CHAPTER › 05

Principles of Inheritance and Variation

NEET KEY NOTES

- **Genetics** is the branch of biology which deals with the inheritance and variation of characters from parents to their offspring.

Mendel's Laws of Inheritance

- **Gregor Mendel** conducted hybridisation experiments on **garden peas** for seven years (1856-1863). He applied statistical analysis and mathematical logic while studying inheritance patterns.
- Mendel investigated two opposing traits of 14 characters in true breeding pea plant (produced by continuous self-pollination and which showed stable trait inheritance). The characters selected by Mendel are tabulated below

Contrasting Traits Studied by Mendel in Pea

S. No.	Characters	Traits	
		Dominant	**Recessive**
1.	Stem height	Tall	Dwarf
2.	Flower colour	Violet	White
3.	Flower position	Axial	Terminal
4.	Pod shape	Inflated	Constricted
5.	Pod colour	Green	Yellow
6.	Seed shape	Round	Wrinkled
7.	Seed colour	Yellow	Green

Inheritance of One Gene

- Mendel observed one trait or character at a time, e.g. he crossed a tall and a dwarf pea plants to study the inheritance of one gene.
- He hybridised plants with alternate forms of a single trait (monohybrid cross). The seeds produced by these crosses were grown to develop into plants of **Filial$_1$ progeny** or F_1-generation (F_1-plants).
- Mendel then self-pollinated the tall F_1-plants to produce plants of **Filial$_2$** progeny or F_2-generation (F_2 -plants).
- In later experiments, Mendel also crossed pea plants with two contrasting characters known as **dihybrid cross**.

Mendel's Observation

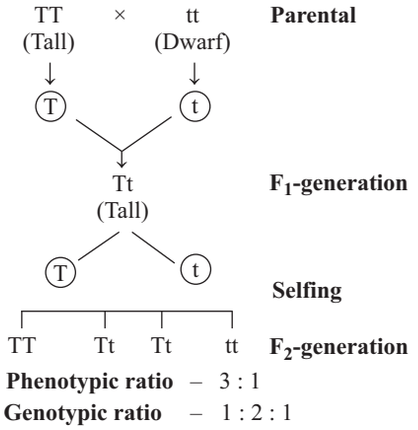
- In F_1-generation, Mendel found that all pea plants were tall and none was dwarf.
- He also observed other pair of traits and found that F_1-plant always resembled either one of its parent and the trait of other parent was not found.
- In F_2-generation, he found that some of the offspring were 'dwarf', i.e. the characters which were not seen in F_1-generation were expressed in F_2- generation.
- The proportion of plants that were dwarf, were 1/4th of the F_2-plants, while 3/4th of the F_2-plants were tall.
- These contrasting traits (tall/dwarf) did not show any mixing either in F_1 or in F_2-generation as none was of intermediate height.

- Similar results were obtained with the other traits that he studied. Only one of the parental traits was expressed in F_1-generation, while in F_2-generation stage, both the traits were expressed in the ratio of 3 : 1.
- Mendel also found identical results in dihybrid cross as in monohybrid cross.

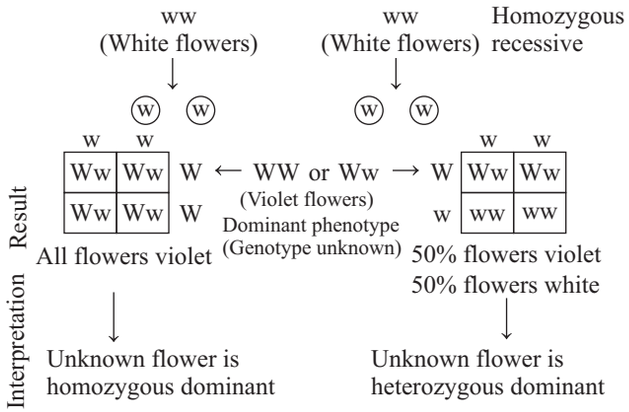
Mendel's Inferences

Following inferences were made by Mendel based on his observations

- Mendel proposed that **factors** or **genes** pass down from parent to offspring through gametes over successive generations.
- **Genes** are units of inheritance and they code for a pair of contrasting traits called **alleles** (different forms of the same gene).
- The alleles of a character are denoted as capital and small letters, e.g. T(tall) and t(dwarf).
- **Genotype** is the genetic constitution of an individual while the **phenotype** is the external appearance.
- **Dominant allele** The factor or an allele pair, which can express itself in both homozygous and heterozygous states.
- **Recessive allele** The factor or allele pair, which can express only in homozygous state.
- **Homozygous condition** The state in which an organism has two similar genes or alleles of a particular character, e.g. TT or tt for tallness or dwarfness.
- **Heterozygous condition** In this, an organism contains two different alleles for a particular character, e.g. Tt.
- In a **monohybrid cross**, genes controlling one character (e.g. height) are considered, e.g. cross between TT × tt (Tall × Dwarf plant).
  - The resultant F_1 progeny in such a cross is heterozygous (Tt).
  - In F_2-generation, the recessive parental trait is expressed without any blending which represents that alleles of parental pair **segregate** during gamete formation. It is a random process.



- **Punnett square** is the diagrammatic representation of gametes produced by the parents, the formation of the zygotes and F_1, F_2 plants. It helps to calculate the probability of all possible genotypes of offspring in a genetic cross. It was developed by British geneticist, Reginald C Punnett.
- **Test cross** is performed between the dominant phenotype (obtained in F_1 or F_2) and recessive parent, so as to determine the genotype of former. The resultant progeny appear in ratio 1 : 1.



- **Back cross** The cross of an organism with the organism of its previous generation is known as back cross.
- **Reciprocal cross** A cross in which same two parents are used in such a way that if in one experiment 'A' is used as female parent and 'B' is used as male parent, in other experiment 'A' will be used as male parent and 'B' is used as female parent is called reciprocal.
- Based on his observations on monohybrid crosses, Mendel proposed two general rules in order to consolidate his understanding of inheritance in monohybrid crosses. Today, these rules are called the **principles** or **laws of inheritance**. These are

Law of Dominance (First Law)

- Characters are controlled by discrete units called **factors**.
- Factors occur in pairs.
- In a dissimilar pair of factors, one member of the pair is dominant while the other is recessive.
- This law is used to explain the expression of only one of the parental characters in a monohybrid cross in the F_1-generation and the expression of both in the F_2-generation. It also explains the proportion of 3:1 ratio obtained in the F_2-generation.

Law of Segregation (Second Law)

- This law states that, though the parents contain two alleles during gamete formation, the factors or alleles of a pair segregate from each other, such that a gamete receives only one of the two factors.

- Hence, alleles do not show any blending and both the characters are recovered as such in the F_2-generation, though one of these is not seen in the F_1-generation.
- All the patterns of inheritance could not be explained exclusively on the basis of Mendel's original principles alone and certain complexities were observed by later workers which deviated from Mendel's laws or Mendelism.

1. Incomplete Dominance

- The F_1-progeny develop a new phenotype which do not resemble either of the two parents and lies in between the two. For example, inheritance of flower colour in snapdragon (*Antirrhinum*) .
- In this case, both phenotypic and genotypic ratio is 1 : 2 : 1. The phenotypic ratio deviates from the Mendelian ratio of 3 : 1.
- Incomplete dominance result due to the production of non-functional enzyme or no enzyme by the recessive allele.

2. Codominance

- The F_1-progeny resemble both the parents due to the equal expression of both alleles.
- For example, ABO blood group in humans is controlled by gene I which exhibit three alleles–I^A, I^B and i. I^A and I^B are codominant alleles and these both are dominant over i.
- Due to the presence of three different alleles, six genotype of human ABO blood groups are possible. These are tabulated below

Table Showing the Genetic Basis of Blood Group in Human Population

Allele from Parent 1	Allele from Parent 2	Genotype of Offspring	Blood Group of Offspring
I^A	I^A	I^AI^A	A
I^A	I^B	I^AI^B	AB
I^A	i	I^Ai	A
I^B	I^A	I^AI^B	AB
I^B	I^B	I^BI^B	B
I^B	i	I^Bi	B
i	i	ii	O

3. Multiple Allelism

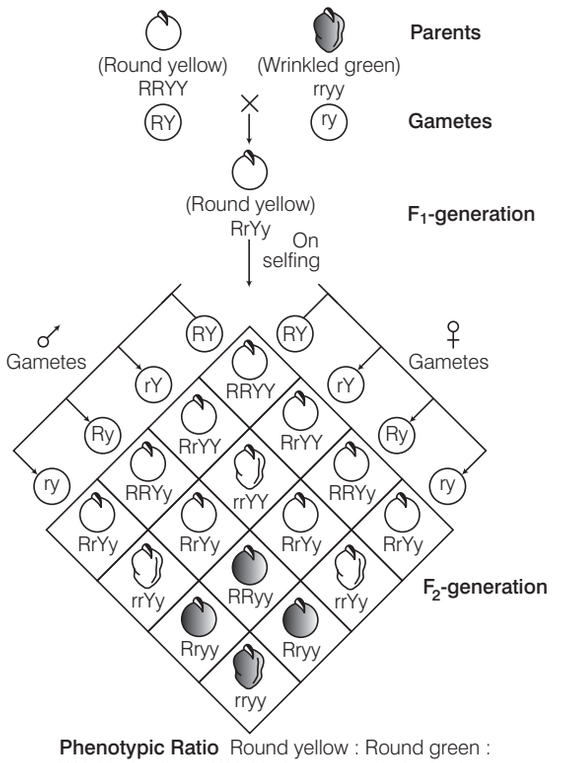
- More than two alleles governs the same character. These are found during population studies. The human blood group gene provides an example of multiple allele as well as an interesting dominance relationship.

Inheritance of Two Genes

- To verify his results of monohybrid cross, Mendel also crossed pea plants differing in two characters (dihybrid cross). This helped him to understand inheritance of two genes (i.e. two pairs of alleles) at a time.
- It was found that inheritance of one pair of allele (one trait) does not interfere in the inheritance of other pair of allele (second trait).
- Based upon this, Mendel proposed a second set of generalisations or postulates which is called **law of independent assortment.**

Law of Independent Assortment (Third Law)

This law states that 'when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters' at the time of gamete formation. It also gets randomly rearranged in the offspring producing both parental and new combinations of characters. This can be understood from the figure given below



Phenotypic Ratio Round yellow : Round green : Wrinkled yellow : Wrinkled green = 9 : 3 : 3 : 1

Result of dihybrid cross where the two parents differed in two pairs of contrasting traits, i.e. seed colour and seed shape

In 1900, **de Vries, Correns** and **von Tschermak** rediscovered Mendel's results independently. Due to microscopy, they carefully observed cell division. This led to discovery of **chromosomes** (structure in the nucleus that appeared in pairs and divide just before each cell division).

Chromosomal Theory of Inheritance

It was proposed independently by **Walter Sutton** and **Theodore Boveri** in 1902. They united the knowledge of chromosomal segregation with Mendelian principles and

called it **chromosomal theory of inheritance**. According to this theory

- All hereditary characters must be with sperms and egg cells as they provide bridge from one generation to the other.
- The hereditary factors must be carried by the nuclear material.
- Chromosomes are also found in pairs like the Mendelian alleles.
- The two alleles of a gene pair are located on homologous sites on the homologous chromosomes.
- The sperms and eggs have haploid sets of chromosomes, which fuse to re-establish the diploid state.
- The genes are carried on to the chromosomes.
- Homologous chromosomes synapse during meiosis and get separated to pass into different cells. This is the basis for segregation and independent assortment.

Comparison between the Behaviour of Chromosomes and Genes

Chromosomes	Genes
These occur in pairs.	These also occur in pairs.
Segregate at the time of gamete formation such that only one of each pair is transmitted to a gamete.	Segregate at gamete formation and only one of each pair is transmitted to a gamete.
One pair segregates independently of other pairs.	One pair segregates independently of another pairs situated on different chromosome. However, segregation of linked genes shows dependency on each other.

- It was done by **Thomas Hunt Morgan** and his colleagues.
- Morgan carried out various dihybrid crosses in *Drosophila* with the genes that were sex-linked, i.e. the genes present on the X-chromosome.
- Morgan selected fruitfly, *Drosophila melanogaster* for his experiments because
  - They could be grown on simple artificial medium in the laboratory.
  - Their life cycle is only about two weeks.
  - A single mating could produce a large number of flies.
  - It has four pairs of chromosomes which differ in size.
  - There was a clear differentiation of the sexes, i.e. male (smaller) and female (bigger).
  - It has many types of hereditary variation, which can be easily seen through low power microscope.

Linkage and Recombination

- **Morgan** and his group observed in *Drosophila* that when the two genes in a dihybrid cross were situated on the same chromosome, the proportion of parental gene combinations were much higher than the non-parental type.
- They attributed this due to physical association of the two genes and coined the term **'linkage'** to describe this physical association of genes on a chromosome and the term '**recombination**' to describe the generation of non-parental gene combinations.
- Thus, linkage is a phenomenon of genetic inheritance in which genes of a particular chromosome show their tendency to inherit together.
- Morgan and his group also found that even when genes were grouped on the same chromosome, some genes were tightly linked, i.e. linkage is stronger between two genes, if the frequency of recombination is low.
- Whereas, the frequency of recombinations is higher, if genes are loosely linked, i.e. linkage is weak between two genes.
- Recombination of linked genes is by **crossing over** (exchange of corresponding parts between the chromatids of homologous chromosomes).

Polygenic Inheritance

- It was given by **Galton** in 1833. In this, traits are controlled by three or more genes (multiple genes). These traits are called **polygenic traits**.
- The phenotype shows participation of each allele and is also influenced by the environment and is called **quantitative inheritance** as the character/phenotype can be quantified. For example, human skin colour which is caused by a pigment melanin. The quantity of melanin is due to three pairs of polygenes (A, B and C).
- If a black or very dark (AA BB CC) and white or very light (aa bb cc) individuals marry each other, the offspring show intermediate colour, also called **mulatto** (Aa Ba Ca). A total of eight allele combinations are possible in the gametes, forming 27 distinct genotypes.

Pleiotropy

- It is the phenomenon in which a single gene product may produce multiple or more than one phenotypic effect.
- For example, **phenylketonuria**, a disorder caused by mutation in the gene coding the enzyme phenylalanine hydroxylase. The affected individuals show hair and skin pigmentation and mental retardation.
- Therefore, it can be said that dominance is not an autonomous feature of the gene, or its product, but it depends on the production of a particular phenotype from the gene product.

Sex-Determination

- The establishment of sex through differential development in an individual at the time of zygote formation is called sex-determination.
- **Henking** in 1891, could trace a specific nuclear structure all through spermatogenesis in few insects. He observed that 50% of sperms received this specific structure after spermatogenesis, whereas the other 50% of sperms did not receive it. He named this structure as **X-body**.

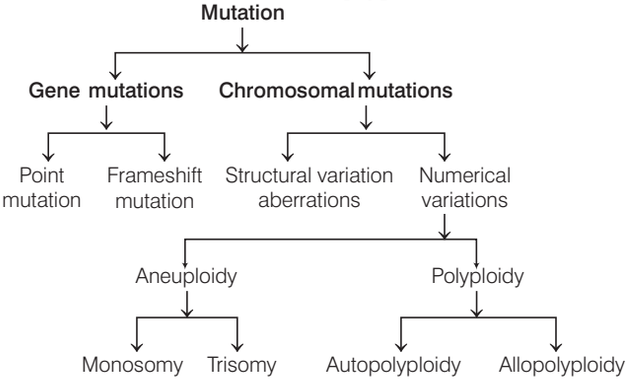
Scientists further explained that X-body was a chromosome and called it as **X-chromosome**.

