**

115. Male XX and female XY sometimes occur due to:
(A) deletion
(B) transfer of segments in X and Y-chromosomes
(C) aneuploidy
(D) hormonal imbalance **[AIPMT 2001]**

116. *Drosophila* flies with XXY genotype are females, but human beings with such genotype are abnormal males. It shows that:
(A) Y-chromosome is female determinating in *Drosophila*
(B) Y-chromosome is essential for sex determination in *Drosophila*
(C) Y-chromosome has no role in sex determination either in *Drosophila* or in human beings
(D) Y-chromosome is male determining in human beings.
[AIPMT 2000]

117. A fruit fly is heterozygous for sex-linked genes, mated with normal female fruit fly. Male specific chromosome will enter egg cell in the proportion:
(A) 1 : 1 (B) 2 : 1
(C) 3 : 1 (D) 7 : 1. **[AIPMT 1997]**

118. Genetic identity of a human male is determined by:
(A) Autosome (B) Nucleosome
(C) Sex chromosome (D) Cell organelles **[AIPMT 1997]**

119. An individual exhibiting both male and female sexual characteristics in the body is known as:
(A) Hermaphrodite (B) Intersex
(C) Gynandromorph (D) Bisexual **[AIPMT 1996]**

120. A fruit fly exhibiting both male and female traits is:
(A) Heterozygous (B) Gynandromorphs
(C) Hemizygous (D) Gynander **[AIPMT 1994]**

121. In human beings, sex is determined:
(A) by ovum
(B) seventh to eight week when genitals differentiate in foetus
(C) at the time of fertilisation
(D) 40 days after fertilisation **[AIPMT 1993]**

122. Genes located on Y-chromosome are:
(A) Mutant genes (B) Sex-linked genes
(C) Autosomal genes (D) Holandric genes **[AIPMT 1994]**

123. Diploid chromosome number in humans is:
(A) 46 (B) 44
(C) 48 (D) 42 **[AIPMT 1989]**

124. A family of five daughters is expecting sixth issue. The chance of its being a son is:
(A) Zero (B) 25%
(C) 50% (D) 100% **[AIPMT 1988]**

4.7. Mutation

125. Genetic variation in a population arises due to:
(A) Reproductive isolation and selection
(B) Recombination only
(C) Mutation only
(D) Mutation as well as recombination **[NEET Karnataka 2013]**

126. Mutations can be induced with:
(A) IAA (B) ethylene
(C) gamma radiations (D) infrared radiations. **[AIPMT Screening 2011]**

127. Haploids are more suitable for mutation studies than the diploids. This is because:
(A) haploids are reproductively more stable than diploids
(B) mutagenes penetrate in haploids more effectively than in diploids
(C) haploids are more abundant in nature than diploids
(D) all mutations, whether dominant or recessive are expressed in haploids. **[AIPMT Screening 2008]**

128. One of the parents of a cross has a mutation in its mitochondria. In that cross, that parent is taken as a male. During segregation of F_2 progenies that mutation is found in:
(A) one-third of the progenies
(B) none of the progenies
(C) all the progenies
(D) fifty percent of the progenies. **[AIPMT 2004]**

129. Which one of the following discoveries resulted in a Nobel Prize?
(A) X-rays induce sex-linked recessive lethal mutations
(B) Cytoplasmic inheritance
(C) Recombination of linked genes
(D) Genetic engineering **[AIPMT 2003]**

130. Minor changes at gene level are described as:
(A) Point mutations (B) Chromosomal mutations
(C) Reverse mutations (D) Forward mutations **[AIPMT 1997]**

131. The most striking example of point mutation is found in a disease called:
(A) Thalassemia (B) Night blindness
(C) Down's syndrome (D) Sickle cell anaemia **[AIPMT 1995]**

4.8. Genetic Disorders

132. Given below are two statements

Statement I: Failure of segregation of chromatids during cell cycle resulting in the gain or loss of whole set of chromosome in an organism is known as aneuploidy.

Statement II: Failure of cytokinesis after anaphase stage of cell division results in the gain or loss of a chromosome is called polyploidy.

In the light of the above statements, choose the correct answer from the options given below:
(A) Statement I is true but Statement II is false.
(B) Statement I is false but Statement II is true.
(C) Both Statement I and Statement II are true.
(D) Both Statement I and Statement II are false. **[Re-NEET 2024]**

133. Aneuploidy is a chromosomal disorder where chromosome number is not the exact copy of its haploid set of chromosomes, due to:

(I) Substitution (II) Addition

(III) Deletion (IV) Translocation

(V) Inversion

Choose the most appropriate answer from the options given below:

(A) (III) and (IV) only

(B) (IV) and (V) only

(C) (I) and (II) only

(D) (II) and (III) only **[Re-NEET 2024]**

134. Match List I with List II:

List I	List II
(a) Down's syndrome	(i) 11^{th} chromosome
(b) α-Thalassemia	(ii) 'X' chromosome
(c) β-Thalassemia	(iii) 21^{st} chromosome
(d) Klinefelter's syndrome	(iv) 16^{th} chromosome

Choose the correct answer from the options given below:

	(a)	(b)	(c)	(d)
(A)	(ii)	(iii)	(iv)	(i)
(B)	(iii)	(iv)	(i)	(ii)
(C)	(iv)	(i)	(ii)	(iii)
(D)	(i)	(ii)	(iii)	(iv)

[NEET 2024]

135. Broad palm with single palm crease is visible in a person suffering from:

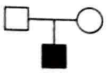
(A) Klinefelter's syndrome

(B) Thalassemia

(C) Down's syndrome

(D) Turner's syndrome **[NEET 2023]**

136. Which one of the following symbols represents mating between relatives in human pedigree analysis?

(A) 

(B) 

(C) 

(D) 

[NEET 2023]

137. Which of the following statements are correct about Klinefelter's Syndrome?

(I) This disorder was first described by Langdon Down (1866).

(II) Such an individual has overall masculine development. However, the feminine development is also expressed.

(III) The affected individual is short-statured.

(IV) Physical, psychomotor and mental development is retarded.

(V) Such individuals are sterile.

Choose the correct answer from the options given below:

(A) (II) and (V) only (B) (I) and (V) only

(C) (I) and (II) only (D) (III) and (IV) only

[NEET 2023]

138. In a cross between a male and female, if both partners are heterozygous for sickle cell anaemia gene what percentage of the progeny will be diseased?

(A) 50% (B) 75%

(C) 25% (D) 100% **[NEET 2021]**

139. In which genetic condition, each cell in the affected person, has three sex chromosomes XXY?

(A) Thalassemia (B) Klinefelter's syndrome

(C) Phenylketonuria (D) Turner's syndrome

[NEET Odisha 2019]

140. Thalassemia and sickle-cell anaemia are caused due to a problem in globin molecule synthesis. Select the correct statement.

(A) Both are due to a qualitative defect in globin chain synthesis.

(B) Both are due to a quantitative defect in globin chain synthesis.

(C) Thalassemia is due to less synthesis of globin molecules.

(D) Sickle-cells anaemia is due to a quantitative problem of globin molecules. **[NEET 2017]**

141. A disease caused by an autosomal primary non-disjunction is:

(A) Down's syndrome (B) Klinefelter's syndrome

(C) Turner's syndrome (D) Sickle-cell anemia.

[NEET 2017]

142. Pick out the correct statements.

(I) Haemophilia is a sex-linked recessive disease.

(II) Down's syndrome is due to aneuploidy.

(III) Phenylketonuria is an autosomal recessive gene disorder.

(IV) Sickle cell anaemia is an X-linked recessive gene disorder.

Choose the correct option:

(A) (II) and (IV) are correct

(B) (I), (III) and (IV) are correct

(C) (I), (II) and (III) are correct

(D) (I) and (IV) are correct **[NEET Phase-I 2016]**

143. Which of the following most appropriately describes haemophilia?

(A) X-linked recessive gene disorder

(B) Chromosomal disorder

(C) Dominant gene disorder

(D) Recessive gene disorder **[NEET Phase-I 2016]**

144. If a colourblind man marries a woman who is homozygous for normal colour vision, the probability of their son being colourblind is:

(A) 0 (B) 0.5

(C) 0.75 (D) 1 **[NEET Phase-II 2016]**

145. An abnormal human baby with 'XXX' sex chromosomes was born due to:

(A) formation of abnormal sperms in the father

(B) formation of abnormal ova in the mother

(C) fusion of two ova and one sperm

(D) fusion of two sperms and one ovum.

[AIPMT Cancelled 2015]

146. A man whose father was colourblind marries a woman, who had a colourblind mother and normal father. What percentage of male children of this couple will be colourblind?

(A) 25% (B) 0%

(C) 50% (D) 75% **[AIPMT 2014]**

147. A human female with Turner's syndrome:

(A) has 45 chromosomes with XO

(B) has one additional X-chromosome

(C) exhibits male characters

(D) is able to produce children with normal husband.

[AIPMT 2014]

148. Which one is the incorrect statement with regard to haemophilia?

(A) It is a sex-linked disease.

(B) It is a recessive disease.

(C) It is a dominant disease.

(D) A single protein involved in the clotting of blood is affected. **[NEET 2013]**

149. If both parents are carriers for thalassemia, which is an autosomal recessive disorder, what are the chances of pregnancy resulting in an affected child?

(A) No chance (B) 50%

(C) 25% (D) 100% **[NEET 2013]**

150. Down's syndrome in humans is due to:

(A) three 'X' chromosomes

(B) three copies of chromosome 21

(C) monosomy

(D) two 'Y' chromosomes. **[NEET Karnataka 2013]**

151. Which one is the incorrect statement with regard to the importance of pedigree analysis?

(A) It confirms that DNA is the carrier of genetic information.

(B) It helps to understand whether the trait in question is dominant or recessive.

(C) It confirms that the trait is linked to one of the autosome.

(D) It helps to trace the inheritance of a specific trait.

[NEET Karnataka 2013]

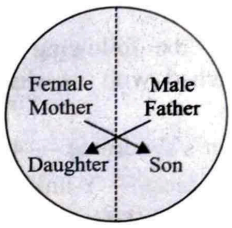
152. A normal-visioned man whose father was colourblind, marries a woman whose father was also colourblind. They have their first child as a daughter. What are the chances that this child would be colourblind?

(A) 100% (B) 0%

(C) 25% (D) 50%

[AIPMT Screening 2012, 1990]

153. Represented below is the inheritance pattern of a certain type of traits in humans. Which one of the following conditions could be an example of this pattern?

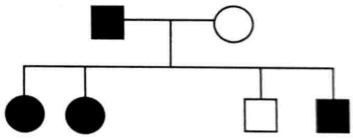


(A) Phenylketonuria (B) Sickle cell anaemia

(C) Haemophilia (D) Thalassemia

[AIPMT Mains 2012]

154. Study the pedigree chart of a certain family given below and select the correct conclusion which can be drawn for the character.



(A) The female parent is heterozygous.

(B) The parents could not have had a normal daughter for this character.

(C) The trait under study could not be colour blindness.

(D) The male parent is homozygous dominant.

[AIPMT Mains 2011]

155. Which one of the following symbols and its representation, used in human pedigree analysis is correct?

(A) □=○ = Mating between relatives

(B) ○ = Unaffected male

(C) □ = Unaffected female

(D) ◆ = Male affected **[AIPMT Screening 2010]**

156. Sickle cell anaemia is:

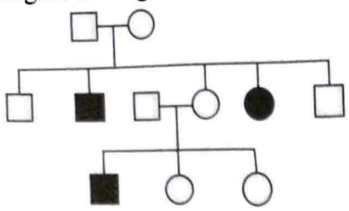
(A) an autosomal linked dominant trait

(B) caused by substitution of valine by glutamic acid in the β-globin chain of haemoglobin

(C) caused by a change in base pair of DNA

(D) characterized by elongated sickle like RBCs with a nucleus. **[AIPMT Screening 2009]**

157. Study the pedigree chart given below.



What does it show?

(A) Inheritance of a sex-linked inborn error of metabolism like phenylketonuria.

(B) Inheritance of a condition like phenylketonuria as an autosomal recessive trait.

(C) The pedigree chart is wrong as this is not possible.

(D) Inheritance of a recessive sex-linked disease like haemophilia. **[AIPMT Screening 2009]**

158. Which one of the following condition in humans is correctly matched with its chromosomal abnormality/ linkage?

(A) Klinefelter's syndrome — 44 autosomes + XXY

(B) Colourblindness — Y-linked

(C) Erythroblastosis foetalis — X-linked

(D) Down's syndrome — 44 autosomes + XO

[AIPMT Screening 2008]

159. Sickle cell anaemia has not been eliminated from the African population because:

(A) it is controlled by dominant genes

(B) it is controlled by recessive genes

(C) it is not a fatal disease

(D) it provides immunity against malaria.

