8 CHAPTER

Heredity and Evolution

Level - 1

MULTIPLE CHOICE QUESTIONS (MCQs) (1 Mark)

1. Option (D) is correct.
   Explanation: In snails, sex is not strictly genetically determined; rather, it can change based on environmental factors. This phenomenon is known as sequential hermaphroditism, where individuals can start life as one sex (male) and later change to the other sex (female) depending on external conditions like size, age, or population dynamics.
2. Option (D) is correct.
   Explanation: Changes in proteins can impact the function and structure of cells, tissues, and organs, which in turn can affect an organism's traits or features. Since proteins are crucial in determining the phenotype, any alteration in a protein could lead to changes in how traits are expressed, regardless of whether the genetic information remains the same. Thus, statement (D) is not correct.
3. Option (C) is correct.
   Explanation: Chromosomes are thread-like structures located in the nucleus of animal cells that carry genetic information from parents to offspring. They play a vital role in inheritance and cell division, ensuring the precise distribution of genetic material during cell division, which enables the transmission of genetic information across generations. Statement (iii) is incorrect because human reproductive cells (gametes) are haploid and do not exist in pairs.
4. Option (C) is correct.
   Explanation: T represents the dominant gene for tallness. t represents the recessive gene for shortness. A plant will only be short if it has two recessive genes (tt). The cross must involve heterozygous tall parent (Tt) and one homozygous short parent (tt). Option (C), Tt and tt is the only option that gives 50% tall and 50% short plants.
5. Option (C) is correct.
   Explanation: If two traits (such as seed shape and colour) are inherited independently, and both are governed by dominant and recessive alleles, for example, R for round shape vs. r for wrinkled, and Y for yellow colour vs. y for green, the F_2 progeny would result in four different combinations of seeds. They will be wrinkled-yellow, round-yellow, wrinkled-green seeds and round-green in the phenotypic ratio of 9:3:3:1.
6. Option (A) is correct.
   Explanation: For dwarf plants (tt) to appear, both parents must carry the recessive t allele. A cross between two Tt (heterozygous tall) plants will produce TT, Tt, and tt offspring, with 25% of them being dwarf (tt).
7. Option (C) is correct.
   Explanation: A human zygote is formed by the fusion of a male gamete (sperm, 23 chromosomes) and a female gamete (egg, 23 chromosomes). Together, they result in a zygote with 46 chromosomes (23 pairs).
8. Option (A) is correct.
   Explanation: When pure tall plants (TT) are crossed with pure dwarf plants (tt), all offspring in the F_1 generation will have the genotype Tt (heterozygous), and they will all be tall since the tall trait (T) is dominant over the dwarf trait (t). When the F_1 generation (Tt) is self-crossed, the possible genotypes of the offspring will be:

	T	t
T	TT	Tt
t	Tt	tt

   The results from the Punnett square show the following genotypes:
   1 TT (homozygous tall)
   2 Tt (heterozygous tall)
   1 tt (homozygous dwarf)
   So, the ratio of the genotypes in the F_2 generation is 1 TT: 2 Tt: 1 tt
9. Option (A) is correct.
   Explanation: In individuals of a given species, a specific gene is located on a particular chromosome. This is because genes are segments of DNA that are located on specific locations on chromosomes, and they carry the instructions for making proteins and other molecules that are essential for the functioning of cells.

10. Option (A) is correct.
Explanation: When the F_1 plants (Vv) are self-crossed to produce the F_2 generation, the possible genotypes and phenotypes of the offspring can be determined using a Punnett square. In this case, the genotypic ratio would be: 1 VV : 2 Vv : 1 vv
And the phenotypic ratio (ratio of violet flowers to white flowers) would be:
3 Violet: 1 White
So, in the F_2 progeny, the ratio of violet (VV) to white (vv) flowers will be 1:1.

11. Option (C) is correct.
Explanation: The trait that expresses itself in the F_1 generation refers to a trait that is visible or dominant when the first filial generation is produced from a cross between two parent organisms. In genetics, this trait is known as the dominant trait.
The trait that keeps on passing from one generation to another refers to traits that are inherited from parents to offspring. In genetics, this is referred to as an inherited trait.

12. Option (B) is correct.
Explanation: The cross between a plant with red flowers (Rw) and a plant with white flowers (ww) results in the following Punnett square:

	w	w
R	Rw	Rw
w	ww	ww

Thus, the genotypes of the offspring are:
- 2 Rw (red flowers)
- 2 ww (white flowers)

This gives us a ratio of:
- 2 red (Rw): 2 white (ww)

Simplifying the ratio, we get:
- 1 red: 1 white

Thus, 50% of the offspring will have white flowers (ww).

13. Option (A) is correct.
Explanation: Traits are characteristics that an individual possesses. The traits developed in an organism due to the effect of environmental factors are known as acquired traits. These traits are not encoded in the DNA of the organism and therefore cannot be passed on to future generations. Examples of acquired traits include the muscular body of a wrestler, playing a musical instrument, reading, writing, animal behavior, and short hair. On the other hand, tall height, brown eyes, and body mass are examples of inherited traits.

