CHAPTER : 5

PRINCIPLES OF INHERITANCE AND VARIATION

STUDY-NOTES

Inheritance is the process by which characters are passed on from parent to progeny; it is the basis of heredity.

Variation is the degree by which progeny differ from their parents.

Heredity is a process of transmission of traits from parents to their offspring either through asexual reproduction or sexual reproduction.

Gregor Johann Mendel is known as the "**Father of genetics**". He proposed 3 main laws which are known as Mendel's laws.

MENDEL'S LAWS OF INHERITANCE

Gregor Mendel, conducted hybridisation experiments on garden peas for seven years (1856-1863) and proposed the laws of inheritance in living organisms. He experimented on Garden pea using seven contrasting characters. He selected the characters that has two opposing traits. He conducted these hybridisation experiments on 14 true-breeding pea plant varieties.

There were 3 laws that were proposed by Mendel.

(A) **Law of dominance:** The dominant allele masks the effect of recessive allele. Only the dominant allele expresses its phenotype.
  (i) Characters are controlled by discrete units called factors.
  (ii) Factors occur in pairs.
  (iii) In a dissimilar pair of factors one member of the pair dominates (dominant) the other (recessive). "For example: Allele for tallness is dominant over allele for dwarfism".

(B) **Law of segregation of genes:** Individuals possess two alleles of a gene and each allele separates or segregates at the time of meiosis, that is, during the formation of gametes.

(C) **Law of independent assortment:** It states that alleles for separate traits are passed independently from parents to the offspring. Mendel used dihybrid (cross of two different traits) cross in order to explain independent assortment.

MONOHYBRID CROSS (INHERITANCE OF ONE GENE)

Inheritance of one gene can be explained using Mendel's one of the hybridisation experiments such as crossing between tall and dwarf plants. When the tall and dwarf plants are crossed, the resulting progeny of first hybrid generation is known as First Filial progeny (F1). Mendel observed that all the plants formed are tall. When F1 plants were self-pollinated and produce F2 generation. The progeny obtained has three tall plants and one dwarf. The resulting phenotypic ratio was 3:1.

Incomplete dominance

If the dominant allele is not completely dominant over recessive allele and the F1 hybrid forms intermediate of the two parents, the phenomenon is called **incomplete dominance**.

Multiple Allelism or Co-dominance

If a gene exists in more than two allelic forms, the phenomenon is known as **multiple allelism**. Multiple alleles can be seen in the A, B and O blood groups of human being. The humans possess the three genes for blood group i.e. I^A, I^B and i. An individual can possess any two of these alleles. The gene I^A codes for glycoprotein A which is responsible

for A blood group and gene I^B codes for glycoprotein B which is responsible for blood group B. The gene 'i' do not produce any glycoprotein and so the person who is homozygous for it, will have O group blood. The genes I^A and I^B are dominant over 'i'. I^A and I^B alleles are equally dominant and produce both glycoproteins A and B and the blood group is AB. Such alleles are known as co-dominant alleles.

DIHYBRID CROSS (INHERITANCE OF TWO GENES)

Mendel worked with pea plants that differ in two characters. Inheritance of two genes explained the Law of Independent Assortment. Based on the crosses, the F2 ratio was found to be 9:3:3:1.

Chromosomal theory of inheritance

Chromosomal theory is proposed by the Boveri-Sutton. According to this theory

- Genes are located at specific locations on the chromosomes.
- Homologous chromosomes separate during meiosis.
- Fertilisation restores chromosome number to diploid condition.
- Chromosomes segregate as well as assort independently.

Linkage

Morgan carried out several dihybrid crosses in *Drosophila* to study genes that were sex-linked. The crosses were similar to the dihybrid crosses carried out by Mendel in peas. Morgan conducted different experiments to understand the process of linkage and recombination. For example, He hybridised yellow-bodied, white-eyed females to brown-bodied, red-eyed males and intercrossed those F1 progeny. He observed that the two genes did not segregate independently of each other and the F2 ratio deviated very significantly from the 9:3:3:1 ratio (expected when the two genes are independent). This leads to the conclusion, that genes are linked. Such genes are called linked genes while this process is known as **linkage**.

Recombination

Recombination is defined as rearrangement of genetic material, by crossing over. It is responsible for the formation of recombinants (progeny formed by the combination of two parents). It is responsible for the variation.

SEX DETERMINATION

Sex determination is a system that determines the development of sexual characteristics in an organism. Different organisms have different types of sex determination. In insects, the mechanism of sex determination is of XO type. In this, eggs have X chromosomes, but sperms may have one X chromosome, some do not have any X chromosome. As X chromosome is determining the sex of an individuals, X chromosome is known as sex chromosomes. Chromosomes other than the sex chromosome is known as **autosomes**. Mammals including man has XX-XY type of sex determination. Females carry X chromosomes in their eggs whereas males have either X chromosomes or Y chromosomes. That is why females are said to be homogametic (same type of gametes) and males to be heterogametic (different types of gametes).