[AIPMT 2006]

160. If a colourblind woman marries a normal visioned man, their sons will be:

(A) all colourblind

(B) all normal visioned

(C) one-half colourblind and one-half normal

(D) three-fourth colourblind and one-fourth normal.

[AIPMT 2006]

161. Both Sickle cell anaemia and Huntington's chorea are:

(A) virus-related diseases

(B) bacteria-related diseases

(C) congenital disorders

(D) pollutant-induced disorders. **[AIPMT 2006]**

162. A woman with normal vision, but whose father was colourblind, marries a colourblind man. Suppose that the fourth child of this couple was a boy. This boy:

(A) may be colourblind or may be of normal vision

(B) must be colourblind

(C) must have normal colour vision

(D) will be partially colour blind since he is heterozygous for the colourblind mutant allele. **[AIPMT 2005]**

163. Which of the following is not a hereditary disease?

(A) Cystic fibrosis (B) Thalassemia

(C) Haemophilia (D) Cretinism **[AIPMT 2005]**

164. Haemophilia is more commonly seen in human males than in human females because:

(A) a greater proportion of girls die in infancy

(B) this disease is due to a Y-linked recessive mutation

(C) this disease is due to an X-linked recessive mutation

(D) this disease is due to an X-linked dominant mutation.

[AIPMT 2005, 1990]

165. A women with 47 chromosomes due to three copies of chromosome 21 is characterized by:

(A) superfemaleness (B) triploidy

(C) Turner syndrome (D) Down's syndrome.

[AIPMT 2005]

166. A man and a woman, who do not show any apparent signs of a certain inherited disease, have seven children (2 daughters and 5 sons). Three of the sons suffer from the given disease but none of the daughters affected. Which of the following mode of inheritance do you suggest for this disease?

(A) Sex-linked dominant

(B) Sex-linked recessive

(C) Sex-limited recessive

(D) Autosomal dominant. **[AIPMT 2005]**

167. A normal woman, whose father was colour-blind is married to a normal man. The sons would be:

(A) 75% colour-blind (B) 50% colour-blind

(C) all normal (D) all colour-blind.

[AIPMT 2004]

168. A male human is heterozygous for autosomal genes A and B and is also hemizygous for haemophilic gene h. What proportion of his sperms will be abh?

(A) 1/8 (B) 1/32

(C) 1/16 (D) 1/4 **[AIPMT 2004]**

169. Which one of the following conditions though harmful in itself, is also a potential saviour from a mosquito borne infectious disease?

(A) Pernicious anaemia (B) Leukaemia

(C) Thalassemia (D) Sickle-cell anaemia

[AIPMT 2003]

170. Down's syndrome is caused by an extra copy of chromosome number 21. What percentage of offspring produced by an affected mother and a normal father would be affected by this disorder?

(A) 100% (B) 75%

(C) 50% (D) 25% **[AIPMT 2003]**

171. Christmas disease is another name for:
(A) haemophilia B (B) hepatitis B
(C) Down's syndrome (D) sleeping sickness.
[AIPMT 2003]

172. Which of the following is a correct match?
(A) Down's syndrome = 21st chromosome
(B) Sickle cell anaemia = X chromosome
(C) Haemophilia = Y chromosome
(D) Parkinson's disease = X and Y chromosomes
[AIPMT 2002]

173. Which of the following is the example of sex-linked disease?
(A) AIDS (B) Colour blindness
(C) Syphilis (D) Gonorrhoea
[AIPMT 2002]

174. Sickle cell anaemia is induced by:
(A) Change of amino acid in α-chain of haemoglobin
(B) Change of amino acid in β-chain of haemoglobin
(C) Change of amino acid in both α- and β-chain of haemoglobin
(D) Change of amino acid in either α- or β-chain of haemoglobin
[AIPMT 2001]

175. Mongoloid idiocy in humans is also known as:
(A) Tay Sachs disease
(B) Klinefelter's syndrome
(C) Down's syndrome
(D) Turner's syndrome **[AIPMT 2000]**

176. One child is haemophilic (sex-linked trait), while its fraternal twin brother is normal. Which one of the following information is most appropriate?
(A) The child is a monozygotic twin.
(B) The mother must have been heterozygous.
(C) The haemophilic child is a male.
(D) The other child is a female and the father is haemophilic. **[AIPMT 1999]**

177. A normal woman whose father was colour blind marries a colour blind man. What proportion of their daughters are expected to be colour blind?
(A) 3/4 (B) 1/2
(C) 1/4 (D) all **[AIPMT 1999]**

178. Haemophilic man marries a normal woman. Their offspring will be:
(A) All boys haemophilic
(B) All normal
(C) All girls haemophilic
(D) All haemophilic **[AIPMT 1999]**

179. A woman with two genes (one on each X-chromosome) for haemophilia and one gene for colour blindness on the chromosomes marries a normal man. How will the progeny be?
(A) All sons and daughters haemophilic and colour blind.
(B) 50% haemophilic colour blind sons and 50% haemophilic sons.
(C) 50% haemophilic daughters and 50% colour blind daughters.
(D) Haemophilic and colour blind daughters.
[AIPMT 1998]

180. Mental retardation in man, associated with sex chromosomal abnormality is usually due to:
(A) increase in X-complement
(B) reduction in X-complement
(C) large increase in Y-complement
(D) moderate increase in Y-complement **[AIPMT 1998]**

181. In Down's syndrome, karyotyping has shown that the disorder is associated with trisomy of chromosome number-21 usually due to:
(A) addition of extra chromosome during mitosis of the zygote
(B) non-disjunction during egg cell formation
(C) non-disjunction during sperm cell formation
(D) non-disjunction during formation of egg cells and sperm cells. **[AIPMT 1998]**

182. Loss of an X-chromosome in a particular cell, during its development, results into:
(A) diploid individual (B) triploid individual
(C) gynandromorphs (D) Both (A) and (B)
[AIPMT 1998]

183. A person with 47 chromosomes due to an additional Y-chromosome suffers from a condition called:
(A) Down's syndrome (B) Super female
(C) Turner's syndrome (D) Klinefelter's syndrome
[AIPMT 1997, 96]

184. If both parents are normal, what is the chance of a male child becoming colour blind:
(A) possible only when mother's father was colour blind.
(B) possible only when all the four grandparents had normal vision
(C) possible only when father's mother was colour blind
(D) none **[AIPMT 1993]**

185. In a normal couple, if half the sons are haemophilic while half the daughters are carriers. The gene is located on:
(A) One X-chromosome of mother
(B) Both the X-chromosomes of mother

(C) X-chromosome of father

(D) Y-chromosome of father **[AIPMT 1993]**

186. A colourblind girl is rare because she will be born only when:

(A) her mother and maternal grandfather were colourblind

(B) her father and maternal grandfather were colourblind

(C) her mother is colour blind and father has normal vision

(D) parents have normal vision but grand parents were colour blind. **[AIPMT 1991]**

187. The sex chromosome in Down's syndrome of a male child is:

(A) XO (B) XY

(C) XX (D) XXY **[AIPMT 1990]**

SOLUTIONS

1. (D) Both statements I and II are correct. Gregor John Mendel proposed the laws of inheritance in living organisms after conducting several hybridisation experiments on garden pea for seven years (1856-1863). He studied seven pairs of contrasting traits in pea plants as described in statement II.

2. (D) Mendel conducted breeding experiments on *Pisum sativum* (garden pea) by selecting 7 pairs of contrasting characters (or 14 characters in total). Every contrasting pair showed dominant-recessive traits and none of them were linked genes.

Caution

Students choose option- 14 instead of 7, as they ignore the difference between the terms traits and characters. A character is a heritable feature that varies among individuals. While, trait is a variant for character which is a distinct variation of a phenotypic characteristic of an organism. Example, height is character, whereas tall, dwarf, intermediate are the traits for the character height.

3. (B) Mendel selected 14 true breeding pea plant varieties, in pairs which were similar except for one character with contrasting trait. A true breeding pea plant refers to homozygous plant, which has undergone continuous self pollination and showed stable trait inheritance and expression for several generations.

4. (A) Mendel is known as the father of Genetics. He hybridised the contrasting characters of pea plant (*Pisum sativum*) and conducted his experiments for around 7 years, between 1856-1863. His work was published in 1865.

Related Theory

Gregor Mendel was an Austrian monk who discovered the basic principles of heredity through experiments in his garden. Mendel's observations became the foundation of modern genetics and the study of heredity, and he is widely considered a pioneer in the field of genetics. Mendel used seven pea plant traits in his experiments which include flower colour (purple or white), flower position (axil or terminal), stem length (long or short), seed shape (round or wrinkled), seed colour (yellow or green), pod shape (inflated or constricted), and pod colour (yellow or green).

5. (B) Trichomes are epidermal tissue structures. When epidermal cells become glandular hair, it is called trichome. This character was not considered by Mendel during his experiment. The traits that Mendel studied are:

(1) Seed shape (round-R or wrinkled-r)

(2) Seed colour (green-y or yellow-Y)

(3) Pod shape (constricted-i or inflated-I)

(4) Pod colour (green-G or yellow-g)

(5) Flower colour (purple-P or white-p)

(6) Stem height (tall-T or dwarf-t)

(7) Flower Position (axial-A or terminal-a)

Related Theory

In pea plant, the locus for flower colour and the locus for pod shape are on the same chromosome i.e., they are linked trait. However Mendel was lucky enough that these linked genes did not inferred with his experiment.

6. (B) In his experiments on pea plant, Mendel did not consider the pod length character for his studies. Instead he used traits related to pods such as pod shape and pod colour.

Related Theory

A trait is a state of a character i.e., it is a distinct variation of a phenotypic characteristic of an organism whereas a character is a recognizable feature, which helps in the identification of the organism.

7. (B) Axial flower position was a dominant trait selected by Mendel in pea plant along with purple flower colour, in case of seed shape round seed with yellow colour the dominant traits with green and wrinkled being recessive traits. In pod colour, green is dominant over yellow.

8. (C) In Mendel's garden pea experiment, green pod colour was a dominant character, in comparison to the yellow pods, which was a recessive trait.

9. (D) In heterozygous condition where both the contrasting alleles are present and only one allele is able to express, called dominant, while the other which remain suppressed is called recessive. It is denoted by a small letter.

10. (B) Gregor John Mendel formulated the laws of heredity and is regarded as the father of genetics. Hugo De Vries gave the mutation theory, *i.e.*, living organisms can develop changes to their genes due to variations, that greatly alter the organism. Charles Robert Darwin gave the theory of evolution and natural selection. Thomas Hunt Morgan is known as the father of experimental genetics. He gave the experimental evidence of the chromosomal theory of inheritance by working on fruit fly, *Drosophila*. He explained the principles of linkage and recombination.

11. (D) Considering one character with two contrasting conditions on one time contributed to Mendel's success in proposing the laws of inheritance of traits. His choice of experimental plant as pea and use of statistical methods also contributed to his success.

12. (B) Flower colour in *Antirrhinum* is an example of incomplete dominance, a genetic condition where both the alleles expressed partly.

The co-dominance is best describes by the Blood group in human, where both the alleles are expressed equally.

Phenylketonuria is a simple example of pleiotropy in which many traits affected by one genes.

Skin colour in humans is the example of polygenic inheritance, which refers to the pattern of inheritance control by more than one gene.

13. (D) Mother with A+ blood group: Possible genotypes are I^AI^A or I^Ai with Rh factor ++ or + −.

Father with B+ blood group: Possible genotypes are I^BI^B or I^Bi with Rh factor ++ or + −.

Child with A+ blood group: Possible genotypes are I^AI^A or I^Ai with Rh factor ++ or + −.

To result in an A+ child, the child must inherit I^A from the mother and either I^A or i from either parent, considering Rh factor from both parents.

The possible combinations from the given options are:

(ii) I^AI^A, I^Bi, I^Ai

(v) I^Ai, I^Bi, I^Ai

14. (B) Allele is the two or more alternative forms of gene.

Test cross is the cross of F_1 progeny with homozygous recessive parent.

Back cross is the cross of F_1 progeny with any of its parents.

Ploidy is the number of sets of chromosomes in a plant.

