

8

Heredity and Evolution

Fastrack® Revision

- **Heredity:** The transmission of characteristics or traits from one generation to another (from parents to offsprings) is known as inheritance or heredity.
- **Inherited Traits:** These are traits or characteristics, which are passed on from parents to their offsprings. They are transferred to the progeny and are helpful in evolution e.g., colour of eyes and hair.
- **Inheritance of Traits (Mendelism):** Gregor Johann Mendel (1822-1884) was the first one to keep count of individuals exhibiting a particular trait in each generation to study inheritance pattern in garden pea (*Pisum sativum*). He is regarded as the 'father of genetics.' Mendel chose pea plants because they are self-pollinating, easily available and have a short life-span.
- Mendel studied Monohybrid inheritance (single trait) and Dihybrid inheritance (two traits) and gave three laws of inheritance. In case of monohybrid cross with pure variety of plants, the phenotypic ratio obtained in F_2 generation is 3 : 1. In case of dihybrid cross involving two pairs of contrasting characters, the phenotypic ratio obtained in F_2 generation is 9 : 3 : 3 : 1.
- **Sex Determination:** It is the phenomenon of determination of sex of a new-born individual. The factors responsible for it are either environmental (e.g., turtle) or genetic (e.g., humans).
- **Characteristics of Sex Determination:**
 - (i) In human beings, the sex of the individual is determined genetically.
 - (ii) There are 22 pairs of autosomes and 1 pair of sex chromosomes.
 - (iii) Males have an imperfect pair of sex chromosomes, i.e., XY, while females have similar perfect pair, i.e., XX.
 - (iv) In a woman, all eggs carry only X-chromosome.
 - (v) Sex of a child depends on the type of sperm which fuses with the egg.
 - (vi) If the sperm carries X-chromosome, a girl child will be produced and if the sperm carrying Y-chromosome fuses with the egg, it will result in birth of a baby boy.



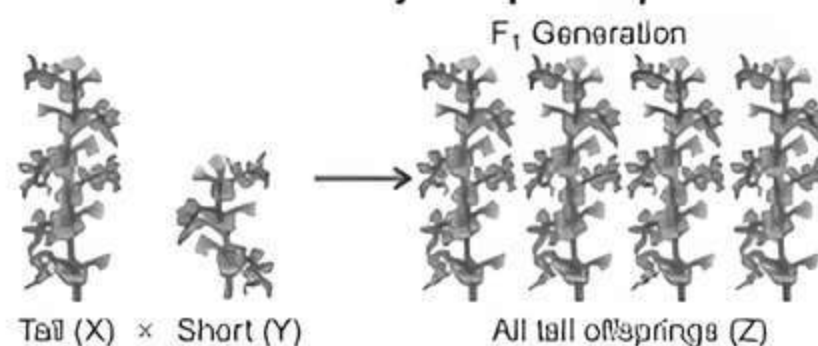
Practice Exercise



Multiple Choice Questions

- Q 1. Which of the following statements is not true with respect to variation?** (NCERT EXEMPLAR)
- a. All variations in a species have equal chance of survival.
 - b. Change in genetic composition results in variation.
 - c. Selection of variants by environmental factors forms the basis of evolutionary processes.
 - d. Variation is minimum in asexual reproduction.
- Q 2. A cross between a tall plant (TT) and short pea plant (tt) resulted in progeny that were all tall plants because:** (NCERT EXEMPLAR)
- a. tallness is the dominant trait.
 - b. shortness is the dominant trait.
 - c. tallness is the recessive trait.
 - d. height of pea plant is not governed by gene 'T' or 't'.

- Q 3. Refer to the given figure showing a cross between a tall and a short variety of a plant species.**



What could be genotype of X, Y and Z in the given figure?

X	Y	Z
a. TT	tt	Tt
b. Tt	Tt	Tt
c. Tt	Tt	TT
d. TT	tt	TT

- Q 4. Select the statements that describe characteristics of genes:**
- (i) genes are specific sequence of bases in a DNA molecule.
 - (ii) a gene does not code for proteins.
 - (iii) in individuals of a given species, a specific gene is located on a particular chromosome.

(iv) each chromosome has only one gene.

(NCERT EXEMPLAR)

- a. (i) and (ii) b. (i) and (iii)
c. (i) and (iv) d. (ii) and (iv)

Q 5. A cross between pea plant with white flowers (vv) and pea plant with violet flowers (VV) resulted in F_2 progeny in which ratio of violet (VV) and white (vv) flowers will be: (CBSE 2023)

- a. 1:1 b. 2:1 c. 3:1 d. 1:3

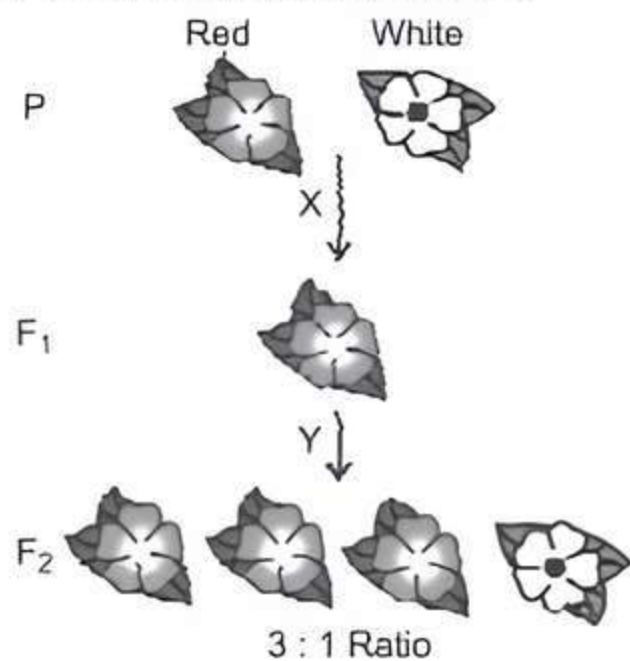
Q 6. If a tall pea plant is crossed with a pure dwarf pea plant, then what percentage of F_1 and F_2 generation respectively will be tall? (CBSE SQP 2022-23)

- a. 25%, 25% b. 50%, 50%
c. 75%, 100% d. 100%, 75%

Q 7. Two pink coloured flowers on crossing resulted in 1 red, 2 pink and 1 white flower progeny. The nature of the cross will be: (NCERT EXEMPLAR)

- a. double fertilisation b. self pollination
c. cross fertilisation d. no fertilisation

Directions (Q. Nos. 8-9): Refer to the given figure and answer the following questions:



Q 8. Identify process X and Y in the figure and select the correct option:

- | X | Y |
|------------------------|---------------------|
| a. Cross-fertilisation | Self-fertilisation |
| b. Self-fertilisation | Cross-fertilisation |
| c. Cross-fertilisation | Cross-fertilisation |
| d. Self-fertilisation | Self-fertilisation |

Q 9. Select the correct statement(s) regarding the given figure:

- (i) It is a monohybrid cross.
(ii) Red flower colour trait is dominant over white flower colour trait.
(iii) Both the traits red flower colour and white flower colour were inherited in F_1 plants, but only red flower trait was expressed.

- a. (ii) and (iii) b. Only (i)
c. Only (ii) d. (i), (ii) and (iii)

Q 10. Which of the following statement is incorrect?

(NCERT EXEMPLAR)

- a. For every hormone, there is a gene.
b. For every protein, there is a gene.
c. For production of every enzyme, there is a gene.
d. For every molecule of fat, there is a gene.