- The chromosomal theory of sex-determination was worked out by **EB Wilson** and **Stevens** (1902-1905). They named XY-chromosomes as **allosome** or **sex chromosomes** and other chromosomes, which have no relation with the sex and contain genes, which determine the somatic characters as **autosomes** (AA).
- Thus, on the basis of the type of allosome present in the gamete, the parents can be of two types
  - Homogametic, i.e. producing similar gametes.
  - Heterogametic, i.e. producing different gametes.
- Sex-determination pattern in different organisms is as follows

Types of sex-determination mechanism	Features	Examples
XX-XY method	Females are homogametic as all the chromosomes bear only X-chromosome. Males are heterogametic as half of the gametes have X-chromosomes and the other half bears Y-chromosomes.	Humans, *Drosophila,* etc.
XX-XO method	Females are homogametic as all gametes bear only X-chromosome. Males are heterogametic as half of the gametes bear X-chromosome and the other half does not have any sex-chromosome.	Roundworms, insects, etc.
ZW-ZZ method	Females are heterogametic half of the gametes have Z-chromosome and the other half have W-chromosome. Males are homogametic as all the gametes possess only Z-chromosome.	Fishes, reptiles etc.
ZO-ZZ method	Females are heterogametic as half of the gametes have Z-chromosome and the other half has no chromosome. Males are homogametic and all the gametes bear only Z-chromosome.	Moths, butterflies, etc.
Haplodiploidy	Unfertilised egg produces a haploid male. Fertilised egg produces a diploid gamete.	Honeybees, etc.

Mutation

- It is a sudden, stable and inheritable change in genetic material or DNA sequences of an organism. The organism, which undergoes mutation is called **mutant**.
- The chemical and physical factors that induce mutations are called **mutagens**, e.g. UV radiations, etc.
- The mutations are of following types

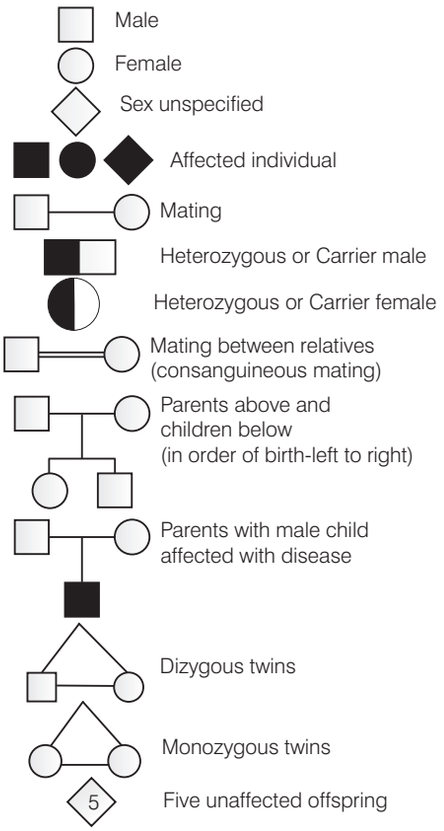


- Mutation occurring due to change in a single base pair of DNA. This is called **point mutation**, e.g. sickle-cell anaemia.
- Deletions and insertions of base pairs of DNA cause **frameshift mutation**.
- The loss or gain of a segment of DNA, results in **structural alteration in chromosomes** because genes are located on the chromosomes. This alteration in chromosomes results in abnormalities and is common in cancerous cells.
- When members of a homologous pair of chromosomes fail to segregate during meiosis, **aneuploidy** occurs. It means, there is loss or gain of one or more chromosomes.
  - **Monosomy**, i.e. lack of one chromosome of normal complement.
  - **Trisomy**, i.e. three instead of normal two chromosomes.
- **Polyploidy** occurs when there is failure of cytokinesis after telophase stage of cell division resulting in an increase in a whole set of chromosomes in an organism. In this phenomenon, the cell has loss or gain of three, four or more sets of chromosomes.
  - **Autopolyploids** are polyploids with multiple chromosome sets derived from a single species.
  - **Allopolyploids** where chromosomes are derived from different species, i.e. result of multiplying the chromosome number and forming a hybrid.

Pedigree Analysis

- The analysis of traits in several generations of a human family in the form of a family tree or diagram is called **pedigree analysis**. It serves as a strong tool, which is utilised to trace the inheritance of a specific trait, abnormality or disease.
- Inheritance pattern of traits in human beings cannot be studied by crosses as in case of other organisms due to following reasons
  - The progeny produced is very small (usually one) and therefore, takes long time.
  - Controlled crosses cannot be performed.

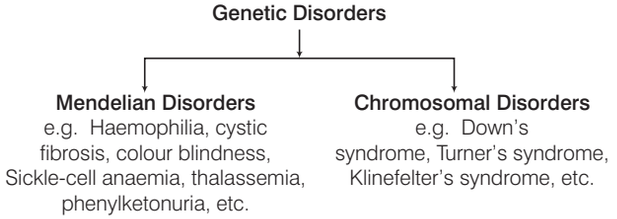
The symbols used in pedigree analysis are given below



Symbols used in the human pedigree analysis

Genetic Disorders

- These are disorders or illness which caused by one or more abnormalities in the autosomes or sex chromosomes of the person. Thus, referred to as **autosomal disorders** or sex-linked disorders, respectively.
- The genetic disorders are divided into



Mendelian Disorders

- It caused due to alteration or mutation in a single gene. These are of two types
  - **Sex-linked recessive disorder**, e.g. colour blindness and haemophilia.
  - **Autosomal recessive disorder**, e.g. thalassemia, phenylketonuria and sickle-cell anaemia.
- Various Mendelian disorders are tabulated below

Disorders	Characteristics
Colour blindness	• Sex-linked recessive disorder caused due to mutation in genes present on X-chromosome. • Mostly females are carrier while males contract the disease. • Affected person fails to discriminate red and green colour.
Haemophilia	• Sex-linked recessive disorder which prevent clotting of blood. • Heterozygote females are carrier who transmit the disease to sons.
Sickle-cell anaemia	• Autosome linked recessive trait. • Caused due to the substitution of glutamic acid by valine as the sixth codon of β-globin gene gets substituted from GAG to GUG. • RBCs become sickle-shaped under low O_2 tension.
Phenylketonuria	• Autosomal recessive trait. • Individual lack enzyme that convert phenylalanine into tyrosine leading to accumulation of phenylpyruvic acid in body, brain, etc.
Thalassemia	• Autosome linked recessive trait. • α-thalassemia is caused due to the mutation in HBA1 and HBA2 genes on chromosome 16. • β-thalassemia is caused due to the mutation in HBB gene on chromosome 11. • The rate of synthesis of α or β-chain gets reduced leading to the formation of abnormal haemoglobin.

Chromosomal Disorders

- It caused due to excess, the absence or abnormal arrangement of one or more chromosomes. These are of two types as follows
  - **Autosomal abnormality or disorder**, e.g. Down's syndrome (Mongolian idiocy).
  - **Sex chromosome abnormality**, e.g. Klinefelter's syndrome and Turner's syndrome.
- Various chromosomal disorders are tabulated below

Disorders	Characteristics
Down's syndrome	• 21 trisomy (described by Langdon Down) • Cause short statured, furrowed tongue, small round head, palm crease, retarded mental development and physical appearance.
Klinefelter's syndrome	• Presence of an additional X-chromosome (XXY). • Cause sterility, gynaecomastia, overall masuline development, etc.
Turner's syndrome	• Absence of one X-chromosome (XO). • Sterile females, rudimentary ovaries, lack of secondary sexual characters.

Mastering NCERT

MULTIPLE CHOICE QUESTIONS

TOPIC 1 ~ *Mendel's Laws of Inheritance*

1 Genetics is the branch of biology which deals with
(a) variation (b) inheritance
(c) Both (a) and (b) (d) study of characters

2 The inheritance of characters from parents to offspring is
(a) variation (b) heredity
(c) inheritance (d) resemblance

3 The tendency of offspring to differ from their parents is called
(a) variation (b) heredity
(c) inheritance (d) resemblance

4 Mendel's hybridisation experimental material was
(a) *Pisum sativum* (b) *Lathyrus odoratus*
(c) *Oryza sativa* (d) *Mirabilis jalapa*

5 Which one from those given below is the period of Mendel's hybridisation experiments? ***NEET 2017***
(a) 1856-1863 (b) 1840-1850
(c) 1857-1869 (d) 1870-1877

6 Mendel investigated characters in garden pea plant manifested in two traits which were
(a) similar (b) non-zygote
(c) identical (d) opposite

7 A true breeding line is characterised by the presence of
(a) stable trait inheritance due to the continuous self-pollination
(b) varying traits in different generations due to the cross pollination
(c) single trait in all generations due to allogamy
(d) varying trait inheritance in a single generation due to geitonogamy

8 How many pairs of true breeding varieties were selected by Mendel for his experiment on pea plant?
(a) 12 (b) 13 (c) 14 (d) 15

9 Out of 7 contrasting trait pairs selected by Mendel, how many traits were dominant and recessive?
(a) 7 and 7
(b) 8 and 6
(c) 6 and 8
(d) 5 and 9

10 Among the following characters, which one was not considered by Mendel in his experiments on pea?
(a) Stem – Tall or Dwarf ***NEET 2017***
(b) Trichomes – Glandular or Non-glandular
(c) Seed – Green or Yellow
(d) Pod – Inflated or Constricted

11 Which is correct about traits choosen by Mendel for his experiment on pea plant?
(a) Terminal pod was dominant
(b) Constricted pod was dominant
(c) Green coloured pod was dominant
(d) Tall plants were recessive

12 What contributed to Mendel's success?
I. Selection of pureline pea varieties.
II. Knowledge of history.
III. Selecting one character at a time.
IV. Statistical analysis and mathematical logic.
Choose the correct option.
(a) I, II, III and IV (b) II and III
(c) I, III and IV (d) II, III and IV

TOPIC 2 ~ *Inheritance of One Gene*

13 The first hybrid progeny obtained by Mendel were called
(a) F_1-progeny (b) F_0-progeny
(c) F_2-progeny (d) F_3-progeny

14 F_1-progeny of a cross between pure tall and dwarf plant is always
(a) tall
(b) short
(c) intermediate
(d) None of these

15 According to Mendel's observation, which generation of progeny always represents the phenotype of the dominant parent?
(a) F_4 (b) F_2 (c) F_1 (d) F_0

16 The Mendel crossed true breeding tall and dwarf plant varieties in his experiment. Tallness was the dominant character and dwarfness was recessive. The recessive character appeared in
(a) F_1 (b) F_2
(c) F_3 (d) F_2 and F_3

17 How did Mendel obtained recessive (dwarf) character in F_2-generation?
(a) By self-pollinating F_1 (b) By self-pollinating F_2
(c) By cross-pollinating F_1 (d) By cross-pollinating F_2

18 The proportion of plants that were dwarf and tall, respectively in F_2-generation of Mendel's experiment was
(a) $\frac{1}{4}$th and $\frac{3}{4}$th (b) $\frac{3}{4}$th and $\frac{1}{4}$th
(c) $\frac{2}{3}$rd and $\frac{1}{3}$rd (d) $\frac{1}{3}$rd and $\frac{4}{3}$rd

19 Mendel crossed tall and dwarf plants. In F_2-generation both the tall and dwarf plants were produced. This shows
(a) blending of characters
(b) atavism
(c) non-blending of characters
(d) intermediate characters

20 During his experiments, Mendel used the term factor for
(a) genes (b) traits
(c) characters (d) qualities

21 Genes which codes for a pair of contrasting characters are
(a) recessive character (b) dominant character
(c) alleles (d) alternative gene

22 Choose the incorrect match.
(a) Phenotype – Physical appearance of an organism
(b) Genotype – Expressed genes
(c) Homozygous – Identical alleles of a gene present at the same locus
(d) Heterozygous – Genes of an allelic pair are not same

23 Number of gametes produced by a homozygous and a heterozygous individuals of genotype AA and Aa, respectively are
(a) 1 and 2 (b) 2 and 3
(c) 3 and 5 (d) many

24 A cross in which parents differ in a single pair of contrasting character is called
(a) monohybrid cross (b) dihybrid cross
(c) trihybrid cross (d) tetrahybrid cross

25 The phenotypic ratio of a monohybrid cross in F_2-generation is
(a) 3 : 1 (b) 1 : 2 : 1
(c) 2 : 1 : 1 (d) 9 : 3 : 3 : 1

26 The genotypic ratio of a monohybrid cross in F_2-generation is
(a) 3 : 1 (b) 1 : 2 : 1
(c) 2 : 1 : 1 (d) 9 : 3 : 3 : 1

27 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 ***CBSE-AIPMT 2012***
(a) codominance
(b) dihybrid cross
(c) monohybrid cross with complete dominance
(d) monohybrid cross with incomplete dominance

28 If the male plant has the genotype TT and the female plant has the genotype tt then they contribute pollen and egg, respectively with
(a) T and T gametes (b) tt and TT gametes
(c) TT and tt gametes (d) T and t gametes

29 Graphical representation to calculate the probability of all possible genotype of an offspring in genetic cross is called
(a) Bunett square (b) Morgan square
(c) Punnett square (d) Mendel square

30 Test cross involves a cross between
(a) recessive F_1-plant and dominant F_2-plant
(b) recessive F_2-plant and dominant F_3-plant
(c) dominant F_2-plant and recessive parent plants
(d) dominant F_2-plant and heterozygous parent plants

31 Mendel performed test cross to know the
(a) genotype of F_1 (b) genotype of F_2
(c) genotype of F_3 (d) genotype of F_4

32 When alleles of two contrasting characters are present together and one of the character expresses itself during the cross while the other remains hidden gives the
(a) law of purity of gametes
(b) law of segregation
(c) law of dominance
(d) law of independent assortment

33 The allele which expresses itself in both homozygous and heterozygous condition is called
(a) dominant allele
(b) recessive allele
(c) incomplete dominant allele
(d) split allele

34 3:1 ratio in F_2-generation is explained by
(a) law of partial dominance
(b) law of dominance
(c) law of incomplete dominance
(d) law of purity of gametes

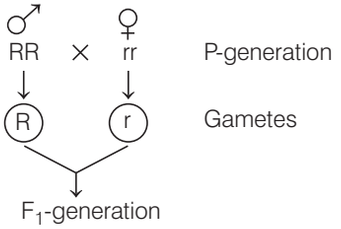
35 The law of dominance is applicable in inheritance of
(a) seed colour in pea
(b) flower colour in *Mirabilis jalapa*
(c) starch grain size in pea
(d) roan coat colour in cattles

36 Mendel's principle of segregation means that the germ cells always receive
(a) one pair to alleles
(b) one quarter of the genes
(c) either one allele of father or one allele of mother
(d) any pair of alleles

37 The law based on fact that the characters do not show any blending and both the characters are recovered as such in F_2-generation although one character was absent in F_1-progeny, is
(a) law of purity of gametes
(b) law of independent assortment
(c) law of incomplete dominance
(d) law of dominance

38 Mendel crossed tall and dwarf plant. In F_2-generation the observed ratio was 3:1 (tall : short). From this result, he deduced
I. law of dominance.
II. law of independent assortment.
III. law of segregation.
IV. incomplete dominance.
Choose the correct option.
(a) I, II, III and IV (b) I and III
(c) II, III and IV (d) I, II and III

39 Correctly select the genotype and phenotype of F_1-generation (R = dominant and red, r = recessive and white) from the given cross in plant snapdragon showing incomplete dominance.