15. (A) A pink flowered snapdragon plant when crossed with a red flowered snapdragon plant, progeny expected can be shown with the help of following cross:

Pink flowered Snapdragon plant (Rr) × Red flowered Snapdragon plant (RR)

Pink flower

Red flower	R	r
R	RR	Rr
R	RR	Rr

Thus, red flowers and pink flowers appear in the ratio of 1 : 1.

16. (A) Alleles show expression in F_2 generation.

According to Law of Dominance:

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

(2) Factors occur in pairs.

(3) In a dissimilar pair of factors one member of the pair dominates (dominant) the other (recessive).

The law of dominance is used to explain the expression of only one of the parental characters in a monohybrid cross in the F_1 and the expression of both in the F_2. It also explains the proportion of 3:1 obtained at the F_2.

17. (D) Genotype of father with blood group $B^+ = I^Bi/iI^B$

Genotype of mother with blood group $A^+ = I^Ai/iI^A$

Genotype of child with blood group $O^+ = ii$

18. (A) To find out the genotype of the black seed plant, a test cross is performed by crossing the black seeded plant with unknown genotype with the homozygous recessive (bb) plant.

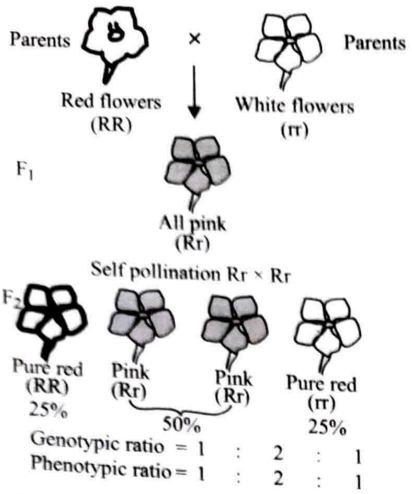
19. (D) In blood group AB, the red blood cells have both A and B antigens, but the plasma does not contain anti-A or anti-B antibodies. Individuals with type AB can receive any ABO blood type.

Related Theory

For blood group O, the plasma contains both anti-A and anti-B antibodies, but the surface of the red blood cells does not contain any A or B antigens. Therefore it is called universal donor.

20. (D) 'When I^A and I^B are present together, they express same type of sugar' is a wrong statement. Gene 'I' controls ABO blood group. I^A and I^B are completely dominant over I^o, but when I^A and I^B are present together, they both express their own types of sugar and thus behaving as co-dominant alleles.

21. (C) *Antirrhinum* (Snapdragon) shows incomplete dominance. Thus, in heterozygous condition, alleles show intermediate trait of the character in F_1 (*i.e.*, pink coloured flowers). Hence, they do not follow the law of dominance. When F_1 plants are self-crossed, reappearance of parental character indicates that the alleles segregate during division. Here the genotypic ratios were similar to any of the Mendelian monohybrid cross but the phenotypic ratios changed from 3 : 1 dominant recessive ratio



22. (C) Starch synthesis in pea is an example of pleiotropy. A pleiotropic gene is a single gene which produces multiple unrelated phenotypes. XO type of sex determination is found in most insects. ABO blood grouping is an example of co-dominance where A and B groups are co-dominant genes. It also shows multiple allelism. T.H. Morgan discovered linkage in *Drosophila*.

Related Theory

Starch synthesis in pea seeds is controlled by one gene. It has two alleles - B and b. In BB (dominant homozygotes) and therefore, large starch grains are produced while bb homozygotes have lesser efficiency in starch synthesis and produce smaller starch grains. After maturation of the seeds, BB seeds are round and the bb seeds are wrinkled. Heterozygotes produce round seeds, and so B seems to be the dominant allele. But, the starch grains produced are of intermediate size in Bb seeds showing incomplete dominance.

Caution

Students often get confused between multiple allelism and pleiotropy. In multiple allelism, multiple genes affects the one phenotypic character, while in pleiotropy, single gene affect multiple phenotypic characters.

23. (C) Punnett Square was devised by a British genetist, Reginald C. Punnett (1927). It is a checker-board for the graphical representation of the result of a cross between two organisms. It represents the probability of all the possible genotypes and phenotype of the progeny.

Related Theory

Franklin Stahl proved the semi-conservative replication of DNA along with Matthew Meselson. Spliceosome is formed during post-transcriptional changes in eukaryotes. It is a complex formed between 5'end (GU) and 3'end (AG) of intron to remove it. Transduction was discovered by Zinder and his teacher Lederberg (1952) in Salmonella typhimurium. It is a method of sexual reproduction in Bacteria, which involves the transfer of foreign genes by means of viruses.

24. (B) In humans, blood group is determined by the presence of either two of the three alleles, *i.e.*, I^A, I^B and I^o (multiple alleles). Alleles I^A and I^B are co-dominant to gene I^o. Incomplete dominance is when a gene, does not completely mask the effects of other allele, resulting physical appearance showing a blending of both alleles. In polygenic inheritance, multiple genes affects the single phenotype.

25. (C) The cross between the husband with genotype I^AI^B and wife with I^Ai can be represented as:

	I^A	I^B
I^A	I^AI^A Blood group A	I^AI^B Blood group AB
i	I^Ai Blood group A	I^Bi Blood group B

Genotypes: I^AI^A, I^AI^B, I^Ai, I^Bi

Phenotypes: Blood group A, B and AB

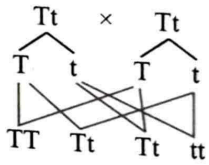
26. (D) Parent -TT × tt

(Tall) (Dwarf)

F_1 generation - Tt (Heterozygous tall)

On selfing

Gametes



F_2 generation TT Tt Tt tt

Phenotypic ratio = 3 : 1 [Tall : Dwarf]

Genotypic ratio = 1 : 2 : 1 [Homozygous tall : Heterozygous tall : Homozygous dwarf]

27. (A) Dominance means only one allele express itself during heterozygous condition. Co-dominance occurs when both the allele express itself equally, when together. Pleiotropy is the condition where single gene exhibit multiple phenotypic expression. Polygenic inheritance occurs when multiple genes affect the expression of single character.

28. (C) An allele is one of the two or more forms of the same gene at the same place on a chromosome.

29. (D) In co-dominance the alleles of a gene pair in a heterozygote are equally expressed. As a result, the phenotype of the offspring is a combination of the phenotype of both the parents. Thus, the trait is neither dominant nor recessive. When one allele is dominant to the other, it is called as dominant allele, showing dominance. While, when allele is recessive to the other, then it is a recessive allele. When alleles are tightly linked on each other, then they show linkage.

Caution

➥ *Students often get confused between co-dominance and incomplete dominance. In co-dominance, both alleles in the genotype are seen in the phenotype. In incomplete dominance, a mixture of the alleles in the genotype is seen in the phenotype.*
Case I: *male is I^AI^A and female is I^BI^B*

30. (A) AB blood group is characterised by the presence of both antigen A and B *i.e.*, I^A and I^B over the surface of RBCs. Here, both alleles are able to express themselves forming antigens A and B. This is called as co-dominance.

31. (D) In co-dominance, both alleles of a pair express themselves fully in F_1 hybrid, so it resembles both its parents. In complete dominance, the two genes of allelomorphic pair are not related as dominant or recessive but each of them express itself partially. Law of dominance states that when a cross is made between two homozygous individuals considering contrasting trait of simple character then the trait that appear in F_1 hybrids is called dominant. Inheritance of one gene is based on crossing between single traits.

32. (C) Blood group O negative is a universal donor, while Blood group AB positive is a universal acceptor. Blood Group O negative have no antigens and hence can be transfused to any patient, while blood group AB positive have antigen A, B and Rh, but no antibodies, hence can receive blood from any group type.

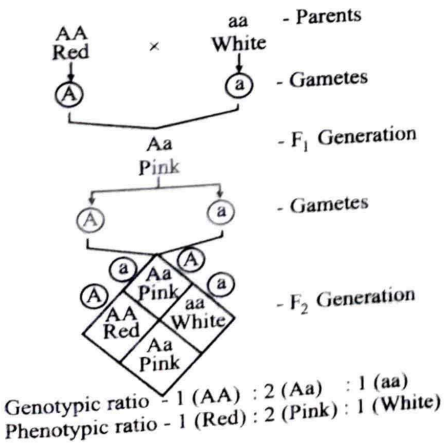
Caution

➥ *Always remember the donors' antigens reacts with recipients' antibodies.*

Mnemonics

➥ ***RaBied DoG:***
Recipient – *anti**B**odies*
Donor – *anti**G**ens*

33. (D) Monohybrid cross with incomplete dominance shows both genotypic and phenotypic ratio as 1:2:1.



Genotypic ratio - 1 (AA) : 2 (Aa) : 1 (aa)
Phenotypic ratio - 1 (Red) : 2 (Pink) : 1 (White)

With complete dominance, phenotypic ratio is 3:1 and genotypic ratio is 1:2:1. In dihydrid cross, the number of progenies formed is 16, not 4. In co-dominance, the genotypic ratio and phenotypic ratio will be 1: 2 :1.

Caution

➥ *In case of multiple allelism, one cannot assess generalised phenotypic and genotypic ratio from a single cross, as it changes with each different pair of alleles.*

34. (A) By performing a test cross, one can determine whether the individual is homozygous or heterozygous dominant. Since the homozygous recessive individual can only pass on recessive alleles, the allele the individual in question passes on determines the phenotype of the offspring. The test cross can be used to support the idea that the reappearance of the recessive character in the F_2 generation is due to the heterozygous condition of the F_1 plant.

Related Theory

➥ *The difference between test cross and the back cross is that test cross is used to discriminate the genotype of an individual which is phenotypically dominant whereas a back cross is used to recover an elite genotype from a parent which bears an elite genotype.*

35. (C) Irrespective of an organism, test cross involves the crossing between the F_1 hybrid and recessive parent.

Related Theory

➥ *The purpose of a test cross is to determine if this individual is homozygous dominant or heterozygous.*

36. (C) Parents Rr (Pink) × Rr (Pink)

	R	r
R	RR (Red)	Rr (Pink)
r	Rr (Pink)	rr (White)

The parents have pink flowers.

This is the case of incomplete dominance.

37. (C) Test cross is a cross between an organism with unknown genotype and a recessive parent. Back cross include cross of F_1 with any of the parents *i.e.*, (Tt × tt) or (Tt × TT). A monohybrid cross is defined as the cross happening in the F_1 generation, offspring of parents differing in one trait only. A dihybrid cross is a cross happens F_1 generation, offspring of parents differing in two traits.

38. (C) ABO Blood Grouping

Blood group	Antigen(s) present on the red blood cells	Antibodies present in the serum	Geno-type(s)
A	A antigen	Anti-B	AA or AO
B	B antigen	Anti-A	AB or BO
AB	A antigen and B antigen	None	AB
O	None	Anti-A and Anti-B	OO

Blood Group A, B, AB and O are four possible phenotypes.

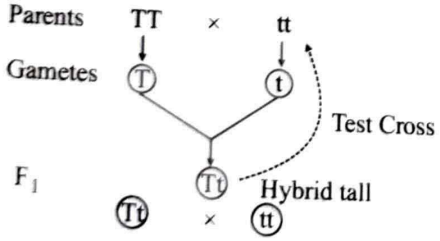
39. (D) Landsteiner divided human population into four groups based on the presence of antigens found in their RBCs. Each group represented a blood group. Thus, there are four types of blood groups A, B, AB and O. Blood group O does not contain any antigen on RBCs.

40. (A) When tall hybrid plants of garden pea are crossed with each other, they produce 25% dwarf plants.

41. (C) A common test to find the genotype of a hybrid is a test cross. Here, F_1 hybrids are crossed with the recessive parent. Phenotypic ratios of 1:1 confirm that the F_1 hybrid is heterozygous.

Related Theory

➥ ***Test cross:***

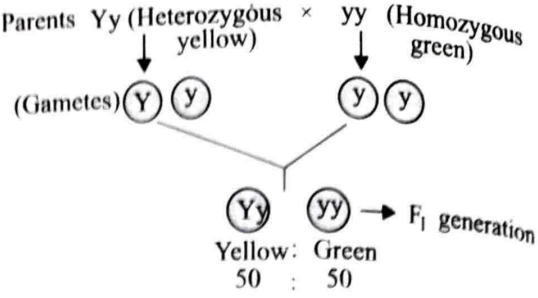


♀ / ♂	T	t
t	Tt Tall	tt Dwarf
t	Tt Tall	tt Dwarf

Caution

➥ *This is a misleading question. Students consider the question as wrong, as they miss the word recessive parent. However, they do not realise that test cross is cross between F_1 hybrid progeny with recessive parent, and F_1 is only present in option (C).*

42. (D)



43. (D) Test cross is a cross between an organism with unknown genotype and a recessive parent. It is used to determine whether an individual is homozygous or heterozygous for a trait.

