CHAPTER 9

Heredity and Evolution

EXAM DRILL

ANSWERS

1. Traits related to pod studied by Mendel were pod shape and pod colour. Inflated (I) shaped and green coloured (G) pod were dominant traits while constricted (i) pod and yellow coloured (g) pod were recessive traits.

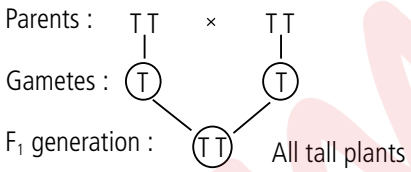
OR

Test cross ratio of dihybrid cross is 1 : 1 : 1 : 1.

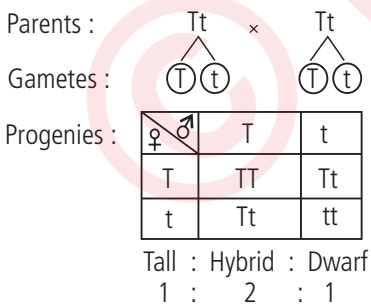
2. Tallness is more wide spread among pea plants because tallness is dominant over dwarfness.

3. **(c) :** A pure tall plant on selfing produce all tall plants while it is not in case of hybrid tall plant. It can be depicted as follows:

(i) Self pollination of pure tall plant.



(ii) Self pollination of hybrid tall plant.



4. Axial flower position is dominant over terminal flower position. Violet colour is dominant over white colour.

5. Phenotype is the observable or measurable characteristics that may be visible to eye (*e.g.*, height of a plant, colour of flower, etc.).

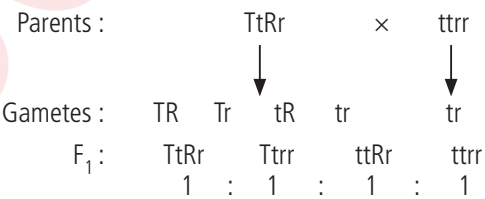
6. Pea plants used by Mendel for his experiments had 7 pairs of contrasting characters.

OR

Differences between a gene and an allele are as follows :

	Gene	Allele
(i)	A gene is the unit of DNA responsible for the appearance and inheritance of a character.	An allele is one of the forms in which a gene can exist. Normally there are two alleles for a given gene that are located at the same locus in the homologous chromosomes.
(ii)	It refers to section of DNA that controls certain traits, *e.g.*, eye colour, blood group type, skin colour, etc.	It refers to specific variation of a gene *e.g.*, blue eyes, green eyes, blood group A, B, etc.

7.



Genotype of tall red-flowered plant is TtRr.

8. Test cross is a cross between an individual of unknown genotype and recessive parent to test whether an individual is homozygous (pure) or heterozygous (hybrid).

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

OR

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

10. Genotype of parent = Tt

Genotype of dwarf progeny = tt

11. The characters that are seen in an individual (*e.g.*, height, facial features, etc.) are called traits. The trait inherited from parents are called inherited traits.

OR

Mendel selected seven pairs of true breeding varieties of garden pea.

12. Human sperm has 22 autosomes.

13. When male produces two types of gametes, *i.e.*, 50% with X and 50% with Y, it is called male heterogamy. It is shown by human beings, *Drosophila*, etc.

14. **(c) :** In mammals, the presence of a Y chromosome is required for the development of a male sex phenotype. Y chromosome is required for maleness, moreover, the presence of a single Y chromosome is sufficient even in the presence of several X chromosomes (*e.g.*, XXXY).

15. **(c) :** Monohybrid cross is a cross between two organisms of a species considering a single pair of alleles or factors of a character. Dominant character express itself whether present in homozygous or heterozygous state. In F1 generation, progenies are heterozygous dominant.

OR

(b)

16. **(c) :** Gene for black hair colour is dominant to gene for red hair colour in humans. Mother has black hair and can be represented by (BB) whereas father can be represented by (bb).

(i) Parents : ♀ BB × bb ♂

Gametes : B b

Progeny : Bb

Heterozygous black

So, the child will be heterozygous for black hair colour.

17. **(i) (a) :** When red (RR) flower and white (rr) flower are cross-fertilised (Rr) red hybrid flower progeny is produced, as RR is dominant over white rr.