Q 11. If a round, green seeded pea plant (RRyy) is crossed with wrinkled, yellow seeded pea plant (rrYY), the seeds produced in F_1 generation are:

(NCERT EXEMPLAR)

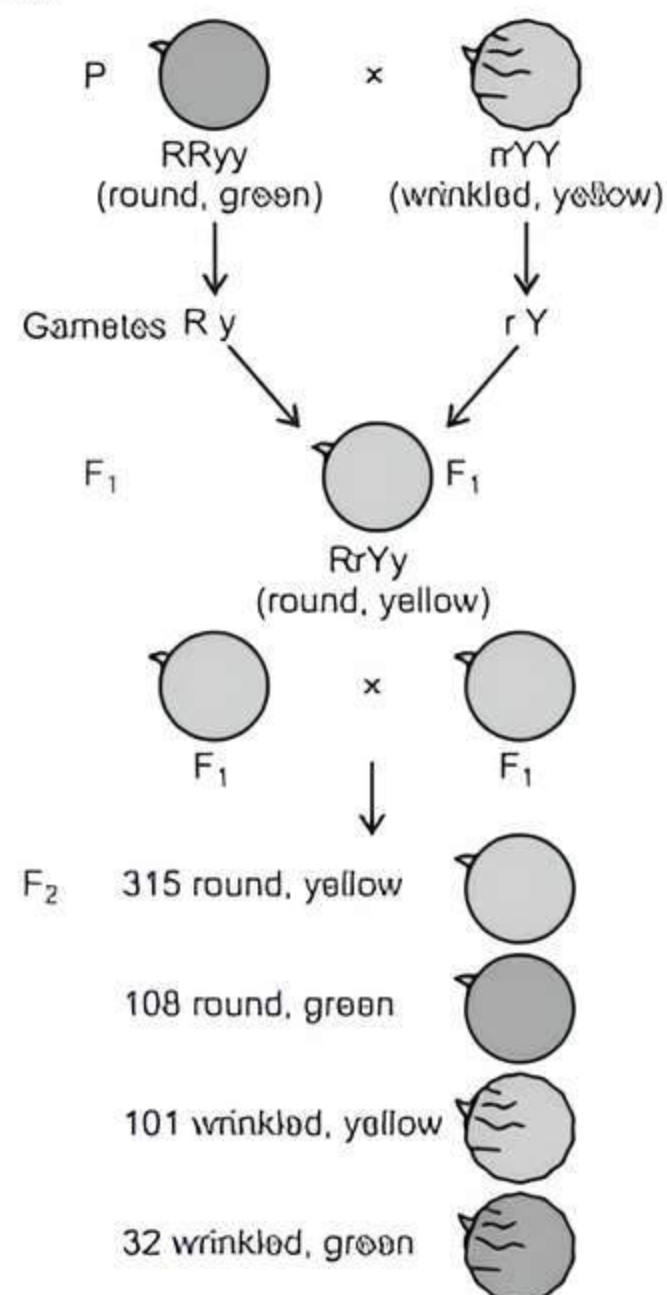
- a. round and yellow b. round and green
c. wrinkled and green d. wrinkled and yellow

Q 12. Two pea plants one with round green seeds (RRyy) and another with wrinkled yellow (rrYY) seeds produce F_1 progeny that have round, yellow (RrYy) seeds. When F_1 plants are selfed, the F_2 progeny will have new combination of characters. Choose the new combination from the following:

(NCERT EXEMPLAR)

- (i) Round, yellow (ii) Round, green
(iii) Wrinkled, yellow (iv) Wrinkled, green
a. (i) and (ii) b. (i) and (iv)
c. (ii) and (iii) d. (i) and (iii)

Q 13. Mendel performed a cross between two garden pea plants; one with round and green seed and the other with yellow and wrinkled seed as shown below:



It is an example of:

- a. dihybrid cross b. monohybrid cross
c. trihybrid cross d. back cross

Q 14. The number of pair(s) of sex chromosomes in the zygote of humans is: (NCERT EXEMPLAR)

- a. one b. two c. three d. four

Q 15. A trait in an organism is influenced by:

(NCERT EXEMPLAR)

- a. paternal DNA only
b. maternal DNA only
c. Both maternal and paternal DNA
d. Neither by paternal nor by maternal DNA

Q 16. When an 'X' bearing sperm fertilizes the egg, the resulting zygote has the following combination of chromosomes: (CBSE 2023)

- a. $44 + XX$ b. $44 + XY$
c. $22 + XX$ d. $22 + XY$

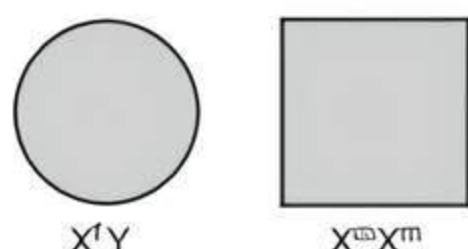
Q 17. The two versions of a trait (character) which are brought in by the male and female gametes are situated on: (NCERT EXEMPLAR)

- a. copies of the same chromosome
b. two different chromosomes
c. sex chromosomes
d. any chromosome

Q 18. Humans have two different sex chromosomes, X and Y. Based on the Mendel's laws, a male offspring will inherit which combination of chromosomes?

- a. Both the X chromosomes from one of its parents.
b. Both the Y chromosomes from one of its parents.
c. Combination of X chromosomes from either of its parents.
d. Combination of X and Y chromosome from mother and father respectively.

Q 19. Two individuals are as shown using geometric shapes.



Their sex chromosomes are respectively denoted by X^f , X^m and Y. What are the possible combinations of sex chromosomes for their male and female offspring respectively?

- a. $X^f X^m$ and $X^m X^m$ b. $X^m Y$ and $X^m X^m$
c. $X^f Y$ and $X^m Y$ d. $X^m Y$ and $X^m X^f$

Q 20. In human males, all the chromosomes are paired perfectly except one. This/these unpaired chromosome is/are: (NCERT EXEMPLAR)

- (i) large chromosome (ii) small chromosome
(iii) Y-chromosome (iv) X-chromosome
a. (i) and (ii) b. (iii) only
c. (iii) and (iv) d. (ii) and (iv)

Q 21. Which pair of sex chromosome will determine a male? (CBSE 2023)

- a. XO b. XX c. XY d. YY



Assertion & Reason Type Questions

Directions (Q. Nos. 22-30): Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:

- a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

- b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 22. Assertion (A): Accumulation of variation in a species increases the chances of its survival in changing environment.

Reason (R): Accumulation of heat resistance in some bacteria ensure their survival even when temperature in environment rises too much.

Q 23. Assertion (A): Height in pea plants is controlled by efficiency of enzymes and is thus genetically controlled.

Reason (R): Cellular DNA is the Information source for making proteins in the cell. (CBSE SQP 2022-23)

Q 24. Assertion (A): In humans, if gene (B) is responsible for black eyes and gene (b) is responsible for brown eyes, then the colour of eyes of the progeny having gene combination Bb, bb or BB will be black only.

Reason (R): The black colour of the eyes is a dominant trait. (CBSE 2023)

Q 25. Assertion (A): Monohybrid cross deals with inheritance of one pair of contrasting characters.

Reason (R): Dihybrid cross deals with inheritance of two pairs of contrasting characters.

Q 26. Assertion (A): When pea plants having round yellow seeds, are crossed with plants possessing wrinkled green seeds, then all the pea plants obtained in F_1 generation bear wrinkled yellow seeds.

Reason (R): Round and yellow characters are dominant over wrinkled and green characters.

Q 27. Assertion (A): The sex of a child in human beings will be determined by the type of chromosome he/she inherits from the father.

Reason (R): A child who inherits 'X' chromosome from his father would be a girl (XX), while a child who inherits a 'Y' chromosome from the father would be a boy (XY). (CBSE 2020)

Q 28. Assertion (A): In humans, males play an important role in determining the sex of the child.

Reason (R): Males have two X chromosomes.

Q 29. Assertion (A): In human males, all the chromosomes are perfectly paired except X and Y chromosomes.

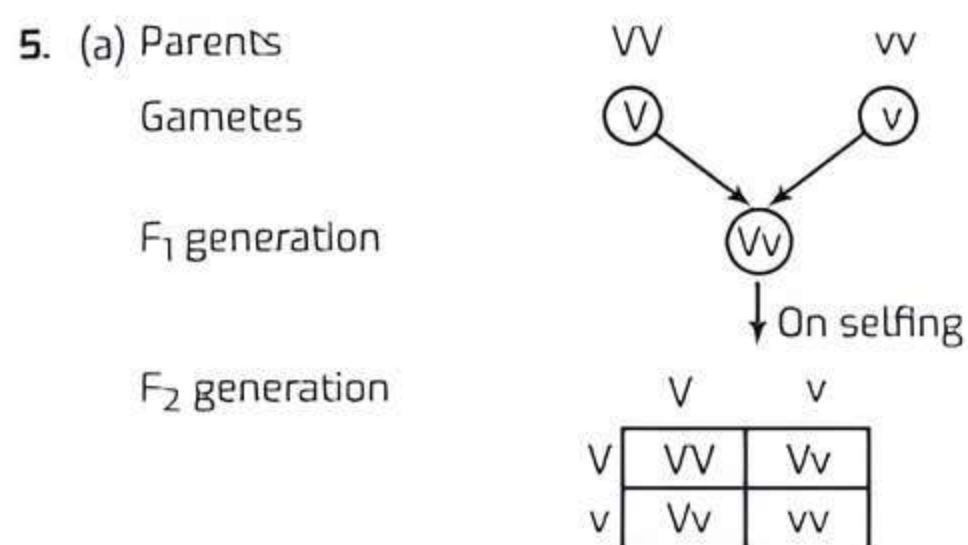
Reason (R): X and Y are sex chromosomes.