Sex Determination is Humans

In females, a pair of X chromosomes are present while in male one X chromosome and one Y chromosome are present. Therefore, a male sex chromosome determines whether the offspring will develop into a male or a female.

In each pregnancy, there is always 50% probability of either male or female child.

MUTATION

Any change in the DNA sequence is known as mutation. It causes a heritable change in the DNA. The genotype as well as phenotype will be affected due to mutation. There are different types of mutation such as frameshift mutations, deletions, insertions, substitutions, duplications, etc. Some mutations are harmful.

- Frameshift mutations causes loss or addition of DNA bases which changes the reading frame.
- Addition of DNA bases is known as insertions.
- Removal of DNA bases is known as deletions.
- A piece of DNA, if copied more than one time is known as duplications.

Thus, these mutations change the DNA sequence which ultimately leads to the formation of wrong protein.

GENETIC DISORDER

Genetic disorders are grouped into two categories- Mendelian disorders and chromosomal disorders.

Pedigree analysis

An analysis of traits in several generations of a family is called the pedigree analysis. It is also used to find out the genetic disorders in the family also. All the family members are mapped in the form of a tree.

Mendelian disorders

- Mendelian disorders are mainly determined by alteration or mutation in the single gene.
- Most common of these are Haemophilia, Cystic fibrosis, Sickle-cell anaemia, Colour blindness, Phenylketonuria, Thalassemia, etc. Such Mendelian disorders can be dominant or recessive. Trait can also be linked to sex chromosome, such as haemophilia and colour blindness.

Chromosomal disorders

- When disorders are caused due to absence or excess or abnormal arrangement of one or more chromosomes.
- Improper segregation of chromatids during cell division cycle results in the gain or loss of a chromosome(s), called aneuploidy.
- **Down's syndrome** results in the gain of extra copy of chromosome 21.
- **Turner's syndrome** results due to loss of an X chromosome in human females.
- **Klinefelter's syndrome** is caused due to the presence of an additional copy of X chromosome, resulting into XXY and karyotype of 47.
- Absence of cytokinesis after the telophase stage of cell division results in an increase in a whole set of chromosomes in an organism and, this phenomenon is known as **polyploidy**. This condition is often seen in plants such as wheat, banana, potato, coffee, etc.

QUESTION BANK

MULTIPLE CHOICE QUESTIONS

1. The individual with the Klinefelter's syndrome results from the fusion of

(a) an X egg and a YY sperm.
(b) an XY egg and an X sperm.
(c) an XX egg and a Y sperm.
(d) an XX egg and a YY sperm.

2. Which of the following statements is not true?

(a) Mutations provide variation upon which natural selection can act.
(b) The vast majority of mutations produce alleles which are dominant.
(c) Mutations arise spontaneously, infrequently and at random.
(d) Mutation rate can be increased by artificial means.

3. A comparison of the karyotypes of a normal human male and a male sufferer of Down's syndrome shows which of the following?

(a) One extra chromosome
(b) Two Y chromosomes
(c) One extra pair of chromosomes
(d) Twice the normal number of chromosomes

4. Mutation can be defined as

(a) sudden temporary change in an organism's genetic material
(b) change in phenotype followed by a change in genotype
(c) change in hereditary material directed by a changing environment
(d) change in genotype which may result in a new expression of a characteristic feature

5. The ratio 9 : 7 is produced due to

(a) complementary genes
(b) supplementary genes
(c) lethal genes
(d) epistatic genes

6. **When a pair of genes hides the effect of another gene, the phenomenon is called**
   (a) mutation (b) dominance (c) epistasis (d) none of these

7. **Mendel did not propose the theory of**
   (a) dominance (b) incomplete dominance
   (c) segregation (d) independent assortment

8. **A cross between hybrid of F1 and recessive parent is**
   (a) back cross (b) test cross
   (c) monohybrid cross (d) dihybrid cross

9. **Inheritance of gene of skin colour in human beings is an example of**
   (a) polygenic inheritance (b) Mendelian inheritance
   (c) monogenic inheritance (d) Complementary genes

10. **Which of the following proved an exception to Mendel's principles?**
   (a) Dominance (b) Linkage
   (c) Independent assortment (d) Purity of gametes/segregation

11. **In a cross between red and white flowered plants of *Mirabilis jalapa*, F2 generation has red, pink and white-flowering plants in the ratio of**
   (a) 2 : 1 : 1 (b) 1 : 1 : 2 (c) 1 : 2 : 1 (d) 1 : 0 : 1