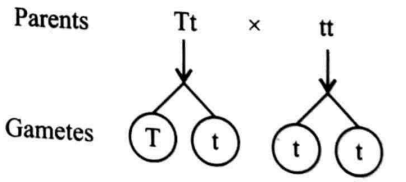
44. (C) A dominant allele is expressed in homozygous as well as heterozygous condition. A recessive trait is only expressed in the homozygous condition.

45. (B) According to the principle of dominance, out of the two factors of alleles representing different traits of a character, only one expresses itself. But when both alleles express themselves together it is co-dominance.

Related Theory

➥ *Pseudodominance is the situation in which the inheritance of a recessive trait mimics a dominant pattern. This mainly occurs with sex-linked genes. Amphidominance is defined as the sudden appearance of a resessive phenotype in a pedigree, due to deletion of a masking dominant gene.*

46. (A) Cross between Tt and tt:



	T	t
t	Tt Tall	tt Dwarf
t	Tt Tall	tt Dwarf

Tall : Dwarf
50 : 50
1 : 1

Offsprings with genotypes Tt (heterozygous tall) and tt (homozygous dwarf) are produced in the ratio 1:1.

47. (C) Blood group is determined by three alleles – I^A, I^B, and I^O. Allele I^A and I^B are co-dominant. Blood group A is determined by I^AI^A or $I^A I^O$. Blood group B is I^BI^B or I^BI^O. Blood group O is I^OI^O. Blood group AB is I^AI^B.

48. (A) The inheritance of blood group of a child is determined by allelic genes I^A, I^B and I^O. In an individual two allelic genes are present, where I^A and I^B are dominant over I^O, which is recessive in heterozygous condition. So if one of the parent either mother or father is of blood group AB, then she or he will have both genes, *i.e.*, I^A and I^B and a child of such parent cannot have blood group O, because he or she must have the genes I^OI^O and thus cannot have the parents of blood group AB and AB/O.

49. (B) Blood groups of offspring from parents having A and AB blood groups are A and AB. These parents cannot have children possessing blood group O. AB blood group parent is heterozygous while A blood group parent can be either homozygous or heterozygous. If the male parent with blood group A is homozygous no child with blood group B will be born. Only blood group B of progeny shows that male parent is heterozygous because in blood group B, allele 'i' is present.

$$\left.\begin{array}{rl} \text{Man (A): } I^AI^O \longrightarrow I^AI^A \longrightarrow & A \\ \longrightarrow I^AI^B \longrightarrow & AB \\ \text{Woman (AB): } I^AI^O \longrightarrow & A \\ \longrightarrow I^BI^O \longrightarrow & B \end{array}\right] \text{ all show heterozygous}$$

OR

$$\left.\begin{array}{rl} I^AI^A \longrightarrow I^AI^A \longrightarrow & A \\ I^AI^B \longrightarrow & AB \\ I^AI^B \longrightarrow I^AI^A \longrightarrow & A \\ I^AI^B \longrightarrow & AB \end{array}\right]$$

50. (A) An alternative form of a character in a pair, controlled by a single gene is called an allele. Dominant alleles express itself both in the homozygous as well as heterozygous condition. It is denoted by a capital letter.

51. (D) The genotype of the child would be I^OI^O (recessive). The father with B group can have the genotype I^OI^B or I^BI^B.

I^OI^O – Blood group O,

I^BI^B – Blood group B,

I^AI^B – Blood group AB,

I^BI^O – Blood group B.

52. (D) An organism with two identical alleles is homozygous, *e.g.*, rr, tt, RR, TT, *etc.*

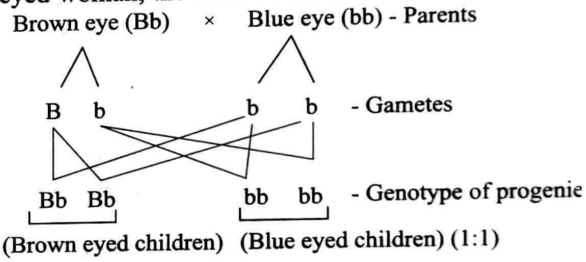
Related Theory

Homozygous individuals have identical Mendelian factors or alleles for a character (TT or tt). They are always pure for a particular trait or character.

53. (B) The pink colour of an offspring is an example of incomplete dominance, in which the expression of the characters in F_1 individual is intermediate of the factors found in homozygous condition. Here, both the genes are not able to express themselves completely.

54. (D) Two allelomorphs or alleles are the different forms of a gene which are responsible for different expression or traits of the same characters, e.g., colour of flower is R and *r*. Alleles are different forms of a gene present in the same locus, on a homologous pair of chromosomes. Multiple allelism occurs when two or more than two gene forms exist for the same locus. Alleles with different loci are alloloci. Paramorphs is a kind of pseudomorph in which there has been a change of physical characteristics without alterations of chemical composition.

55. (D) A brown eyed man, whose mother was blue eyed must have the genotype Bb, where B represents brown eye colour and b represents blue eye colour. When a man of such genotype will marry a blue eyed woman, the children shall be



56. (D) Multiple allelism is responsible to control inheritance of blood groups in humans. A gene can have more than two alleles or allelomorphs, which can be expressed by mutation in more than one ways. These alleles or allelomorphs make a series of multiple alleles. A well-known example of multiple allelism is the inheritance of ABO blood group in human beings.

57. (B) A gene may have more than two alternative forms occupying the same locus on a chromosome. Such alleles are known as multiple alleles and the phenomenon is known as multiple allelism. ABO blood group has three alleles – I^O, I^A or A and I^B or B. Incomplete dominance is the appearance of new phenotypes in the progeny, which does not resemble either of the parents, e.g., Snapdragon flower with pink progeny. Epistasis is the process in which a gene masks the action of another gene, e.g,, skin colour in mice. Multifactor inheritance, also called polygenic inheritance. Controlling of a character by two or more genes is called multifactor inheritance, *e.g.*, Sickle cell anaemia.

58. (D) In haploid organisms, every gene, irrespective of dominant or recessive and every mutation finds expression because there is only one allele for each gene in the haploid individual. Recessive allele is able to express as there is no alternative dominant allele for producing its masking effect on recessive allele. Hybrid is an organism containing two different alleles or individual containing both dominant and recessive genes of an allelic pairs.

59. (D) According to the type of given progeny *i.e.*, Tall round and Tall wrinkle the genotype of the parent will be TTRr.

Selfing TTRr × TTRr

F_1 generation

	TR	Tr
TR	TTRR	TTRr
Tr	TTRr	TTrr

Genotype : TTRR: TTRr: TTrr

Phenotype : Tall and round: Tall and round : Tall and wrinkle

60. (A) Alfred Sturtevant was the first person to use the frequency of recombination between gene pairs on the same chromosome as a measure of the distance between genes to map their position on the chromosome. He was a student of Thomas Hunt Morgan, who pioneered the study of genetics using the fruit fly *Drosophila melanogaster* as a model organism. Sturtevant was a member of Morgan's lab at Columbia University and worked on mapping the genes on the chromosomes of *Drosophila*.

61. (B) Mendel's law of independent assortment does not imply for the genes that are located closely on the same chromosome. These genes are called 'linked genes'. Closely located genes do not assort independently and distantly located genes assort independently, due to recombination. Linkage map, therefore corresponds to the arrangement of genes on the chromosome.

62. (A) Sutton and Boveri gave the chromosomal theory of inheritance, which states that genes are found at specific locations on chromosomes, and the behaviour of chromosomes during meiosis can explain Mendel's laws of inheritance. Bateson and Punnett discovered linkage. T.H. Morgan confirmed the chromosomal theory of inheritance with the experiment on *Drosophila melanogaster* (fruit fly). Watson and Crick gave the double helical structure of DNA.

Related Theory

The chromosomal theory of inheritance states that chromosomes are the basis for all genetic inheritance. The chromosomal theory of inheritance is based on a few fundamental principles:

(1) Chromosomes contain the genetic material.

(2) Chromosomes are replicated and passed on from parents to offspring.

(3) The nuclei of most eukaryotic cells contain chromosomes that are found in homologous pairs.

(4) During the formation of gametes, non-homologous chromosomes segregate independently.

(5) Each parent contributes one set of chromosomes to its offspring.

63. (C) Thomas Hunt Morgan experimentally verified the Chromosomal Theory of Inheritance, given by Sutton and Boveri. Mendel gave three principles of genetics, namely Law of Dominance, Law of Segregation and Law of Independent Assortment.

Related Theory

Thomas Hunt Morgan used Drosophila melanogaster (fruit fly) to show how sexual reproduction gave rise to variations. Morgan conducted dihybrid cross between yellow-bodied, white-eyed females and brown-bodied, red-eyed males. Interestingly, the self-crossing of F_1 generation gave an F_2 generation but not in the ratio of 9:3:3:1. The result showed a deviation from Mendel's dihybrid cross. If two genes were present on the same chromosome, the probability of getting a parental combination was much higher in the next generation as compared to the non-parental combination. This physical association of genes was termed as linkage. In addition, he noted that the probability of recombination is dependent on how strong the linkage is.

Caution

Students should remember that Sutton and Boveri gave the Chromosomal Theory of Inheritance and T.H. Morgan gave experimental basis of the theory with the help of Drosophila melanogaster.

64. (B) Map unit or centimorgan is the unit of distance between genes on chromosomes.

i.e., 1 map unit = 1% cross over

Hence, the genetic distance between genes is based on average of cross over frequency between them.

Related Theory

In genetics, a centimorgan (abbreviated cM) or map unit (m.u.) is a unit for measuring genetic linkage. It is defined as the distance between chromosome positions (also termed as loci or markers) for which the expected average number of intervening chromosomal crossovers in a single generation is 0.01. Map units can be determined by calculating the percent recombination (recombination frequency) between the two genes on the chromosome. 1% recombination is equal to one map unit, 2% recombination is equal to two map units, and so forth.

Caution

Student should remember that more the value of map unit, more is the recombination frequency.

65. (D) Woman is a carrier of X-linked condition, when one of her chromosome is abnormal. She can transmit the carrier allele to both her son and daughter.

66. (B) When two genes are situated on a same chromosome, then during a cross, the ratio of parental type progenies is much higher than non-parental/recombinant type. Such genes are said to be linked genes. When two genes are situated on different chromosomes, then the ratio of non-parental type is much higher. When chromosome failed to separate during mitosis it is known as non-disjunction of chromosome. When one character is controlled by more than one gene it is said to be polygenic character.

67. (C) In a diploid organism, there are two alleles for each gene. Multiple allelism is a term used to describe a condition in which a gene exists in more than two allelic variants. The presence of three or more alleles for a gene is known as 'multiple alleles'. Multiple alleles are found at the same locus of the homologous chromosomes.

68. (B) When genes are tightly linked, then they show 100% parental types and no recombinant type progenies. For 50% recombinant frequencies, genes are either on non-homologous chromosomes or on homologous chromosomes located much far from each other. When present on same chromosomes, they undergo more than one crossover in every meiosis. As the distance between genes increases, crossover frequency also increases and shows independent assortment.

Related Theory

- *The frequency of recombination or the crossing over of any two genes is the number of crossovers formed between them. It is directly proportional to the distance between the two genes. Frequency of crossing over is used as an index of relative distances between the genes on a chromosome.*
- $$\textit{Frequency of Recombination} = \frac{\textit{(No. of Recombinants in the progeny of test cross}}{\textit{Total no. of progeny of the test cross)}}$$

69. (D) T.H. Morgan used fruit flies for his genetical experiments for the following reasons:

(1) Fruit flies have a short life cycle (2 weeks) so genetic traits can be studied in many generations in a short span.

(2) They reproduce sexually and produce many offspring from single mating.

(3) They have four pairs of polytene chromosomes which are large and can be easily seen under a light microscope.

(4) They have three pairs of autosomes and a pair of sex chromosomes.

(5) Sexual dimorphism is present. Female is larger, while male is smaller.

Related Theory

- *At the time of experiment, Morgan already knew that X and Y have to do with gender. He used normal flies with red eyes and mutated flies with white eyes and cross bred them. In flies, the wild type eye color is red (XW) and is dominant to white eye color (Xw). He was able to conclude that the gene for eye color was on the X chromosome. This trait was thus determined to be X-linked and was the first X-linked trait to be identified. Males are said to be hemizygous, in that they have only one allele for any X-linked characteristic.*

70. (D) Genes that are present on the same chromosome and are tightly linked which shows very few recombination as they are linked genes. Whereas genes that are not close to each other or which are loosely linked shows a higher degree of recombination between them.