Q 30. Assertion (A): In human beings, the sex of the individual is largely genetically determined.

Reason (R): In snails, sex is not genetically determined.

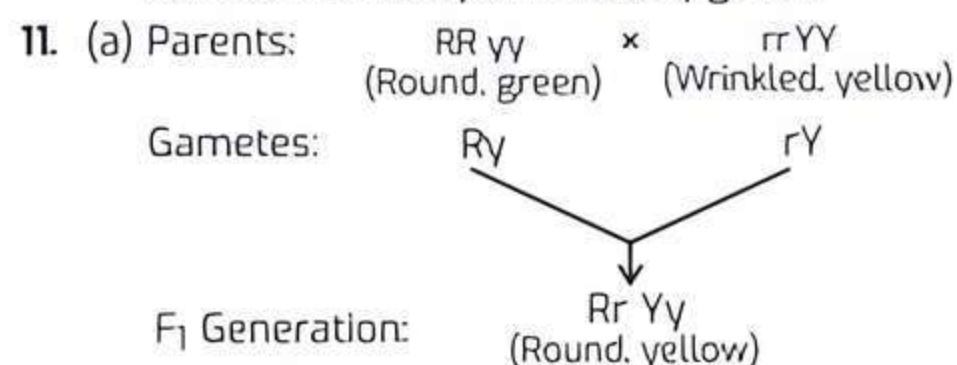
Answers

1. (a) All variations in a species have equal chance of survival.
2. (a) tallness is the dominant trait.
3. (a) The given figure shows a monohybrid cross between pure-bred tall pea plants (TT) and pure-bred dwarf pea plants (tt). Only tall pea plants (Tt) were produced in F_1 generation.
4. (b) A gene is the section in a DNA that codes for the formation of a protein. There are thousands of genes on a chromosome, which control various characteristics of an organism.



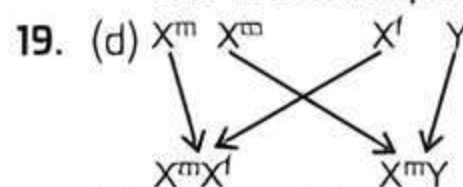
Required ratio = VV : vv = 1 : 1

6. (d) 100%, 75%
7. (b) self pollination
8. (a) X-Cross-fertilisation, Y-Self-fertilisation
9. (d) It is a monohybrid cross because a single pair of contrasting characteristics or traits is taken into consideration here. 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 flower colour plants and 1 white flower colour 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.
10. (d) For every protein, hormone and an enzyme, there is a gene which directs and controls their synthesis. But fats are not synthesised by genes.



12. (b) When the F_1 generation pea plants having round-yellow seeds were cross-bred by self pollination, then four types of seeds having different combinations of shape and colour were obtained in F_2 generation. These were round yellow, round green, wrinkled yellow and wrinkled green seeds. Thus, the new combination of characters are: Round yellow and wrinkled green.

13. (a) dihybrid cross
14. (a) An adult human has 23 pairs of chromosomes out of which 22 pairs are autosomes and one pair is sex chromosome.
15. (c) This is because each parent contribute equally for genetic material of their child.
16. (a) 44 + XX
17. (a) copies of the same chromosome
18. (d) Combination of X and Y chromosome from mother and father respectively.



20. (c) (iii) and (iv)
21. (c) XY
22. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
23. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
24. (d) Assertion (A) is false because in case of bb, the person will have brown eyes.
25. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
26. (d) Assertion (A) is false because when a cross was made between round yellow seeds and wrinkled green seeds, only round and yellow seeds are obtained in F_1 generation.
27. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
28. (c) Reason (R) is false because A male has one 'X' chromosome and one 'Y' chromosome.
29. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
30. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).



Case Study Based Questions

Case Study 1

The most obvious outcome of the reproductive process is the generation of individuals of similar design, but in sexual reproduction they may not be exactly alike. The resemblances as well as differences are marked. The rules of heredity determine the process by which traits and characteristics are reliably inherited. Many experiments have been done to study the rules of inheritance.

Read the above passage carefully and give the answer of the following questions:

- Q 1. Why an offspring of human being is not a true copy of his parents in sexual reproduction?
- Q 2. While performing experiments on inheritance in plants, what is the difference between F_1 and F_2 generation?

Q 3. Why do we say that variations are useful for the survival of a species over time?

Or

Study Mendel's cross between two plants with a pair of contrasting characters.

RRYY × rryy
Round Yellow × Wrinkled Green

He observed 4 types of combinations in F_2 generation. Which of these were new combinations? Why do new features which are not present in the parents, appear in F_2 generation? (CBSE 2023)

Answers

1. Because in sexual reproduction, both the father and mother contribute practically equal amounts of genetic material to the offspring. Thus, each trait is influenced by both paternal and maternal DNA.
2. F_1 generation is produced by the breeding of two parental organisms while F_2 generation is produced by the interbreeding of two F_1 generation offsprings.
3. Variations are useful for the survival of a species over time as variation makes species more adapted to survive and grow in the changing environmental conditions. If a population of reproducing organisms were suited to a particular niche and if the niche were drastically altered, the population could be wiped out. However, if some variations were to be present in a few individuals in these populations, there would be some chance for them to survive. Variation is thus useful for the survival of species over time.

Or

Round green and wrinkled yellow were the new combinations. In crossing, if two or more traits are involved, the factors responsible for each pair of traits separate and behave independently in F_2 generation irrespective of the combinations present in parents. So, new features appear in F_2 generation.

Case Study 2

Sahil performed an experiment to study the inheritance pattern of genes. He crossed tall pea plants (TT) with short pea plants (tt) and obtained all tall plants in F_1 generation.

Read the above passage carefully and give the answer of the following questions:

- Q 1. What will be set of genes present in the F_1 generation?
- Q 2. Given reason why only tall plants are observed in F_1 progeny.
- Q 3. When F_1 plants were self-pollinated, a total of 800 plants were produced. How many of these would be tall, medium height or short plant? Give the genotype of F_2 generation.

Or

When F_1 plants were cross-pollinated with plants having tt genes, a total of 800 plants were produced. How many of these would be tall, medium height or short plants? Give the genotype of F_2 generation. (CBSE SQP 2022 Term-2)

Answers

1. Genes present in F_1 generation is Tt.
2. It is so because tallness (T) is a dominant trait and short (t) is a recessive trait in pea plants.
3. When F_1 plants were self-pollinated, both tall and short traits are expressed in F_2 generation in the ratio 3 : 1.
Thus, 600 plants will be tall and 200 plants will be short.

The genotype of F_2 generation is $\frac{TT : Tt : tt}{1 : 2 : 1}$

Or

	t	t
T	Tt	Tt
t	tt	tt

In this cross, 400 tall (Tt) and 400 short (tt) will be produced.

The genotype of F_2 generation is $\frac{Tt : tt}{1 : 1}$

Case Study 3

Pooja has green eyes while her parents and brother have black eyes. Pooja's husband Ravi has black eyes while his mother has green eyes and father has black eyes.

Read the above passage carefully and give the answers of the following questions:

- Q 1. On the basis of the above given information, is the green eye colour a dominant or recessive trait? Justify your answer.
- Q 2. What is the possible genetic makeup of Pooja's brother's eye colour?
- Q 3. What is the probability that the offspring of Pooja and Ravi will have green eyes? Also, show the inheritance of eye colour in the offspring with the help of a suitable cross.

Or

50% of the offspring of Pooja's brother are green eyed. With help of cross show how this is possible? (CBSE SQP 2022-23)

Answers

1. Green eye colour is recessive trait as it will express only in homozygous condition.
2. BB, Bb
3. bb × Bb

Gametes	B	b
b	Bb	bb
b	Bb	bb

50% of the offsprings can have green eye colour.