12. **The different forms of a single gene are called**
   (a) homozygotes (b) alleles
   (c) supplementary genes (d) complementary genes

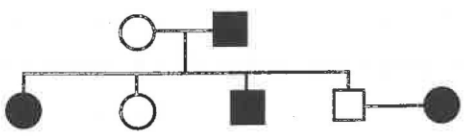
13. **In keeping with the law of independent assortment what is actually assorted?**
   (a) Different genes on the same chromosome (b) Centromeres
   (c) Homologous chromosomes (d) Heterologous chromosomes

14. **In the AB blood group the two genes are**
   (a) codominant (b) corecessive
   (c) incompletely dominant (d) dominant-recessive

15. **A woman with one gene for haemophilia and one gene for colour blindness on one of the X chromosomes marries a normal man. The progeny will be**
   (a) All sons and daughters are haemophilic and colourblind
   (b) 50% are haemophilic-colourblind sons and 50% normal sons
   (c) 50% are haemophilic daughters and 50% colourblind daughters
   (d) Haemophilic and colourblind daughters

16. **Haemophilia is more common in males because it is a**
   (a) recessive trait carried by X chromosome
   (b) dominant trait carried by X chromosome
   (c) recessive character carried by Y chromosomes
   (d) dominant character carried by Y chromosome

17. **From the pedigree of a family given below, it is clear that the trait is inherited as dominant autosomal trait. What will be the genotype of mother and father?**



   (a) Mother is aa and father is Aa (b) Father is AA and mother is aa
   (c) Father is Aa and mother is Aa (d) None of these

18. Which of the following male animals is not heterogametic?

Animal	Chromosome complement
(a) Fruit fly	2n = 6 + XY
(b) Fowl	2n = 14 + XX
(c) Grasshopper	2n = 16 + XO
(d) Human	2n = 44 + XY

19. A sex-linked allele never passes from a

(a) man to his sons (b) woman to her daughters
(c) man to his grandsons (d) woman to her granddaughters

20. Mendel crossed pure tall plants (TT) having white flowers (rr) with pure dwarf plants (tt) having red flowers (RR). The number (ratio) of dwarf progeny in F2 generation after self pollinating the F1, will be

(a) $\frac{9}{16}$ (b) $\frac{4}{16}$ (c) $\frac{3}{16}$ (d) $\frac{1}{16}$

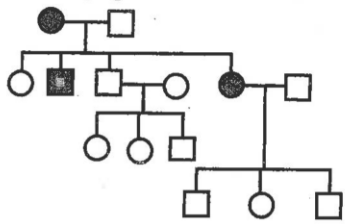
21.

Column A	Column B
I. Gene	A. Homozygote
II. TT	B. DNA
III. Alternate form of gene	C. Dihybrid cross
IV. TtRrxTtRr	D. Allele

The correct match is

(a) I-B, II- A, III-D, IV-C (b) I-D, II-A, III-B, IV-C
(c) I-D, II-B, III-A, IV-C (d) I-B, II-C, III-D, IV-A

22. Study the pedigree chart of a certain family given below. It is related to myotonic dystrophy.



The trait traced in the above pedigree chart is

(a) dominant X-linked (b) recessive X-linked
(c) autosomal dominant (d) recessive Y-linked

23. Which one of the following is a sex-linked disease?

(a) Nightblindness (b) Glaucoma (c) Haemophilia (d) All of these

24. The substance, which causes a definite change in genes is called

(a) toxin (b) alkaloid (c) cytotoxin (d) mutagen

25. Multiple alleles control the character of

(a) only skin colour (b) only blood groups
(c) blood groups and skin colour (d) sickle-cell

26. Human skin colour is controlled by

(a) a single allele (b) two alleles (c) three pairs of genes (d) four alleles

27. A child with a mother of A blood group and father of AB group will not have the following blood group

(a) A (b) B (c) AB (d) O

28. When the two dominant independently assorting alleles of genes react with each other, they are called

(a) supplementary (b) complementary (c) duplicate (d) collaborative

29. A blue fowl obtained from mating between black and white fowls, is self-crossed. The F2 ratio is

(a) 1 black : 2 white : 1 blue
(b) 1 black : 2 blue : 1 white
(c) 2 black : 1 white : 1 blue
(d) none of these

30. Crossing over in diploid organisms is responsible for

(a) linkage between genes
(b) segregation of alleles
(c) dominance of genes
(d) recombination of linked genes

31. In Mendel's experiments the alleles were

(a) codominant
(b) corecessive
(c) dominant-recessive
(d) incompletely dominant

32. A single recessive trait which can express its effect should occur on

(a) any chromosome
(b) an autosome
(c) X chromosome of male
(d) X chromosome of female