14. Option (D) is correct.
Explanation: Attached earlobes in humans is a recessive trait, meaning an individual must inherit two copies of the recessive allele (ee) to express the trait. If both parents have attached earlobes, their genotype must be ee (homozygous recessive), as this is the only way the trait is expressed. When both parents have the genotype ee, they can only pass on the recessive allele (e) to their offspring. As a result, all children will inherit the ee genotype and exhibit the attached earlobes trait. Therefore, the chances of their child having attached earlobes is 100%.

15. Option (A) is correct.
Explanation: A monohybrid cross is a cross between two parents that differ in one specific trait with contrasting alleles. In this case, the full pod shape (FF) is a dominant trait, whereas the constricted pod shape (ff) is a recessive trait. When a pea plant with full pods (FF) is crossed with a pea plant with constricted pods (ff), all the F_1 progeny will be heterozygous (Ff). This means they will all display the dominant full pod shape. Therefore, 100% of the F_1 generation will have the full pod shape.

ASSERTION-REASON QUESTIONS (1 Mark)

1. Option (B) is correct.
Explanation: The assertion states that human females have a perfect pair of sex chromosomes (XX), which is true because their sex chromosomes are homologous. The reason explains that the sex chromosome contributed by the human male in the zygote determines the sex of the child, which is also true. While both statements are true, reason does not explain assertion. The chromosome pair in females being perfect is unrelated to how the male gamete determines the sex of a child.

2. Option (D) is correct.
Explanation: The assertion that the sex of the children is determined by what they inherit from their mother is false because the mother's contribution is always an X chromosome, and the sex of the child is determined by the father's contribution (either an X for a female or a Y for a male). The reason that women have XX sex chromosomes is true, as females possess two homologous X chromosomes. Therefore, assertion is false, but reason is true.

3. Option (C) is correct.
Explanation: The assertion that each human trait is influenced by both paternal and maternal DNA is true, as every child inherits one set of chromosomes from each parent, which together determine their traits. However, the reason that the mother contributes more genetic material to the child compared to the father is false, as both parents contribute an equal amount of genetic material (23 chromosomes each). While the mother does provide additional cytoplasmic material, such as mitochondrial DNA, it does not increase her nuclear genetic contribution. Therefore, assertion is true, but reason is false.

4. Option (C) is correct.
Explanation: The sex of a child is determined by the combination of sex chromosomes inherited from the parents. A child inherits one sex chromosome from each parent: an X chromosome from the mother and

either an X or Y chromosome from the father. If the child inherits an X chromosome from the father, the child will be female (XX). If the child inherits a Y chromosome from the father, the child will be male (XY). Therefore, in a male child, the father provides the Y chromosome that determines the child will be male. Thus, assertion is true but reason is false.

5. Option (D) is correct.
Explanation: The assertion states that in humans, if gene B is responsible for black eyes (dominant) and gene b is responsible for brown eyes (recessive), then progeny with the combinations Bb, bb, or BB will have black eyes. This is false because only individuals with at least one dominant B allele (Bb or BB) will have black eyes, while individuals with bb (homozygous recessive) will have brown eyes. The reason that black eye colour is a dominant trait is true, as it explains why Bb and BB combinations express the black eye phenotype. Thus, assertion is false but reason is true.

6. Option (C) is correct.
Explanation: Humans exhibit a wide range of variations in their traits, including physical traits like skin color, eye colour, and height, as well as non-physical traits like personality and intelligence. These variations arise due to genetic differences and environmental influences, which contribute to the diversity in human populations. However, not all variations have an equal chance of survival and reproduction. Some variations may provide an advantage, helping individuals adapt better to their environment, survive and reproduce, while others may be neutral or even harmful. Thus, assertion is true but reason is false.

Level - 2

CASE-BASED QUESTIONS (4 Marks)

1. (i) The two observations made by Mendel were:
(1) All F_1 plants were tall, indicating that the tall trait is dominant over the short trait.
(2) No F_1 plants exhibited the short trait, showing that the short trait is recessive and is masked in the presence of the dominant allele.

(ii)

Dominant Trait	Recessive Trait
In a heterozygous individual, the dominant trait overpowers the recessive trait and is always expressed. It is denoted using capital letters (e.g., T for tall plants). For example, in Tt, the tall trait is expressed because the dominant allele T masks the recessive allele.	This trait is only expressed in homozygous individuals (tt) and remains hidden in the presence of a dominant allele. It is represented by lowercase letters (e.g., t for short plants). For example, in Tt, the short trait remains masked.