(a) Rr and white (b) Rr and red
(c) Rr and pink (d) cannot predict

40 Theoretically in incomplete dominance one allele functions as normal, while another allele may function as
(a) normal allele
(b) non-functional allele
(c) normal but less efficient allele
(d) All of the above

41 Incomplete dominance is similar to codominance in having identical
(a) phenotypic ratio
(b) genotypic ratio
(c) Both (a) and (b)
(d) None of the above

42 TtRr represents (heterozygous tall, heterozygous pink). If this plant is self crossed then
(T–dominant, t–recessive, R–dominant, r–recessive)
I. 25% plants have red flowers.
II. 25% plants have white flowers.
III. 50% plants have pink flowers.
IV. 50% plants are tall.
Choose the correct option.
(a) I and II (b) I, II and III
(c) II, III and IV (d) I, II, III and IV

43 Which Mendelian idea is depicted by a cross in which the F_1-generation resembles both the parents?
NEET 2013
(a) Incomplete dominance (b) Law of dominance
(c) Inheritance of one gene (d) Codominance

44 What will be the ratio of offspring in a cross between the red coloured and pink coloured flowers of *Mirabilis jalapa*.
(a) Red : Pink = 1 : 1 (b) Red : Pink = 3 : 1
(c) Red : Pink = 1 : 3 (d) Red : Pink = 2 : 3

45 The recessive trait in case of incomplete dominance is seen due to the
(a) non-functional enzyme produced by modified gene
(b) absence of any enzyme that may otherwise be produced by modified gene
(c) normal or less efficient enzyme produced by recessive allele
(d) Both (a) and (b)

46 The ABO blood groups are controlled by
(a) I-gene (b) c-gene
(c) B-gene (d) n-gene

47 Out of the three alleles of gene I, the sugar polymers on the plasma membrane of RBCs is controlled by how many alleles?
(a) All three (b) Two
(c) One (d) O

48 In human blood group inheritance
(a) I^A and I^B are codominant
(b) I^A and I^B are dominant over i
(c) I^A is dominant over I^B
(d) Both (a) and (b)

49 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 ***NEET 2013***
(a) codominance (b) incomplete dominance
(c) partial dominance (d) complete dominance

50 In a marriage between male with blood group A and female with blood group B, the progeny had either blood group AB or B. What could be the possible genotype of parents? ***NEET (Odisha) 2019***

(a) I^Ai (Male) : I^BI^B (Female)
(b) I^AI^A (Male) : I^BI^B (Female)
(c) I^AI^A (Male) : I^Bi (Female)
(d) I^Ai (Male) : I^Bi (Female)

51 Blood group of the father is 'A' and blood group of mother is 'B'. Then predict the blood group of the progeny. ***AIIMS 2019***

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

52 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? ***NEET 2017***

(a) 3 genotypes; 3 phenotypes
(b) 3 genotypes; 4 phenotypes
(c) 4 genotypes; 3 phenotypes
(d) 4 genotypes; 4 phenotypes

53 Which of the following characteristics represents 'Inheritance of blood groups' in humans? ***NEET 2018***

I. Dominance
II. Codominance
III. Multiple allele
IV. Incomplete dominance
V. Polygenic inheritance

(a) I, IV and V (b) I, II and III
(c) II, III and V (d) I, III and V

54 When there are more than two alleles controlling the same character. These are called

(a) pleiotropy (b) polyalleles
(c) multiple alleles (d) All of these

55 Which of the following option (s) is/are correct for starch synthesis in pea seeds controlled by single gene which has two allelic forms B and b?

(a) BB is round seed with large starch synthesis
(b) bb is wrinkled seed with large starch synthesis
(c) Bb is round seed with less starch synthesis
(d) All of the above

56 Starch synthesis gene in pea plant in heterozygous condition produces starch grain of intermediate size. This shows

(a) complete dominance
(b) incomplete dominance
(c) codominance
(d) None of the above

TOPIC 3 ~ *Inheritance of Two Genes*

57 The types of gametes formed by the genotype RrYy are

(a) RY, Ry, rY, ry (b) RY, Ry, ry, ry
(c) Ry, Ry, Yy, ry (d) Rr, RR, Yy, YY

58 In law of independent assortment how many factors are involved (for a dihybrid cross)

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

59 In Mendel's experiments with garden pea, round seed shape (RR) was dominant over wrinkled seeds (rr) and yellow colour (YY) was dominant over green colour (yy). What are the expected phenotypes in the F_1-generation of the cross RRYY × rryy?

(a) Only round seeds with yellow cotyledons
(b) Only wrinkled seeds with yellow cotyledons
(c) Only wrinkled seeds with green cotyledons
(d) Round seeds with yellow cotyledons and wrinkled seeds with yellow cotyledons

60 In cross between pure breeding pea plants having yellow round (YYRR) and green wrinkled (yyrr) seeds, find out the total seeds (plants) having yellow colour in F_2-generation.

(a) 12 (b) 10
(c) 14 (d) 11

61 In a cross between plants having yellow round (YYRR) and green wrinkled (yyrr) seeds, what will be the ratio between seeds having yellow and green seed colour?

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

62 Total number of round seed in the F_2-generation of a cross between plants having pure yellow round and pure green wrinkled seeds is

(a) 9 (b) 12 (c) 11 (d) 1

63 Ratio observed in dihybrid cross (phenotypically)

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

64 The number of different genotypes observed in the F_2-generation of a dihybrid cross are

(a) 9 (b) 12 (c) 4 (d) 6

65 Mendel's result on inheritance of characters were rediscovered by

(a) de Vries (b) Correns
(c) von Tschermak (d) All of these

66 The literal meaning of chromosome is

(a) painted body (b) coloured body
(c) doubling body (d) thread-like body

67 The concept of chromosome movement during meiosis to explain Mendel's laws was used by
(a) Sutton and Boveri
(b) Malthus
(c) Correns
(d) Morgan

68 The chromosomes as well as genes occur in pair and the two alleles of a gene pair are located on
(a) homologous chromosomes
(b) non-homologous chromosomes
(c) single chromosome
(d) All of the above

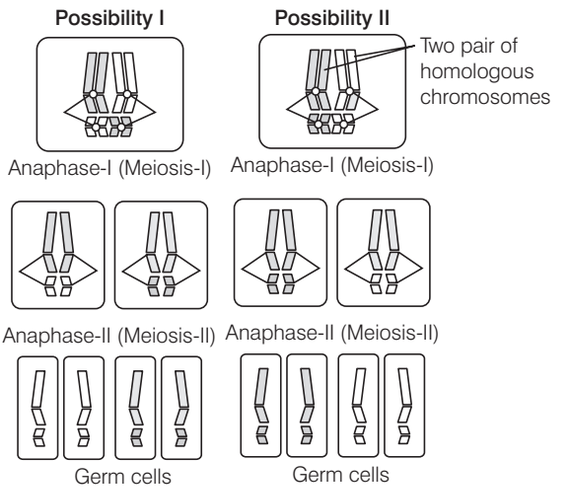
69 Who proposed the chromosomal theory of inheritance?
(a) Sutton and Mendel
(b) Boveri and Morgan
(c) Morgan and Mendel
(d) Sutton and Boveri

70 Experimental evidences of chromosomal theory of inheritance was given by
(a) S Boveri (b) TH Morgan
(c) de Vries (d) W Sutton

71 Morgan's experimental organism was
(a) *Drosophila melanogaster*
(b) *Mangifera indica*
(c) *Mirabilis jalapa*
(d) *Drosophila indica*

72 Both chromosome and gene (Mendelian factors) whether dominant or recessive are transmitted from generation to generation in
(a) changed form
(b) unaltered form
(c) altered form
(d) disintegrated form

73 The figure depicts.



(a) Linkage
(b) Independent assortment
(c) Law of dominance
(d) Equational division

74 Choose the incorrect pairing among the following.
(a) Sutton and Boveri – Chromosome theory
(b) Walter and Boveri – Behaviour of chromosome during cell divisions
(c) TH Morgan – Mutation
(d) Henking – Barr bodies

75 Linked genes that were observed by Morgan were present on
(a) X-chromosome
(b) different chromosome
(c) heterologous chromosome
(d) paired chromosome

76 Strength of the linkage between the two genes is
(a) proportionate to the distance between them
(b) inversely proportionate to the distance between them
(c) depend on the chromosomes
(d) depend upon the size of chromosomes

77 In Morgan's experiment, white and yellow genes were linked tightly, while white and miniature wing were loosely linked. The per cent recombination shown by these genes were
(a) 50% each
(b) 72% and 8.3%, respectively
(c) 0.3% and 53%, respectively
(d) 1.3% and 37.2%, respectively

78 In a test cross involving F_1 dihybrid flies, more parental-type offspring were produced than the recombinant type offspring. This indicates
NEET 2016
(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 genes are located on two different chromosomes

79 The frequency of recombination between gene pairs on the same chromosome as a measure of the distance between genes was explained by
NEET (National) 2019
(a) Gregor J Mendel (b) Alfred Sturtevant
(c) Sutton-Boveri (d) TH Morgan

80 What map unit (centi Morgan) is adopted in the construction of genetic maps? ***NEET (National) 2019***
(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

81 Map units on linkage map cannot be relied upon to calculate physical distances on a chromosome for which of the following reasons?
(a) The relationship between recombination frequency and map units is different in every individual
(b) Physical distances between genes change during the coures of cell cycle
(c) Linkage map distances are identical between males and females
(d) The frequency of crossing over varies along the length of the chromosome

82 Linkage group is
(a) linearly arranged group of linked gene
(b) non-linearly arranged group of linked gene
(c) non-linearly arranged group of unlinked gene
(d) non-linearly arranged group of single gene

83 Linkage groups are always present on the
(a) homologous chromosomes
(b) analogous chromosomes
(c) sex chromosomes
(d) heterologous chromosomes

84 Genetic maps can be used in human genome project
(a) starting point in the sequencing of whole genome
(b) measure the distance between genes
(c) map the position of genes on chromosomes
(d) All of the above

85 Genes A, B and C are linked. Genes A and B are more close than A and C.
I. A might be before B and C.
II. B might be between A and C.
III. C might be between A and B.
IV. More crosses cannot occur between A and C than A and B.
Find out the correct option for the given information.
(a) I and II
(b) II and III
(c) III and IV
(d) I, II and IV

TOPIC 4 ~ *Polygenic Inheritance and Pleiotropy*

86 Polygenic traits are controlled by
(a) one gene
(b) two genes
(c) three or more genes
(d) mutant genes

87 The polygenic traits
(a) are influenced by environment
(b) phenotype reflect the contribution of each allele
(c) effect of each allele is additive
(d) All of the above

88 In human skin colour which is a polygenic trait, all dominant and all recessive alleles show
(a) Darkest and lightest skin colour, respectively
(b) Lightest and darkest skin colour, respectively
(c) Only darkest skin colour
(d) Only lightest skin colour

89 In human skin colour inheritance, the genotype with three dominant and three recessive alleles will produce
(a) darkest skin colour
(b) lightest skin colour
(c) intermediate skin colour
(d) patches of black and white

90 A pleiotropic gene
(a) is not found in humans
(b) is a single gene which exhibit multiple phenotypic expressions
(c) show effect on metabolic pathways, so as to produce various phenotypes
(d) Both (b) and (c)

91 Phenylketonuria is caused due to
(a) pleiotropy
(b) multiple alleles
(c) codominance
(d) incomplete dominance

92 Phenylketonuria in human
(a) manifests through phenotypic expressions
(b) is characterised by mental retardation
(c) leads to hair reduction and skin pigmentation
(d) All of the above

93 Which one of the following pairs is wrongly matched? ***NEET 2018***
(a) XO type of sex-determination – Grasshopper
(b) ABO blood grouping – Codominance
(c) Starch synthesis in pea – Multiple allele
(d) TH Morgan – Linkage

TOPIC 5 ~ *Sex-Determination*

94 Sex-determination is controlled by …*A*… and the remaining chromosomes which are not involved in sex-determination are …*B*… .

	A	B
(a)	Allosomes	Autosomes
(b)	Allosomes	Sex-chromosomes
(c)	Sex-chromosomes	Allosomes
(d)	Autosomes	Sex-chromosomes

95 Choose the incorrect pair with respect to sex determination in different organisms.
(a) Grasshopper = XO type
(b) Birds = ZZ-ZW type
(c) *Drosophila* = XX-XO type
(d) Human = XX-XY type

96 In XX and XY type of sex-determination,
(a) males are heterogametic
(b) females are isogametic
(c) Both (a) and (b)
(d) None of the option is correct

97 Male heterogamety is seen in
(a) Humans (b) Grasshopper
(c) *Drosophila* (d) All of these

98 Choose the incorrect pair amongst the following.
(a) Male bird – Homogametic
(b) Female bird – Heterogametic
(c) Male *Drosophila* – Heterogametic
(d) None of the above

99 The chromosomal denotation for heterogametic female and homogametic males are
(a) ZW and ZZ (b) ZO–ZZ
(c) XX–XO (d) Both (a) and (b)

100 A human male contains the karyotype of …*A*… and a human female has …*B*… chromosomes.

	A	B
(a)	44 + XX	44 + XY
(b)	44 + XY	44 + XX
(c)	44 + XO	44 + XX
(d)	44 + XX	44 + XO

101 The number of chromosomes in females and males honeybees are
(a) 32
(b) 16
(c) 32 and 16, respectively
(d) 16 and 32, respectively

102 The unfertilised eggs in honeybees develop into
(a) males (b) queen
(c) worker (d) Both (a) and (c)

103 In honeybees, male and female gametes are produced through
(a) mitosis (b) mitosis and meiosis, respectively
(c) meiosis (d) meiosis and mitosis, respectively

TOPIC 6 ~ *Mutation*

104 Mutation is a phenomena which results in alteration in sequences of
(a) DNA (b) RNA
(c) proteins (d) Both (a) and (b)

105 Mutation may result in
(a) change in genotype (b) change in phenotype
(c) change in metabolism (d) All of these

106 Chromosomal abberation is commonly found in the
(a) cancer cells (b) normal cells
(c) healthy cells (d) autosomal cells

107 Point mutation arises due to the change in
(a) single base DNA
(b) single base pair of DNA
(c) segment of DNA
(d) double base pair of DNA

108 If there are four different types of nitrogenous bases (A, T, G and C) then how many different types of transitions and transversion are possible?
(a) Transition = 8, Transversion = 4
(b) Transition = 4, Transversion = 4
(c) Transition = 8, Transversion = 4
(d) Transition = 4, Transversion = 8

109 Sickle-cell anaemia is a classical example of
(a) frame-shift mutation
(b) point mutation
(c) Both (a) and (b)
(d) None of the above

110 Frame-shift mutation arises due to
(a) deletion of base pair of DNA
(b) insertion of base pair of DNA
(c) Both (a) and (b)
(d) change in single base pair of DNA

111 Mutagens are
(a) chemical agents which cause change in DNA
(b) physical agents which cause mutation
(c) Both (a) and (b)
(d) None of the abvoe

TOPIC 7 ~ Genetic Disorders

112 Analysis of traits of several generation of a family in the form of diagram is called
(a) gene analysis (b) chromosome analysis
(c) allele analysis (d) pedigree analysis

113 Pedigree analysis is very important in human beings because
(a) it helps genetic counselors to avoid disorders
(b) it shows origin of traits
(c) it shows the flow of traits in family
(d) All of the above

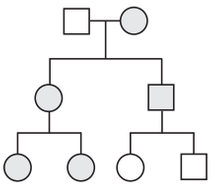
114 Identify the correct choice for given symbols (*A* and *B*).