Parents : RR × rr

Gametes : R r

F_1 Generation : Rr

Selfing of F_1 generation : Rr × Rr

Gametes : R r R r

F_2 generation : RR Rr Rr rr

(Red) (Red) (Red) (white)

(ii) (d)

(iii) (a) : In the given figure, F_1 progeny were all red flower colour plants. However, in the F_2 generation both the traits were seen, *i.e.*, 3 red colour flower plants and 1 white colour flower plant. This indicates that both the traits; red flower colour and white flower colour were inherited in F_1 plants, but only the red flower colour trait was expressed. Thus, the trait, red flower colour is dominant over white flower colour. This cross is in accordance with Mendel's law of dominance which states that in heterozygous individuals or hybrids, a character is represented by two contrasting factors called alleles or allelomorphs. Out of the two alleles, only one is able to express its effect in the individual. It is called dominant factor or dominant allele. The other allele, which does not show its effect in the heterozygous individual, is called recessive factor or recessive allele. In hybrid red (Rr) only factor (gene) of red expresses itself, hence it is called dominant character.

(iv) (b)

18. **(i) (c)**

(ii) (b) : According to the given passage some children show recessive trait, *i.e.*, homozygous. So, the woman must be heterozygous.

(iii) (c) : Human ova are haploid, hence they only contain one copy of each gene. Since the woman has a Bb genotype her ova would contain either B or b allele.

(iv) (d) : According to the given passage, within a single family, the sample size of offspring in each generation is very small. Hence, the actual phenotypic and genotypic ratios often deviate from expected ratios. It is only when sample sizes of offspring is large that actual ratios approach theoretical or expected ratios more closely.

(v) (c) : Human sperm is haploid, hence they only contain one copy of each gene. Since the man has a bb genotype, his sperm would contain allele b only.

19. **(i) (c) :** X and Y parents must have 'a' allele (recessive) that is respective for albinism, the genotype of both X and Y individuals would be Aa and Aa as they are normal and 3rd generation, normal and albino male and female is formed in 3 : 1 ratio.

(ii) (b) : Albinism is caused by the recessive allele. The children of generation-1, male and female all are normal (Aa). So, in generation-1, the genotype of female must be AA as she is normal and genotype of male is aa as he is albino male.

(iii) (d) : Albinism is caused by the recessive allele and father of X is albino male so, the genotype of X is Aa and genotype of albino female is aa. So, the probability that their children would be albino is 50%.

Parents ♂ Aa × ♀ aa

Gametes A a a a

Offspring Aa aa Aa aa

Normal Albino Normal Albino

(iv) (a)

(v) (a) : *Refer to answer 19(iii).*

20. (i) (d)

(ii) (a)

(iii) (a) : 25% of the total number of eggs will not hatch (genotype cc). 50% of the offspring will be curly- winged (Cc) and 25% of the offspring are straight-winged (CC).

(iv) (c)

(v) (b)

21. Basic features of inheritance are:

(i) Characters are controlled by genes and each gene controls one character.

(ii) Chromosomes are gene bearers and genes are basic unit of heredity.

(iii) One form of allele may be dominant on other, *i.e.*, genes are allelic in nature.

(iv) The two forms of alleles, separate at the time of gamete formation, *i.e.*, they do not mix with each other.

(v) Two allelic forms of a gene are brought together in zygote.

OR

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

22. In a monohybrid cross, the phenotypic ratio of F_2 generation is 3:1 whereas in dihybrid cross, the phenotypic ratio of F_2 generation is 9:3:3:1.

23. Tall plants may either have genotype TT or Tt. Two tall pea plants that produce some dwarf plants among their progenies must be heterozygous with the genotype Tt, because TT plants cannot produce dwarf offspring as they lack the allele for dwarfness (t) and hence cannot transfer it to the progeny. Besides, both of them should have a 't' allele as dwarfness is expressed in homozygous (tt) condition only. It can be expressed using Punnett square as follows:

Tt × Tt

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

OR

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

(a) Parent : Tall × Dwarf

Genotype : Tt × tt

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

F_1 generation :

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

Phenotypic ratio ⇒ Tall : Dwarf = 1 : 1

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

24. Parents Tall × Dwarf

Genotype : TT tt

Gametes : (T) (t)

F_1 : Tt

Selfing

F_2 :

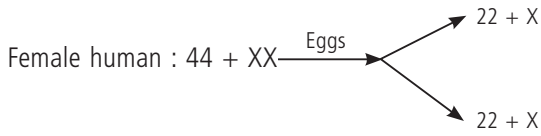
♀ \ ♂	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Dwarf

Fraction of heterozygous tall plants in $F_2 = \frac{1}{2}$.