Related Theory

- *The phenomenon of linkage has great significance as it reduces the possibility of variability in gametes and retains parental combination unless crossing over separates the linked genes.*

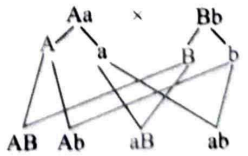
71. (D) Baldness is not a sex-limited trait, but a sex influenced trait. Linkage is an exception to Mendelian principle. Galactosemia is a hereditary disease that is caused by the lack of a liver enzyme required to digest galactose. Small population size results in random genetic drift in population.

Related Theory

- *Sex-linked traits are determined by genes located on the sex chromosomes. Sex-limited traits are determined by genes located on autosomes and express only in one sex. Sex-influenced traits do not show distinctive expression between women and men.*

72. (C) When the linked genes are situated quite close, the chances of crossing over are highly reduced. Due to this, large number of parental gametes are formed and only few recombinant gametes are formed. This results in higher number of parental types in F_2 generation as compared to recombinants.

73. (D) As the person produces sperm having both the alleles for both the characters. So the person must be heterozygous for both the genes, hence, the genotype will be AaBb.



74. (A) Phenotype all the observable characteristics of an organism that result from the interaction of its genotype (total genetic inheritance) with the environment. Examples of observable characteristics include behaviour, biochemical properties, colour, shape, and size.

75. (D) *Drosophila melanogaster* is commonly called fruit fly and is often used in genetic and developmental biology research. Ripe bananas are ideal for the culture of this fly.

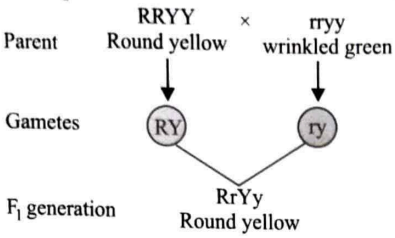
76. (A) Number of types of gametes = 2^n

Where, n = number of heterozygous pair

Number of types of gametes = $2^1 = 2$

The gametes are ABC and AbC.

77. (A) When a cross (dihybrid) is made between plants bearing round yellow (RRYY) and wrinkled green (rryy) seeds, all the plants in F_1 are round yellow but in F_2 generation, the ratio of the phenotype is 9:3:3:1 as shown by the below cross.



	RY	rY	Ry	ry	
RY	RRYY Round yellow	RrYY Round yellow	RRYy Round yellow	RrYy Round yellow	9/16 Yellow-round
rY	RrYY Round yellow	rrYY Wrinkled yellow	RrYy Round yellow	rrYy Wrinkled yellow	3/16 Green-round
Ry	RRYy Round yellow	RrYy Round yellow	RRyy Round green	Rryy Round green	3/16 Yellow-wrinkled
ry	RrYy Round yellow	rrYy Wrinkled yellow	Rryy Round green	rryy Wrinkled green	1/16 Green-wrinkled

78. (C) A test cross is an experimental cross of an individual organism of dominant phenotype but unknown genotype and an organism with a homozygous recessive genotype (and phenotype). It determines whether the individual with dominant phenotype is homozygous dominant or heterozygous dominant, by determining its genotype.

Related Theory

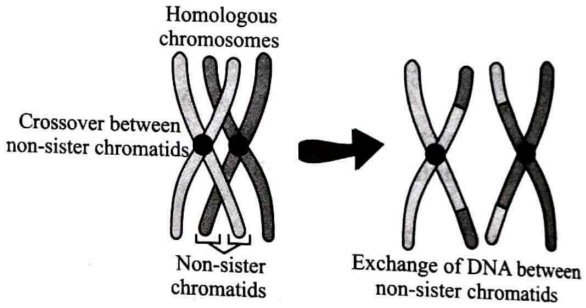
The purpose of the test cross is to determine the genetic makeup of the dominant organism. Mendel wanted to do this so that he could be sure he was working with a dominant organism which was homozygous, or contained only dominant alleles. However, the phenotype alone doesn't tell you the genotype of an organism.

79. (C) Sex linkage was discovered by Thomas H. Morgan. He discovered it by conducting experiments on eye character in fruit fly, *Drosophila*. Independent assortment of genes does not occur during cell division.

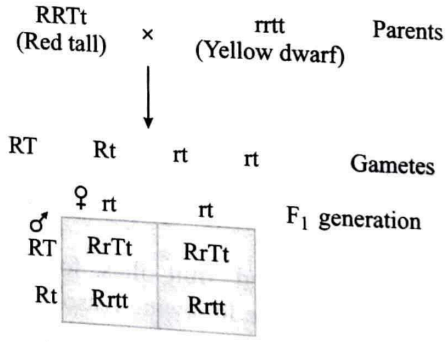
Related Theory

Coupling and repulsion are two aspects of gene linkages. Coupling is the presence of two dominant alleles of two genes on the same chromosome (AB). The remaining recessive genes of the two genes are present on the other chromosome (ab). Hence, the dominant alleles of genes tend to remain together. Repulsion is the presence of dominant genes on the two homologous chromosomes (Ab/aB).

80. (B) Crossing over is the exchange of chromosomal segments between non-sister chromatids of homologous chromosomes during the production of gametes. It occurs during pachytene stage.



81. (B)



Conclusion:

(1) All plants are red.

(2) 50% are red tall.

(3) 50% are red dwarf.

82. (C) The yellow body gene (y) and bobbed hair (B) gene are present 66 map unit apart which means that there is ≤ 50% chances of recombination between them (recombination frequency).

Related Theory

One map unit is equal to 1% recombination frequency. This linear relationship holds true for lower values only; as the

recombination frequency increases beyond 50%, the linear relationship does not hold true owing to double and multiple cross overs and recombination frequency is always less than map distance and never exceeds more than 50%.

83. (D) Mendel studied the following genes (the dominant trait is given first).

Chromosome 1: Purple/white flowers; Yellow/ green peas.

Chromosome 4: Axial/terminal flowers; Tall/short plant; Inflated/constricted pods.

Chromosome 5: Green/yellow pods.

Chromosome 7: Round/wrinkled seeds

Related Theory

- *Mendel studied inheritance in peas (Pisum sativum). He chose peas because they had been used for similar studies, are easy to grow and can be sown each year. Pea flowers contain both male and female parts, called stamen and stigma respectively, and usually self-pollinate.*

84. (C) Genes present near each other have less probability of being separated onto different chromatids during chromosomal crossover. Therefore, when a cluster of genes show linkage behaviour, they do not show independent assortment.

Related Theory

- *The strength of linkage between two genes is inversely proportional to the distance between them in the chromosome i.e., it decreases with increase in distance between the genes. It ensures the maintenance of parental trait in the offspring and reduces the chance of creation of variability with sexual reproduction.*

85. (A) Sex limited traits are those which are limited to one sex only. Moustaches and beard are found in human males only. It was suggested on the basis of statistical analysis that premature baldness is controlled by a dominant gene, which expresses only in the presence of a certain level of male hormone (androgen). Sex linked traits are the ones that are influenced by genes carried on the sex chromosomes like sickle cell anaemia and colour blindness. These are said to be linked because more males (XY) develop these traits than females (XX). Sex determining traits determine the sex of an individual organism.

86. (C) The relative position of genes on the chromosomes is represented by a diagram called genetic map. The first genetic map was prepared by Strutevant in 1911 while studying the two chromosomes of a fruit fly.

87. (A) The genotype of F_1 generation is AABbCC

Number of gametes that are obtained by crossing can be obtained by formula = 2^n

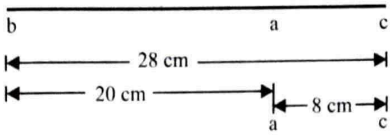
(where n represents the number of heterozygous gametes)

Thus, the number of heterozygous gametes = $2^1 = 2$

2 gametes formed are: ABC and AbC.

On self crossing F_1 generation, the phenotypes that are formed in F_2 generation are in the ratio of 3:1.

88. (A) The sequence of a, b, c gene is b, a, c.



89. (A) 'Linked' genes situated on the same chromosome cannot separate during gametes formation and hence cannot assort independently.

90. (B) Linked genes occur on the same chromosome and do not separate during inheritance (complete linkage).

AB ab × ab ab

♀ / ♂	ab	ab
AB	AaBb	AaBb
ab	aabb	aabb

Genotype is AaBb and aabb

91. (C) If Mendel would have studied a plant with seven traits in 12 chromosomes instead of 14, he would have come across the linked genes and hence he would not have arrived at the principle of independent assortment.

92. (D) Crossing over in diploid organisms is responsible for recombination of linked alleles. Crossing over is the reciprocal exchange of segments between non-sister chromatids of a pair of homologous chromosomes.

Related Theory

- *In organisms, one chromosome equals one linkage group. A diploid organism has a pair of similar chromosomes called homologous chromosomes. Traits are always represented in pairs along the same loci of the homologous chromosomes and each chromosome has multiple traits, represented by genes, which forms the linkage group.*
- *The exchange of genetic matter takes place between two non-sister chromatids of a homologous pair during the prophase I (pachytene phase) of meiosis I. This exchange of genetic matter during crossing over changes the composition of the linkage group and is responsible for the recombination of linked alleles.*

93. (D) Genotype is the genetic makeup of an organism. The given 4 genotypes AABB, AABb, AaBB and AaBb will be in the ratio of 1:2:2:4. In a dihybrid cross the genotypic ratio can be represented as follows, when a cross is made between AABB and aabb.

AABB × aabb — Parents
AB ↓ ab — Gametes
AaBb — F_1 - generation
Selfing ↓ — F_2 - generation

	AB	Ab	aB	ab
AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBB	aaBb
ab	AaBb	Aabb	aaBb	aabb

So, the ratio of AABB, AABb, AaBB and AaBb will be 1:2:2:4.

94. (B) Due to linkage, the genes present on the same chromosome stay together during transmission. AABB × aabb is suitable for experiment on linkage. All other combinations show recombination and thus does not show linkage and hence not suitable for experiment on linkage.

Related Theory

Linkage is defined as the tendency of two genes of the same chromosome to remain together in the process of inheritance.

95. (C) Law of independent assortment is applicable to only those genes which are located on different chromosomes, so if in one of the combination independent assortment is not observed that means Mendel might not have studied all the combinations. Probably, the characters were present on the same chromosome and showed linkage, which Mendel might not have studied.

96. (D) Chromosome mapping is based on two genetic principles. They are:

(1) Genes are arranged in the linear order in the chromosome.

(2) The frequency of crossing over between two genes is directly proportional to the distance between them on the chromosome.

When both dominant or recessive allelic genes are located on the same chromosome, the arrangement is called *cis* arrangement. In *trans* type linkage both recessive and dominant allelic genes are expressing different characteristics on the same chromosome. Complete linkage shows alleles within the same chromosome that are near to each other but do not exhibit crossover. So 50 map unit distance between the genes is sufficient enough to change the *cis* arrangement into *trans* and vice-versa. So there is no fixed linkage present.

97. (A) At the end of anaphase-I, two groups of chromosomes (one at each pole) are segregated. Each such group is having half the original no. of chromosomes present in the parent nucleus. So, anaphase-I results in the reduction of chromosome no. to half and segregation of Mendelian factors.

Caution

Students should remember at anaphase-I actual segregation occurs but two similar alleles occur in the dyad chromosome which separate at anaphase-II.

98. (C) Genotype is the genetic makeup of an individual irrespective of the Mendelian characters or genes impressing. In a dihybrid cross the genotypic ratio can be represented as follows.

Assuming a cross between AABB and aabb

Parent: AABB × aabb

Gametes: (AB) ↓ (ab)

F_1: AaBb

	AB	Ab	aB	ab
AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBb	aaBb
ab	AaBb	Aabb	aaBb	aabb

So the ratio of AABB, AaBB, Aabb and aabb would be 1:2:2:1.

99. (C) Law of independent assortment is the Mendel's last law of inheritance. This principle states that when two individuals differ from each other in two or more pairs of factors, the inheritance of one pair is quite independent of the inheritance of the other.

100. (D) Dihybrid condition means simultaneous transmission of two pairs of genes. Therefore, the dihybrid condition is TtRr.

101. (B) Polygenic inheritance refers to the inheritance of a trait governed by more than one gene.

102. (B) Inheritance of skin colour in human is controlled by three pairs of genes, A, B and C which is polygenic inheritance. Co-dominance is shown by blood group AB. Chromosomal aberration and point mutation change the genetic sequence of human genome.