Or

Brother is heterozygous (Bb) and wife is green (bb).
bb × Bb

Gametes	B	b
b	Bb	bb
b	Bb	bb

50% of the offsprings can have green eye colour as per the cross shown.

Case Study 4

Figures (a) to (d) given below represent the type of ear lobes present in a family consisting of 2 childrens—Rahul, Nisha and their parents.



Excited by his observation of different types of ear lobes present in his family, Rahul conducted a survey of the type of ear lobes found (Figures (e) and (f)) in his classmates. He found two types of ear lobes in his classmates as per the frequency given below:

Sex	Free	Attached
Male	36	14
Female	31	10

On the basis of above data, answer the following questions:

- Q 1. Which of the two characteristics 'free ear lobe' or 'attached ear lobe' appears to be dominant in this case? Why?
- Q 2. Is the inheritance of the free ear lobe linked with sex of the individual? Give reason for your answer.
- Q 3. What type of ear lobe is present in father, mother, Rahul and his sister Nisha? Write the genetic constitution of each of these family members which explains the inheritance of this character in this family.

(Gene for Free ear lobe is represented by F and gene for attached ear lobe is represented by f for writing the genetic constitution).

Or

Suresh's parents have attached ear lobes. What type of ear lobe can be seen in Suresh and his sister Siya? Explain by giving the genetic composition of all.

(CBSE SQP 2023-24)

Answers

1. Free ear lobe is dominant because it is found in a large majority of the population.
2. No, it is not sex linked. As per the data of the family as well as the class, it is indicated that free ear lobe is present in males as well as in females.
3. Father—Ff (free ear lobe), Mother—ff (free ear lobe), Rahul—ff (attached ear lobe) and Nisha—Ff (free ear lobe).

Or

Suresh's father—ff (attached ear lobe), mother—ff (attached ear lobe), Suresh—ff (attached ear lobe), Siya—ff (attached ear lobe). If both parents have recessive character, then all the children can have recessive character only.

Case Study 5

Sex determination is the method by which distinction between males and females is established in a species. The sex of an individual is determined by specific chromosomes. These chromosomes are called sex chromosomes. X and Y chromosomes are called sex chromosomes. The normal chromosomes other than the sex chromosomes of an individual are known as autosomes.

Read the above passage carefully and give the answer of the following questions:

- Q 1. A normal baby girl receives her X chromosome from whom: mother, father, both mother and father or either from mother or father?
- Q 2. A couple has six daughters. What is the possibility of them having a girl next time?
- Q 3. Do genetic combination of mothers play a significant role in determining the sex of a new born?
- Q 4. Which vital function is not controlled by autosomes?

Answers

1. From both mother and father.
2. The possibility of having a girl or boy child is equal i.e., 50%, as 50% male gametes are Y type and 50% are X type.
3. No, because mothers have a pair of X chromosomes. All children will inherit an X chromosome from their mother regardless of whether they are boys or girls.
4. Sex of a child is not controlled by autosomes.



Very Short Answer Type Questions

- Q 1. All the variations in a species do not have equal chances of survival. Why?

Ans. All the variations do not have equal chances of survival because some variations are caused by environmental changes and they do not bring out any change in DNA.

Q 2. What is DNA?

(CBSE 2015, 16)

Ans. Deoxyribonucleic Acid (DNA) is a molecule which carries the hereditary information in a coded form from one generation to the other in all the organisms.

Q 3. Where is DNA found in a cell?

(CBSE 2015)

Ans. DNA is found in the nucleus of a cell.

Q 4. What is the effect of DNA copying which is not perfectly accurate, on the reproduction process?

Ans. It will result in variations which may further lead to adaptation to changing environment, thus giving more chances of survival.

Q 5. No two individuals are absolutely alike in a population. Why?

(CBSE 2015)

Ans. No two individuals are absolutely alike in a population due to variations taking place during the process of DNA copying.

Q 6. What is heredity?

Ans. Heredity is the process in which the characters or traits of the parents are passed onto the offspring and through successive generations.

Q 7. Name the plant on which Mendel performed his experiments.

Ans. Garden pea (*Pisum sativum*).

Q 8. A Mendelian experiment consisted of breeding pea plants bearing violet flowers with pea plants bearing white flowers. What will be the result in F_1 progeny?

(CBSE 2018)

Ans. All the flowers in F_1 progeny will be violet in colour because violet colour of the flowers is a dominant trait in pea plants.

Q 9. Why is the progeny always tall when a tall pea plant is crossed with a short pea plant? (CBSE 2016)

Ans. The trait which represents the tallness in a pea plant is dominant over the other trait, shortness (dwarf).

Q 10. Mendel observed a contrasting trait in relation to position of flowers. Mention the trait.

Ans. Axial flower position (dominant)
Terminal flower position (recessive)

Q 11. What is the phenotypic ratio of a dihybrid cross in F_2 generation?

Ans. 9 : 3 : 3 : 1

Q 12. What is a gene?

Ans. A gene is a functional unit of heredity made up of DNA, which is responsible for the transmission of traits or characters from parents to the offspring.

Q 13. Write the sex of the baby that inherits Y-chromosomes from the father.

Ans. Male.

Q 14. How many pairs of chromosomes are present in human beings?

Ans. 23 pairs.

Q 15. Give an example where sex determination is regulated by environmental factors.

Ans. Reptiles (lizard etc.)

**Short Answer Type-I Questions****Q 1. In an asexually reproducing species, if a trait X exists in 5% of a population and trait Y exists in 70% of the same population, which of the two traits is likely to have arisen earlier? Give reason.**

(CBSE SQP 2022, Term-2)

Ans. Trait Y which exists in 70% of the population, is likely to have arisen earlier because in asexual reproduction, identical copies of DNA are produced and variations do not occur.

New traits come in the population due to sudden mutation and then are inherited. 70% of the population with trait Y is likely to have been replicating that trait for a longer period than 5% of population with trait X.

Q 2. Mustard was growing in two fields—A and B. While field A produced brown coloured seeds, field B produced yellow coloured seeds.

It was observed that in field A, the offspring showed only the parental trait for consecutive generations, whereas in field B, majority of the offsprings showed a variation in the progeny.

What are the probable reasons for these?

(CBSE SQP 2022 Term-2)

Ans. In field A, the reason of offsprings showing only parental trait for consecutive generations is self-pollination.

In field B, offspring showed a variation in progeny because of recombination of genes as cross-pollination is taking place.

Q 3. Why did Mendel choose garden pea for his experiments?

(NCERT EXEMPLAR)

Ans. Mendel selected pea plant (*Pisum sativum*) because of the following reasons:

- (i) These plants are easily available.
- (ii) They have contrasting characters.
- (iii) They are self-pollinating.
- (iv) These plants are easier to maintain.

Q 4. Mendel crossed a pure tall pea (TT) with a pure short pea plant (tt) and obtained all tall plants in F_1 generation.

(i) What is the gene combination present in the plants of F_1 generation?

(ii) Give reason why only tall plants are observed in F_1 progeny.

(iii) What will be the ratio of the plants obtained in the F_2 generation when F_1 plants are self-pollinated?

(CBSE 2023)

Ans. (i) Tt
(ii) It is so because tallness (T) is a dominant trait and shortness (t) is a recessive trait in pea plant.
(iii) When F_1 plants are self-pollinated, both tall and short traits are expressed in F_2 generation in the ratio 3 : 1.

Q 5. Give the pair of contrasting traits of the following characters in pea plant and mention which is dominant and recessive (i) yellow seed (ii) round seed. (NCERT EXEMPLAR)

Ans. (i) Yellow — dominant green — recessive
(ii) Round — dominant wrinkled — recessive

Q 6. Differentiate between dominant and recessive traits.

Ans. (i) The character which gets expressed in the presence of its contrasting form is termed as dominant trait.
(ii) The trait which remains unexpressed in the presence of its contrasting form is called recessive trait.

Q 7. Study the following cross and showing self-pollination in F_1 , fill in the blank and answer the question that follows:

Parents	RRYY	×	rryy
	Round, yellow		wrinkled, green
F_1	RrYy	×	?
	Round, yellow		

What are the combinations of character in the F_2 progeny? (NCERT EXEMPLAR)

Ans. In this case, RrYy (Round, yellow) would come in the blank.