(a) A–Consanguineous mating; B–Mating
(b) A–Mating; B–Mating between relatives
(c) A–Mating; B–Consanguineous mating
(d) Both (b) and (c)

115 Identify the symbols given below and the correct option with respect of *A*, *B*, *C* and *D*.

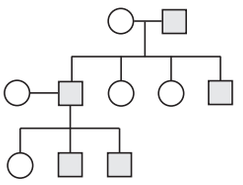
(a) A–Male, B–Female, C–Sex unspecified, D–Affected male
(b) A–Male, B–Female, C–Sterile, D–Carrier male
(c) A–Male, B–Female, C–Fertile, D–Affected female
(d) A–Female, B–Male, C–Sex unspecified, D–Carrier female

116 Identify the type of inheritance in the given diagram.



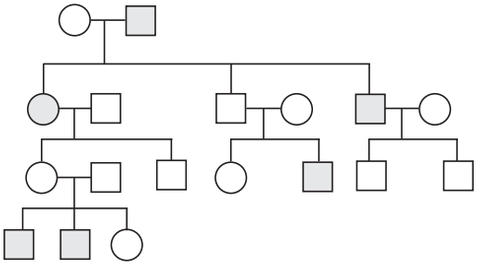
(a) Dominant X-linked
(b) Recessive X-linked
(c) Dominant Y-linked
(d) Cytoplasmic or Mitochondrial inheritance

117 Following pedigree chart shows



(a) character is carried by Y-chromosome
(b) character is sex-linked recessive
(c) character is sex-linked dominant
(d) character is recessive autosomal

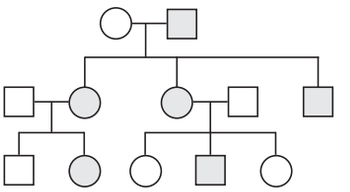
118 In the following human pedigree, the filled symbols represent the affected individuals. Identify the type of given pedigree.



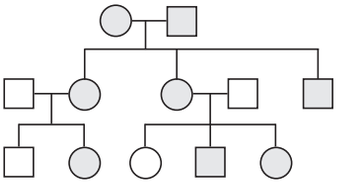
(a) X-linked dominant (b) Autosomal recessive
(c) Autosomal dominant (d) X-linked recessive

119 In a family, father had a trait but mother did not. All their sons and daughter had this trait. The same trait was found in some grand daughters, though daughter were married to the normal persons.
Choose the correct pedigree chart for this condition.

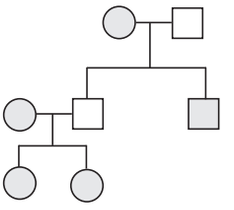
(a)



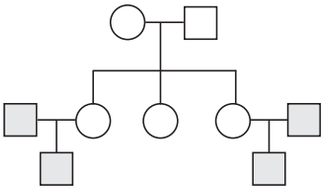
(b)



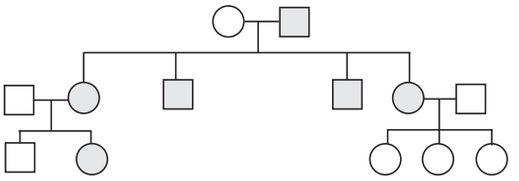
(c)



(d)

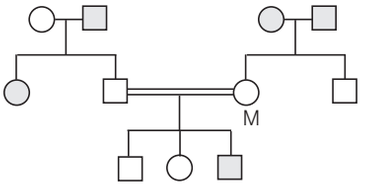


120 Observe the pedigree chart given below. Find out the cause of trait, i.e. it is due to



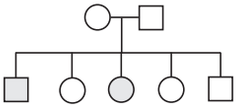
(a) Incompletely dominant allele
(b) Dominant allele
(c) Either dominant or recessive allele
(d) Recessive allele

121 The diagram given below show the inheritance of haemophilia in a family. What will be the genotype of the individual marked M?



(a) M – XY (b) M – XX
(c) M – X^hX^h (d) M – X^hX

122 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. Which of the following condition can be drawn?



(a) Parents are heterozygous
(b) Parents are homozygous recessive
(c) Parents are homozygous dominant
(d) All are incorrect

123 Colour blindness in humans
(a) results in defect in either red or green cone of eyes
(b) is caused due to the mutation in gene found on X-chromosome
(c) affects males more frequently than females
(d) All of the above

124 A woman has an X-linked condition on one of her X-chromosomes. This chromosome can be inherited by ***NEET 2018***
(a) Only grand children (b) Only sons
(c) Only daughters (d) Both (b) and (c)

125 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? ***CBSE-AIPMT 2012***
(a) 100% (b) 0%
(c) 25% (d) 50%

126 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 ? ***CBSE-AIPMT 2014***
(a) 25% (b) 0%
(c) 50% (d) 75%

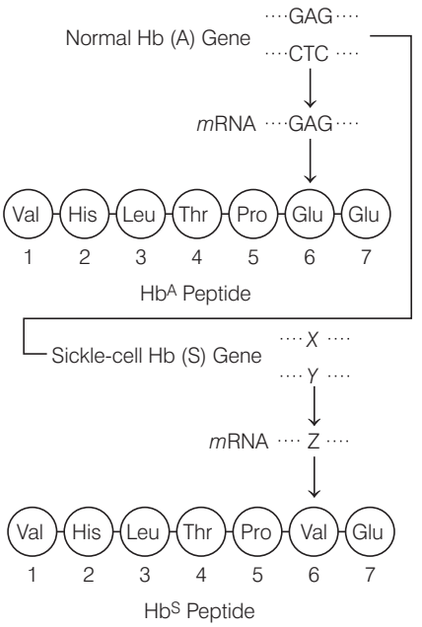
127 A normal woman whose father was colourblind, marries a normal man. What kinds of children can be expected and in what proportion ? ***AIIMS 2018***
(a) All daughters normal, 50% of sons colourblind
(b) All daughters normal, all sons colourblind
(c) 50% daughters colourblind, all sons normal
(d) All daughters colourblind, all sons normal

128 Which of the following most appropriately describes haemophilia? ***NEET 2016***
(a) X-linked recessive gene disorder
(b) Chromosomal disorder
(c) Dominant gene disorder
(d) Recessive gene disorder

129 In haemophilia, the affected protein is a part of a cascade of protein which is involved in the
(a) formation of RBCs
(b) formation of WBCs and platelets
(c) coagulation of blood
(d) anticoagulation

130 Sickle-cell anaemia is an autosomal linked recessive trait that can be transmitted from parents to the offspring when both the partners are carriers for all the genes or heterozygous.

The disease is controlled by a single pair of allele, Hb^A and Hb^S. Identify *X, Y* and *Z*.



	X	Y	Z
(a)	GTG	CAC	Val (GUG)
(b)	CAC	CTC	Val (GUG)
(c)	GTA	GAG	Val (GUG)
(d)	GTC	GAC	Val (GUG)

131 In sickle-cell anaemia,
(a) Both parents are heterozygous carriers, but are unaffected
(b) Single pair of allele controls the disease
(c) Only Hb^sHb^s show diseased phenotype
(d) All of the above

132 In individual suffering from phenylketonuria,
(a) enzyme phenylalanine hydroxylase is absent
(b) phenylalanine do not convert to tyrosine
(c) phenylpyruvic acid is formed
(d) All of the above

133 Thalassemia in humans
(a) is an autosome linked recessive blood disorder
(b) can transmit from parents to offspring when both parents are unaffected carriers (heterozygous)
(c) caused due to the mutation or deletion of one of the α or β-globin chain
(d) All of the above

134 α-thalassemia in humans is controlled by
(a) HBA1 and HBA2 genes on chromosome 16
(b) HBA1 gene on chromosome 12
(c) HBA2 gene on chromosome 11
(d) HBA1 and HBA2 genes on chromosome 9

135 β-thalassemia in humans is controlled by
(a) HBA2 gene on chromosome 16
(b) HBB gene on chromosome 11
(c) HBA1 gene on chromosome 15
(d) HBA1 and HBA2 gene on chromosome 8

136 Failure of segregation of chromatid during cell division cycle results in the gain or loss of chromosome which as called
(a) aneuploidy (b) hypopolyploidy
(c) hyperpolyploidy (d) polyploidy

137 A cell telophase stage is observed by a student in a plant brought from the field. He tells his teacher that this cell is not like other cells at telophase stage. There is no formation of cell plate and thus the cell is containing more number of chromosomes as compared to other dividing cells. This would result in ***NEET 2016***
(a) polyploidy
(b) somaclonal variation
(c) polyteny
(d) aneuploidy

138 Non-disjunction in meiosis results in ***JIPMER 2018***
(a) trisomy (b) normal diploid
(c) gene mutation (d) None of these

139 A disease caused by an autosomal primary non-disjunction is ***NEET 2017***
(a) Down's syndrome (b) Klinefelter's syndrome
(c) Turner's syndrome (d) Sickle-cell anaemia

140 Karyotype of Down's syndrome has how many chromosomes? ***JIPMER 2019***
(a) 43 (b) 46 (c) 47 (d) 45

141 I. Short statured body with small round head.
II. Furrowed tongue and partially opened mouth.
III. Palm is broad with characteristic palm crease.
IV. Slow physical, psycomotor and mental development.
These are the characters of
(a) Down's syndrome (b) Turner's syndrome
(c) Klinefelter's syndrome (d) Edward syndrome

142 Choose the correct pair.
(a) Gynacoemastia – Development of breasts
(b) Turner's syndrome – Loss of an X-chromosome in females
(c) Polyploidy – Seen in plants
(d) All of the above

143 What is the genetic disorder in which an individual has an overall masculine development gynaecomastia and is sterile? ***NEET (National) 2019***
(a) Klinefelter's syndrome (b) Edward syndrome
(c) Down's syndrome (d) Turner's syndrome

144 Klinefelter's syndrome results from
(a) XX egg and Y from sperm
(b) XX egg and XY sperm
(c) X egg and XY sperm
(d) Both (a) and (c)

145 In which genetic condition, each cell in the affected person, has three sex chromosomes XXY? ***NEET (Odisha) 2019***
(a) Thalassemia (b) Klinefelter's syndrome
(c) Phenylketonuria (d) Turner's syndrome

146 Monosomy and trisomy are represented respectively as
(a) $n-1, n+2$ (b) $2n+2, 2n+1$
(c) $2n-1, 2n+1$ (d) $2n-2, 2n+1$

147 Female suffering from Turner's syndrome possess
(a) 45 + XO
(b) rudimentary ovaries
(c) lack of secondary sexual characters
(d) All of the above

148 Which of the following are chromosomal disorders.
I. Colour blindness II. Down's syndrome
III. Phenylketonuria IV. Turner's syndrome
V. Thalassaemia
(a) I, II and III (b) II, IV and V
(c) III, IV and V (d) II and IV

NEET

SPECIAL TYPES QUESTIONS

I. Assertion and Reason

■ **Direction** (Q. No. 149-163) *In each of the following questions, a statement of Assertion (A) is given followed by corresponding statement of Reason (R). Of the statements, mark the correct answer as*

(a) If both A and R are true and R is the correct explanation of A
(b) If both A and R are true, but R is not the correct explanation of A
(c) If A is true, but R is false
(d) If A is false, but R is true

149 **Assertion** (A) Offspring have characteristics of both the parents.
Reason (R) Characters pass from the parents to their progeny.

150 **Assertion** (A) True breeding lines have stable trait inheritance for several generations.
Reason (R) Mendel conducted cross-pollination experiments on true breeding lines.

151 **Assertion** (A) In F_2-generation, the traits seen in the progeny were identical to their parents.
Reason (R) The progeny of the F_2-generation show no blending of traits.

152 **Assertion** (A) Genes are not passed on from one generation to the next.
Reason (R) Genes serves as the units of inheritance.

153 **Assertion** (A) Gametes receives only one allele of a gene.
Reason (R) Mitosis occurs during gamete formation leading to the formation of haploid gametes.

154 **Assertion** (A) In codominance, the F_1-generation resembles both the parents.
Reason (R) An example is different type of red blood cells that determine ABO blood grouping in humans.

155 **Assertion** (A) Behaviour of chromosome is parallel to gene.
Reason (R) Genes are located on the chromosome.

156 **Assertion** (A) Some genes tend to pass together from one generation to another.
Reason (R) Such genes are located for away from each other on a chromosome.

157 **Assertion** (A) Insects show female heterogamety.
Reason (R) In insects, males have XO sex chromosome and females have XX sex chromosome.

158 **Assertion** (A) The mechanism of sex-determination in honeybee is called haplodiploidy.
Reason (R) Female honeybees are haploid while male honeybees are diploid.

159 **Assertion** (A) The non-allelic genes for red hair and prickles are usually inherited together. ***AIIMS 2018***
Reason (R) The genes for red hair and prickles are located on the same chromosome in close association.

160 **Assertion** (A) Down's syndrome, Klinefelter's syndrome and Turner's syndrome are chromosomal disorders.
Reason (R) In Klinefelter's syndrome females are sterile. ***AIIMS 2019***

161 **Assertion** (A) Phenylketonuria is recessive hereditary disease caused by body's failure to oxidise an amino acid phenylalanine to tyrosine, because of defective enzyme. ***AIIMS 2018***
Reason (R) It is characterised by in the presence of phenylalanine acid in urine.

162 **Assertion** (A) Sickle-cell anaemia is an autosome linked recessive trait.
Reason (R) It is controlled by a single pair of allele.

163 **Assertion** (A) Down's syndrome is a Mendelian disorder.
Reason (R) It is caused due to the presence of an additional copy of chromosome 21.