33. Chiasma formation in the meiosis represents the site of

(a) homologous chromosome
(b) crossing over
(c) pachytene
(d) diakinesis

34. A family of five daughters only is expecting the sixth issue. The chance of its being son is

(a) zero (b) 25% (c) 50% (d) 100%

35. Gene located on the same locus but having different expressions are

(a) oncogenes (b) polygenes (c) multiple alleles (d) codominants

36. Polygenes are defined as

(a) genes which control continuously variable characters like height, weight, etc.
(b) multiple copies of a single gene
(c) always linked genes
(d) pseudogenes

37. How many types of gametes will be produced by individuals having genotype AaBbCc?

(a) Two (b) Four (c) Six (d) Eight

38. The phenotypic and genotypic ratios remain same in F2 generation in case of

(a) dihybrid cross
(b) supplementary genes
(c) incomplete dominance
(d) inhibitory genes

39. Which one of the following is the genotypic ratio in monohybrid cross?

(a) 9:3:3:1 (b) 1:2:1 (c) 9:7 (d) 3 : 1

40. Which of the following truly represents a heterozygous organism?

(a) XXyy (b) RRYy (c) xxYY (d) RrYy

41. The meaning of syndrome is related to

(a) dwarf organism
(b) diseased condition
(c) a group of symptoms
(d) viral disease

42. If the DNA codons are ATG ATG ATG and a cytosine base is inserted at the beginning, which of the following will result?

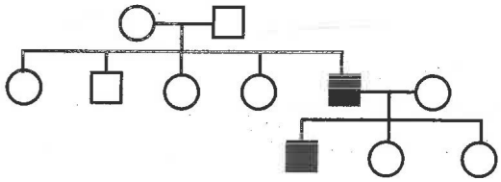
(a) CATGATGATG (b) CAT GAT GAT G (c) CATGATGATG (d) a nonsense mutation

43. In humans, the gene for red blood corpuscle shape (alleles elliptical E and normal e) is linked to the gene for Rhesus blood (alleles Rhesus positive R and Rhesus negative r).

If crossing over occurs between these two genes, then the two additional types of gametes that could result as

(a) RE and re (b) EE and rr (c) Er and eR (d) ee and RR

44. In the following pedigree chart, the mutant trait is shaded black. The gene responsible for the trait is



(a) dominant and sex linked
(b) dominant but autosomal
(c) recessive and sex linked
(d) recessive and autosomal

45.

	Column A		Column B
I.	Autosomal linked recessive trait	A.	Down's syndrome
II.	Sex linked recessive disease	B.	Phenylketonuria
III.	Metabolic error linked to autosomal recessive	C.	Haemophilia trait
IV.	Additional 21st chromosome	D.	Sickle Cell Anaemia

The correct match is

(a) I-B, II-A, III-D, IV-C
(b) I-D, II-A, III-B, IV-C
(c) I-D, II-C, III-B, IV-A
(d) I-C, II-D, III-A, IV-B

46. The following table shows the genotypes for ABO blood grouping and their phenotypes. In which one of the four options the components of reaction labelled as W, X, Y and Z are identified correctly?

S. No.	Genotype	Blood Group
1	I^AI^A	A
2	W	A
3	I^BI^B	B
4	X	B
5	I^AI^B	Y
6	Z	O

	W	X	Y	Z
(a)	$I^A i$	$I^B i$	AB	ii
(b)	$I^B i$	$I^A i$	B	ii
(c)	$I^B i$	$I^B i$	A	ii
(d)	$I^A i$	$I^A i$	O	ii

47.

	Column A		Column B
I.	Turner syndrome	A.	Trisomy
II.	Linkage	B.	AA + XO
III.	Y-chromosome	C.	Morgan
IV.	Down's syndrome	D.	TDF

The correct match is

(a) I-B, II-A, III-D, IV-C
(b) I-D, II-A, III-B, IV-C
(c) I-D, II-B, III-A, IV-C
(d) I-B, II-C, III-D, IV-A

48. Mutations used in agriculture are commonly

(a) spontaneous (b) lethal (c) induced (d) recessive and lethal

49. Harmful mutations do not get eliminated from gene pool because

(a) they have survival valve
(b) they are recessive and carried by heterozygous individuals
(c) they are formed repeatedly
(d) they show genetic drift

50. Which one of the following would represent allotetraploid?
(a) AAABB (b) AAAB (c) AABB (d) BBBB

51. The Klinefelter's syndrome has chromosomal constituent
(a) 2A + XX (b) 2A + XXY (c) 2A + Y (d) 2A-XY

52. At which stage of meiosis crossing over takes place?
(a) Leptotene (b) Cytokinesis (c) Pachytene (d) Diakinesis

53. Which of the following statements is true about Mendel?
(a) His discoveries concerning genetic inheritance were generally accepted by the scientific community when he published them during the mid 19th century.
(b) He believed that genetic traits of parents will usually blend in their children.
(c) His ideas about genetics apply equally to plants and animals.
(d) He discovered linkage.