The combination of characters in the F_2 progeny are:

- Round yellow — 9
- Round green — 3
- Wrinkled yellow — 3
- Wrinkled green — 1



TIP

Practice dihybrid cross with the help of different characteristic features in three stages:

(i) Parents (ii) F_1 generation (iii) F_2 generation

Q 8. 'Gene control traits'. Explain this statement with an example.

Ans. Gene controls the trait by synthesising the specific enzyme. Consider tallness as a trait. Plant height depends upon particular plant hormone which in turn will depend on the efficiency of the process for making it. If the enzyme responsible for the production of this hormone is efficient, plant will be tall. If the gene for that enzyme has an alteration that makes enzyme less efficient, the amount of hormone will be less and plant will be short.

Q 9. (i) What is the genetic constitution of human sperm?
(ii) Mention the chromosomes pair present in zygote determining the sex of a male child. (CBSE 2016)

Ans. (i) $22 + Y$ or $22 + X$ (ii) XY



Short Answer Type-II Questions

Q 1. Name the plant Mendel used for his experiment. What type of progeny was obtained by Mendel in F_1 and F_2 generations when he crossed the tall and short plants? Write the ratio he obtained in F_2 generation plants. (CBSE 2019)

Ans. Mendel used pea plant (*Pisum sativum*) for his experiment.

When Mendel crossed tall pea plants with short pea plants, all plants in the F_1 generation were tall. However, in F_2 generation, all plants are not tall. Instead, one quarter of them are short.

The genotypic ratio in F_2 generation is 1 : 2 : 1 (TT : Tt : tt) and the phenotypic ratio is 3 : 1 (Tall : Short).

Q 2. How did Mendel explain that it is possible that a trait is inherited but not expressed in an organism? (CBSE 2017)

Ans. Let us take the following example to explain the given statement. Mendel crossed tall pea plants with dwarf pea plants.

Parents	:	(TT) Pure tall plant	×	(tt) Pure dwarf plant
F_1 generation	:	(Tt) (Tt)	×	(Tt) (Tt)
Selfing of F_1	:	(Tt) Tall	×	(Tt) Tall
F_2 generation	:	(TT) (Tt) Tall Tall	×	(Tt) (tt) Tall Dwarf

The reappearance of the dwarf pea plants in the F_2 generation proves that the dwarf trait was inherited by the organism but not expressed in the F_1 generation.

Q 3. A green stemmed rose plant denoted by GG and a brown stemmed rose plant denoted by gg are allowed to undergo a cross with each other.

- List your observations regarding:
 - Colour of stem in their F_1 progeny.
 - Percentage of brown stemmed plants in F_2 progeny if F_1 plants are self-pollinated.
 - Ratio of GG and Gg in the F_2 progeny.
- Based on the findings of this cross, what conclusion can be drawn? (CBSE 2022 Term-2)

Ans. (i) Cross between a green stemmed and a brown stemmed rose plant:

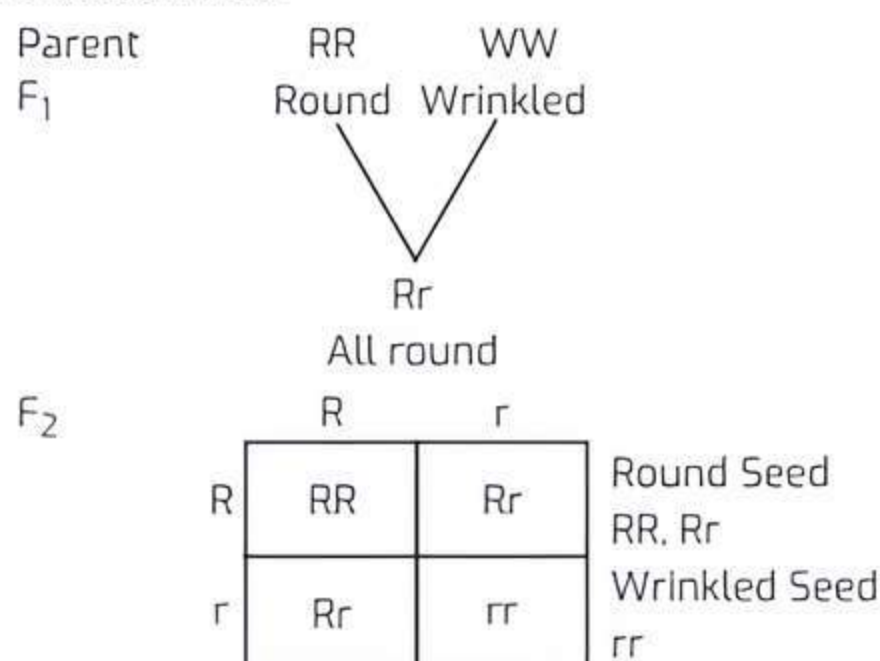
Parents	:	(GG)	×	(gg)
		Green stem		Brown stem
Gametes	:	(G)	×	(g)
F_1 generation:		(Gg)		All Green stemmed
Selfing of F_1	:	(Gg)	×	(Gg)
F_2 generation				
Gametes		G		g
G		(GG) Green stem		(Gg) Green stem
g		(Gg) Green stem		(gg) Brown stem

- All plants of F_1 generation will have green stem.
- 25% plants in F_2 generation will have brown stem.
- The ratio of GG and Gg in F_2 generation is 1 : 2

(ii) It can be concluded that green colour is dominant as expressed in F_1 generation, whereas brown colour is recessive, does not express in F_1 generation but reappear in F_2 generation.

Q 4. Mendel, in one of his experiments with pea plants, crossed a variety of pea plant having round seeds with one having wrinkled seeds. State Mendel's observations giving reasons of F_1 and F_2 progeny of this cross. Also, list any two contrasting characters, other than round seeds of pea plants that Mendel used in his experiments. (CBSE 2019)

Ans. Mendel cross-bred round seed plants with wrinkled seed plants, it was observed that in F_1 progeny, only round seed plants were obtained and no wrinkled seed plant was obtained.



But in F_2 generation, both round and wrinkled seed plants were obtained in 3 : 1 ratio. Since, in F_1 progeny, only round seeds were obtained, so dominant trait was round seed and recessive trait was wrinkled seeds.

The two contrasting characters that Mendel used in his experiment with pea plants are as follows:

- Tallness and dwarfness.
- Green seed and yellow seed.

Q 5. How do Mendel's experiments show that the traits are inherited independently? Explain.

(CBSE 2017, 2022 Term-2)

Ans. Mendel conducted a dihybrid cross in which he crossed tall pea plants having round seeds with short pea plants having wrinkled seeds. The plants of F_1 generation were all tall with round seeds indicating that the traits of tallness and round seeds are dominant.

But in F_2 generation, some are tall plants with round seeds, some are short plants with wrinkled seeds, some are short plants with round seeds and some are tall plants with wrinkled seeds.

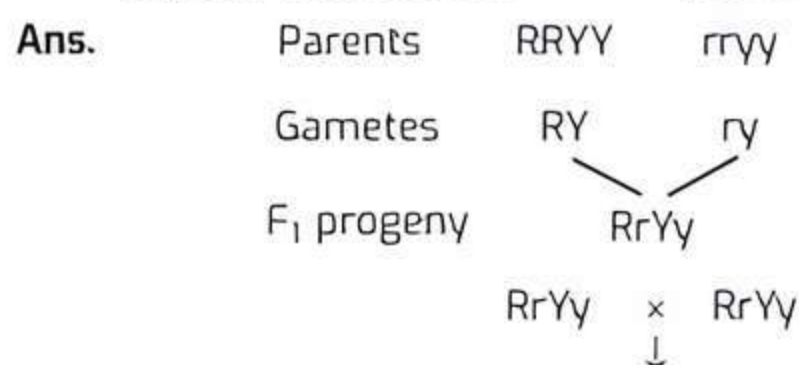
Thus, in F_2 generation, he obtained two parental characters and two new recombinations. This indicates that traits are inherited independently.

COMMON ERROR

Most students commit error in explaining this question.

Q 6. Two pea plants— one with round yellow seeds (RRYY) and another with wrinkled green (rryy) seeds produce F_1 progeny that have round, yellow (RrYy) seeds.