II. Statement Based Questions

164 Which of the following statement is not true for two genes that show 50% recombination frequency? ***NEET 2013***

(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 cross overs in every meiosis

165 In *Antirrhinum* (Snapdragon), a red flower was crossed with a white flower and in F_1-generation, pink flowers were obtained.
When pink flowers were selfed, the F_2-generation showed white, red and pink flowers. Choose the incorrect statement from the following. ***NEET (National) 2019***

(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

166 Select the incorrect statement. ***NEET (National) 2019***

(a) In male grasshoppers, 50% of sperms have no sex-chromosome

(b) In domesticated fowls, sex of progeny depends on the type of sperm rather than egg

(c) Human males have one of their sex-chromosomes much shorter than the other

(d) Male fruitfly is heterogametic

167 Which one of the following conditions correctly describes the manner of determining the sex? ***AIIMS 2018***

(a) Homozygous sex chromosomes (ZZ) determine female sex in birds

(b) XO type of sex chromosomes determine male sex in grasshopper

(c) XO condition in humans as found in Turner's syndrome determines female sex

(d) Homozygous sex-chromosomes (XX) produce males in *Drosophila*

168 The following statements are regarding sex-determination. Choose the incorrect one.

(a) There are two types of sex-determining mechanism

(b) In male heterogamety, male has autosomes and sex chromosome XY

(c) In female heterogamety, it has autosomes and one Z and one W chromosomes

(d) Female heterogamety is found in mammals

169 Which of the following statement is incorrect?

(a) X-body of Henking was given the name X-chromosomes

(b) In many insects, all eggs bear an additional X-chromosomes besides autosomes

(c) X-chromosomes is a sex chromosomes as it is involved in sex-determination

(d) None of the above

170 Identify the incorrect statement for sex-determination in humans.

(a) Humans contain 23 pairs of autosomes

(b) Females produce only one type of ovum

(c) Genetic makeup of sperm determine the sex of the child

(d) In males, two types of gametes are produced

171 Which among the following statement is not true for haemophilia?

(a) It is a sex-linked dominant disease

(b) It is transmitted to unaffected carrier female to male progeny

(c) The possibility of a female becoming a haemophilic is extremely rare

(d) The family pedigree of Queen Victoria shows a number of haemophilic descendents

172 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 global chain synthesis

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

(c) Thalassemia is due to the synthesis of abnormal haemoglobin molecules

(d) None of the above

173 Select the incorrect statement.

(a) RBCs become sickle-shaped under low oxygen tension in sickle-cell anaemia

(b) Phenylpyruvic acid gets accumulated in brain and excreted in urine due to poor absorption by kidney

(c) In thalassemia, α and β-globin chains are altogether absent in body

(d) Thalassemia is an autosome linked recesive disease

174 Which of the following statement is correct with respect to monohybrid and dihybrid cross?

(a) A monohybrid cross is performed for one generation whereas dihybrid cross is performed for two generations

(b) A monohybrid cross involves a single parent, whereas a dihybrid cross involved two parents

(c) A monohybrid cross produces a single progeny whereas a dihybrid cross produce two progenies

(d) A monohybrid cross involves individuals with one heterozygous character, whereas a dihybrid corss involves individuals with two heterozygous characters

175 Which of the following statement(s) is/are correct with respect to the law of segregation?

(a) Alleles do not show blending

(b) The paired factors or alleles segregate from each other such that a gamete receives the two factors as in the original paired form

(c) Homozygous parent produce similar types of gametes whereas heterozygous ones produce two types of gametes each having one allele with unequal proportion

(d) All of the above

176 Which of the following statement(s) is/are true with respect to sickle-cell anaemia?

(a) The mutant haemoglobin of sickle-cell anaemic individual undergo polymerisation under low oxygen tension causing sicking of RBCs

(b) Sickle-cell anaemia occur due to the single base substitution (GAG $\rightarrow$ GUG) at the sixth codon of β-globin gene

(c) Individuals heterozygous for sicke-cell anaemia (Hb^SHb^A) are resistant towards malaria

(d) All of the above

177 Which of the following statement is incorrect?

(a) Mutations provide variations on which natural selection acts

(b) The vast majority of mutations produce dominant alleles

(c) Mutations arise spontaneously, infrequently and randomly

(d) Rate of mutation can be increased by artificial means

178 Read the following statements.

I. Mendelian factors are now called genes.

II. Characters blend in homozygous condition only.

III. All characters in human show dominance.

IV. Hugo de Vries was involved in rediscovery of Mendel's works.

Which of the above statements are true?

(a) I and II (b) II and III

(c) I and IV (d) IV and III

179 Which of the following is true about linkage ?

I. It is phenomenon in which more recombinants are produced in F_2-generation.

II. More parental combinations are produced in F_2-generation.

III. Genotype which are present in F_1 hybrid, reappear in high frequency in F_2-generation.

IV. It is a phenomenon in which two chromosomes are linked.

Choose the correct option.

(a) Only I (b) Only II

(c) I and III (d) III and IV

180 Which of the following statements are false?

I. A dominant allele determines the phenotype when paired with a recessive allele.

II. A recessive allele is weaker than a dominant allele.

III. A recessive allele do not shows its effects when paired with a dominant allele.

IV. A dominant allele is always better for an organism.

(a) II, I and IV (b) II, III and IV

(c) I, II and III (d) I, III and IV

181 Which of the following statements are false?

I. Specific mutations are acquired and occur only when required.

II. Inheritance of specific trait can be determined using pedigree analysis.

III. Like recombination, mutations cause variations in the DNA sequence.

IV. Chromosomal aberrations are observed in cancer cells randomly irrespective of the alleles present.

Choose the correct option.

(a) II and III (b) Only I

(c) II, III and IV (d) I, II and IV

182 Consider the following statements regarding ABO blood group in human.

I. It is controlled by multiple alleles.

II. It shows codominance.

III. Codominance can be manifested phenotypically in human.

IV. It follows the Mendel's law of inheritance.

Which of the statments(s) given above are correct?

(a) Only I (b) I and II

(c) II and III (d) IV and II

183 Consider the following statements.

I. 100% parental combinations are found in F_2-generation.

II. F_2 phenotypic ratio is 3 : 1 in dihybrid cross.

III. Dihybrid test cross ratio is 1 : 1 in F_2-generation.

IV. Linked genes tends to separate frequently.

Which of the statement given above are correct?

(a) I, II and IV (b) I, III and IV

(c) II, III and IV (d) I and II

184 Select the incorrect statement(s) from the options given below with respect to dihybrid cross. ***AIIMS 2018***

I. Tightly linked genes on the same chromosome show higher recombinations.

II. Genes far apart on the same chromosome show very few recombinations.

III. Genes loosely linked on the same chromosome show similar recombinations.

(a) I and II (b) III and II

(c) I and III (d) All of these

185 Consider the following statements and select the statement(s) which are correct with respect to the reasons as to why Mendel could not find out about linkage?

I. Some genes are linked, but they are too far apart for crossing over to be distinguished from independent assortment.

II. Linked genes, were never tested for the same time in same cross.

III. All seven genes, were present on the same chromosomes.

IV. All seven genes were present on 4 chromosomes, but they were present far apart.

(a) I and II (b) II and III

(c) III and IV (d) Only IV

186 Consider the following statement and select the statements which are correct with respect to the reasons as to why Mendel's work remain unrecognised for a long time.

I. Communication was not easy.

II. Concept of factors which did not blend was not accepted.

III. Use of mathematics to explain biological problem was unacceptable.

IV He could not provide any physical proof for the existance of factors.

(a) I and II (b) II and III
(c) III and IV (d) All of these

187 Consider the following statements.

I. Henking found specific nuclear structures through spermatogenesis in the 50% sperms of few insects.

II. The sex-determination in honeybee is based on the number of sets of chromosomes an individual receives.

Select the correct option.

(a) Both I and II are true (b) I is true, II is false
(c) Both I and II are false (d) I is false, II is true

188 Which of the following statements are correct reasons for why fruitfly is excellent model for genetics?

I. Small life cycle (two week).

II. Can be feed on simple synthetic medium.

III. Single mating produce large number of progeny.

IV. Clear differentiation of sexes.

V. Many heredity variation can be seen with low power microscopes.

Choose the correct option.

(a) I, II and III (b) III, IV and V
(c) I, IV and V (d) All of these

189 Consider the following statements.

I. The crosses carried out by Morgan on *Drosophila* were sex-linked dihybrid crosses.

II. The F_2-ratio in Morgan's experiment deviated significantly from 9 : 3 : 3 : 1 ratio.

Select the correct option.

(a) I is true, II is false (b) I is false, II is true
(c) Both I and II are true (d) Both I and II are false

190 Consider the following statements.

I. The number of chromosomes in male and female insects is same.

II. The female insects are heterozygous while male insect is homozygous.

Select the correct option.

(a) I is true, II is false (b) Both I and II are true
(c) I is false, II is true (d) Both I and II are false

191 Consider the following statements.

I. Both colour blindness and haemophilia are sex-linked recessive traits.

II. In sex-linked recessive traits, heterozygous or carrier female transmit disease to sons.

Select the correct option.

(a) Both I and II are true (b) I is true, II is false
(c) Both I and II are false (d) I is false, II is true

192 Pick out the correct statements. ***NEET 2016***

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.

(a) II and IV (b) I, III and IV
(c) I, II and III (d) I and IV

III. Matching Type Questions

193 Match the following columns.

Column I (Genetic crosses)	**Column II** (Phenotypic ratios)
A. Test cross	1. 9 : 3 : 3 : 1
B. Monohybrid cross	2. 1 : 1
C. Dihybrid cross	3. 3 : 1

Codes

	A	B	C		A	B	C
(a)	2	1	3	(b)	2	3	1
(c)	3	2	1	(d)	1	3	2

194 Match the following columns. ***AIIMS 2019***

	Column I (Chromosomal abberation)		**Column II** (Features)
A.	Inversion	1.	Change in linear order of genes by 180º rotation
B.	Duplication	2.	Loss of part of chromosome
C.	Deletion	3.	Addition of part of chromosome so that it is represented twice
D.	Translocation	4.	Shifting of a part of chromosome to another non-homologous chromosome

Codes

	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	4	3	2	1
(c)	1	3	2	4	(d)	2	1	4	3

195 Match the following columns.

	Column I (Genetic interactions)		**Column II** (Genetic cross ratios)
A.	Incomplete dominance	1.	12 : 3 : 1
B.	Dominant epistasis	2.	1 : 2 : 1
C.	Recessive epistasis	3.	9 : 7
D.	Complementary genes	4.	9 : 3 : 4

Codes

	A	B	C	D		A	B	C	D
(a)	2	1	4	3	(b)	1	2	3	4
(c)	3	4	1	2	(d)	4	3	2	1

196 Match the following columns.

	Column I (Scientists)		Column II (Discoveries)
A.	Gregor Mendel	1.	Chromosomal theory of inheritance
B.	Sutton and Boveri	2.	Law of inheritance
C.	Henking	3.	Linkage
D.	Morgan	4.	Discovered X-body
E.	de Vries	5.	Mutation

Codes

	A	B	C	D	E
(a)	4	2	1	3	5
(b)	2	1	4	3	5
(c)	4	1	5	3	2
(d)	2	3	4	5	1

197 Match the following columns.

	Column I		Column II
A.	ABO blood groups	1.	Dihybrid cross
B.	Law of segregation	2.	Monohybrid cross
C.	Law of independent assortment	3.	Base pairs substitution
D.	Gene mutation	4.	Multiple allelism

Codes

	A	B	C	D
(a)	2	1	4	3
(b)	2	3	4	1
(c)	4	1	2	3
(d)	4	2	1	3

198 Match the terms in Column I with their description in Column II and choose the correct option. ***NEET 2016***

	Column I (Terms)		Column II (Description)
A.	Dominance	1.	Many genes govern a single character
B.	Codominance	2.	In a heterozygous organism only one allele expresses itself
C.	Pleiotropy	3.	In a heterozygous organism both alleles express themselves fully
D.	Polygenic inheritance	4.	A single gene influences many characters

Codes

	A	B	C	D
(a)	4	1	2	3
(b)	2	3	4	1
(c)	4	3	1	2
(d)	2	1	4	3

199 Match the following columns.

	Column I		Column II
A.	Non-parental gene exchange	1.	Crossing over
B.	Non-sister chromatids	2.	X and Y
C.	Sex chromosome	3.	Polyploidy
D.	More than two sets of chromosomes	4.	Recombination

Codes

	A	B	C	D		A	B	C	D
(a)	4	1	2	3	(b)	2	1	4	3
(c)	2	4	3	1	(d)	2	4	1	3

200 Match the following columns and choose the correct option from the codes given below. ***AIIMS 2019***

	Column I		Column II
A.	Pleiotropic gene	1.	Both alleles express equally
B.	Codominance.	2.	Change in nucleotides
C.	Epistasis	3.	One gene shows multiple phenotypic expression
D.	Mutation	4.	Non-allelic gene inheritance

Codes

	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	2	3	4	1
(c)	3	1	4	2	(d)	1	3	4	2

201 Match the items of Column I with Column II. ***NEET (Odisha) 2019***

	Column I		Column II
A.	XX-XO method of sex-determination	1.	Turner's syndrome
B.	XX-XY method of sex-determination	2.	Female heterogamety
C.	Karyotype-45	3.	Grasshopper
D.	ZW-ZZ method of sex-determination	4.	Female homogamety

Codes

	A	B	C	D		A	B	C	D
(a)	2	4	1	3	(b)	1	4	2	3
(c)	3	4	1	2	(d)	4	2	1	3

202 Match the following columns.

	Column I (Animals)		Column II (Chromosome complement)
A.	Fruitfly	1.	$2n = 6 + XY$
B.	Fowl	2.	$2n = 14 + XX$
C.	Grasshopper	3.	$2n = 16 + XO$
D.	Human	4.	$2n = 44 + XY$

Codes

	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	2	3	4	1
(c)	3	4	1	2	(d)	2	1	4	3

203 Match the following columns.

	Column I (Pedigree symbols)		Column II (Refers to)
A.		1.	Death
B.		2.	Five unaffected offspring
C.		3.	Sex unspecified
D.		4.	Female
E.		5.	Male

Codes

	A	B	C	D	E
(a)	1	2	5	4	3
(b)	1	2	4	3	5
(c)	1	2	3	4	5
(d)	5	4	3	2	1

204 Match the following columns.

	Column I (Types of polyploid)		Column II (Chromosomes constitution)
A.	Monoploidy	1.	$2n-1$
B.	Monosomy	2.	$2n+1$
C.	Nulisomy	3.	$2n+2$
D.	Trisomy	4.	$2n-2$
E.	Tetrasomy	5.	n

Codes

	A	B	C	D	E
(a)	2	1	3	4	5
(b)	5	2	4	1	3
(c)	1	5	3	4	2
(d)	5	1	4	2	3

205 Match the following columns.

	Column I (Genetical trait)		Column II (Name of disorders)
A.	Autosomal linked recessive trait	1.	Down's syndrome
B.	Sex-linked recessive disease	2.	Phenylketonuria
C.	Inborn metabolic error linked to autosomal recessive trait	3.	Haemophilia
D.	Additional 21st chromosome	4.	Sickle-cell anaemia

Codes

	A	B	C	D
(a)	3	4	1	2
(b)	4	1	2	3
(c)	2	1	4	3
(d)	4	3	2	1

NCERT Exemplar

MULTIPLE CHOICE QUESTIONS

206 Which of the following is/are Mendelian disorder?
(a) Thalassemia (b) Cystic fibrosis
(c) Phenylketonuria (d) All of these

207 All genes located on the same chromosome
(a) form different groups depending upon their relative distance
(b) form one linkage group
(c) will not form any linkage group
(d) form interactive groups that affect the phenotype

208 A cross between two tall plants resulted in offspring having few dwarf plants. What would be the genotypes of both the parents?
(a) TT and Tt (b) Tt and Tt (c) TT and TT (d) Tt and tt

209 In a dihybrid cross, if you get 9 : 3 : 3 : 1 ratio it denotes that
(a) the alleles of two genes are interacting with each other
(b) it is a multigenic inheritance
(c) it is a case of multiple allelism
(d) the alleles of two genes are segregating independently

210 In the F_2-generation of a Mendelian dihybrid cross the number of phenotypes and genotypes are
(a) phenotypes-4, genotypes-16
(b) phenotypes-9, genotypes-4
(c) phenotypes-4, genotypes-8
(d) phenotypes-4, genotypes-9

211 Two genes 'A' and 'B' are linked. In a dihybrid cross involving these two genes, the F_1 heterozygote is crossed with homozygous recessive parental type (aa bb). What would be the ratio of offspring in the next generation?
(a) 1 : 1 : 1 : 1
(b) 9 : 3 : 3 : 1
(c) 3 : 1
(d) 1 : 1