(iii) (a) Mendel crossed the F_1 hybrids (RrYy) obtained from the parental cross RRYY × rryy (Round Yellow × Wrinkled Green) through self-pollination to produce the F_2 generation.
Observations in F_2 generation:
- Mendel observed 4 types of combinations: Round Yellow, Round Green, Wrinkled Yellow, and Wrinkled Green in a phenotypic ratio of 9:3:3:1.
- The ratio of parental combinations (Round Yellow and Wrinkled Green) was 9 (Round Yellow):1 (Wrinkled Green).

From this experiment, Mendel concluded the following:
- **Law of Independent Assortment:** Mendel found that genes for various characteristics segregate independently during gamete development. Seed shape (round or wrinkled) and colour (yellow or green) are not inherited.
- **Dihybrid Ratio:** The F_2 generation exhibits a phenotypic ratio of 9:3:3:1, supporting the Law of Independent Assortment. The dihybrid ratio shows the distribution of attributes between two opposing pairs in a genetic cross.

OR

(b) If pea plants with yellow seeds are crossed with plants of green seeds, it is found that in F_1 generation all the plants have yellow seeds. When F_1 generation, plants with yellow seeds and plants with green seeds are obtained. This shows that both the traits are inherited but only one trait is visible in F_1 progeny while the others remains unexpressed.

2. (i) **Flower colour:** Purple (dominant) vs. White (recessive)
Height of the plant: Tall vs. Dwarf.

(ii)

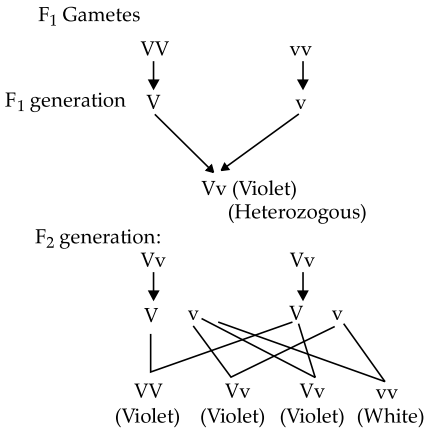
Dominant trait	Recessive trait
The trait which gets expressed in F_1 generation is called dominant trait.	The trait which remains suppressed in F_1 generation, which cannot express itself in presence of dominant trait is called recessive trait.
It gets expressed in both homozygous and heterozygous condition.	It gets expressed only when present in homozygous condition.

(iii) (a) The F_2 generation seeds shows the 9:3:3:1 phenotypic ratio
- Round yellow seeds: 9
- Round green seeds: 3
- Wrinkled yellow seeds: 3
- Wrinkled green seeds: 1

This 9:3:3:1 ratio is a classic Mendelian dihybrid cross result, demonstrating his law of independent assortment. This ratio indicates that Mendel observed nine plants with the dominant phenotype for both traits, three plants with the dominant phenotype for one trait and the recessive phenotype for the other trait, three plants with the recessive phenotype for one trait and the dominant phenotype for the other trait, and one plant with the recessive phenotype for both traits.

OR

(b)



Hence,

F_1 Generation:

- **Genotype:** All plants will be heterozygous (Vv)
- **Phenotype:** All plants will have violet flowers (since violet is dominant)

F_2 Generation (Selfing F_1 plants):

- **Genotypes:**
  - 1 VV (homozygous dominant)
  - 2 Vv (heterozygous)
  - 1 vv (homozygous recessive)
- **Phenotypes:**
  - 3 violet-flowered plants (VV and Vv)
  - 1 white-flowered plant (vv)

This demonstrates Mendel's principle of dominance and segregation, where the recessive trait reappears in the F_2 generation in a predictable ratio.

3. (i) An offspring of a human is not a true copy of its parents in sexual reproduction because it inherits a unique combination of genes from both parents, resulting in genetic variation.

(ii)

F_1 generation	F_2 generation
(1) In F_1 generation only the dominant traits are expressed.	In F_2 generation, both dominant and recessive triats are expressed.
(2) It refers to the offspring/plants resulting immediately from a cross between the first set of parents.	It refers to the offspring/plants resulting from a cross among the plants of F_1 generation.

(iii) (a) Variations are useful for the survival of a species over time because they provide a genetic diversity that allows populations to adapt to changing environments. Variations can lead to the development of new traits that may offer a survival advantage, such as resistance to diseases, ability to find new food sources, or adaptability to different climates.

OR

(b) The new combinations observed in the F_2 generation are "round green" (RRyy) and "wrinkled yellow" (rryy). These combinations were not present in the parental generation and result from the independent assortment of alleles during gamete formation.

These new combinations arise due to Mendel's laws of independent assortment and segregation, which contribute to genetic diversity in the offspring.

4. (i) The sex of a newborn baby in humans is determined by the sex chromosome inherited from the father: an X chromosome results in a female (XX), while a Y chromosome results in a male (XY).

(ii) The pair of sex chromosomes in males is called a mismatched pair because they consist of one X chromosome and one Y chromosome, which are different in size and genetic content.