Related Theory

Polygenic inheritance refers to the kind of inheritance in which the trait is produced from the cumulative effects of many genes in contrast to monogenic inheritance in which the trait results from the expression of one gene (or one gene pair). Polygenic inheritance is a Non-Mendelian form since it is controlled by multiple genes at different loci on different chromosomes expressed together in the same trait. Some examples of polygenic inheritance are: human skin and eye colour; height, weight and intelligence in people; and kernel colour of wheat

103. (A) Pleiotropy is a genetic effect that occurs when a single gene affects multiple, seemingly unrelated traits. In other words, a single gene influences multiple phenotypic trait. For example, sickle cell anemia is a human genetic disorder caused by a single gene mutation that affects multiple traits, including the shape of red blood cells, the risk of infection, and susceptibility to malaria.

104. (B) Phenylketonuria is an example of pleiotropy. Skin colour is an example of polygenic inheritance. Colour blindness is an X-linked inheritance. ABO blood group is an example of multiple alleles, co-dominant inheritance.

Related Theory

Pleiotropy is the phenomenon in which the single gene has multiple effects on a phenotype. The common example of pleiotropy is phenylketonuria. There is a single gene which can control the various chemical reactions involved in the metabolism of phenylalanine. Mutation in the gene can result in phenylketonuria (PKU).

Caution

Students often get confused between pleiotropic inheritance and polygenic inheritance. In pleiotropy, single genes express the multiple phenotypes while in polygenic inheritance, multiple genes determine the expression of single phenotype.

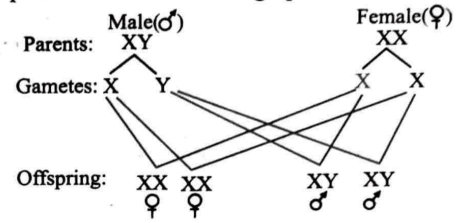
105. (C) Sickle cell anaemia is an example of pleiotropic gene because here the mutation in the single gene carries out a number of changes throughout the body and affects the body in different ways.

106. (B) Pleiotropy is the condition in which a single gene influences more than one traits or multiple phenotypic expressions, *e.g.*, gene for single cell produces anaemia as well as resistance to malaria. Epistasis occurs when two or more separate genes interact to control a single trait. Genes at two or more different loci in an organism's DNA interactively contribute to the same phenotype. Pseudodominance involves the phenotypic expression of a recessive allele, when the dominant allele has been lost due to deletion. If the lost segment contains dominant alleles, the recessive phenotype is expressed. Pseudodominance is similar to the hemizygous condition.

107. (B) The XO type of sex determination is found in grasshoppers, crickets, cockroaches and some other insects. In this system, there is only one sex chromosome, referred to as X. The females are homogametic, *i.e.*, they produce only one single type of chromosome that is XX, whereas males have only one X chromosome (XO).

108. (C) XX-XO method of sex determination is seen in crickets, grasshoppers, and some other insects, where males have only one X chromosome while females have one pair of X chromosomes. XX-XY method of sex determination is seen in humans, where male is heterogametic (XY) while female is homogametic (XX). Karyotype-45 is found in females suffering from Turner's syndrome, with 45 + XO. ZW-ZZ method of sex determination is found in fowls, where male is homogametic (ZZ) while female is heterogametic (ZW).

109. (B) In human beings both females and males have the same number of chromosomes (23 pairs). Females are homogametic with XX chromosomes (22 pairs + XX). They produce ova having X chromosome. All ova are similar. Males are heterogametic with X and Y-chromosomes (22 pairs + XY). They produce two kinds of sperms, one type with X-chromosome and other with Y-chromosome. On fertilization, the zygotes may have either the XX or XY. The zygote with XX becomes the female and the zygote with XY becomes the male. The sex of the offspring depends on the fertilizing sperm.



110. (A) In insects (*e.g.*, grasshoppers), XO type of sex determination is present. All the eggs have an additional X-chromosome besides the autosomes. Some sperms bear X-chromosome where as some do not. Turner's syndrome is not a manner of sex determination. In *Drosophila*, sex determination is achieved by a balance of female determinants on the X chromosome and male determinants on the autosomes. In birds, ZZ condition determines males and ZW determines female.

Related Theory

Chromosomal Sex Determination in Drosophila

X chromo-somes	*Autosome sets (A)*	*X:A ratio*	*Sex*
3	*2*	*1.50*	*Metafemale*
4	*3*	*1.33*	*Metafemale*
3	*3*	*1.00*	*Normal female*
2	*2*	*1.00*	*Normal female*
2	*3*	*0.66*	*Intersex*
1	*2*	*0.50*	*Normal male*
1	*3*	*0.33*	*Metamale*

111. (A) In human beings and insects like *Drosophila*, females are homogametic with XX chromosomes. They produce ova having X chromosome. All ova are similar. Males are heterogametic with X and Y-chromosomes. They produce two kinds of sperms, one type with X-chromosome and other with Y-chromosome.

Related Theory

The sex of the offspring depends on the fertilizing sperm. In the case of human beings, a single gene (SRY) on the Y-chromosome determines maleness. The SRY gene that acts as a switch for other sex determining genes. This gene activates in the embryo so that it develops as a male and dismantles all female embryonic structures.

112. (C) In human, male sex chromosome is heterozygous, XY while female is homozygous XX. Thus, any recessive gene present on X chromosome will get expressed in male. In female, those genes can only be expressed if present in homozygous recessive condition on both X-chromosomes.

113. (B) Reciprocal cross is the cross, with the phenotype of each sex reversed as compared with the original cross, to test the role of parental sex on inheritance pattern.

Related Theory

Forward genetics is the examination of the genetic cause of an altered or abnormal phenotype introduced by a chemical mutagenesis or mutation by irradiation (e.g., phenotype → genotype). In reverse genetics, a particular gene is altered and the phenotype is investigated (e.g., genotype → phenotype).

114. (A) In *Drosophila*, sex is primarily determined by the X:Y ratio, or the ratio of the number of X chromosomes to the number of sets of autosomes not because of the presence of a Y chromosome as in human sex determination. Although the Y chromosome is entirely heterochromatic, it contains at least 16 genes, many of which are thought to have male-related functions.

Related Theory

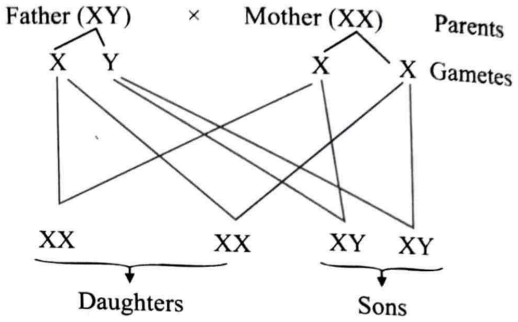
In butterflies, sex is determined by chromosome differences. But unlike in humans with the familiar X and Y, in butterflies, it is the females that determine the sex of offspring. Males are ZZ, while females are ZW.

115. (D) Hormonal imbalance may lead to development of male characters in female or vice-versa. Deletion is the removal of one or few nitrogenous bases from a nucleotide chain. Aneuploidy is chromosomal aberration in which certain chromosomes are present in extra copies or certain are deficient in number.

116. (D) In human beings, there are X and Y sex chromosomes. The presence of Y-chromosome is required for the development of male sex phenotype. X-chromosomes present in any number (XXX, XXXX) in the absence of Y-chromosome gives rise to female. Presence of even a single Y-chromosome confers maleness. In *Drosophila*, Y-chromosome plays no significant role in sex determination. In *Drosophila*, male determines are located on autosomes. One X and two autosomes produce male while two X (XX) and two autosomes produce female.

117. (A) In *Drosophila*, female possesses two homomorphic sex chromosomes, (XX) and the male contains two heteromorphic sex chromosomes (XY). The differential or non-homologous region of Y-chromosome is mostly heterochromatic. The female parent produces only one type of eggs (22 + X). The male parent produces two types of gametes (22 + Y) and (22 + X). They are produced in equal proportions. As the two types of sperms are produced in equal proportions, there are equal chances of getting a male or female fly in a particular mating.

118. (C) Genetic identity of a human male is determined by sex chromosomes. Sex of the child is determined at the time of fertilization. If male gamete containing X-chromosome fertilizes the ovum, the child would be female, If Y-chromosome does it, the child would be male.



119. (C) Hermaphrodite or bisexual refers to an organism having both male and female sex organs. Intersex is a group of condition in which there is a discrepancy between the external genitals and the internal genitals (the testies and ovaries). Gynandromorph is individual who exhibits both male and female characteristics. They are typically male in certain portions of the body and typically females in the other portions. The cases of gynandromorphs has been reported in man, *Drosophila*, silkworm, bees, butterflies, beetles, *etc*.

120. (B) An individual exhibiting both male and female characteristics is known as gynandromorph (In Greek, 'gyne' means female, 'andro' means male and 'morphe' means form). These characteristics can be seen in man, butterflies, beetles, bees, fruit fly, silkworm, *etc*. Here both the male and female characterisitics can be seen physically because of sexual dimorphism. A gynandromorphy can have bilateral symmetry, one side female and one side male or they can be mosaic, where two sexes are not defined clearly.

121. (C) Sex of human baby is determined by the karyotype of the zygote or fertilised egg. Sex of the baby depends on the sperm which fertilises the ovum.

122. (D) Sex-linked genes are the one which are located and inherited with sex chromosomes. Since both X and Y chromosomes serve as sex chromosomes in animals, sex-linked genes can be present on both X and Y chromosomes. Holandric genes are the sex-linked genes which are present on Y chromosome specific loci only and thus are transmitted from father to son. Any chromosome other than sex chromosome is

referred to as autosome which controls normal traits of the organism and the genes present on autosomes are called autosomal genes. Y-chromosome is the sex chromosome. Any gene both autosomal and sex-linked genes, that has undergone mutation obtains a mutant gene which in turn codes for mutant mRNA and thus mutant polypeptide.

123. (A) Chromosomes occur in homologous pairs. Somatic cells have diploid no. of chromosomes. Humans have 23 pairs *i.e.*, 46 chromosomes, 22 pairs of autosomes and one pair of sex chromosomes *i.e.*, XX in females and XY in males.

124. (C) In human beings there are 22 pairs of autosomes and one pair of sex chromosome. Female is homozygous while male is heterozygous and genetically responsible for sex of a child. Sperms are of two types, *i.e.*, sperm having X-chromosome is responsible for a female child and sperm having Y-chromosome is responsible for producing a male child. Hence, chances of a baby to be either boy or a girl is always 50%.

125. (D) Crossing over leads to recombination of genetic material on the two chromosomes. Mutation results in alternation of DNA sequences and consequently results in change in the genotype and the phenotype of an organism. In addition to recombination, mutation is another phenomenon that leads to variation in DNA.

126. (C) Gamma radiations are ionizing radiations and are physical mutagens. They are used as mutagens in such materials, where nucleus is deep seated, *e.g.*, seeds, stem cuttings, *etc.* IAA and ethylene are plant hormone and does not cause mutation. Infrared radiation is felt as heat and leads to skin to burn and cause cancer.

Related Theory

Mutagens are chemical compounds or forms of radiation that cause irreversible and heritable changes (mutations) in the cellular genetic material DNA. UV rays and X-rays also cause mutations. Sharbati Sonora, a variety of wheat has been developed by gamma radiations on 'Sonora-64' variety (Mexican dwarf wheat variety).

127. (D) Haploid plants, are always pure because they possess only one set of chromosomes. So, the mutations are expressed very easily in haploid plants as compared to diploid plants.

Related Theory

However, the only drawback with haploid plants is that they do not normally occur in nature so haploids are useful for induction of mutations and mutation breeding. Use of haploids in the production of homozygous pure line by doubling of chromosomes reduces the total time for developing a new variety from 10 years to 5 to 6 years.

128. (B) Cytoplasmic inheritance or extranuclear inheritance is the transmission of genes that occur outside the nucleus such as mitochondria and chloroplasts or from cellular parasites like viruses or bacteria. In mammals, cytoplasmic genes are only contributed by female gamete, *i.e.*, male gamete only contribute its nuclear genes. Thus, none of the progenies would inherit any mutated genes in mitochondria by father.

Related Theory

The phenotypes that are controlled by nuclear factors found in the cytoplasm of the female are said to express a maternal effect. Those phenotypes controlled by organelle genes exhibit maternal inheritance. The classic phenotype which exhibits maternal effects is coiling direction of snail shells.