212 Mendel's law of independent assortment holds good for genes situated on the
(a) non-homologous chromosomes
(b) homologous chromosomes
(c) extra nuclear genetic element
(d) same chromosome

213 It is said that Mendel proposed that the factor controlling any character is discrete and independent. This proposition was based on the
(a) results of F_3-generation of a cross
(b) observations that the offspring of a cross made between the plants having two contrasting characters shows only one character without any blending
(c) self-pollination of F_1 offsprings
(d) cross-pollination of F_1-generation with recessive parent

214 Occasionally, a single gene may express more than one effect. The phenomenon is called
(a) multiple allelism
(b) mosaicism
(c) pleiotropy
(d) polygeny

215 Person having genotype $I^A I^B$ would show the blood group as AB. This is because of
(a) pleiotropy
(b) codominance
(c) segregation
(d) incomplete dominance

216 Mother and father of a person with 'O' blood group have 'A' and 'B' blood group, respectively. What would be the genotype of both mother and father?
(a) Mother is homozygous for 'A' blood group and father is heterozygous for 'B'
(b) Mother is heterozygous for 'A' blood group and father is homozygous for 'B'
(c) Both mother and father are heterozygous for 'A' and 'B' blood group, respectively
(d) Both mother and father are homozygous for 'A' and 'B' blood group, respectively

217 Distance between the genes and percentage of recombination shows
(a) a direct relationship
(b) an inverse relationship
(c) a parallel relationship
(d) no relationship

218 ZZ/ZW type of sex-determination is seen in
(a) platypus
(b) snails
(c) cockroach
(d) peacock

219 In a certain taxon of insects some have 17 chromosomes and the others have 18 chromosomes. The 17 and 18 chromosome-bearing organisms are
(a) males and females, respectively
(b) females and males, respectively
(c) all males
(d) all females

220 The inheritance pattern of a gene over generations among humans is studied by the pedigree analysis. Character studied in the pedigree analysis is equivalent to
(a) quantitative trait
(b) Mendelian trait
(c) polygenic trait
(d) maternal trait

221 If a genetic disease is transferred from a phenotypically normal, but carrier female to only some of the male progeny, the disease is
(a) autosomal dominant
(b) autosomal recessive
(c) sex-linked dominant
(d) sex-linked recessive

222 In sickle-cell anaemia glutamic acid is replaced by valine. Which one of the following triplet codes for valine?
(a) G G G (b) A A G
(c) G A A (d) G U G

223 Conditions of a karyotype $2n \pm 1$ and $2n \pm 2$ are called
(a) aneuploidy
(b) polyploidy
(c) allopolyploidy
(d) monosomy

Answers

Mastering NCERT with MCQs

1 (c)	2 (b)	3 (a)	4 (a)	5 (a)	6 (d)	7 (a)	8 (c)	9 (a)	10 (b)
11 (c)	12 (c)	13 (a)	14 (a)	15 (c)	16 (b)	17 (a)	18 (a)	19 (c)	20 (a)
21 (c)	22 (b)	23 (a)	24 (a)	25 (a)	26 (b)	27 (d)	28 (d)	29 (c)	30 (c)
31 (b)	32 (c)	33 (a)	34 (b)	35 (a)	36 (c)	37 (a)	38 (b)	39 (c)	40 (d)
41 (c)	42 (b)	43 (d)	44 (a)	45 (d)	46 (a)	47 (b)	48 (d)	49 (a)	50 (a)
51 (b)	52 (c)	53 (b)	54 (c)	55 (a)	56 (b)	57 (a)	58 (a)	59 (a)	60 (a)
61 (b)	62 (b)	63 (d)	64 (a)	65 (d)	66 (b)	67 (a)	68 (a)	69 (d)	70 (b)
71 (a)	72 (b)	73 (b)	74 (c)	75 (a)	76 (b)	77 (d)	78 (b)	79 (b)	80 (b)
81 (d)	82 (a)	83 (a)	84 (d)	85 (a)	86 (c)	87 (d)	88 (a)	89 (c)	90 (d)
91 (a)	92 (d)	93 (c)	94 (a)	95 (c)	96 (a)	97 (d)	98 (d)	99 (d)	100 (b)
101 (c)	102 (a)	103 (b)	104 (a)	105 (d)	106 (a)	107 (b)	108 (d)	109 (b)	110 (c)
111 (c)	112 (d)	113 (d)	114 (d)	115 (a)	116 (d)	117 (a)	118 (b)	119 (a)	120 (c)
121 (d)	122 (a)	123 (d)	124 (d)	125 (b)	126 (a)	127 (a)	128 (a)	129 (c)	130 (a)
131 (d)	132 (d)	133 (d)	134 (a)	135 (b)	136 (a)	137 (a)	138 (a)	139 (a)	140 (c)
141 (a)	142 (d)	143 (a)	144 (d)	145 (b)	146 (c)	147 (d)	148 (b)		

NEET Special Types Questions

149 (a)	150 (b)	151 (a)	152 (d)	153 (c)	154 (a)	155 (b)	156 (c)	157 (d)	158 (c)
159 (a)	160 (c)	161 (b)	162 (b)	163 (d)	164 (b)	165 (c)	166 (b)	167 (b)	168 (d)
169 (d)	170 (a)	171 (a)	172 (c)	173 (c)	174 (d)	175 (a)	176 (d)	177 (b)	178 (c)
179 (a)	180 (b)	181 (b)	182 (b)	183 (d)	184 (d)	185 (a)	186 (d)	187 (a)	188 (d)
189 (c)	190 (d)	191 (a)	192 (c)	193 (b)	194 (c)	195 (a)	196 (b)	197 (d)	198 (b)
199 (a)	200 (c)	201 (c)	202 (a)	203 (d)	204 (d)	205 (d)			

NCERT Exemplar Questions

206 (d)	207 (b)	208 (b)	209 (d)	210 (d)	211 (d)	212 (b)	213 (b)	214 (c)	215 (b)
216 (c)	217 (a)	218 (d)	219 (a)	220 (b)	221 (d)	222 (d)	223 (a)		

Answers & Explanations

5 (*a*) Mendel performed his hybridisation experiment on *Pisum sativum* (garden pea) for 7 years between 1856-1863.

6 (*d*) Mendel investigated characters in the garden pea plant that were manifested as two opposite traits, e.g. tall or dwarf plants, yellow or green seeds. This allowed him to set up a basic framework of rules governing inheritance, which was expanded on by later scientists to account for all the diverse natural observations and the complexity inherent in them.

7 (*a*) A true breeding line is one that have undergone continuous self-pollination, shows stable trait inheritance and expression for several generations.

9 (*a*) Mendel selected 7 dominant traits and 7 recessive traits out of the total 14 traits or 7 opposing pairs of traits. The traits have been tabulated below

Characters	Dominant traits	Recessive traits
Seed shape	Round	Wrinkled
Seed colour	Yellow	Green
Flower colour	Violet	White
Pod shape	Inflated	Constricted
Pod colour	Green	Yellow
Flower position	Axial	Terminal
Stem height	Tall	Dwarf

10 (*b*) Trichomes are the epidermal tissues structure. These are formed when epidermal cells become glandular and hair like, called as trichomes. This character was not amongst the seven pairs of characters of the pea plant. Mendel selected for his hybridisation experiments.

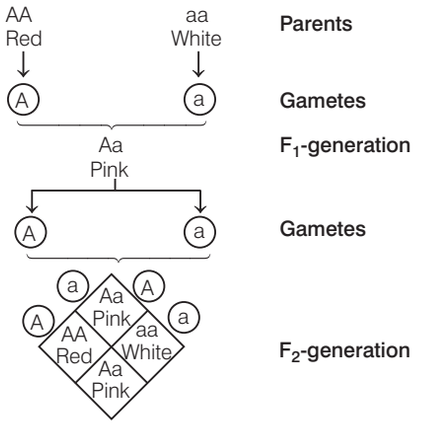
19 (*c*) In Mendel's experiment dominant and recessive traits were expressed or appeared separately. This shows that there was no mixing of characters, thus non-blending of character in F_2-generations is observed.

22 (*b*) Option (b) is incorrect and can be corrected as The genetic composition of an organism, with respect to one or more characters whether the gene is expressed or not is called genotype.

23 (*a*) The formula to calculate the number of gametes from a given genotype is 2^n.

Where, n = number of heterozygosity in the given genotype. Thus, number/types of gametes produced by a homozygous individual of genotype AA is $2^{(0)} = 1$ and by heterozygous individual of genotype Aa is $2^{(1)} = 2$.

27 (*d*) Monohybrid cross with incomplete dominance shows the same genotypic and phenotypic ratio, i.e. 1 : 2 : 1, as depicted by the cross given below



Genotypic ratio – 1 (AA) : 2 (Aa) : 1 (aa)

Phenotypic ratio – 1 (Red) : 2 (Pink) : 1 (White)

28 (*d*) Since, both the male and female parents are homozygous with genotype TT and tt, respectively they will contribute only one type of gamete. The male will produce gamete (pollen) of type T and the female will produce a gamete (egg) of type t.

31 (*b*) Mendel performed test cross to know the genotype of F_2. Test cross involves a cross between dominant F_2 plant with the homozygous recessive parent plant. The ratio of monohybrid test cross is 1 : 1 between Tt and tt. So, if the ratio of test cross comes as mentioned, then the F_2 genotype is heterozygous tall and if it deviates from this, then the F_2 genotype is homozygous tall.

34 (*b*) 3:1 ratio in F_2-generation can be explained by the law of dominance. It states that, only dominant allele shows its effect even in the heterozygous condition and masks the effect of recessive allele. In the given ratio, 3 represents the dominant phenotype, while 1 represents the recessive phenotype.

36 (*c*) Mendel's principle of segregation means that the germ cells (gametes) always receive either one allele of father or one allele of mother. The law of segregation states that, hereditary characters in the form of allele segregate from each other during the formation of gametes. Half of the gametes carry one allele and other half carry other allele for a character.

37 (*a*) Law of purity of gametes states that the characters which were hidden or masked in F_1 progeny get recovered in the progeny of F_2-generation.

38 (*b*) Option (b) is correct as the ratio of 3 : 1 helped to deduce law of dominance and law of segregation. Whereas law of independent assortement was deduced by Mendel by performing dihybrid cross (9 : 3 : 3 : 1). Incomplete dominance was not deduced by Mendel.

40 (*d*) In incomplete dominance, the two genes of an allelomorphic pair are not related as dominant or recessive but each of them express themselves partially. In this phenomenon, one allele may function normally and the other may either function normally, may be non-functional or may perform normally, but with less efficiency. This occurs due to some changes in the allele which modifies the information present in it.

Thus, option (d) is correct.

41 (*c*) Both codominance and incomplete dominance give an identical genotypic and phenotypic ratio of 1 : 2 : 1. Codominance and incomplete dominance differ in the fact that in codominance both the alleles are dominant and express themselves at the same time. But in incomplete dominance, the two alleles are neither dominant nor recessive to each other.

42 (*b*) On self-crossing TtRr plant, the following cross is obtained

Tt Rr (heterozygous tall and pink)

↓ (self-crossed)

Tt Rr × Tt Rr

Gametes	TR	Tr	tR	tr
TR	TTRR (Tall red)	TTRr (Tall pink)	TtRR (Tall red)	TtRr (Tall pink)
Tr	TTRr (Tall pink)	TTrr (Tall white)	TtRr (Tall pink)	Ttrr (Tall white)
tR	TtRR (Tall red)	TtRr (Tall pink)	ttRR (Dwarf red)	ttrR (Dwarf pink)
tr	TtRr (Tall pink)	Ttrr (Tall white)	ttRr (Dwarf pink)	ttrr (Dwarf white)

Plants with pink flower = 8 = 50%

Plants with red flower = 4 = 25%

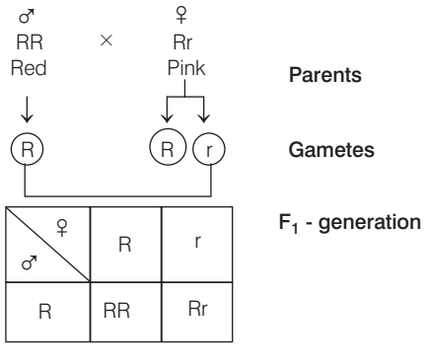
Plants with white flower = 4 = 25%

Tall plants = 75%

Dwarf plants = 25%

43 (*d*) Option (d) is correct as in codominance, both alleles of a pair express themselves fully in F_1-generation, so it resembles both the parents.

44 (*a*) The cross between red flowered and pink flowered plants of *Mirabilis jalapa* is depicted below



Thus, the ratio of offspring produce would be

Red : Pink = 1 : 1

46 (*a*) The ABO blood groups are controlled by the I-gene, which has three alleles (I^A, I^B, i).

47 (*b*) The plasma membrane of the red blood cells has sugar polymers that protrude from its surface and the kind of sugar is controlled by 'I' gene. It has three alleles I^A, I^B and i. Out of these only two alleles I^A and I^B produce a slightly different form of the sugar, while allele i does not produce any sugar. Because humans are diploid organisms, each person possesses any two of the three I gene alleles. I^A and I^B are completely dominant over i.

49 (*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.

Phenotype AB

↓

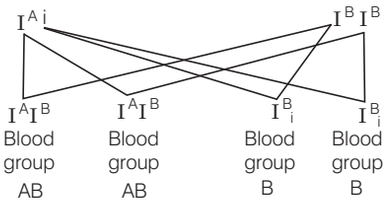
Genotype $I^A I^B$

↓

Antigen A + Antigen B

Here, both alleles are able to express themselves forming antigens A and B. This is called as codominance, a phenomenon in which both the alleles in a heterozygote are expressed.

50 (*a*) The possible genotype of parents, male with blood group A and female with blood group B, having progeny with either blood group AB or B is $I^A i$ (male) : $I^B I^B$(female). It can be depicted by the cross given below



51 (*b*) Since, it has not been specified whether the parents are homozygous or heterozygous for the alleles of gene I the possible genotype of ♀ and ♂ parent could be

- When only one parent is homozygous

Genotype	♂ $I^A I^A$	♀ $I^B i$	or	♂ $I^A i$ ♀ $I^B I^B$
Phenotype	A	B		A B

- When both parents are homozygous

Genotype	♂ $I^A I^A$	♀ $I^B I^B$
Phenotype	A	B

- When both parents are heterozygous

Genotype	♂ $I^A i$	♀ $I^B i$
Phenotype	A	B

Thus, when blood group of father is A and of mother is B, then the blood group of progeny will be A, B, AB and O.

52 (*c*) A cross between a husband and wife one with AB blood group and the other with A blood group will produce four genotypes and three phenotypes. It has been depicted by the cross given below

		Husband	
	♂ / ♀	I^A	I^B
Wife	I^A	$I^A I^A$	$I^A I^B$
	i	I^A i	I^B i

Thus, the genotypes and the phenotypes of the offspring would be

Genotypes : 4($I^A I^A$, $I^A I^B$, I^A i, I^B i)

Phenotypes : 3 (A, B, AB)

53 (*b*) Dominance, codominance and multiple alleles are the characteristics that represent 'inheritance of blood groups' in humans. ABO blood groups are determined by the gene I.

There are multiple (three) alleles; I^A, I^B and i of this gene. Allele I^A and I^B are dominant over i. However, when I^A and I^Balleles are present together, they show codominance. Therefore, option (b) is correct.