(iii) (a) The original number of chromosomes present in the parents is restored in the progeny through the processes of meiosis and fertilisation. During meiosis, the number of chromosomes in germ cells (sperm and egg) is halved, resulting in haploid cells with 23 chromosomes each in humans. When fertilisation occurs, the haploid sperm and egg combine to form a diploid zygote with 46 chromosomes, restoring the original number of chromosomes.

OR

(b) **Temperature-Dependent Sex Determination in Turtles:** In many turtle species, the sex of the offspring is determined by the temperature at which the eggs are incubated. For example, eggs incubated at higher temperatures often produce females, while those at lower temperatures produce males.

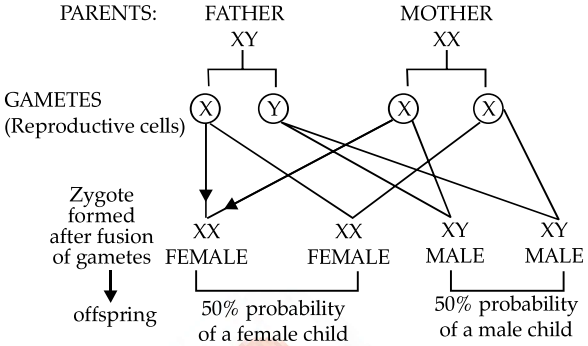
Sequential Hermaphroditism in Clownfish: All clownfish are born male, and the

dominant male can change to female if the current female dies, allowing the next male in the hierarchy to become the new breeding male.

5. (i)
- In a human zygote, there are 46 chromosomes.
- In each human gamete (sperm or egg), there are 23 chromosomes.

(ii) In some reptiles, such as turtles, sex determination is influenced by the incubation temperature of the eggs, with higher temperatures producing females and lower temperatures producing males; this is called temperature-dependent sex determination (TSD).

(iii) (a) The sex of a child is determined by the combination of sex chromosomes from the parents. The mother contributes an X chromosome, while the father can contribute either an X or a Y chromosome. If the father's sperm carries an X chromosome, the child will be female (XX). If the father's sperm carries a Y chromosome, the child will be male (XY). Thus, there is an equal chance of fusion of either X or Y chromosome with the egg. Therefore, we can say that the sex of a newborn child is a matter of chance and none of the parents are responsible for it.



OR

(b) All gametes (eggs) formed in human females have an X chromosome because females have two X chromosomes (XX). During meiosis, the two X chromosomes separate, ensuring that each egg receives one X chromosome. Since, females do not have a Y chromosome, they can only produce gametes with an X chromosome.

Level - 3

VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

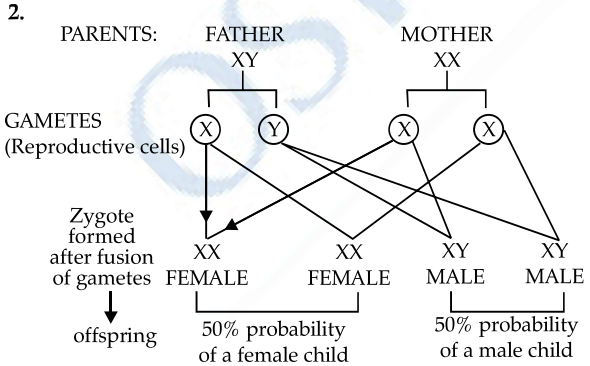
1. Two of the most famous pairs of traits that Mendel studied were:

Seed Shape:
- **Dominant Trait:** Round seeds (symbolised by "R")
- **Recessive Trait:** Wrinkled seeds (symbolised by "r")

Flower Colour:
- Dominant Trait: Purple flowers (symbolised by "P")
- Recessive Trait: White flowers (symbolised by "p")

These contrasting pairs of traits allowed Mendel to observe clear patterns of inheritance and formulate his laws of segregation and independent assortment.

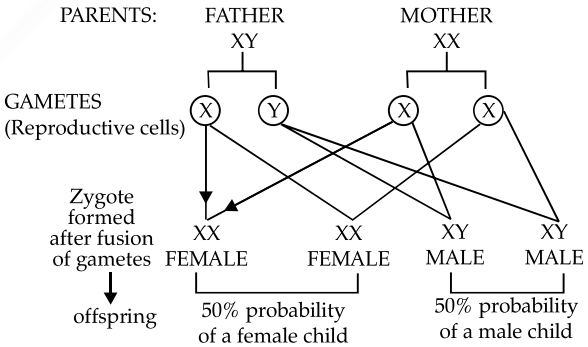
2.



3. The survival of species is promoted through creation of variations because variations increase the chances of species adapting of changing environments. This principle is central to evolution.

Example: A population of bacteria living in temparate waters that can withstand heat due to the rise in temperature due to global warming will survive better in a heat wave than the non-variant bacteria having no capacity to tolerate heat wave. Thus, suitable variations promote survival.