54. If Mendel had studied the 7 traits using a plant with 12 chromosomes instead of 14, in what way his interpretation would have been different?
(a) He would have discovered crossing over.
(b) He would have discovered blending or incomplete dominance.
(c) He could not have proposed that genes are earned on chromosomes.
(d) He would not have discovered the law of independent assortment.

55. Imagine that in maize plant, the factors for controlling seed coat and seed shape are present on the same chromosome very close together. Performing dihybrid experiments with these characters, Mendel would not have been able to arrive at the idea of
(a) Dominance (b) Independent assortment
(c) Incomplete dominance (d) Segregation

56. Substitution of a purine nucleotide by pyrimidine nucleotide is called
(a) transition (b) transversion (c) inversion (d) transduction

57. The exposure of X-rays enhances the frequency of
(a) linkage (b) crossing over
(c) pairing of chromosomes (d) segregation

58. The combined form of coupling and repulsion is
(a) crossing over (b) mutation (c) linkage (d) disjunction

59. How many pairs of autosomes are found in human?
(a) 46 (b) 23 (c) 1 (d) 22

60. Which one of the following is sex-linked disease?
(a) Haemophilia (b) Down's syndrome (c) Albinism (d) Turner's syndrome

61. What will be the number of linkage groups in a cell having 2n = 20?
(a) 15 (b) 40 (c) 10 (d) 4

62. Which of the following genes have similar genotypic effect while present separately but produce different traits after interacting together and give a ratio of 9 : 7 in F2 generation?
(a) Complementary genes (b) Jumping genes
(c) Duplicate genes (d) House-keeping genes

63. Trisomy has a chromosome complement of
(a) 2n-1 (b) 2n + 2 (c) 2n + 3 (d) 2n + 1

64. In mice, black coat colour (allele B) is dominant to brown coat colour (allele b). The offspring of a cross between a black mouse (BB) and a brown mouse (bb) were allowed to interbreed. What percentage of the progeny would have black coats?
(a) 25% (b) 50% (c) 75% (d) 100%

65. In mice, Y is the dominant allele for yellow fur and y is the recessive allele for grey fur. Since Y is lethal when homozygous, the result of cross Yy x Yy will be

(a) 3 yellow : 1 gray
(b) 2 yellow : 1 gray
(c) 1 yellow : 1 gray
(d) 1 yellow : 2 gray

66. In snapdragon plants, the alleles for red and ivory flower colour show incomplete dominance.When a homozygous red-flowered plant is crossed with a homozygous ivory-flowered plant, all the members of the F1 generation are found to bear pink flowers. Which of the following would be the outcome of crossing a red-flowered plant with a pink one?

(a) 1 red : 2 pink : 1 ivory
(b) 3 red : 1 ivory
(c) 1 red : 1 pink
(d) all red

67. A certain type of anemia exists in two forms, major (severe) and minor (mild). The following table relates the genotypes of both types of sufferer to that of a normal person.

Person	Genotype
non sufferer	NN
minor sufferer	NA
major sufferer	AA

If NA marries NA, the chance of each of their children being mildly affected is

(a) 1 in 1
(b) 1 in 2
(c) 1 in 3
(d) 1 in 4

68. In *Drosophila*, long wing (L) is dominant to dumpy wing (*l*) and grey body (G) is dominant to ebony body (g). The two genes involved are not on the same chromosome.

A true-breeding long-winged, ebony-bodied fly is crossed with a true-breeding dumpy-winged, gray-bodied fly. The genotype of the F1 generation will be

(a) LlGg
(b) LLGg
(c) LLGG
(d) LlGG

69. In a certain species of sweet pea plant, flowers are either purple or white. Colour is determined by two unlinked genes. The alleles of the first gene are X and x; those of the second gene are Y and y. In order to bear purple flowers, a plant must possess at least one X and one Y allele. Those genotypes which fail to do so, result in the formation of white flowers.

If two purple-flowering plants of genotype XxYy are crossed then the expected phenotypic ratio of offspring would be

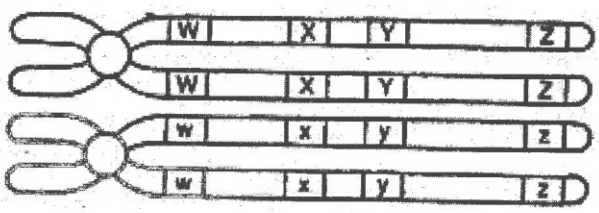
(a) 12 purple 4 white
(b) 9 purple 7 white
(c) 10 purple 6 white
(d) 8 purple 8 white

70. In a certain plant, yellow fruit colour (Y) is dominant to green (y) and round shape (R) is dominant to oval (r). The two genes involved are located on different chromosomes.