55 (*a*) Option (a) is correct. This can be explained as occasionally a single gene product may produce more than one effect. Like in starch synthesis in pea seeds controlled by one gene having two alleles (B and b). Thus, the phenotype and genotype expressed are

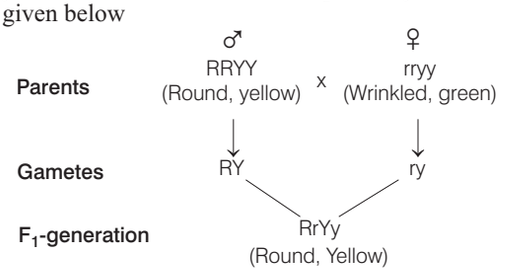
- BB–round seed, large starch synthesis.
- bb–wrinkled seed, less starch synthesis.
- Bb–round seed, intermediate starch synthesis.

Thus, if we take size as a phenotype, allele B shows complete dominance over 'b', but if we take starch synthesis as a phenotype, allele B and b shows incomplete dominance.

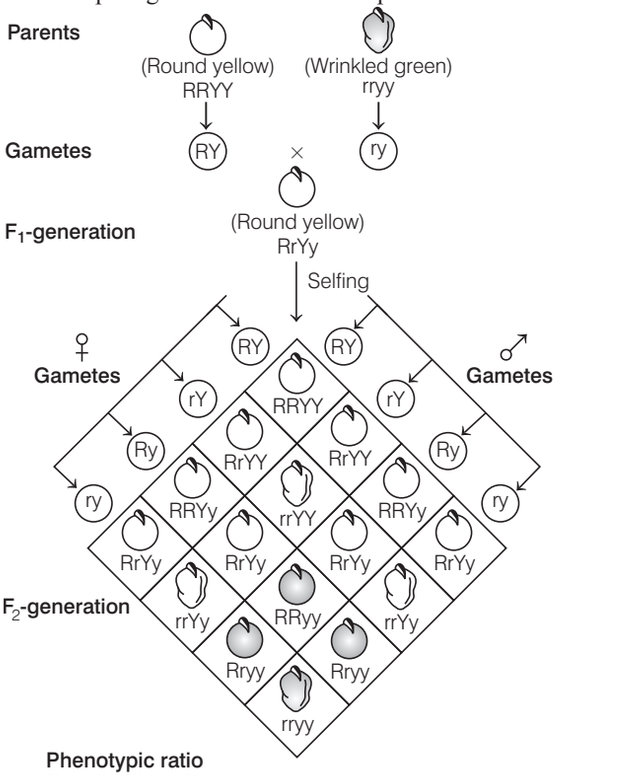
57 (*a*) The formula to determine the number of gametes is $2^n = 2^{(2)} = 4$

Thus, RrYy would produce 4 gametes of the types RY, Ry, rY, ry.

59 (*a*) When plants bearing round yellow (RRYY) seeds are crossed with plants bearing and wrinkled green (rryy) seeds, all the plants in F_1-generation will have yellow round seeds. It can be depicted by the cross given below



60 (*a*) A cross between pure yellow round seeded plants and pure green wrinkled seeded plants is shown below



Phenotypic ratio

Round yellow : Round green : Wrinkled yellow : Wrinkled green

9 : 3 : 3 : 1

Genotypic ratio 1 (RRYY) : 2 (RRYy) : 2 (RrYY) : 4 (RrYy) : 1 (RRyy) 2 (Rryy) : 1 (rrYY) : 2 (rrYy) : 1(rryy)

Thus, the number of plants of F_2-generation having yellow coloured seeds are 12 (out of 16).

64 (*a*) The genotypic ratio of a dihybrid cross is 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

Thus, we see that 9 different genotypes are observed in the F_2-generation.

65 (*d*) In 1900, three scientists (de Vries, Correns and von Tschermak) independently rediscovered Mendel's results on the inheritance of characters. Also, by this time due to advancements in microscopy that were taking place, scientists were able to carefully observe cell division.

This led to the discovery of structures in the nucleus that appeared to double and divide just before each cell division.

69 (*d*) Sutton and Boveri proposed the chromosomal theory of inheritance. In 1902, the chromosomal movement during meiosis was worked out. Walter Sutton and Theodore Boveri stated that pairing and separation of a pair of chromosomes would lead to the segregation of a pair of factors they carried. They united the knowledge of chromosomal segregation with Mendelian principles and called it chromosomal theory of inheritance.

72 (*b*) Both genes and chromosomes (Mendelian factors) wheather dominant or recessive are transmitted from generation to generation in the pure or unaltered form. It is also called law of purity of gametes.

74 (*c*) The pair given in option (c) is incorrect. It can be corrected as

TH Morgan – Linkage

de Vries – Mutation

Rest of the pairs are correct.

78 (*b*) When two genes in a dihybrid cross are situated on the same chromosome, the proportion of the parental gene combinations are much higher than the non-parental or recombinant type as linked genes are inherited together in offspring.

79 (*b*) Alfred Sturtevant was the first to explain the concept of chromosomal mapping. It is constructed on the basis of recombination frequency between gene pairs on the same chromosome. This frequency is directly proportional to the distance between these two genes.

It can be used to determine the exact location of a gene on the chromosome.

80 (*b*) In the construction of genetic maps, map unit or centi Morgan is a unit or distance between genes on chromosomes, representing 1% cross over,

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

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

85 (*a*) Since, genes A and B are more close than genes A and C, therefore, gene A has to be present before genes B and C with gene B present in between genes A and C.

Other options are incorrect and can be corrected as

- Gene C is not between genes A and B.
- More crosses have occurred between A and C than A and B.

88 (*a*) Human skin colour is another classic example for polygenic trait the phenotype reflects the contribution of each allele, i.e. the effect of each allele is additive. To understand this better let us assume that three genes, i.e. A, B and C control skin colour in human with the dominant forms A, B and C responsible for dark skin colour and the recessive forms a, b and c for light skin

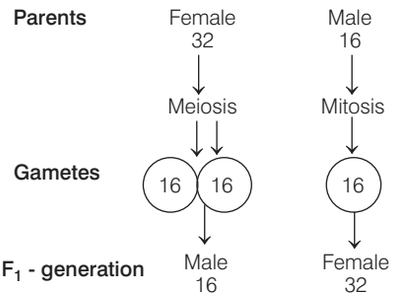
colour. The genotype with all the dominant alleles (AABBCC) will have the darkest skin colour and that with all the recessive alleles (aabbcc) will have the lightest skin colour.

93 (*c*) In the given pairs, option (c) is wrongly matched. It can be corrected as
Starch synthesis in pea is an example of pleiotropy.
Rest of the pairs are correctly matched.

95 (*c*) Option (c) contains the incorrect pair. It can be corrected as
In *Drosophila*, XX-XY type of sex-determination is seen, i.e. same as humans.
Rest of the pairs are correct.

96 (*a*) In XX-XY type of sex-determination, male are heterogametic, i.e. produces two types of sperms with X and Y. But females are homogametic, i.e. produces only single type of ovum with X.

101 (*c*) Sex-determination in honeybee is called haplo-diploid sex-determination system.



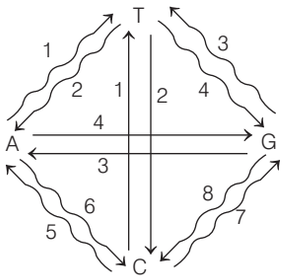
102 (*a*) The sex-determination in honeybee is based on the number of sets of chromosomes an individual receives. An offspring formed from the union of a sperm and an egg develops as a female (queen or worker) and an unfertilised egg develops as a male (drone) by means of parthenogenesis.

104 (*a*) Mutation is the phenomenon which results in alteration of DNA sequences and consequently results in change in the phenotype and genotype of an organism. The term 'mutation' was introduced by Hugo de Vries in 1901 in his mutation theory of evolution.

105 (*d*) In most cases if there is a change in genotype than it ultimately leads to change in phenotype too. Mutation may also involve change in the rate of metabolism in some individuals.

107 (*b*) Point mutations refer to those mutations which arise due to change in a single base pair of DNA. This change may either be deletion or addition of one or more bases or it may be due to substitution of one base by another.

108 (*d*) Transition occurs when a purine base (A or G) is replaced by another purine base. Transversion occurs when a purine base is substituted by a pyrimidine base or *vice-versa*.
Thus, the number of possible transitions and transversions among the four bases (A, T, G, C) are 4 and 8, respectivley and can be represented by the figure given below



(Transition → and Transversion ⇝)

110 (*c*) Deletion and insertion of one base leads to a change in the entire DNA base pair sequence, which leads to frame shift mutation. Since the deletion or insertion in DNA base pair sequence is occurring in the reading frame. This is named as frame shift mutation.

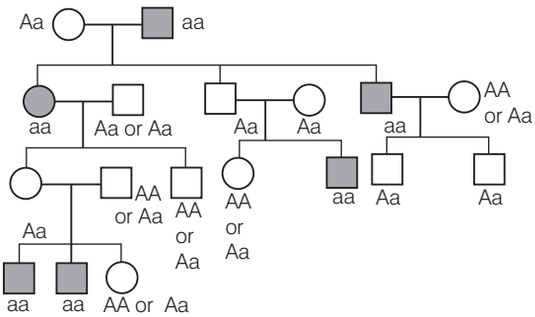
111 (*c*) Mutagens may be physical agents such as X-rays, α-rays, etc., which cause mutation and chemical agents such as mustard gas, etc., which cause changes in the DNA sequence in an organism.

112 (*d*) The study of inheritance of genetic traits in several generations of a family of human beings is done in the form of a family tree diagram called the pedigree chart and the method is called pedigree analysis.

116 (*d*) Cytoplasmic or Mitochondrial inheritance is the inheritance in which a trait is passed only from the mother to offspring. The genes involved in this mode of inheritance are present in the cytoplasm of ova.
Since, after fertilisation, cytoplasm is contributed to the zygote by ova, the genes for a specific trait are passed on from the mother to the offspring.

117 (*a*) In the given pedigree chart only males are affected. So, it can be easily inferred that the given trait is connected to Y-chromosome.

118 (*b*) The type of pedigree given is autosomal recessive. It can be explained by the detailed pedigree chart given below
Let 'a' be the recessive autosomal allele.

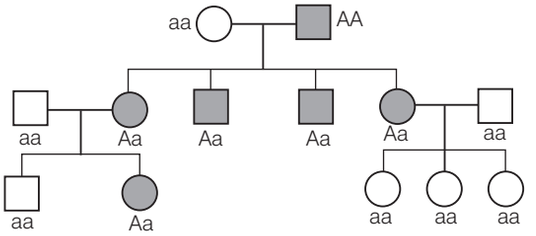


119 (*a*) Figure (a) is correct as the case is that of *criss-cross* inheritance. It is a type of sex-linked inheritance, where a parent passes the traits to the grand child of the same sex through offspring of the opposite sex. The father passes the traits to grandson through his daughter (diagynic), while the mother transfers traits to her grand daughter through her son (dia-andric).

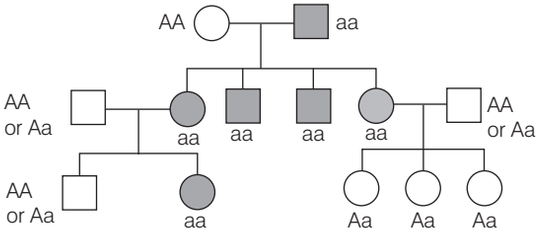
120 (*c*) For the pedigree chart given in the question, the cause of the trait can either be due to a dominant allele or a recessive allele.

It can be depicted by the two cases given below

I. When 'A' is the dominant allele for the trait and 'a' is the normal recessive allele.

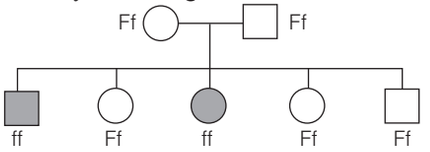


II. When 'a' is the recessive allele for the trait and 'A' is the normal dominant allele.

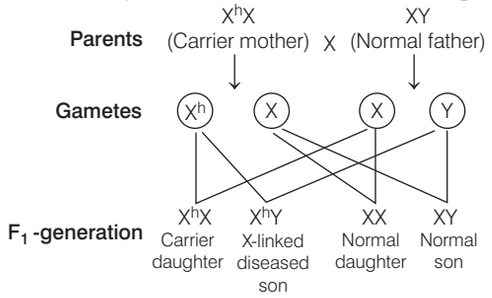


121 (*d*) The genotype of the individual marked 'M' has to be X^hX, i.e. she has to be the carrier, so as to produce an individual who is affected, in the last generation.

122 (*a*) Inheritance of ear lobes is determined by an autosomal gene with two alleles. The allele 'F' for free ear lobe is dominant over allele 'f' for attached ear lobe. Thus, the type of pedigree chart can only the obtained when the parents are heterozygous. It can be explained by the chart given below

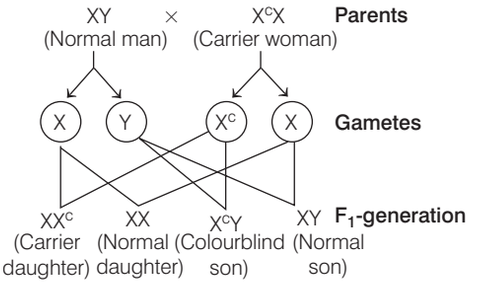


124 (*d*) In the given problem, the woman has an X-linked condition and she can transmit the carrier allele to both her son and daughter. The resulting son will affected because X-linked disorder always affect males as males contain a single X-chromosome. The daughter offspring will be a carrier, but not diseased because females are affected by X-linked disorder in homozygous recessive condition only, i.e. two recessive alleles are required.



Hence, out of the 4 offspring possible 25% of sons are diseased and 25% are normal. Similarly, 50% daughters normal out of which half are carriers.

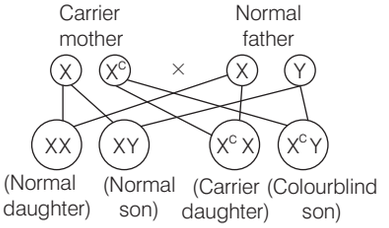
125 (*b*) Colour blindness is an X-linked disease. So, a woman whose father is colourblind will be a carrier for the disease.



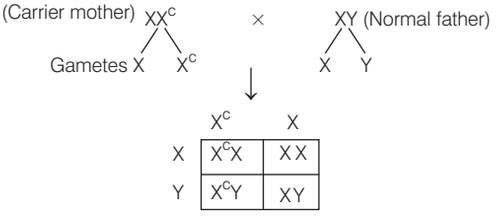
So, the possibility of a colourblind daughter (i.e. X^cX^c) in F_1-generation is 0%.

126 (*a*) Colour blindness is a sex-linked recessive genetic disorder involving the X-chromosome. Thus, according to the situation given in the question, a man whose father was colourblind will be, normal, i.e. XY and a woman whose mother was colourblind and father was normal is a carrier, i.e. XX^c.

Thus, when marriage happens between two such individuals percentage of a male child to be colourblind is 25% (this can be easily observed from the cross given below)



127 (*a*) A colourblind father (genotype X^cY) would produce carrier daughters (genotype XX^c). When a carrier female (XX^c) marriages a normal man (XY), the types of offspring produced would be all normal daughters and half of the sons (50%) would be colourblind and the remaining half would be normal. This pattern of inheritance can be explained by the following cross



128 (*a*) Haemophilia is an X-linked recessive gene disorder. It is a blood clotting disorder and shows *criss-cross* inheritance. In this, characters from father are transmitted to daughter and from mother to son.