4. A newborn child who inherits 'X' chromosome from father will be a girl and one who inherits a 'Y' chromosome from the father will be a boy. This can be explained with the help of a flow diagram given below:



5. (i) The gene combination present in the plants of the F_1 generation is Tt. All F_1 plants are heterozygous with one allele for tallness (T) and one allele for shortness (t).

(ii) Only tall plants are observed in the F_1 progeny because the allele for tallness (T) is dominant over the allele for shortness (t). In a heterozygous combination (Tt), the dominant trait (tallness) is

expressed, masking the effect of the recessive trait (shortness). This phenomenon is explained by Mendel's Law of Dominance, which states that "among the different alleles of a specific gene located at the same chromosomal position, some alleles are dominant over others".

(iii) When F_1 plants are self-pollinated:

	T	t
T	TT	Tt
t	Tt	tt

Genotypic ratio: 1 : 2 : 1 (TT = 25% Tt = 50% tt = 25%)

Phenotypic ratio: 3 : 1 (Tall = 75% Short = 25%)

Based on Punnet Square analysis, the F_2 generation will have the following genotype ratio:

- TT (homozygous tall): 1/4
- Tt (heterozygous tall): 2/4
- tt (homozygous short): 1/4

Therefore, the phenotypic ratio of tall to short plants in the F_2 generation will be:

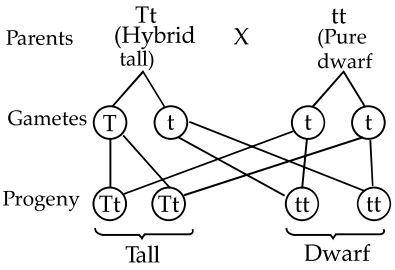
- 3 tall plants (TT and Tt): 1 short plant (tt)

So, the ratio of tall to short plants in the F_2 generation is 3:1.

6. In sexually reproducing organisms, the number of chromosomes in the progeny is re-established through meiosis and fertilisation. The process of meiosis reduces the chromosome number by half, producing haploid gametes (sperm and egg), each containing one set of chromosomes (n). During fertilisation, a haploid sperm cell fuses with a haploid egg cell, combining their genetic material to form a diploid zygote with two sets of chromosomes (2n). This restores the original chromosome number in the progeny.

7. Humans have 23 pairs of chromosomes, with one pair being sex chromosomes. Females have identical sex chromosomes (XX), while males have non-identical sex chromosomes (XY). During gametogenesis, the chromosome number is halved, resulting in male sperm containing either an X or a Y chromosome in equal proportions. During ejaculation, millions of sperm are released, and the sperm that fertilises the egg determines the sex of the zygote. If an X-bearing sperm fertilises the egg, the zygote will be XX (female). If a Y-bearing sperm fertilises the egg, the zygote will be XY (male). Since the ratio of X to Y chromosomes in male sperm is 50:50, the probability of having a male or female child is also 50:50. Thus, the statistical probability of conceiving either a male or female child is equal.

8. This can be shown as



9. Variation refers to the differences in the genetic makeup and physical traits among individuals within a population. The two main reasons that may lead to variation in a population are:

(i) Mutations: Mutations are changes in the DNA sequence that can occur spontaneously or due to environmental factors. These changes can introduce new traits into a population, increasing genetic diversity.

(ii) Sexual Reproduction: During sexual reproduction, the combination of genes from two parents leads to offspring with a unique set of genetic information. This recombination of genes during the formation of gametes (meiosis) and fertilisation results in variation among offspring.

10. (i) All F_1 progeny will have violet flowers (Vv) because the violet flower trait is dominant over the white flower trait.

(ii) The F_2 progeny will show a phenotypic ratio of 3:1, where 75% of the plants will have violet flowers and 25% will have white flowers. This is because the F_1 progeny (heterozygous for the flower colour trait) will produce a mix of homozygous dominant, heterozygous, and homozygous recessive offspring.

(iii) Since the recessive trait appears in 25% of the F_2 progeny:

Number of plants with recessive trait = 0.25 x 100 = 25

So, 25 plants will show the white flower (recessive) trait.

11. Mendel observed that crossing two pea plants with contrasting traits (such as tall and short) resulted in F_1 progeny showing only one parental trait (e.g., all tall or all short). This is explained by the principle of dominance:

- Each trait is controlled by a pair of alleles (one from each parent).
- One allele is dominant, and the other is recessive.
- The dominant allele masks the expression of the recessive allele in heterozygous individuals.