This can be explained by law of segregation which states that the members of the allelic pair that remained together in the parent, segregate during gamete formation and only one factor enters a gamete.

25. Human beings have 22 pairs of autosomes and one pair of sex chromosomes. Women bear XX type of sex chromosomes and men are with XY type of sex chromosomes. Thus, men are with 44 + XY combination and women are with 44 + XX combination of chromosomes. Hence,

Male human : 44 + XY —Sperms→ 22 + X, 22 + Y



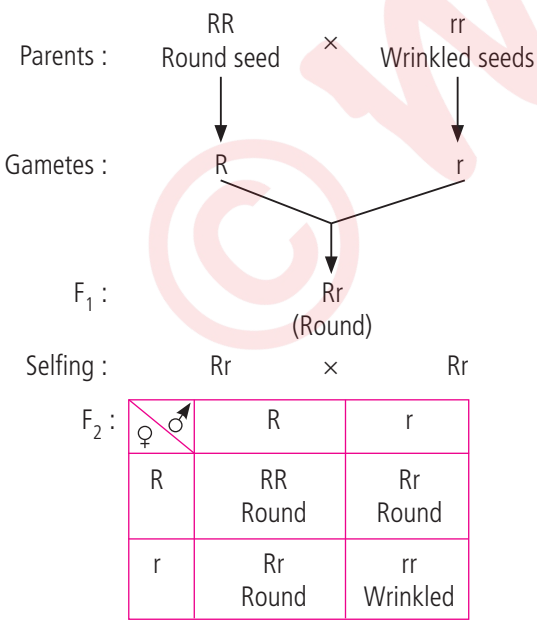
It is just the chance, if sperm 22 + X fuses with egg 22 + X, progeny will be a girl (44 + XX) but if by chance sperm 22 + Y fuses with egg 22 + X; then progeny will be a boy (44 + XY).

26. There is a pair of genes for a particular trait. The genes controlling a particular trait separate from each other during gamete formation. Germs cells make a single set of genes from two normal copies by a process called meiosis or reduction division. Hence gamete is always pure as far as contrasting characters are considered and will possess only one gene set. When male and female gametes fuse during fertilisation, paired condition is restored.

27. (i) 25 per cent of plants are with wrinkled seeds in F_2 generation.

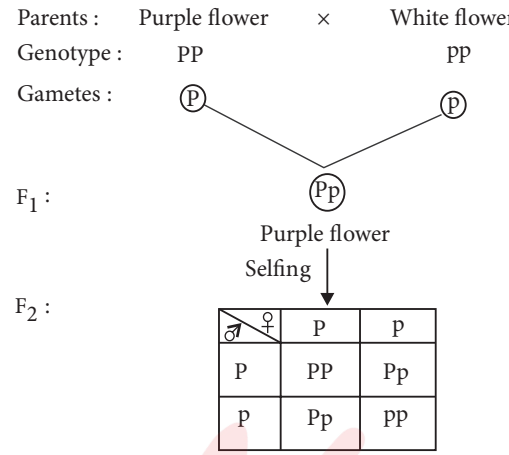
(ii) 50 per cent of plants are hybrid plants (heterozygous), as they contain the genes for both round seed and wrinkled seed.

(iii) Punnett square for the above experiment.



OR

In pea plant purple colour is dominant over the white colour. The cross between the two can be shown as below :



Purple flower : White flower

Phenotypic ratio 3 : 1

Genotypic ratio 1 : 2 : 1

Mendel's law of dominance and law of segregation can be derived from this cross. Law of dominance states that when individuals differing in a pair of contrasting characters are crossed, the character that appears in the F_1 hybrid is dominant over the alternate form that remain hidden. Principle of segregation states that, "when a pair of contrasting factor or gene are brought together in a hybrid; these factors do not blend or mix up but simply associate themselves and remain together and separate at the time of gamete formation", *i.e*, allele pairs segregate during gamete formation and the paired condition is restored by random fusion of gametes during fertilisation.