Which of the above will result when plant YyRr is backcrossed (testcrossed) with the double recessive parent?

(a) 9:3:3:1 ratio of phenotypes only
(b) 9:3:3:1 ratio of genotypes only
(c) 1:1:1:1 ratio of phenotypes only
(d) 1:1:1:1 ratio of phenotypes and genotypes

71. The diagram opposite shows a pair of homologous chromosomes during meiosis.



Most crossing over will occur between genes

(a) W and X
(b) X and Y
(c) Y and Z
(d) W and Z

72.

Column A	Column B
I. Nonparental gene combination	A. Crossing over
II. Nonsister Chromatids	B. X and Y
III. Sex chromosomes	C. Sex-linked disease
IV. Haemophilia	D. Recombination

The correct match is

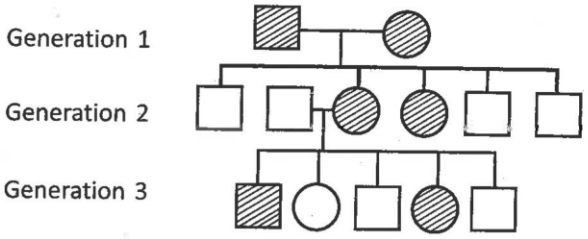
(a) I-B, II-D, III-A, IV-C

(b) I-D, II-A, III-B, IV-C

(c) I-B, II-D, III-C, IV-A

(d) I-B, II-A, III-D, IV-C

73. Given below is a pedigree chart showing the inheritance of a certain sex-linked trait in humans.



The trait traced in the above pedigree chart is

(a) dominant X-linked

(b) recessive X-linked

(c) dominant Y-linked

(d) recessive Y-linked

74. Given below is a pedigree chart of a family with five children. It shows the inheritance of attached, ear-lobes as opposed to the free ones. The squares represent the male and circles the female individuals.

Which one of the following conclusions drawn is correct?

(a) The trait is Y-linked.

(b) The parents are heterozygous.

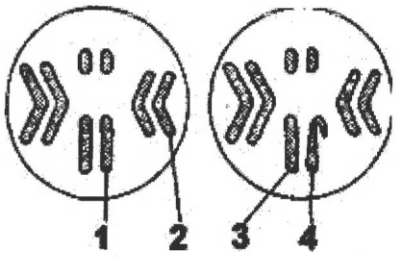
(c) The parents are homozygous recessive.

(d) The parents are homozygous dominant.

75. This question refers to eye colour in the fruit fly. In this sex-linked trait, the allele for red eye is dominant to that for white eye. If a heterozygous red-eyed female is crossed with a white-eyed male, what percentage of the female offspring will be white-eyed?

(a) 0% (b) 25% (c) 50% (d) 100%

76. The diagram refers to the chromosome complement of each sex of fruitfly shown in the diagram.



By which number is a Y chromosome labelled?

(a) 1 (b) 2 (c) 3 (d) 4

77. Match the following

Column A	Column B
I. Linkage	A. Recombination of genes
II. Mutation	B. More than two sets of chromosomes
III. Crossing over	C. Morgan
IV. Polyploidy	D. Hugo-de-Vries

The correct match is

(a) I-B, II-C, III-A, IV-D
(b) I-C, II-D, III-A, IV-B
(c) I-B, II-D, III-C, IV-A
(d) I-B, II-D, III-A, IV-C

78. Polyploid wheat does NOT normally show an increase in

(a) size
(b) vigour
(c) resistance to disease
(d) length of life cycle

79. A human female will definitely be a haemophiliac if

(a) both of her parents are also haemophiliac.
(b) her mother is a carrier and her father is a haemophiliac.
(c) her mother carries the allele for haemophilia on both X chromosomes.
(d) her father is a haemophiliac and her mother is normal.

80. Haemophilia is a condition in which blood fails to clot or clots only very slowly. Studies of this human sex-linked trait show that

(a) every X chromosome carries the dominant allele.
(b) a Y chromosome never carries the dominant allele.
(c) both X and Y chromosomes can bear the recessive allele.
(d) neither X nor Y chromosomes can bear the recessive allele.

81. Two organisms that are true-breeding for a certain genetic characteristic are mated and their offspring analysed. Which of the following statements about this situation is true?