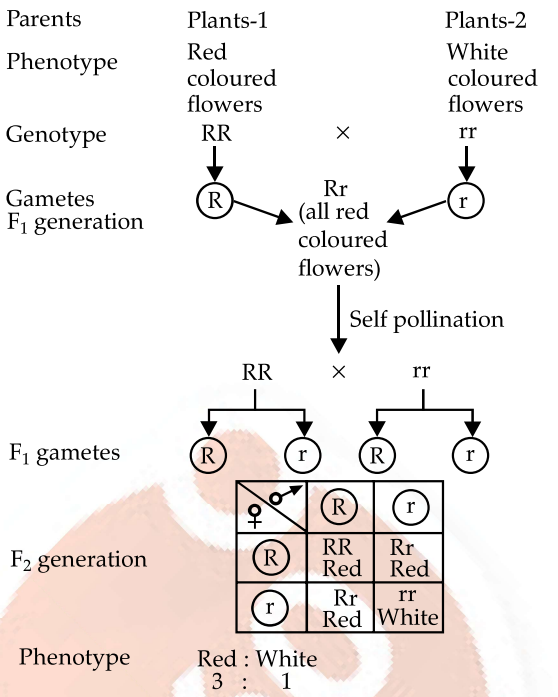
For example, if tallness (T) is dominant over shortness (t), crossing homozygous tall (TT) with homozygous short (tt) results in F_1 progeny that are all heterozygous (Tt) and display the tall phenotype. Thus, no intermediate characteristics appear in the F_1 generation.

12. Humans have two types of sex chromosomes, X and Y, which determine the sex of an individual. Females

have two X chromosomes (XX). Males have one X and one Y chromosome (XY). During reproduction, the mother contributes one X chromosome, whereas a father can contribute either an X or a Y chromosome to the offspring. If the child inherits an X chromosome from the father, the resulting combination will be XX, which means the child will be female. If the child inherits a Y chromosome from the father, the resulting combination will be XY, which means the child will be male. Therefore, sex of the children will be determined by what they inherit from their father.

13. Genes control the characteristics or traits in an organism by encoding instructions for the synthesis of specific proteins. For example, in plants, the gene responsible for tallness codes for proteins that help promote the growth of the plant by enabling efficient cell division and elongation. This results in the production of more plant tissues, leading to greater height. In contrast, the gene for shortness (dwarfness) codes for proteins that limit the plant's growth, either by reducing the efficiency of cell growth or by influencing the plant's overall growth process. Therefore, the gene determines the type of protein produced, which in turn controls the plant's height, showing how genes regulate the traits of an organism.

14. The following flow chart and explanation illustrate the inheritance pattern and the ratio of red to white flowers in the F_2 generation.



The phenotypic ratio of the F_2 generation is 3:1, with 75% of the plants having red flowers and 25% having white flowers. This result confirms Mendelian inheritance principles, where a dominant trait (red flowers) masks the presence of a recessive trait (white flowers) in the heterozygous condition (Rr).

SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. Difference between dominant trait and recessive trait

Dominant Trait	Recessive Trait
It is a trait or characteristic, which is able to express itself over another contrasting trait.	It is a trait which is unable to express its effect in the presence of the dominant trait.
It can express in both heterozygous and homozygous conditions.	It can express only in homozygous condition.

Mendel crossed pea plants with yellow seeds (YY) and green seeds (yy). In the F_1 generation, all offspring were Yy, displaying the yellow seed colour (since Y is dominant). When F_1 plants (Yy) were self-crossed to produce the F_2 generation, the genotypic and phenotypic ratio were:

Genotypic Ratio:

- YY (homozygous dominant): 1/4
- Yy (heterozygous dominant): 2/4
- yy (homozygous recessive): 1/4

Phenotypic Ratio:

- Yellow seeds (YY or Yy): 3/4
- Green seeds (yy): 1/4

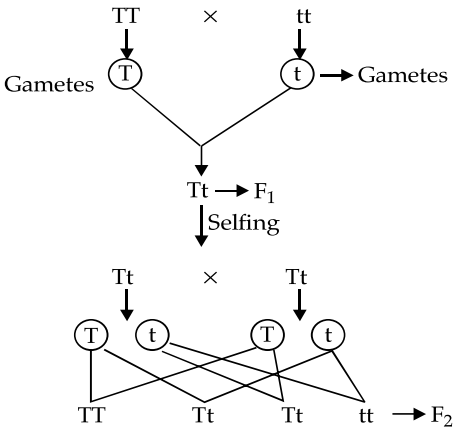
Therefore, 75% of the pea plants in the F_2 generation had yellow seeds.

2. (i) The F_1 progeny from a cross between pure tall (TT) and pure short (tt) pea plants would all be tall. This is because the tall allele (T) is dominant over the short allele (t).

Since, the TT parent contributes a T allele and the tt parent contributes a t allele, all the F_1 plants will have the genotype Tt. So, the F_1 plants were tall, with the genotype Tt.

(ii) In a heterozygous state (Tt), the dominant allele T "masks" the effect of the recessive allele t. As a result, even though the F_1 plants carry the shortness allele (t), they appear tall because the dominant tall allele (T) determines their phenotype.