129 (*c*) Haemophilia is a sex-linked recessive disease, which shows its transmission from unaffected carrier female to some of the male progeny has been widely studied. In this disease, a single protein that is a part of the cascade of proteins involved in the clotting of blood is affected. Due to this, in an affected individual, a simple cut will result in non-stop bleeding.

132 (*d*) During phenylketonuria the affected individual lacks an enzyme that converts amino acid, phenylalanine into tyrosine (i.e. phenylalanine hydroxylase is absent). As a result of this phenylalanine is accumulated and converted into phenylpyruvic acid and other derivatives. This lack of the enzyme is due to the presence of autosomal defective gene on chromosome number 12.

133 (*d*) Thalassemia is also an autosome linked recessive blood disease transmitted from parents to the offspring when both the partners are unaffected carrier for the gene (or heterozygous). The defect could be due to either mutation or deletion which ultimately results in reduced rate of synthesis of one of the globin chains (α and β-chains) that make up haemoglobin. This causes the formation of abnormal haemoglobin molecules resulting into anaemia which is characteristic of the disease.

136 (*a*) Aneuploidy occurs when the chromatids fail to segregate during cell division, resulting in gain or loss of a chromosome.

137 (*a*) Polyploid cells have a chromosome number that is more than double the haploid number, e.g. *Triticum aestivum* (wheat) is a hexaploid ($6n$).

138 (*a*) Non-disjunction in meiosis results in trisomy, i.e. the presence of an extra chromosome. Such individuals have 47 chromosomes instead of 46. Some examples of such abnormalities include Down's syndrome (21-trisomy), Patau's syndrome (13-trisomy) and Edward's syndrome (18-trisomy).

139 (*a*) Down's syndrome is an abnormality caused by an autosomal primary non-disjunction. Non-disjunction is the failure of chromosomes to disjoin or separate and move away to opposite poles. Non-disjunction of 21st chromosome during oogenesis is the cause of Down's syndrome. It occurs due to the presence of an additional copy of chromosome number 21 (trisomy of 21st chromosome) in humans.

140 (*c*) Karyotype of people suffering from Down's syndrome have 47 chromosomes (45 + XY in males, 45 + XX in females) instead of 46. It is caused due to the presence of an extra chromosome, i.e. chromosome number 21. Thus, it is also known as 21 trisomy.

143 (*a*) In Klinefelter's syndrome, the affected individual has overall masculine development, gynaecomastia and is sterile. This condition is represented by the karyotype 44 + X (47) due to the presence of an extra X-chromosome in males.

144 (*d*) Both options (a) and (c) are correct. This can be explained as

In klinefelter's syndrome, the sex chromosomes genotype is XXY, i.e. there is one extra X-chromosome. This extra X can come in two conditions, when there is non-disjunction in egg, i.e. XX egg and Y sperm and where is non-disjunction in sperm, i.e. X egg and XY sperm.

149 (*a*) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

Offspring bear characteristics of both the parents. These characters pass from the parents *via* their gametes into their progeny. This is called inheritance.

150 (*b*) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

True breeding lines show inheritance of pure characters for several generations. This is because true breeding lines are homozygous for the traits. Therefore, Mendel conducted cross-pollination experiments, between different true breeding lines to study the concept of inheritance.

151 (*a*) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

There was no blending of characters in the progeny of F_2-generation. As a result, the offspring exhibited traits which were exactly identical to their parents.

152 (*d*) Assertion is false, but Reason is true. Assertion can be corrected as

Genes are passed on from one generation to the next, and thus called as the units of inheritance.

153 (*c*) Assertion is true, but Reason is false and it can be corrected as

Meiosis occurs during the process of gamete formation which leads to the formation of haploid gametes.

154 (*a*) Both Assertion and Reason are true, but Reason is the correct explanation of Assertion.

In codominance, the progeny of F_1-generation resembles both the parents due to the equal expression of the two alleles involved.

An example of the phenomenon of codominance is ABO blood grouping in humans. In this antigen A, product of the alleles I^A and antigen B, product of the alleles I^B are codominant in individual with AB blood group.

155 (*b*) Both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

Behaviour of chromosomes is considered to be parallel to that of the genes. This is because, as genes are passed on from one generation to the next, chromosomes also get passed on from one generation to the next.

156 (*c*) Assertion is true, but Reason is false and it can be corrected as

Genes, which tend to get passed on together from one generation to the next, are located very close to each other on a chromosome. Such genes are called as linked genes.

157 (*d*) Assertion is false, but Reason is true. Assertion can be corrected as

Insects show male heterogamety as females have XX sex chromosomes and males have XO sex chromosomes.

158 (*c*) Assertion is true, but Reason is false and it can be corrected as

Male honeybees, i.e. drones are haploid whereas female honeybees, i.e. queen and workers are diploid.

159 (*a*) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

The non-allelic genes for red hair and prickles are inherited together as these are located in close association on the same chromosome.

160 (*c*) Assertion is true, but Reason is false and it can be corrected as

In Klinefelter's syndrome males are sterile as individual possess 47 chromosomes (44 + XXY).

161 (*b*) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

Phenylketonuria is an autosomal herditary disease, which occurs due to an autosomal defective gene on chromosome number 12. The defective gene causes body's failure to oxidise amino acid, phenylalanine to tyrosine because of defective enzyme, phenylalanine hydroxylase. Thus, the patient shows the presence of phenylalanine acid in urine.

162 (*b*) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion.

Sickle-cell anaemia is an autosomal linked recessive disorder. The gene for this disorder is present on an autosome and an individual is said to be affected only when both the genes or a pair of allele (mutated or affected) are inherited from the carrier or affected parents.

163 (*d*) Assertion is false, but Reason is true. Assertion can be corrected as

Down's syndrome is a chromosomal disorder. It is caused due to the presence of an additional copy chromosome 21 (trisomy 21).

164 (*b*) The statement in option (b) is not true. It can be corrected as

The tightly linked genes on chromosomes show 100% parental types and 0% recombinants. Two genes that undergo independent assortment indicated by a recombinant frequency of 50% are on non-homologous chromosomes indicated for apart in a single chromosome. As the distance between two genes increases, crossing over frequency increases. This results in the formation of more recombinant gametes and fewer parental gametes.

Rest of the statements are true.

165 (*c*) The statement is option (c) is incorrect and can be corrected as

The law of segregation applies universally. The reappearence of parental (red and white) flowers in the F_2-generation also confirms, that law of segregation applies in this experiment.

Rest of the statements are correct.

166 (*b*) The statement in option (b) is incorrect and can be corrected as

In domesticated fowls, sex of progeny depends on the type of egg rather than type of sperm.

Rest of the statements are correct.

167 (*b*) The statement in option (b) correctly describes the manner of determining the sex.

Rest of the statements are incorrect and can be corrected as

- Heterozygous sex chromosomes (ZW) determine female sex in birds.
- XO condition in humans as found in Turner's syndrome determines male sex.
- Heterozygous sex-chromosomes (XY) produces males in *Drosophila*.

168 (*d*) The statement in option (d) is incorrect and can be corrected as

Female homogamety is found in mammals.

Rest of the statements are correct.

170 (*a*) The statement in option (a) is incorrect and can be corrected as

Humans contain 22 pairs of autosomes (XX) and one pair of sex chromosome (XY).

Rest of the statements are correct.

171 (*a*) The statement in option (a) is incorrect for haemophilia and can be corrected as

It is a sex-linked recessive disease.

Rest of the statements are correct.

172 (*c*) The statement in option (c) is correct. Rest of the statements are incorrect and can be corrected as

- Sickle-cell anaemia is the qualitative defect of synthesising an incorrectly function globin.
- Thalassemia is the quantitative defect of synthesising to few globin molecules.

173 (*c*) The statement in option (c) is incorrect and can be corrected as

In thalassemia, the α and β-globin chains of haemoglobin are not absent rather their production is affected.

Rest of the statements are correct.

174 (*d*) The statement in option (d) is correct with respect to monohybrid cross and dihybrid cross.

Rest of the statements are incorrect and can be corrected as

- Both monohybrid and dihybrid crosses can be performed for one or more generations.
- Both monohybrid cross and dihybrid cross involves two parents.
- Both monohybrid cross and dihybrid cross can produce two or more progeny.

175 (*a*) The statement in option (a) is correct with respect to the law of segregation.

Rest of the statements are incorrect and can be corrected as

- The paired factors or alleles segregate from each other such that a gamete recieves only one of the factor present in the origin at paired form.

- Homozygous parent produces similar types of gametes whereas heterozygous ones produce two types of gametes each with one allele to equal proportion.

177 (*b*) The statement in option (b) is incorrect and can be corrected as

The vast majority of mutations produce recessive alleles.

178 (*c*) Statements I and IV are correct. Statements II and III are incorrect and can be corrected as

- Characters blend in both homozygous and heterozygous conditions.
- Not all characters (only some) show dominance in humans.

179 (*a*) Statement I is the only correct statement about linkage.

Rest of the statements are incorrect and can be corrected as

- Less parental combinations are produced in F_2-generation.
- Genotype which were present in F_1 hybrid, reappeared in low frequency in F_2-generation.
- Linkage is the phenomenon in which two genes are physically linked.

180 (*b*) Statement I is correct. Statements II, III and IV are incorrect and can be corrected as

- A recessive allele is not weaker than the dominant allele.
- A recessive allele does not show its effect because of modified or different enzymes. A recessive allele can express in few cases, e.g. incomplete dominance.
- It is not necessary that dominant allele is always better.

181 (*b*) Statement I is incorrect and can be corrected as

Mutations are not acquired as they occur by chance and are selected by nature.

Rest of the statements are correct.

182 (*b*) Statements I and II are correct. Statements III and IV are incorrect and can be corrected as

- Codominance cannot be manifested phenotypically in humans as ABO blood group in humans is three alleles of gene I (I^A, I^B, i).
- ABO blood grouping system in humans does not follow Mendel's laws of inheritance.

183 (*d*) Statements I and II are correct. Statements III and IV are incorrect and can be corrected as

- Dihybrid test cross ratio is 1 : 1 : 1 : 1 in F_2-generation, i.e. show 4 phenotypes and genotypes in equal proportions.
- Linked genes do not separate frequently.These genes remain together because linked gene lie very closely to each other.

184 (*d*) Statements I, II and III all are incorrect and can be corrected as

- Lightly linked genes on the same chromosome show low recombination.
- Genes far apart on the same chromosome show high or more recombination.
- Genes loosely linked on the same chromosome show higher recombination than tightly linked genes.

185 (*a*) Statements I and II are the correct reasons for why Mendel could not find out about linkage. Statements III and IV are incorrect and can be corrected as

- The genes for all the traits were present on different chromosomes or were located for apart on the same chromosomes.

190 (*d*) Both statements I and II are false and can be corrected as

In male and female insects, the number of chromosomes are not same.

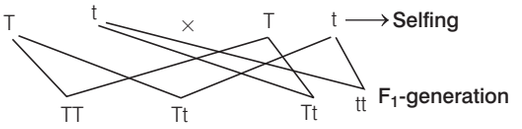
The females are homozygous, containing XX chromosomes, while males contain only one X-chromosome and represented as XO.

207 (*b*) All the genes, present on a particular chromosome form a linkage group. The number of linkage group of a species corresponds to the total number of different chromosomes of that species.

208 (*b*) If a cross between two tall plants resulted in a few dwarf offspring, then the parental genotypes are Tt and Tt.

It can be explained by the following example

The F_1 plants of genotype, Tt are self-pollinated [both tall (T), but with dwarf (t) alleles].



Phenotypic ratio : Tall : Dwarf

3 : 1

Genotypic ratio : Pure tall : Hybrid : Pure dwarf

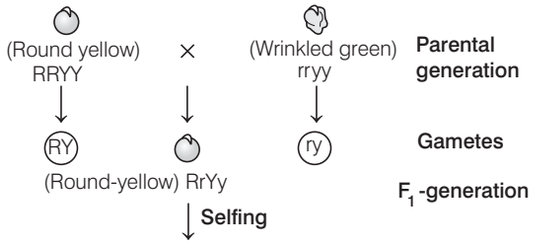
1 : 2 : 1

209 (*d*) If a 9 : 3 : 3 : 1 ratio is obtained in a dihybrid cross, it denotes that alleles of two genes are segregate independently.

It can be explained as follows

If a pea plant with round and yellow seeds is crossed with a plant with wrinkled and green ones all F_1 hybrids possess yellow and round seeds. Since, yellow colour is dominant over the green and the round shape is dominant over the wrinkled.

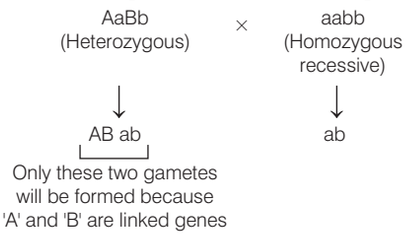
210 (*d*) Mendel's dihybrid cross is depicted below



Phenotypic ratio	Round yellow	:	Round green	:	Wrinkled yellow	:	Wrinkled green					
	9	:	3	:	3	:	1					
Genotypic ratio	1	:	2	:	2	:	4	:	1	:	2	:	1	:	2	:	1

Thus, from the cross, it can be determined that the number of phenotypes and genotypes in the F_2-generation of a Mendelian dihybrid cross is 4 and 9, respectively.

211 (*d*) The ratio of offspring will be 1 : 1 for the cross mentioned in the question. This can be explained as



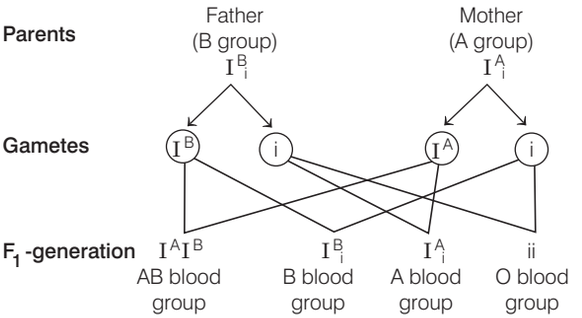
	AB	ab
ab	AaBb 1	aabb 1

Thus, both genotypic and phenotypic ratio will be 1 : 1.

215 (*b*) ABO blood grouping in humans is an example of codominance.

When I^A and I^B are present together, both express equally and produce the surface antigens A and B. Thus, a person having genotype $I^A I^B$ would show the blood group as AB.

216 (*c*) When both mother and father are heterozygous for 'A' and 'B' blood group, respectively. Then few of their progeny would be with 'O' blood group. This can be explained as



217 (*a*) The distance between the genes and percentage of recombination shows a direct relationship. This can be explained as when genes are close together, or are linked exhibit low recombination frequencies. And when they are far apart the recombination is high.

219 (*a*) The 17 and 18 chromosomes bearing organisms are males and females, respectively. In large number of insects like cockroach and grasshopper, XX-XO type of sex-determination is seen, which shows male heterogamety. Here XX represent females and XO (which is basically single X chromosome) represents males. Therefore consequently the number of chromosomes in them would be 17 in males and 18 in females.

223 (*a*) Aneuploidy involves changes in the chromosome number either by additions or deletions of less than a whole set. In this case organism gains or loses one or more chromosomes but not a complete set. Thus, the karyotypic conditions of $2n \pm 1$ or $2n \pm 2$ denote aneuploidy.