28. Dominant trait is a genetic trait which is expressed in a person when only one copy of that gene is present. A dominant gene decides the appearance of an organism or expresses itself even in the presence of an alternate gene and is represented mostly by capital letter.

Recessive trait is a genetic trait that is expressed only when two copies of the gene are present and is represented mostly by small letter.

When plants with two contrasting characters (*e.g.*, tall and dwarf) are crossed, only one character is visible in F_1 generation and other character is suppressed. It shows dominance of one character over other (recessive character).

29. In a dihybrid cross given by Mendel, it was observed that when two pairs of traits or characters were considered, each trait expressed independent of the other. Thus, Mendel was able to propose the Law of Independent Assortment, which says that pair of genes separate independently of each other during gamete formation. This could be explained clearly from the given cross:

P generation: RRYY (Round yellow seeds) × rryy (Wrinkled green seeds)

Gametes: RY, ry

F_1 generation: RrYy

Round yellow seeds

Selfing

	RY	Ry	rY	ry
RY	RRYY Round yellow	RRYy Round yellow	RrYY Round yellow	RrYy Round yellow
Ry	RRYy Round yellow	RRyy Round green	RrYy Round yellow	Rryy Round green
rY	RrYY Round yellow	RrYy Round yellow	rrYY Wrinkled yellow	rrYy Wrinkled yellow
ry	RrYy Round yellow	Rryy Round green	rrYy Wrinkled yellow	rryy Wrinkled green

F_2 generation ratio : 9 (Round-yellow) : 3 (Round-green) : 3 (Wrinkled-yellow) : 1 (Wrinkled-green)

30. 25% of homozygous recessive is obtained in F_2 generation. It can be illustrated as :

Tt (Heterozygous tall)

Selfing

♀ \ ♂	T	t
T	TT	Tt
t	Tt	tt

TT : Tt : tt

25% 50% 25%

31. Human female (XX) produces all gametes (ova) with X-chromosomes, while human male (XY) produces 50% gametes (sperms) with X-chromosome and 50% gametes with Y-chromosome.

If sperm having X chromosome fertilises the ovum with X chromosome then a female child is produced, otherwise a male child is produced.

Parents : XX (♀) XY (♂)

Gametes : (X) Ovum (X) (Y) Sperm

Progenies : XX (♀) XY (♂)

32. Yes, it is possible. Example-when pure tall pea plants (TT) are crossed with pure dwarf pea plants (tt), only tall pea plants (Tt) are obtained in F_1 generation.

On selfing tall plants of F_1, both tall and dwarf plants are obtained in F_2 generation in the ratio 3:1.

Reappearance of the dwarf character, a recessive trait in F_2 generation shows that the dwarf trait/ character was present in individuals of F_1 but it did not get expressed (due to the presence of tallness, a dominant trait/character).

33. Mendel conducted experiments with garden pea plants using a number of contrasting visible characters.

Parents : TT (Tall) × tt (Dwarf)

Gametes : T T t t

F_1 generation : Tt Tt Tt Tt

(All tall plants)

F_1 generation : selfing : Tt × Tt

Gametes : T t T t

F_2 Progenies: TT (Tall) Tt (Tall) Tt (Tall) tt (Dwarf)

He studied (pure) plants of a tall (TT) and short (tt) varieties. He crossed them and obtained F_1 progeny. He found that F_1 progeny all plants were tall (Tt). He selfed the (hybrid) plants of F_1 progeny (Tt). He found that in F_2 progenies were tall as well as short plants. The three quarter plants were tall and one quarter was short.