(iii) When the F_1 plants (Tt) are self-pollinated, the phentoypic and genotypic ratio obtained in F_2 progeny are:



The possible genotypes in the F_2 progeny are:

- TT (homozygous tall)
- Tt (heterozygous tall)
- tt (homozygous short)

Thus, the genotypic ratio in F_2 would be:

- 1 TT: 2 Tt: 1 tt

The phenotypic ratio in terms of height (tall or short) would be:

- 3 tall: 1 short

The experiment shows that the inheritance of the trait for height in pea plants follows Mendel's laws of inheritance, specifically the law of segregation. The tallness allele is dominant over the shortness allele. The 3:1 ratio in the F_2 progeny is consistent with the segregation of a single gene with two alleles (dominant and recessive), confirming Mendel's theory of heredity.

3. (i) The term used for the trait observed in the F_1 generation is "dominance".

When the blue-flowered plant (BB) is crossed with the white-flowered plant (bb), all the plants in the F_1 generation will have the genotype Bb. Since B is dominant, all F_1 plants will have blue flowers, despite carrying the recessive b allele. Thus, the F_1 generation will have blue flowers with the gene combination Bb.

(ii) When the F_1 plants (Bb) are self-pollinated,

Blue Colour Flower → BB
White Colour Flower → bb

Parent BB × bb

Gametes B b

F_1 generation Bb × Bb (selfing)

F_2 generation

	B	b
B	BB	Bb
b	Bb	bb

(1) Percentages of Plants with blue flowers in F_2 Generation: The plants with blue flowers have either the BB or Bb genotype. From the above diagram, it is clear that there are 3 out of 4 plants (1 BB + 2 Bb) with blue flowers. Thus, there are 75% of blue-flowered plants.

(2) Plants with white flowers in F_2 Generation: The plants with white flowers have the bb genotype. There is 1 out of 4 plants (1 bb) with white flowers. Thus, there are 25% of white-flowered plants.

The reappearance of white flowers in the F_2 generation indicates that the white flower colour trait (bb) is recessive and can only be expressed when both alleles are bb. The presence of white flowers in the F_2 generation shows that the recessive allele b has been inherited from both parents (F_1 plants) and is now expressed when no dominant B allele is present. This result confirms Mendel's law of segregation, where alleles for a trait separate during gamete formation, and offspring inherit one allele from each parent.

4. (i) Men produce two types of gametes:

- Sperm carrying the X chromosome.
- Sperm carrying the Y chromosome.

(ii) No, a male child does not inherit the X chromosome from his father. A male child inherits his X chromosome from his mother and his Y chromosome from his father. This is because the mother contributes one of her X chromosomes, whereas, the father contributes either an X or a Y chromosome to the offspring.

(iii) A human female produces one type of gamete, i.e., eggs (ova), all carrying the X chromosome.

5. Mendel's experiments demonstrated the independent inheritance of traits through his dihybrid cross experiments, which led to the formulation of the Law of Independent Assortment. Mendel crossed pea plants that had two different traits, such as seed shape (round or wrinkled) and seed colour (yellow or green). He started with plants that were homozygous for both traits (RRYY and rryy). The F_1 progeny from this cross were all heterozygous for both traits (RrYy) and displayed the dominant traits (round and yellow). Mendel then allowed the F_1 plants (RrYy) to self- pollinate. He observed the F_2 generation and found a phenotypic ratio of 9:3:3:1.

- 9 plants had round yellow seeds (both dominant traits).
- 3 plants had round green seeds (one dominant and one recessive trait).
- 3 plants had wrinkled yellow seeds (one dominant and one recessive trait).
- 1 plant had wrinkled green seeds (both recessive traits).

The appearance of all possible combinations of traits in the F_2 generation, in specific ratios, indicated that the alleles for seed shape and seed colour assorted independently of each other during gamete formation. This independent assortment occurs because the

genes for different traits are located on different chromosomes, or far apart on the same chromosome, allowing them to segregate independently during meiosis.

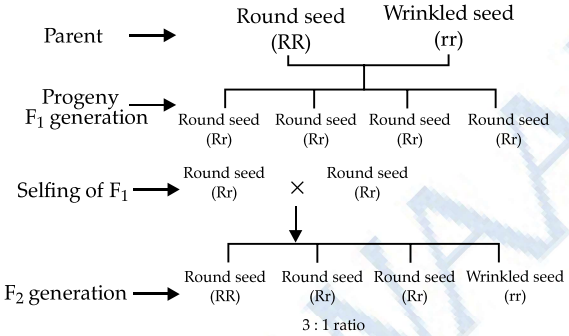
LONG ANSWER TYPE QUESTIONS (5 Marks)

1. (i) Law of Dominance of Traits: The law of dominance is one of the principles established by Gregor Mendel through his work on pea plants. According to this law, when parents having pure contrasting characters are crossed then only one character expresses itself in the F_1 generation. The character that masks the other is called the dominant character, and the one that is masked is called the recessive character.

For example, When pea plants with round seeds (RR) are crossed with plants with wrinkled seeds (rr), all seeds in F_1 generation were found to be round (Rr).

When these round seeds were self fertilised, both the round and wrinkled seeds appeared in F_2 generation in 3: 1 ratio.