When F_1 plants are self-pollinated, which new combination of characters is expected in F_2 progeny? How many seeds with these new combinations of characters will be produced when a total 160 seeds are produced in F_2 generation? Explain with reason. (CBSE SQP 2022 Term-2)



	RY	rY	Ry	ry
RY	RRYY round yellow	RrYY round yellow	RRYy round yellow	RrYy round yellow
ry	RrYY round yellow	rrYY wrinkled yellow	RrYy round yellow	rrYy wrinkled yellow
Ry	RRYy round yellow	RrYy round yellow	RRYY round green	Rryy round green
ry	RrYy round yellow	rrYy wrinkled yellow	Rryy round green	rryy wrinkled green

Two new combination of characters are Round green and wrinkled yellow. New combinations are produced because of independent inheritance of seed shape and seed colour trait.

Number of round green seeds

$$= \frac{3}{(9+3+3+1)} \times 160 = \frac{3}{16} \times 160 = 30$$

Number of wrinkled green seeds

$$= \frac{3}{(9+3+3+1)} \times 160 = \frac{3}{16} \times 160 = 30$$

Q 7. After self-pollination in pea plants with round, yellow seeds, following types of seeds were obtained by Mendel:

Seeds	Number
Round, yellow	630
Round, green	216
Wrinkled, yellow	202
Wrinkled, green	64

Analyse the result and describe the mechanism of inheritance which explains these results.

Ans. The ratio obtained is 9 : 3 : 3 : 1 in which parental as well as new combinations are observed. This indicates that progeny plants have not inherited the whole set of genes from each parent.

Every germ cell takes on chromosome from the pair of maternal and paternal chromosomes. When two germ cells combine, segregation of one pair of characters is independent of other pair of characters.

- Q 8. In a pea plant, find the contrasting trait if:
- the position of flower is terminal.
 - the flower is white in colour.
 - shape of pod is constricted. (CBSE 2016)

Ans. (i) Axial position of flower.
 (ii) Purple colour of flower.
 (iii) Inflated shape.

- Q 9. In pea plant, round seed is dominant over the wrinkled. If a cross is carried between these two plants, give answer to the following questions.

- Mention the genes for the traits of parents.
- State the trait of F_1 hybrids.
- Write the ratio of F_2 progeny obtained from this cross. What is the name of the cross?

Ans. (i) The genes for traits of parents are pure round (RR) and pure wrinkled (rr).
 (ii) Rr/hybrid round
 (iii) Phenotypic ratio – 3 : 1
 Genotypic ratio – 1 : 2 : 1
Monohybrid cross.

- Q 10. (i) On what rules inheritance is based?
 (ii) Is each trait influenced by both paternal and maternal DNA? (CBSE 2016)

Ans. (i) The rules of Inheritance is based on the fact that the traits in the progeny are carried out by DNA's of both the parents (Mother and Father). These rules are known as 'Mendel's Laws of Inheritance'. The rules are:
 (a) Law of dominance.
 (b) Law of segregation. and
 (c) Law of independent assortment.
 (ii) Yes, it is true that each trait is influenced by both paternal and maternal DNA.

- Q 11. In a pea plant, the trait of flowers bearing purple colour (PP) is dominant over white colour (pp). Explain the inheritance pattern of F_1 and F_2 generations with the help of a cross following the rules of inheritance of traits. State the visible characters of F_1 and F_2 progenies.

Ans. Let purple trait be represented by PP and white trait by pp

Parental	PP	×	pp
	↓		
F_1 generation	Pp		
Selfing of F_1	Pp	×	Pp
	↓		
	P		p
	P	PP	Pp
	p	Pp	pp

Visible characters of F_1 progeny all flowers are purple coloured and in F_2 progeny 3 are purple coloured and 1 is white coloured flower.

COMMON ERROR

Students often get confused between phenotype and genotype and between F_1 and F_2 generation.

- Q 12. If we cross-bred tall (dominant) pea plant with pure-bred dwarf (recessive) pea plant, we will get plants of F_1 generation. If we now self-cross the pea plant of F_1 generation, we obtain pea plants of F_2 generation.

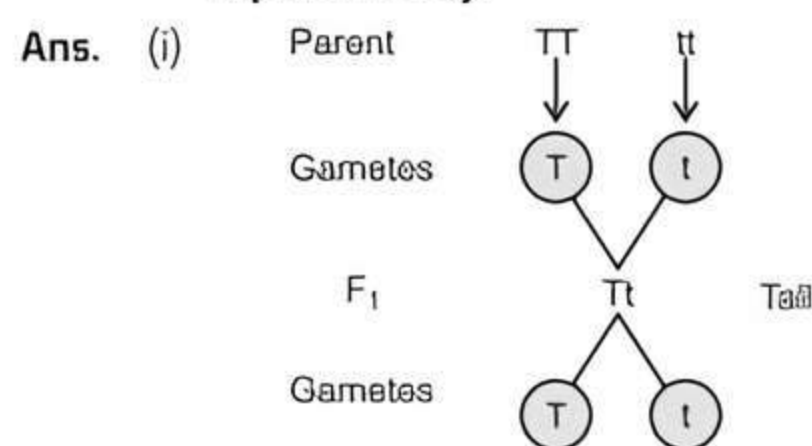
- What do the plants of F_1 generation look like?
- State the ratio of tall plant to dwarf plants in F_2 generation.
- State the type of plants not found in F_1 generation but appeared in F_2 generation. Write the reason for the same. (CBSE 2017)

Ans. (i) Tall (ii) 3 : 1
 (iii) Dwarf.

Reason: Being a recessive trait, dwarfness can only be expressed in the recessive homozygous condition or in the absence of dominant trait.

- Q 13. In one of his experiments with pea plants Mendel observed that when a pure tall pea plant is crossed with a pure dwarf pea plant, in the first generation, F_1 only tall plants appear.

- What happens to the traits of the dwarf plants in this case?
- When the F_1 generation plants were self-fertilised, he observed that in the plants of second generation, F_2 , both tall plants and dwarf plants were present. Why it happened? Explain briefly.



The dwarf traits of the plants is not expressed due to the presence of the dominant tall trait.

(ii) F_2 TT Tt Tt tt
 Tall Tall Tall Dwarf

Tall : Dwarf = 3 : 1

In the F_2 generation, both the tall and dwarf traits are present in the ratio of 3 : 1. This showed that the traits for tallness and dwarfness are present in the F_1 generation, but the dwarfness, being the recessive trait, does not express itself in the presence of tallness, the dominant trait.

COMMON ERROR

Mostly students make error while drawing the cross. Some of them forget to label the stages.

- Q 14. How did Mendel interpret his result to show that traits may be dominant or recessive? Describe briefly. (CBSE 2016)

Ans. Mendel conducted breeding experiments on Pea plants.

- He selected pure breed tall and dwarf plants.
- He cross-pollinated these plants.

- (iii) In the F_1 generation, he obtained only tall plants. Tallness is the dominant trait.
- (iv) Then, he produced F_2 generation by self cross of hybrids/ F_1 .
- (v) He found that $\frac{3}{4}$ th of the plants were tall and $\frac{1}{4}$ th were dwarf.
- (vi) The trait which remains hidden in F_1 generation plants is the recessive trait.

Q 15. In a monohybrid cross between tall pea plants (TT) and short pea plants (tt), a scientist obtained only tall pea plants (Tt) in the F_1 generation. However, on self cross of the F_1 generation pea plants, he obtained both tall and short plants in F_2 generation. On the basis of above observations with other angiosperms also, can the scientist arrive at a law? If yes, explain the law. If not, give justification for your answer.

Ans. Yes, the scientist may arrive at the law of dominance according to which the trait that is expressed in the F_1 generation is the dominant trait, although both the dominant and recessive traits are present in the F_1 generation. In the F_2 generation the recessive traits is also expressed along with the dominant traits.

Q 16. Mention the total number of chromosomes along with the sex chromosomes that are present in a human female and a human male. Explain how in sexually producing organisms the number of chromosomes in the progeny remains the same as that of the parents. (CBSE 2017)

Ans. Human male has 22 pairs of chromosomes along with XY sex chromosome.
Human female has 22 pairs of chromosomes along with XX sex chromosome.
In sexual reproduction, a female gamete fuses with a male gamete. These gametes are haploid in nature, i.e., they contain only half a set of chromosomes. When these haploid gametes fuse during fertilisation, the zygote formed contains the full set of chromosomes. Hence, the progeny formed has the same number of chromosomes as that of parents.