129. (A) H. J. Muller discovered the production of sex-limited recessive lethal mutations by X-ray irradiation.

130. (A) Gene mutation or point mutation is the change in expression of a gene caused by change in number, sequence and type of nucleotides. A mutation from a wild gene type to a new type is called forward mutation. Reversal of mutated gene to wild type is called reverse mutation. Chromosomal mutations are changes in the morphology of chromosomes.

131. (D) Sickle cell anaemia (in which nucleotide triplet GAG is changed to GUG) affects the β-globin chain of haemoglobin. Since these changes occur at a particular locus or point of a chromosome where specific gene is located, they are called as point mutations.

132. (D) Failure of segregation of chromatids during cell division results gain or loss of a single chromosome in an organism is calledaneuploidy. Polyploidy refers to the condition when the whole set of chromosome is increased due to failure of segregation of chromosomes during anaphase, and this results to the failure of cytokinesis after telophase.

133. (D) Aneuploidy is a chromosomal disorder characterised by an abnormal number of chromosomes. This can be due to: (i) Addition that involves the presence of an extra chromosome (*e.g.*, trisomy), and, (ii) Deletion that involves loss of a chromosome or part of a chromosome. Substitution, translocation, and inversion involve structural changes in chromosomes, but do not typically result in a change in the chromosome number.

134. (B) Down's syndrome is caused by the presence of an additional copy of chromosome number 21 (trisomy of 21). α - thalassemia is controlled by two closely linked genes, HBA1 and HBA2, on chromosome 16 of each parent, and it is observed due to mutation or deletion of one or more of the four genes. β - thalassemia is controlled by a single gene HBB

on chromosome 11 of each parent and occurs due to mutation of one or both genes. Klinefelter's syndrome is caused by the presence of an additional copy of the X chromosome, resulting in a karyotype of 47, XXY.

135. (C) Broad palm with a single palm crease is a characteristic feature of Down's syndrome.

Related Theory

Down's syndrome is a condition in which a person has an extra chromosome. Chromosomes are small "packages" of genes in the body. They determine how a baby's body forms and functions as it grows during pregnancy and after birth. Typically, a baby is born with 46 chromosomes. Babies with Down's syndrome have an extra copy of one of these chromosomes, chromosome 21. A medical term for having an extra copy of a chromosome is 'trisomy.' Down's syndrome is also referred to as Trisomy 21.

136. (D) Mating between relatives (also known as consain-guineous mating) is represented by a square joined by two lines with a circle.

Caution

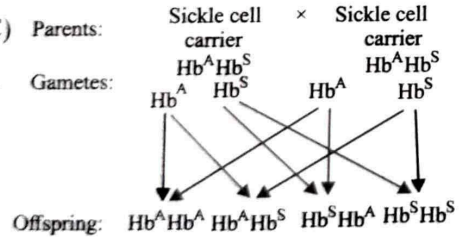
Students usually get confused between option (C) and (D). Option (C) represents mating between a male and female which are not relatives.

137. (A) Out of the given statements about Klinefelter's Syndrome only two statements are correct:

(II) Individuals with Klinefelter's Syndrome have overall masculine development but may also show some feminine physical traits.

(V) Individuals with Klinefelter's Syndrome are typically sterile due to underdeveloped testes and reduced testosterone production.

138. (C)



Phenotypic ratio = Normal (Hb^AHb^A): Sickle cell Carrier (Hb^AHb^S): Sickle cell Anaemic (Hb^SHb^S): 1 : 2 : 1

139. (B) Klinefelter's syndrome also known as XXY syndrome is where a male has an additional copy of the X chromosome. The primary features are infertility and small poorly functioning testicles. Often, symptoms are subtle and subjects do not realize they are affected. Thalassemia is an inherited blood disorder that causes that body to have less haemoglobin than normal. Haemoglobin enables red blood cells to carry oxygen. Phenylketonuria is a birth defect of metabolism that results in decreased metabolism of the amino acid phenylalanine. Turner's syndrome or XO syndrome is a condition that affects only females, results when one of the X chromosomes (sex chromosomes) is missing or partially missing.

Related Theory

Thalassemia is a blood disorder caused when the body doesn't make enough of a oxygen carrying protein called haemoglobin. Red blood cells carry oxygen to all the cells of the body. Oxygen is a sort of food that cells use to function. When there are not enough healthy red blood cells, there is also not enough oxygen delivered to all the other cells of the body, which may cause a person to feel tired, weak or short of breath. This is a condition called anaemia.

140. (C) Thalassemia is an inherited autosomal recessive disease resulting from mutations in the α- and β-globin gene clusters on chromosome 16 and chromosome 11, respectively. It leads to absence or reduced synthesis of globin chains of haemoglobin and includes two main types, α- and β-thalassemia (quantitative defect).

Sickle-cell disease is caused by a single point mutation in the β-haemoglobin gene that converts a GAG codon into GUG, which encodes the amino acid valine rather than glutamic acid (qualitative defect).

Related Theory

The sickle cell trait provides a survival advantage against malaria because the trait confers some resistance to malaria due to the fact that red blood cells cannot harbour sporozoites due to its sickle shaped, containing some abnormal haemoglobin, tend to sickle when they are infected by the malaria parasite. However, the trait does not completely protect a person from infection, but decrease the mortality rate due to malaria.

141. (A) Non-disjunction is the failure of chromosomes to separate during anaphase of cell division. Down syndrome results due to autosomal non-disjunction of 21st chromosome. Klinefelter's syndrome occurs due to non-disjunction of sex chromosome X resulting in XXY condition in male. Turner's syndrome occurs due to partial deletion of X chromosome in females, resulting in XO condition. Sickle cell anaemia is autosomal recessive disorder due to substitution point mutation in haemoglobin gene.

142. (C) Haemophilia is a X linked recessive disease. Down's syndrome is due to the triosomy of 21st chromosome. Phenylketonuria is an autosomal recessive disorder that results in decreased metabolism of the amino acid phenylalanine. Sickle cell anaemia is an autosomal recessive disorder caused due to the point mutation in the β-haemoglobin gene found on chromosome 11.

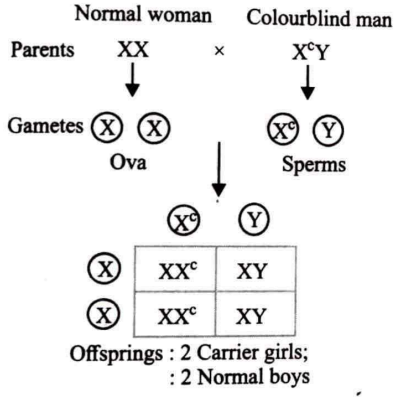
Related Theory

Sickle cell anaemia is due to a recessive gene Hb^S. The normal gene Hb^A is dominant over Hb^S and is responsible for synthesis of haemoglobin. In sickle cell anaemia due to gene Hb^S the haemoglobin produced is defective and the oxygen carrying capacity of haemoglobin is lost. Due to oxygen debt the RBCs become sickle shaped.

143. (A) Haemophilia is a X-linked recessive gene disorder.

144. (A) If a colourblind man marries a homozygous normal woman, then the probability of son becoming colourblind is zero. This is because colourblindness is a X linked recessive trait and shows criss cross inheritance.

For a male to be colourblind, he should atleast receive an abnormal X chromosome from mother.



Offsprings : 2 Carrier girls;
: 2 Normal boys

Related Theory

In females, colourblindness appears only when both sex chromosomes carry recessive gene (X^c X^c). Heterozygous females (X^cX) act as a carrier. In males, Y chromosomes does not carry any gene for colour vision, hence they are affected if their X chromosome carries gene for colour blindness (X^cY).

Caution

Students should remember that when mother is homozygous normal for any X-linked trait while the father is diseased, then the sons are always disease free, daughters are 50% carriers.

145. (B) 'XXX' sex chromosomes are the result of non-disjunction of mother gametic cells formation of abnormal ova in mother.

Caution

Students confuse if the XXX condition includes sperm or not. It is very simple, as in male XY sex chromosome are present. In case of non-disjunction of XY chromosome, then the condition would have atleast one Y chromosome. Since the abnormal condition includes XXX, then it is due to non-disjunction of XX chromosome in females.

146. (C) Colourblindness is a sex linked recessive trait. It shows criss cross inheritance. Hence, man with colour blind father (X^cY) would always be normal, as the defected X^c gene will be inherited by daughter, not son. Similarly, woman with colourblind mother and normal father will be the carrier.

	X^c	X^c
X	X^cX (Carrier woman)	X^cX (Carrier woman)
Y	X^cY (Colourblind man)	X^cY (Colourblind man)

When a carrier woman married normal male, then-

	X^c	X
X	X^cX (Carrier woman)	XX (Normal woman)
Y	X^cY (Colourblind man)	XY (Normal man)

Thus, the percentage of colourblind offspring (male + female) will be = $\frac{1}{4} \times 100 = 25\%$

And the percentage of colourblind male will be $= \frac{1}{2} \times 100 = 50\%$

147. (A) In Turner syndrome, one of the X chromosome is lost or deleted. Thus the genotype is 45 chromosomes, with XO condition. It occurs in females only, which are infertile.

148. (C) Haemophilia or 'Bleeder's disease' a sex-linked recessive disease. It is a disease in which blood lacks the capacity to coagulate. It is found in males and rarely in females. This disease is inherited by a man from his mother. This disease is lethal in homozygous recessive condition.

Related Theory

Haemophilia is caused by a mutation in one of the genes, that provides instructions for making the clotting factor proteins needed to form a blood clot. This change or mutation can prevent the clotting protein from working properly or to be missing altogether. These genes are located on the X chromosome. Males have one X and one Y chromosome (XY) and females have two X chromosomes (XX). Males inherit the X chromosome from their mothers and the Y chromosome from their fathers. Females inherit one X chromosome from each parent. People with haemophilia have low levels of either factor VIII or factor IX.

149. (C) Consider the affected autosomal gene for thalassemia is represented as 'a', which is recessive and normal gene is represented as 'A', which is dominant. Hence, normal individuals are 'AA', carriers are represented as 'Aa', and thalassaemic individuals are 'aa'.

When both parents are carriers of thalassemia, then:

	A	a
A	AA (Normal)	Aa (Carriers)
a	Aa (Carriers)	aa (Thalassaemic)

The ratio of affected thalassaemic individuals is 1 : 4 or 25%.

150. (B) Down's syndrome is due to the presence of an extra chromosome also known as trisomy of chromosome 21.

Related Theory

Down's syndrome is caused due to abnormal cell division. During mitotic and meiotic cell division the chromosome pair separate so that each cell gets the copy of each chromosome. In Down syndrome, the chromosomes are not able to separate, giving rise to cells with an unequal number of chromosomes (non-disjunction).

151. (A) Pedigree analysis is a chart that represents a family tree, which displays the members of the family who are affected by a genetic trait. A family tree can be represented by a pedigree chart with all the members of a family. They may be having a genetic disorder or may be carrier of the disease. In the pedigree analysis, standard symbols are used to distinguish between different family. It helps to understand whether the trait is dominant or recessive, sex linked or autosomal. It helps to trace the inheritance of a specific trait in a family.

Related Theory

Any changes in DNA sequence, e.g., mistakes during DNA replication may lead to a change in the genetic codes or chromosomal aberrations. Inheritance of altered genes causes genetic disorders in offspring. Their genetic inheritance is governed by Mendelian genetics. Mendelian disorders mostly occur in families with a certain pattern reflecting the alteration in a single gene. Prediction of these disorders is based on family history and can be done with the help of a family tree. This process of analysis of a number of generations of a family is called the pedigree analysis. Pedigree analysis is a strong tool in human genetics which helps to predict the pattern of inheritance, even when data is limited.

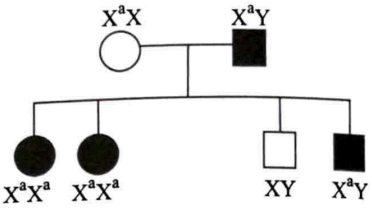
152. (B) A woman with colourblind father will be carrier for the disease, while the husband is normal.

	X^c	X
X	X^cX (Carrier woman)	XX (Normal woman)
Y	X^cY (Colour blind man)	XY (Normal man)

Thus, the couple will have no colour blind daughter. (Carriers are normal phenotypically).

153. (C) This given figure represents the criss cross inheritance, shown by sex linked traits. Colour blindness and haemophilia are two main sex-linked or X-linked recessive diseases. The gene of haemophilia goes to son from mother and to daughter from father. In this disease, the blood fails to clot when exposed to air resulting in continuous bleeding and leads to death.