34. Mendel performed experiments on pea plants for several years and based on his observation, he formu lated three principles/laws of heredity, which are as follows:

(i) Principle of dominance : In a hybrid or heterozygous individual two dissimilar unit factors are present for one character. Out of two factors (genes) only one is able to express itself and it prevents expression of the other. The

one which expressed itself is called dominant gene or factor and the one which remains unexpressed is called recessive factor or gene. For example, in hybrid tall (Tt) only unit factor (gene) of tallness expresses itself, hence it is called dominant. The unit factor (gene) for dwarfness fails to express itself, hence it is called recessive.

(ii) Principle of segregation : The two unit factors of a character which remain together in an individual do not get mixed up, or get contaminated and keep their distinct identity. They separate or segregate during gamete formation so that each gamete receives only one factor (gene) for each character and is always pure. This principle is also called principle of purity of gametes. For example, in a hybrid tall pea plant, unit factors of tallness (T) and dwarfness (t) separate out or segregate out during gamete formation. The two unit factors occur with equal frequency in male and female gametes.

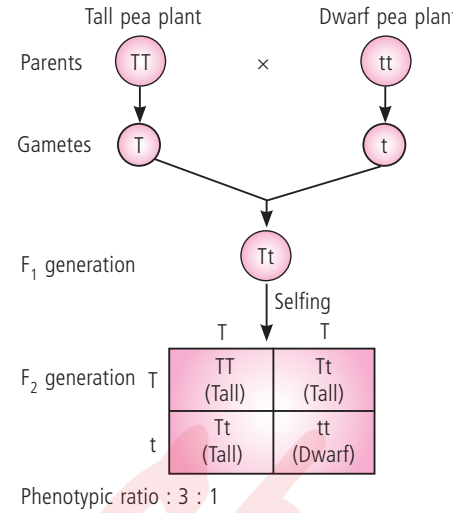
(iii) Principle of independent assortment : This principle states that the unit factor of each character is assorted or distributed into the gametes independently of the unit factors (genes) of any other character and gets randomly rearranged in the offspring. For example, in Mendel's dihybrid cross, the offspring of F_1 generation on self breeding produced four types of offspring. Two types were similar to parents while the remaining two types had combination of traits. This became possible because the unit factors of the two characters assorted independent to each other.

OR

The crosses which were made to study the inheritance of one pair of contrasting characters by Mendel are known as monohybrid crosses. For example in one such cross Mendel selected two sets of pea plants with contrasting characters for height. One set of pea plants was above six feet in height and the other set was of short plants with an average height of one foot. Mendel called these plants homozygous tall and homozygous dwarf. These were called as pure strain.

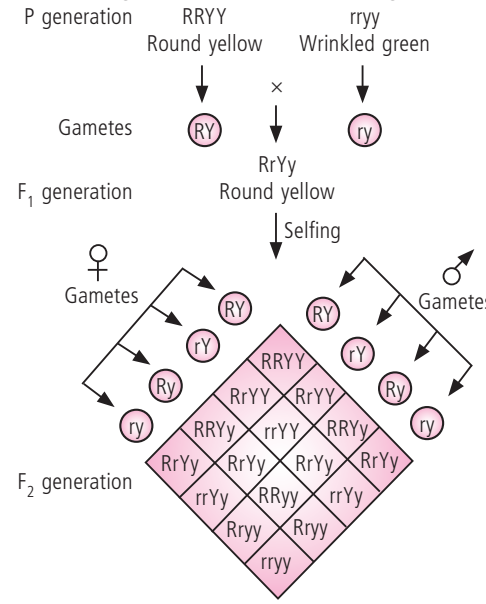
Mendel cross pollinated homozygous tall plants with homozygous dwarf plants. These plants represented the parent generation (P generation).

The plants grown from the seeds of parental plants were hybrid plants, these belonged to the F_1 generation or first filial generation. All plants of F_1 generation were tall. When plants of F_1 generation were self pollinated, seeds produced in next generation in the following ratio:



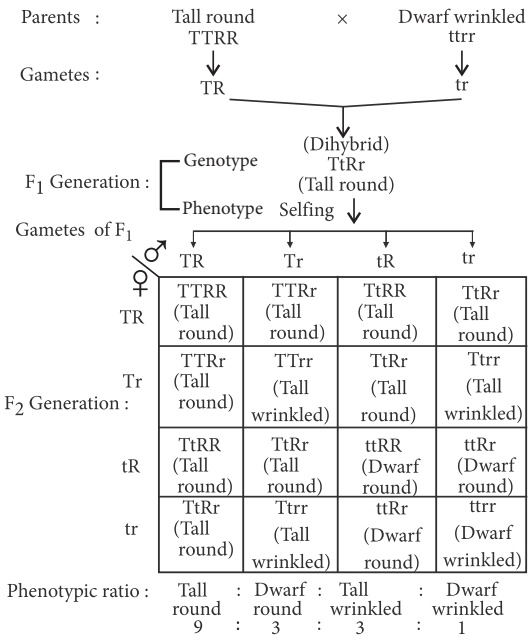
Phenotypic ratio : 3 : 1

The crosses which were made to study the inheritance of two pairs of contrasting characters simultaneously are referred as dihybrid crosses. For example, in one such cross Mendel selected pure breeding plants for (i) yellow and green colour of seeds, (ii) round and wrinkled shape of the seeds. He cross-pollinated flowers of the plants which were developed from homozygous round shape and yellow coloured seeds with flowers of plants raised from homozygous wrinkled shape and green coloured seeds. The plants of this generation were referred as P generation or parent generation. The seeds produced as a result of cross-pollination of P generation plants belonged to F_1 generation or first filial generation. All the seeds produced in this generation were yellow and round. Plants raised from these F_1 seeds belonged to F_2 generation. Plants of F_1 generation were self-pollinated. On self-pollination these produced different seeds in next generation (F_2 generation or second filial generation) in the following ratio:



Yellow and round : 9, yellow and wrinkled : 3, Green and round : 3, Green and wrinkled : 1

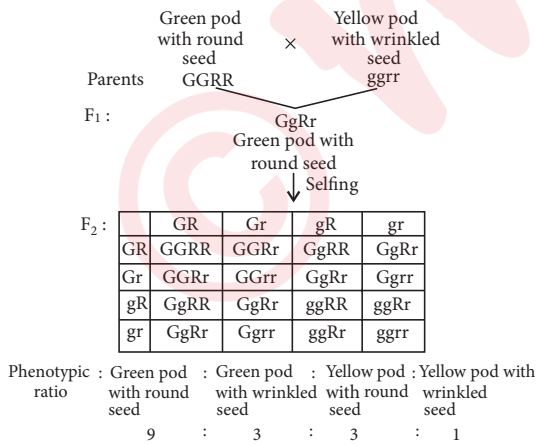
35.



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

Genetic explanation : The genes of different characters located in different pairs of chromosomes are independent of one another in their segregation during gamete formation. This law is called as law of independent assortment.

36.



OR

In human beings, the sex of the individual is genetically determined. In other words, the genes inherited from the parents decide the sex of the offspring. In diploid (2N) organisms with separate sexes, a specific pair of chromosomes determine the sex of the individual. They are called sex chromosomes. All other chromosomes are called autosomes. In case of autosomes, a pair of chromosomes are exactly similar as far as the shape and size are concerned, hence they are called homologous chromosomes. Sex chromosomes are heterologous, *i.e.*, different in shape and size. In human beings, 23 pairs of chromosomes are present in each cell. Out of 23 pairs, 22 pairs of chromosomes carry genes which control somatic traits, these are called autosomes. The 23rd pair of chromosomes determine the sex, hence these chromosomes are called sex chromosomes.

The human females have two X chromosomes (*i.e.*, XX) as sex chromosomes. These sex chromosomes are similar or homomorphic. However, human males have XY sex chromosomes, where X chromosome is morphologically distinct from Y chromosome. Y chromosome is smaller than X chromosome. Thus, they are dissimilar or heteromorphic.

During fertilisation there are equal chances that an ovum is fertilised by either a sperm having X chromosome or a sperm having Y chromosome. When a sperm carrying X chromosome fertilises an egg, the zygote develops into a female (XX condition). When a sperm carrying Y chromosome fertilises an egg, the zygote develops into a male (XY condition). Thus, the sex of a baby is determined at the time of fertilisation. The mechanism by which the sex of an individual is determined as it begins life, is called sex determination.