Hence, in F_1 generation, the dominant character (round seeds) appeared and the recessive character (wrinkled seeds) got suppressed, which reappeared in F_2 generation. This shows that in the F_1 generation, the dominant trait (round seeds) is expressed, while the recessive trait (wrinkled seeds) is suppressed. However, the recessive trait reappears in the F_2 generation.



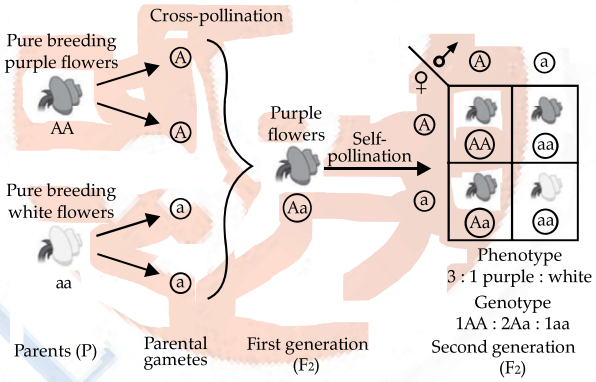
(ii) Traits acquired during an individual's lifetime are known as acquired traits. These traits are not encoded in an individual's DNA but are a result of environmental influences, lifestyle choices, or experiences. Since they do not alter the genetic code, they cannot be passed on to offspring. Inheritance only involves traits that are encoded in the genetic material (DNA) and can be transmitted from parents to their children through genes. For example, if a person builds muscle through exercise, this physical change is an acquired trait and will not be inherited by their children. Thus, the traits acquired during the life time of an individual not inherited.

2. (i) The two visible traits of a garden pea that Mendel considered in his experiments are:

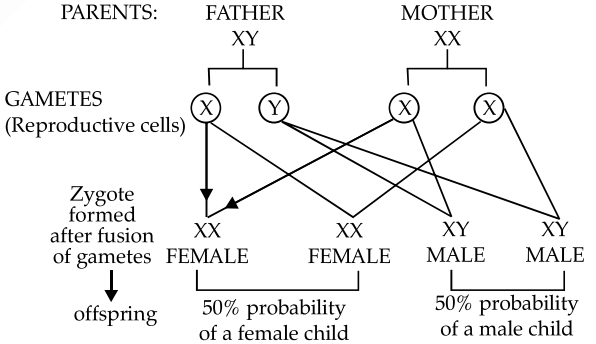
Flower color: Purple (dominant) vs. White (recessive)

Seed shape: Round (dominant) vs. Wrinkled (recessive)

Explanation: Mendel's experiments demonstrated that traits could be dominant or recessive through his method of cross-breeding pea plants. When he crossed pure- breeding plants with different traits (e.g., purple flowers and white flowers), all the F_1 offspring exhibited the dominant trait (e.g., purple flowers). Upon self-fertilisation of the F_1 generation, the F_2 generation showed both the dominant and recessive traits in a 3:1 ratio, respectively. This showed that the dominant trait masked the recessive trait in the F_1 generation, but the recessive trait reappeared in the F_2 generation.



(ii) The sperm carries either an X or a Y chromosome, while the egg carries only an X chromosome. If a sperm carrying a Y chromosome fertilises the egg, the resulting combination (XY) produces a male child. Conversely, if a sperm carrying an X chromosome fertilises the egg, the resulting combination (XX) produces a female child.



Therefore, there is an equal chance of either an X-bearing sperm or a Y-bearing sperm fertilising the egg. This means that the sex of a newborn is determined purely by chance, and neither parent is responsible for the sex of the child.

3. (i) For the offspring to have the dwarf phenotype (tt), both parents must provide a t allele. This

means that at least one t allele must come from each parent.

- tt × tt → 100% tt offspring (dwarf)
- Tt × Tt → 25% tt offspring (dwarf), 50% Tt offspring (tall), 25% TT offspring (tall)
- Tt × tt → 50% Tt offspring (tall), 50% tt offspring (dwarf)
- tt × Tt → 50% Tt offspring (tall), 50% tt offspring (dwarf)

So, the following parent pairs can produce dwarf offspring (tt):

1. tt × tt
2. Tt × Tt
3. Tt × tt
4. tt × Tt

(ii) Let's choose one of the pairs from part (A) and perform a cross.

Example Cross: Tt × tt

The genotypes of the parents are:

- Tt (heterozygous tall) × tt (homozygous dwarf)

To determine the offspring, we can set up a Punnett square,

	T	t
t	Tt (tall)	tt (dwarf)
t	Tt (tall)	tt (dwarf)

Offspring Genotypes: Tt (tall) - 50% and tt (dwarf) - 50%

Phenotypes of Offspring: Tall (Tt) - 50% and Dwarf (tt) - 50%

So, the cross Tt × tt produces offspring with a 50% chance of being dwarf (tt) and a 50% chance of being tall (Tt).