(a) Both parents are homozygotes.
(b) The offspring are either all homozygotes or all heterozygotes.
(c) The offspring represent the F1 generation, the gametes produced by the offspring will carry only one allele for this gene.
(d) All the above

82.

Column A	Column B
I. Gregor Mendel	A. Chromosomal theory of Inheritance
II. Sutton and Boveri	B. Laws of Inheritance
III. Henking	C. Mendelian disorder
IV. Thalassemia	D. Discovered x-body

The correct match is

(a) I-B, II-A, III-D, IV-C
(b) I-D, II-A, III-B, IV-C
(c) I-D, II-B, III-A, IV-C
(d) I-B, II-C, III-D, IV-A

INPUT-TEXT BASED QUESTIONS

Read the following paragraphs and answer the following questions.

I. The total number of chromosomes in a normal human cell is 46 (23 pairs). Out of these 22 pairs are autosomes and one pair of chromosomes are sex chromosome. Sometimes, though rarely, either an additional copy of a chromosome may be included in an individual or an individual may lack one of any one pair of chromosomes. These situations are known as trisomy or monosomy of a chromosome, respectively. Such a situation leads to very serious consequences in the individual. Down's syndrome, Turner's syndrome, Klinefelter's syndrome are common examples of chromosomal disorders. Turner's Syndrome is caused due to the absence of one of the X chromosomes. Such females are sterile as ovaries are rudimentary besides other features including lack of other secondary sexual characters.

1. What is the number of barr body present in a female with Turner's syndrome?

(a) 0 (b) 1 (c) 2 (d) More than 2

2. The Turner's syndrome is an example of

(a) aneuploidy (b) autosomal abnormality

(c) euploidy (d) polyploidy

3. Which of the following statements is true about Turner's syndrome?

(a) It is because of extra chromosome.

(b) Its a case of monosomy of chromosome.

(c) Suffering individual is a sterile female with one missing x chromosome.

(d) Individuals are short statured.

4. Turner's syndrome is an

(a) Autosomal dominant genetic disorder (b) Chromosomal disorder

(c) Autosomal recessive mendelian disorder (d) Sex linked mendelian disorder

II As per the law of dominance, the F1 resembles either of the two parents (dominance). But, in certain cases, the F1 generation resembles both parents. A good example is different types of red blood cells that determine ABO blood grouping in human beings. ABO blood groups are controlled by the gene I. The plasma membrane of the red blood cells has sugar polymers that protrude from its surface and the kind of sugar is controlled by the gene. The gene (I) has three alleles I^A, I^B and i. The alleles I^A and I^B produce a slightly different form of the sugar while allele i does not produce any sugar.

1. On the basis of above inheritance some statements are given as follows:

(i) It is the phenomenon of a single gene influencing two or more distinct phenotypic traits.

(ii) The alleles of a gene pair in a heterozygote are fully expressed.

(iii) Neither of the alleles is completely dominant over the other.

(iv) Human red blood cells have both A and B type of sugar.

Which of the following is/are correct statement(s)?

(a) (i) only (b) (ii) and (iv) (c) (iv) only (d) (i) and (iii)

2. The above paragraph is showing a deviation from Mendelian principle. This form of inheritance is called

(a) Pleiotropy (b) Incomplete dominance

(c) Co-dominance (d) Polygenic inheritance

3. If a person possesses I^A and i genes, which of the following occurs?

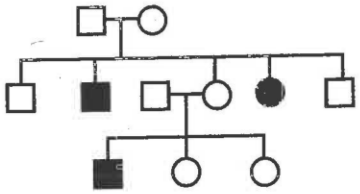
(a) i expresses (b) I^A expresses

(c) Both I^A and i express (d) This case is not possible.

4. The blood type of a child is AB. Which of the following statement(s) is/are correct?
   (i) Allele from parent 1 is I^A and parent 2 is I^B.
   (ii) The genotype of the child is ii.
   (iii) Allele from parent 1 is I^B and parent 2 is I^A.
   (iv) The genotype of child is I^A I^A.
   (a) (iv) only
   (b) (ii) and (iv)
   (c) (i), (ii), (iii) and (iv)
   (d) (i) and (iii)
5. Which of the following are false statements?
   (i) For Human ABO blood types, six different genotypes are possible.
   (ii) If blood type of a child is O, One parent has I^A allele and other parent has i allele.
   (iii) All the three alleles of gene I produce sugars.
   (iv) For Human ABO blood types, three different genotypes are possible.
   Which of the following is most important step?
   (a) (i), (ii) and (iii) only
   (b) (ii), (iii) and (iv)
   (c) (i), (iii) and (iv)
   (d) (i), (ii), (iii) and (iv)

III. Genetic disorders may be grouped into two categories – Mendelian disorders and Chromosomal disorders. Mendelian disorders are mainly determined by alteration or mutation in the single gene. These disorders are transmitted to the offspring on the same lines as we have studied in the principle of inheritance. The pattern of inheritance of such Mendelian disorders can be traced in a family by the pedigree analysis.