Q 17. What is the probability of a girl or a boy being born in a family? Justify your answer. (CBSE SQP 2023-24)

Ans There are 50% chances that a girl may be born and 50% chances that a boy may be born.

It can be explained as follows:

Most human chromosomes have a maternal copy and a paternal copy. We have 22 such chromosomes. One pair of chromosomes called sex chromosomes is odd in not always being a perfect pair. Women have a perfect pair of sex chromosomes, both called X (XX). But men have a mismatched pair of sex chromosomes in which one is normal sized—X chromosome while the other is a short one called Y chromosome (XY). All children will inherit an X chromosome from their mother regardless of whether they are boys or girls. Thus, a child who inherits an X chromosome from her father will be a girl and one who inherits a Y chromosome from him will be a boy.

- Q 18.** (i) Name the two types of gametes produced by men.
(ii) Does a male child inherit X chromosome from his father? Justify.
(iii) How many types of gametes are produced by a human female?

Ans (i) X and Y
(ii) No, a male child inherits a Y chromosome from his father.
(iii) Only one type of gametes (i.e., X) are produced by a human female.



Long Answer Type Questions

Q 1. How do Mendel's experiments show that:

- (i) Traits may be dominant or recessive?
- (ii) Inheritance of two traits is independent of each other? (CBSE 2015, 17)

Ans. (i) Mendel crossed pure tall pea plants with pure dwarf pea plants and found that only tall pea plants were produced in the first generation (F_1). No dwarf plants were obtained in that generation. He then crossed the tall plants of F_1 generation and found that both tall and dwarf pea plants were obtained in F_2 generation in the ratio of 3 : 1.

Thus, he concluded that tallness which is present in both F_1 and F_2 generations is a dominant trait while dwarfness which is absent in F_1 but reappears in F_2 is a recessive trait.

- (ii) Mendel crossed two pea plants differing in contrasting traits of two characters, i.e., a dihybrid cross. The F_1 generation showed only the dominant character among each pair. In the F_2 generation, he obtained two new recombinations along with parental type characters. This indicates that traits are inherited independently of each other.



TIP

Comprehend what is being asked before answering by reading the question carefully. Don't waste time in explaining Monohybrid and Dihybrid cross using diagrams.

- Q 2.** (i) What are dominant and recessive traits?
(ii) Is it possible that a trait is inherited but may not be expressed in the next generation? Give a suitable example to justify this statement. (CBSE 2019)

Ans. (i) The trait which expresses itself in F_1 (first) generation after crossing contrasting (opposite) traits is known as dominant trait.
The trait which is not expressed in F_1 (first) generation after crossing contrasting (opposite) trait is known as recessive trait.
(ii) Yes, it is possible that a trait is inherited but may not be expressed.

Let us take the following example to explain the given statement. Mendel crossed tall pea plants with dwarf pea plants.

Parents	:	(TT)	×	(tt)
		Pure tall plant		Pure dwarf plant
F ₁ generation	:	(Tt) (Tt)		(Tt) (Tt)
		Tall Tall		Tall Tall
Selfing of F ₁	:	(Tt)	×	(Tt)
		Tall		Tall
F ₂ generation	:	(TT) (Tt)		(Tt) (tt)
		Tall Tall		Tall Dwarf

The reappearance of the dwarf pea plants in the F₂ generation proves that the dwarf trait was inherited by the organism but not expressed in the F₁ generation.

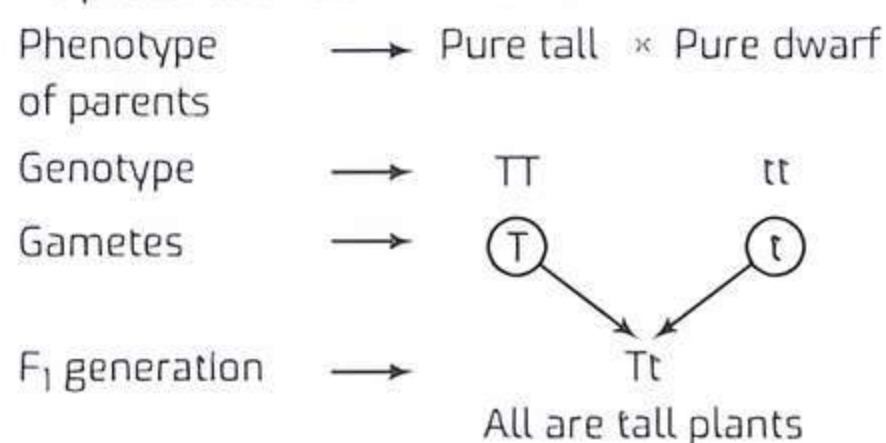
- Q 3. (i) What is the law of dominance of traits? Explain with an example.
(ii) Why are the traits acquired during the lifetime of an individual not inherited? Explain.

(CBSE 2020)

Ans. (I) Law of Dominance of Traits:

The law of dominance of traits states that in a cross between a pair of contrasting characters, only one parental character will be expressed in F₁ generation which is called dominant trait and the other is called recessive trait.

For example, in pea plants when pure tall plants were crossed with pure dwarf plants, all plants in F₁ generation were tall proving that the gene for tallness is dominant over the gene for dwarfness, which is not able to express itself in the presence of dominant trait.



- (II) Traits acquired by an organism during its lifetime are known as acquired traits. These traits are not inherited because they occur in non-reproductive tissues and do not cause any change in the DNA of the germ cells.

For example, a cricket player cannot pass on his skills to his next generation.

Q 4. In the following crosses, write the characteristics of the progeny. (NCERT EXEMPLAR)

Cross	Progeny
(i) RRYy × RRYy (Round, yellow) (Round, yellow)	
(ii) RrYy × RrYy (Round, yellow) (Round, yellow)	

(iii) rryy × rryy (Wrinkled, green) (Wrinkled, green)	
(iv) RRYy × rryy (Round, yellow) (Wrinkled, green)	

- Ans. (i) Parents: RRYy × RRYy
Gametes: RY RY
Offspring: RRYy (Round yellow)
- (ii) Parents: RrYy × RrYy
Gametes: RY, Ry, rY, ry RY, Ry, rY, ry
Offspring: Round yellow, Round green, Wrinkled yellow, Wrinkled green
- (iii) Parents: rryy × rryy
Gametes: ry ry
Offspring: rryy (Wrinkled green)
- (iv) Parents: RRYy × rryy
Gametes: RY ry
Offspring: RrYy (Round yellow)

Q 5. Explain Mendel's concept of heredity, by giving three points. (CBSE 2016)

- Ans. (i) Mendel worked on pea plant (*Pisum sativum*) and discovered the fundamental laws of inheritance. He found that traits (characteristics) are controlled by factors (which are now called genes) and each factor (gene) come in pairs. These factors (genes) are inherited as distinct units, one from each parent.
- (ii) Mendel studied that genes segregate during the formation of gametes (sperms in males and ova in females) and they again combine in the offspring (one from each parent) and appear as dominant or recessive trait. This can be worked out by making a test cross.
- (iii) Mendel proposed three laws, namely:

(a) Law of Dominance: It states that when parents with pure contrasting traits are crossed together, only one form of trait appears in F₁ generation. The character that appears in F₁ generation is called dominant and the other is recessive.

(b) Law of Segregation: It states that during gamete formation pairs of alleles segregate such that each gamete receives only one allele.

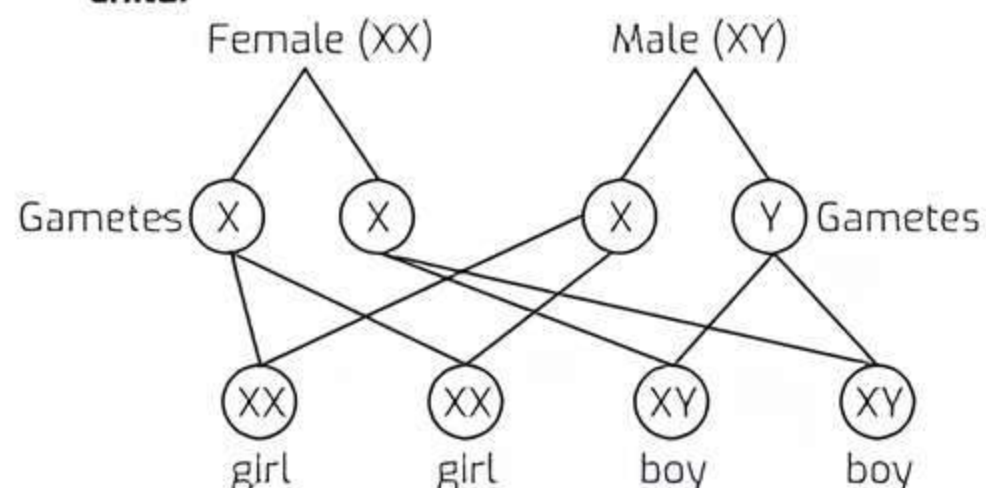
(c) Law of independent assortment: It states that at the time of gamete formation, two genes segregate independently of each other as well as of other traits.