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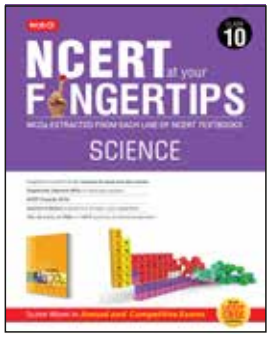

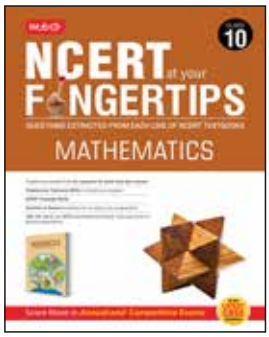

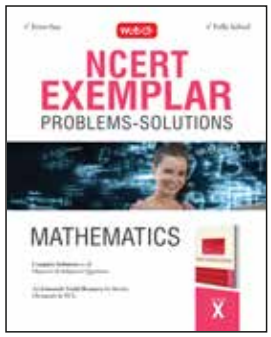

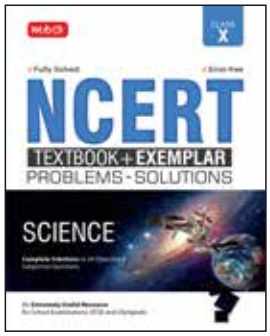

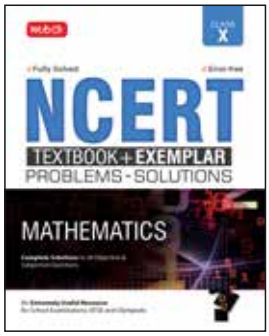

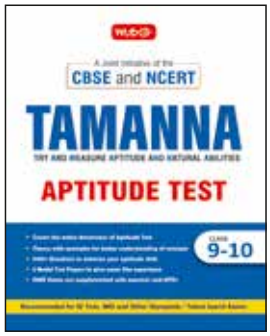

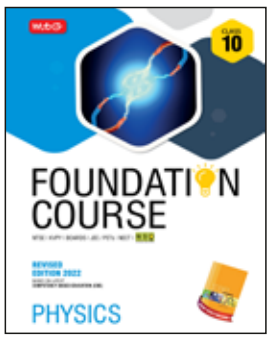

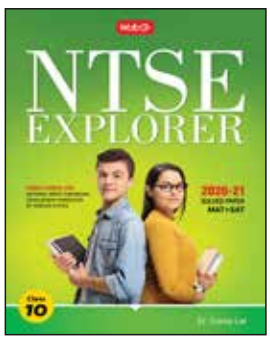

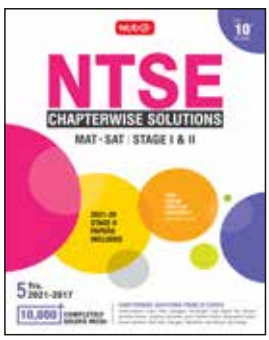

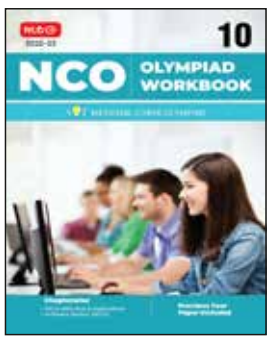

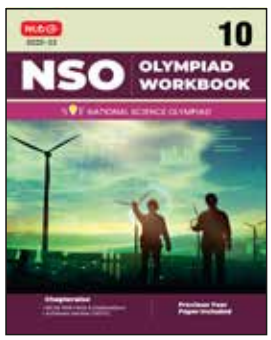

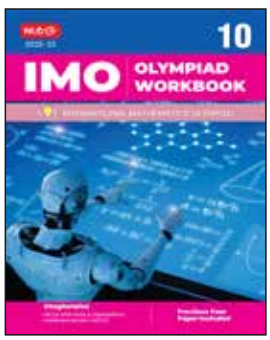

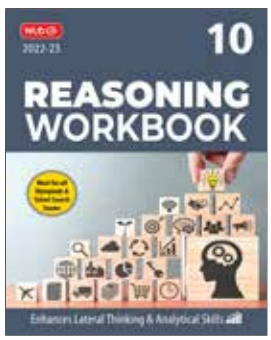

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