1. Which of the following is not a Mendelian disorder?
   (a) Sickle cell anaemia
   (b) Cystic fibrosis
   (c) Turner's syndrome
   (d) Haemophilia
2. Look at the pedigree analysis.



   Which of the following is/are true for the above representation?
   (i) It is showing autosomal dominant trait.
   (ii) It is a sex linked recessive disorder.
   (iii) It is a Mendelian disorder.
   (iv) It is showing autosomal recessive trait.
   (a) (i) and (ii)
   (b) (ii) and (iv)
   (c) (iii) and (iv)
   (d) (i), (ii) and (iii)
3. Autosomal recessive trait is seen in
   (a) Haemophilia and Thalassemia
   (b) Sickle cell anaemia and Phenylketonuria
   (c) Haemophilia and Sickle cell anaemia
   (d) Haemophilia and Cystic fibrosis
4. Which of the following disease is caused due to absence of one of the X chromosome?
   (a) Klinefelter's syndrome
   (b) Turner's syndrome
   (c) Down's syndrome
   (d) All of these
5. Which of the following is/are true for the disease haemophilia?
   (i) It is showing autosomal dominant trait.
   (ii) It is a sex linked recessive disorder.
   (iii) No female members are haemophilic.
   (iv) The females are heterozygous carrier.
   (a) (i), (iii) and (iv)
   (b) (i), (ii) and (iv)
   (c) (ii). (iii) and (iv)
   (d) (i), (ii) and (iii)

ANSWERS

1. (c)	2. (b)	3. (a)	4. (d)	5. (a)	6. (c)	7. (b)	8. (b)	9. (a)	10. (b)
11. (c)	12. (b)	13. (c)	14. (a)	15. (b)	16. (a)	17. (a)	18. (b)	19. (a)	20. (b)
21. (a)	22. (c)	23. (c)	24. (d)	25. (b)	26. (c)	27. (d)	28. (b)	29. (b)	30. (d)
31. (c)	32. (c)	33. (b)	34. (c)	35. (c)	36. (a)	37. (d)	38. (c)	39. (b)	40. (d)
41. (c)	42. (b)	43. (c)	44. (d)	45. (c)	46. (a)	47. (d)	48. (c)	49. (b)	50. (c)
51. (b)	52. (c)	53. (c)	54. (d)	55. (b)	56. (b)	57. (a)	58. (c)	59. (d)	60. (a)
61. (c)	62. (a)	63. (d)	64. (c)	65. (b)	66. (c)	67. (b)	68. (a)	69. (a)	70. (d)
71. (d)	72. (b)	73. (a)	74. (b)	75. (c)	76. (d)	77. (b)	78. (d)	79. (b)	80. (b)
81. (d)	82. (a)								

EXPLANATION

5. The complimentary gene is defined as an interaction between two dominant non-inter allelic genes and the Mendelian ratio 9:3:3:1 is changed to 9:7 due to complementation of both genes.
6. The phenomenon in which when one gene pair hides the effect of another gene pair, is known as epistasis.
8. The test cross is used to determine whether the individuals exhibiting dominant characters are homozygous or heterozygous.
20.

TTrr × ttRR

↓

F1 TtRr

↓ Self pollination

G	TR	Tr	tR	tr
TR	TTRR	TTRr	TtRR	TtRr
Tr	TTRr	TTrr	TtRr	Ttrr
tR	TtRR	TtRr	ttRR	ttRr
tr	TtRr	Ttrr	ttRr	ttrr

The dwarf progeny = 3 + 1 = 4

33. The chiasma is a structure that forms between a pair of homologous chromosomes by crossover recombination and physically links the homologous chromosomes during meiosis.
50. Allotetraploid occurs when a polyploid offspring is obtained from two distinct maternal and paternal species. It possesses four times of chromosomes that are present in haploid organisms.
52. Crossing over is the exchange of genetic material between non-sister chromatids of homologous chromosomes occurs at the pachytene stage of prophase I of meiosis.
61. If 2n=20, then there are 10 pairs of chromosomes. Linkage groups are groups of genes that are so close together on a chromosome that they tend not to assort independently (i.e. recombination rarely occurs between them). This means that these genes will likely be inherited together.

Input-Text Based Answers

I.	1. (a)	2. (a)	3. (c)	4. (a)	
II.	1. (b)	2. (c)	3. (b)	4. (d)	5. (b)
III.	1. (c)	2. (c)	3. (b)	4. (b)	5. (c)