- Q 6. (i) How many pairs of chromosomes are present in human beings?
 (ii) How can the chromosomes be identified?
 (iii) "The sex of a newborn child is a matter of chance and none of the parents may be considered responsible for it." Justify this statement with the help of a flowchart showing sex-determination in human beings. (CBSE 2019)

- Ans. (i) 23 pairs.
 (ii) In human beings, the individual chromosomes are identified by their lengths, position of centromere and banding pattern on staining.
 (iii) In case of human beings, out of 23 pairs, one pair is of sex chromosomes. There are two types of sex chromosomes found in human beings. *Le.*

X and Y. A female has XX- chromosomes and a male has one X and one Y-chromosome.

Flowchart showing determination of sex of a child:



Sex determination in human beings

Thus, sex of a new born child is not according to the will of his/her parents and is purely a matter of chance.



Chapter Test

Multiple Choice Questions

- Q 1. In which of the following animals, individuals can change sex?
 a. Snail b. Human
 c. Fruit fly d. All of these
- Q 2. In human beings, the statistical probability of having a male child is:
 a. 25% b. 50%
 c. 75% d. 60%
- Q 3. Mendel studied seven contrasting characters for his breeding experiment with *Pisum sativum*. Which of the following character he did not use?
 a. Pod colour b. Pod shape
 c. Leaf shape d. Plant height
- Q 4. If a pure tall plant is crossed with a dwarf plant, this type of cross is called:
 a. dihybrid cross
 b. monohybrid cross
 c. back cross
 d. trihybrid cross

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:

- a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
 b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
 c. Assertion (A) is true but Reason (R) is false.
 d. Assertion (A) is false but Reason (R) is true.

- Q 5. **Assertion (A):** Traits like tallness and dwarfness in pea plant are inherited independently.

Reason (R): When a homozygous tall pea plant is crossed with dwarf pea plant, medium sized pea plant is obtained in F_1 generation.

- Q 6. **Assertion (A):** In many reptiles, sex determination rely entirely on environmental factors.

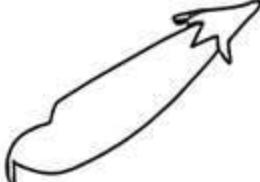
Reason (R): The temperature at which fertilised eggs are kept determines whether the animal developing in the eggs will be a male or female.

Case Study Based Question

- Q 7. Gregor Mendel conducted hybridisation experiments on garden peas for seven years and proposed the laws of inheritance in living organisms. He investigated characters in the garden pea plant that were manifested as two opposing traits, *e.g.*, tall or dwarf plants, yellow and green seeds, etc.

Read the above passage carefully and give the answer of the following questions:

- (i) Among the seven pairs of contrasting traits in pea plant as studied by Mendel, the number of traits related to flower, pod and seed respectively were:
 a. 2, 2, 2 b. 2, 2, 1 c. 1, 2, 2 d. 1, 1, 2
- (ii) The colour based contrasting traits in seven contrasting pairs, studied by Mendel in pea plant were:
 a. 1 b. 2 c. 3 d. 4
- (iii) Refer to the given table of contrasting traits in pea plants studied by Mendel.

Character	Dominant trait	Recessive trait
A. Seed colour	 Yellow	 Green
B. Flower colour	 Violet	 White
C. Pod shape	 Inflated	 Constricted
D. Flower position	 Axial	 Terminal

Which of the given traits is correctly placed?

- a. A, B and C only b. B, C and D only
c. B and C only d. A, B, C and D

(iv) Which of the following characters was not chosen by Mendel?

- a. Pod shape b. Pod colour
c. Position of flower d. Position of pod

Very Short Answer Type Questions

- Q 8. Name the information source for making proteins in the cells.
Q 9. What will be the blood group of an individual with genetic combination 1A 1B?

Short Answer Type-I Questions

- Q 10. "Different species use different strategies for determining the sex of their new born." Justify this statement.
Q 11. What is the difference between F_1 generation and F_2 generation?
Q 12. An angiosperm plant having red coloured flowers when crossed with the other having the same colour produces 40 progenies, out of which 30 plants were with red coloured flowers, 10 plants were with white coloured flowers.

Find out:

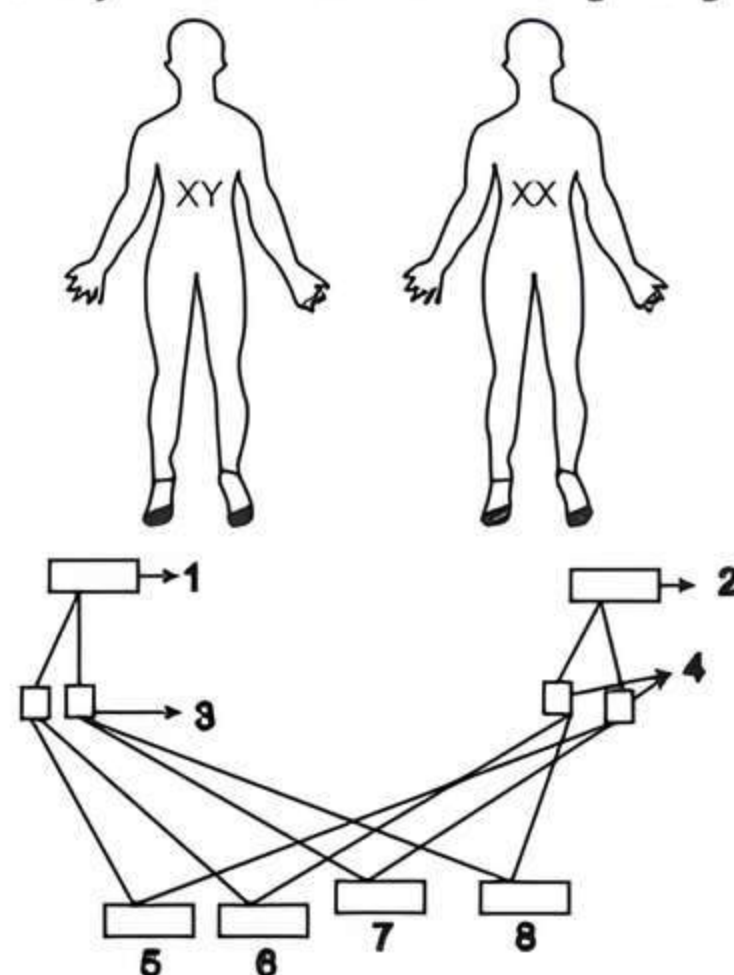
- (i) What is the possible genotype of parent plants?
(ii) Which trait is dominant and recessive?
(iii) What is this cross called and what is its phenotypic ratio?

Short Answer Type-II Questions

- Q 13. List two differences in tabular form between dominant trait and recessive traits. What percentage/proportion of the plants in the F_2 progeny were round, in Mendel's cross between round and wrinkled pea plants?
Q 14. Show inheritance of two characters over two generations by making a cross between round and yellow seeded plants (RRYY) with wrinkled green seeded plant (rryy).
Q 15. Explain with the help of a figure that father is responsible for the sex of a child.

Long Answer Type Questions

- Q 16. (i) Why did Mendel choose garden pea for his experiments? Write two reasons.
(ii) What are monohybrid and dihybrid cross?
(iii) How Mendel proved that tallness is the dominant trait and dwarfness is recessive in a pea plant? Explain with the help of a monohybrid cross.
Q 17. Identify male and female in the figures given below.



Also fill in the blanks 3 to 8 and then clarify about the misconception that mother and not father is responsible for bearing daughters and not sons.