154. (A) The female parent is heterozygous and male parent is homozygous recessive for the trait. For both sons and daughters expressing the trait, both parents must have at least one copy of the allele. The female parent is shown normal which makes her heterozygous carrier. The trait is recessive as it is not expressed in a heterozygous female parent. A daughter receive one X chromosome from father and other one from the mother. Thus, the case in pedigree chart could represent colour blindness.



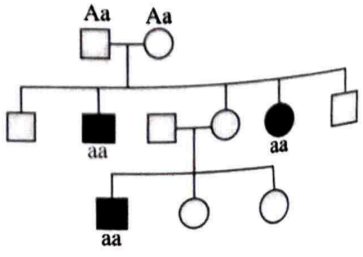
155. (A) = Mating between relatives
□ = Unaffected male
○ = Unaffected female
◆ = Affected unspecified sex

156. (C) Sickle-cell anaemia is caused by a change in a single base pair of DNA (autosomal recessive trait). It is caused when the glutamic acid in the sixth position of the β-globin chain of haemoglobin molecule is replaced by valine. The mutant haemoglobin molecule undergoes a physical change which changes the biconcave shape into the sickle shape. This reduces the oxygen-binding capacity of the haemoglobin molecule.

Related Theory

Sickle cell anaemia characteristic is found on a recessive allele of the haemoglobin gene. This corresponds to saying that one must have two copies of a recessive allele – one from each parent in order for that condition to be expressed. People having one recessive and one dominant copy of the allele will not have sickle cell anaemia.

157. (B) Parents need to be heterozygous as two of their children are known to be sufferer of the disease. In F_1 generation one male and one female are diseased and in next generation the only male is diseased. Therefore, it cannot be recessive sex-linked disease like haemophilia so, it is the autosomal recessive trait like phenylketonuria.



158. (A) Klinefelter's syndrome have an additional copy of X-chromosome, resulting into a karyotype of 47 or 44 autosomes + XXY. Colour blindness: X-linked disease, Erythroblastosis foetalis: Haemolytic anaemia in the foetus, caused when women is Rh -ve and male is Rh +ve. Down's is syndrome: Trisomy of 21st chromosome

Related Theory

When Rh –ve mother bears an Rh +ve child, mother may pick up some of the baby's RBC's and antibodies will develop in her blood. There is usually no problem with the first pregnancy but in subsequent pregnancies, accumulated antibodies from the maternal blood may enter the blood stream of the unborn child and cause agglutination of the foetal blood cells. This abnormality is called erythroblastosis foetalis. It may cause death of the child before birth or neonatal death due to massive destruction of RBC's and production of excess bilirubin which damages the child's brain.

159. (D) In Sickle cell anaemia RBCs become sickle-shaped and is a genetic disorder which is autosomal and linked to a recessive allele. It has not been eliminated from the African population because it provides immunity against malaria. People who are heterozygous for the sickle cell allele are much less susceptible to *falciparum* malaria—one of the main causes of illness and death. Since sickle-shaped RBC effectively kills the malaria parasite, the individuals heterozygous for this variant are able to cope with malaria infections much better than normal persons. The natural selection thus maintains this variant form of haemoglobin along with the normal haemoglobin in malaria prone areas.

160. (A) Colour blindness is a hereditary disease in which the gene for this disease is located on the X-chromosome. So, if a colour-blind woman marries a normal man, then it will produce all colour blind (X^CY) sons. In the case of a carrier woman, the probability of a colour-blind son and a normal son is 50:50.

	X^C	X^C
X	X^CX (Carrier female)	X^CX (Carrier female)
Y	X^CY (Colour blind male)	X^CY (Colour blind male)

161. (C) Sickle cell disease is a group of inherited red blood cell disorders that affects haemoglobin, the protein that carries oxygen through the body. Huntington's disease is a progressive brain disorder caused by a defective gene. This disease causes changes in the central area of the brain, which affect movement, mood and thinking skills. Both sickle cell anaemia and Huntington's chorea are congenital genetic disorders.

162. (D) The woman has normal vision but her father was colourblind so she should be the carrier to the disease as Colourblindness is an X-linked recessive disorder.

The genotype of the woman would be: 22 AA + XX^C

The genotype of man to be colour blind should be: 22 AA + X^CY

	X	X^C
X^C	X^CX (Carrier woman)	X^CX^C (Carrier blind girl)
Y	XY (Noman boy)	X^CY (Colour blind boy)

The probability of male child to be colour blind will 50% and the ratio of diseased to a normal male child is 1:1.

163. (D) Cretinism refers to severe hypothyroidism in an infant or child as a result of maternal iodine deficiency. Cystic fibrosis is an inherited disorder that causes severe damage to the lungs, digestive system and other organs in the body. Thalassemia is a genetic disease caused by mutations in the DNA of RBCs and hampers the haemoglobin production in the body. Haemophilia is a genetic condition, that is characterized by a deficiency in blood clotting.

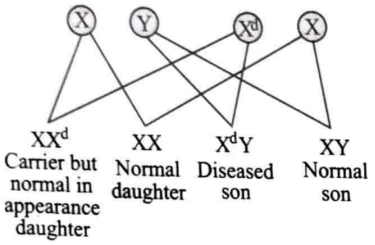
Related Theory

There are two major kinds of haemophilia: haemophilia A, which is a factor VIII deficiency; and hemophilia B, which is a factor IX deficiency. People with haemophilia may bruise and bleed easily, and they may bleed a lot or for a long time after an injury.

164. (C) Haemophilia being a sex chromosome related recessive disorder has its gene present on X chromosome. Since males have one X and one Y chromosome, and the genes present on X don't have counter genes on Y, only one affected gene (to be present on X) is required for the disease in males. While in females, there are 2 X chromosomes. For the disease to occur both the X chromosomes should have the affected genes which is a rare chance. For this to be possible, the father of the female must be diseased while the mother must be atleast a carrier.

165. (D) Down's syndrome is a chromosomal aneuploidy, caused by an extra copy of chromosome 21 known as trisomy 21. Turner's syndrome is caused by partial or complete loss (monosomy) of the second sex chromosome (22 + XO). Triploidy is the presence of an additional set of chromosomes in the cell for a total of 69 chromosomes rather than the normal 46 chromosomes per cell.

166. (B) Since, both parents are normal and all the sons are affected. Then, mother would be carrier of the diseased gene and father is normal. Thus, the gene is sex linked recessive.



167. (B) The genotype of normal woman with colourblind father = XX^h

The genotype of normal man = XY

	X^h	X
X	X^hX	XX
Y	X^hY	XY

∴ 50% of the sons would be colourblind.

168. (A) The genotype of human male in the given question must be $AaBbX^hY$. Hence 8 types of gametes would be formed (2 × 2 × 2): ABX^h, ABY, aBX^h, aBY, AbX^h, AbY, abX^h, abY. Hence, 1/8 proportion of his sperms would be abh.

169. (D) Sickle-cell anaemia is a genetic disorder in which abnormal haemoglobin is formed because valine replaces glutamic acid at the sixth position in beta-chain of haemoglobin, but the persons having this disease do not suffer from malaria as the parasite fails to thrive in sickle-shaped RBCs.

170. (C) Down's syndrome is an autosomal disorder and is caused by an extra copy of chromosome number 21.

According to the question, affected mother carries 47 chromosomes (45+XX) and normal father has (44+XY).

Gametes	23 +X	22 +X
22 +X	45+XX (Diseased)	44+XX (Normal)
22 +Y	45+XY (Diseased)	44+XY (Normal)

Thus, progeny = 50% trisomics and 50% normal child.

171. (A) Christmas disease, also called haemophilia B or factor IX haemophilia is a genetic disorder caused by missing or defective factor IX, a clotting protein. Haemophilia A is caused by a lack of the blood clotting factor VIII.

172. (A) Down's syndrome = trisomy of 21st chromosome

Sickle cell anaemia = autosomal recessive disorder, due to the mutation in β-globin gene of haemoglobin, on chromosome 11.

Haemophilia = Sex (X) linked recessive disease, caused due to deficiency of clotting factor VIII or IX

Parkinson's disease = Caused by a loss of nerve cells in the part of the brain, that produce neurotransmitter dopamine.

173. (B) Colour blindness is an inherited and sex-linked (X-linked) recessive trait. Usually, females are carriers and males are affected.

Related Theory

Colour blindness is usually a hereditary condition that means it is commonly passed down from our parents. Red/green colour blindness is passed from mother to son on the 23rd chromosome that is called as the sex chromosome as it additionally determines sex.

174. (B) Sickle cell anaemia is a hereditary disorder of autosomal nature caused by mutation of the gene controlling β-chain of haemoglobin. It involves substitution of glutamine by valine.

175. (C) Down's syndrome develops due to trisomy of 21st chromosome. Affected individual possess a characteristic appearance. They have short stature, small round head, broad forehead, open mouth and projecting lower lip (Mongoloid idiocy).

176. (B) The mother must have been a haemophilic carrier (X^hX). One of the twins would have inherited the normal X-chromosome and the other would have received the X-chromosome carrying the gene for haemophilia.

177. (B) Normal woman whose father was colour blind would have received the X-chromosome from her father (X^cY).

Parents : (P_1) : (♀) X^c X X^cY (♂)

↓

Progeny (F_1) :

X^cX^c	X^cX	X^cY	XY
Colour blind daughter	Carrier daughter	Colour blind son	Normal son

178. (B) Like colour blindness, haemophilia is also a sex-linked recessive disease. None of the children would suffer from haemophilia, though girls would be carrier of the genes. As a result, all daughters are carriers, while all sons are normal.

179. (B) Both haemophilia and colour blindness are recessive X-linked traits. They express in males in heterozygous condition and in females in homozygous condition.

$X^{hc}X^{h}$ (Woman) × XY (Man) Parents

↓ ↓

$X^{hc}X^{h}$ XY Gametes

↓

♀ \ ♂	X	Y
X^{hc}	$X^{hc}X$	$X^{hc}Y$
X^{h}	$X^{h}X$	$X^{h}Y$

Results:

50% sons are colour blind and haemophilic.

50% sons are haemophilic only.

50% daughters are carriers for colour blindness and haemophilia.

50% daughters are carrier for haemophilia only.

180. (A) Sterile males with undeveloped testes, mental retardation, *etc.*, are due to increase in their X-complement, which takes place in a disorder called Klinefelter's syndrome. These are formed by union of an XX egg and a normal Y sperm or normal X egg and abnormal XY sperm. The individual thus has 47 chromosomes (44 + XXY).

181. (D) Down's syndrome caused by trisomy 21, arises due to an occasional non-disjunction during meiosis when a gamete comes to possess an extra chromosome (n + 1). Fusion with a normal gamete [n + (n + 1)] produces trisomy.

182. (C) Gynandromorphs are the individuals in which one part of the body is female while another part is male. It occurs due to the irregularity in mitosis at the first cleavage of the zygote. It results due to loss of an X-chromosome in a particular cell during its development.

183. (D) In Klinefelter's syndrome, the chromosome no. is 2n = 47 with the formula 44A + XXY. Phenotypically, these individuals are male, but they can show some female secondary sexual characteristics and are usually sterile. H.F. Klinefelter first described this condition in 1942.

184. (A) Colour blindness is a X-linked recessive disease and the chance of a male child becoming colour blind from the normal parents is only when mother's father was colour blind. This is a criss-cross inheritance in which genes are transferred to a child from his maternal grandfather through his mother.

185. (A) Haemophilia is a sex-linked disease. Gene of this disease is located on X-chromosome. In this case, where half the sons are haemophilic and half the daughters are carriers, this is possible only when the gene responsible for haemophilia is located on one X-chromosome of mother.

(Carrier mother) $X^{h}X$ × (Normal father) XY Parents

$X^{h}X$ (Carrier daughter) XX (Normal daughter) $X^{h}Y$ (Haemophilic son) XY (Normal son) Progenies

186. (B) The birth of a colour blind girl is rare because she will be born only when her father and maternal grandfather both were colour blind. The genotype of the mother should be either $X^{C}X^{C}$ or $X^{C}X$ and that of father $X^{C}Y$ so that the daughter becomes colour blind. This combination of mother and father is rare.

187. (B) Down's syndrome is due to trisomy of 21^{st} chromosome and is an autosomal abnormality. XY is the sex complement of a male child with Down's syndrome.

Related Theory

The cause of Down's syndrome is non-disjunction of 21^{st} chromosome during oogenesis. This chromosomal abnormality is related with autosome, so the sex complement of a male child in this syndrome will be XY.