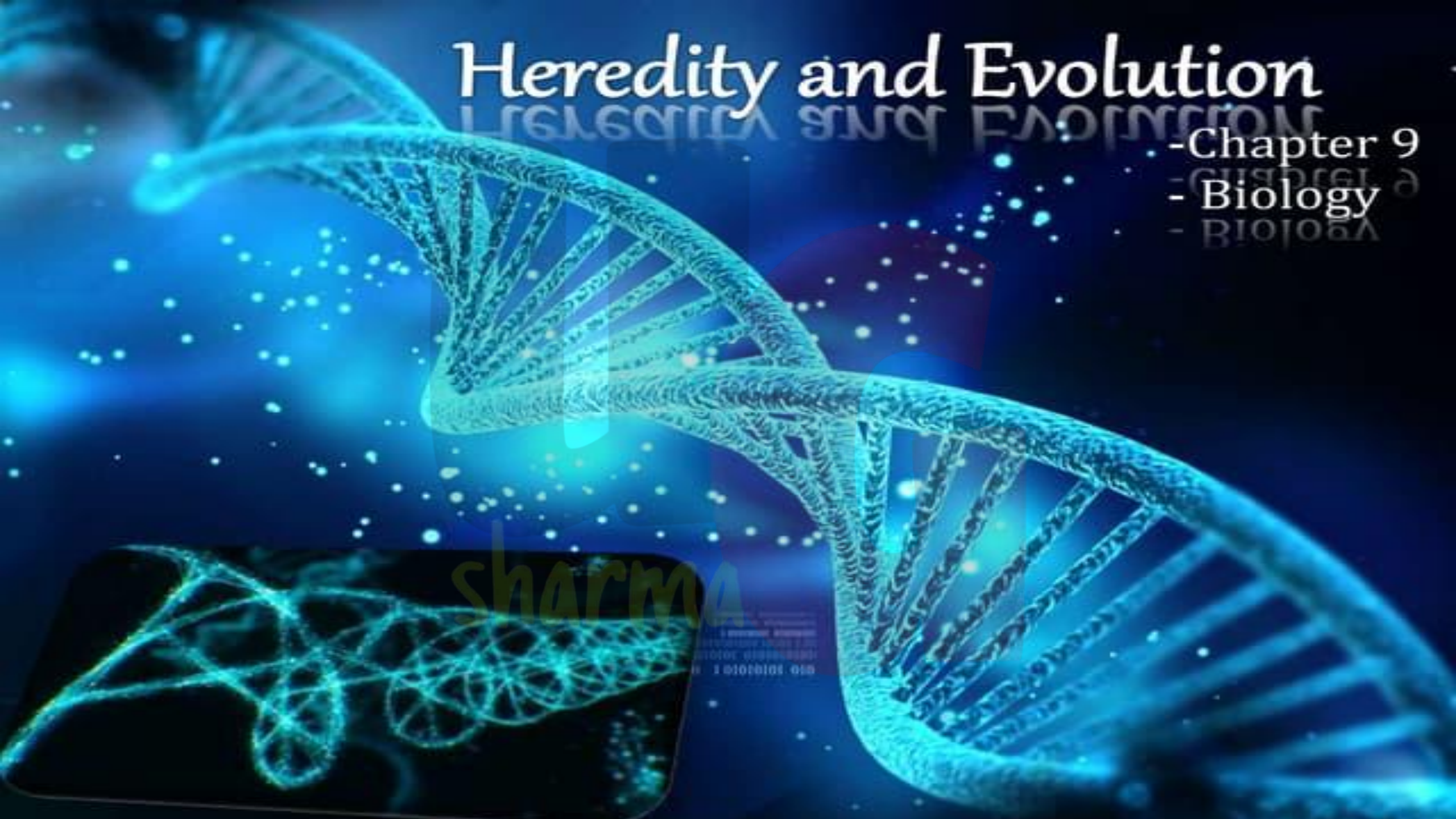
Heredity and Evolution

-Chapter 9

- Biology



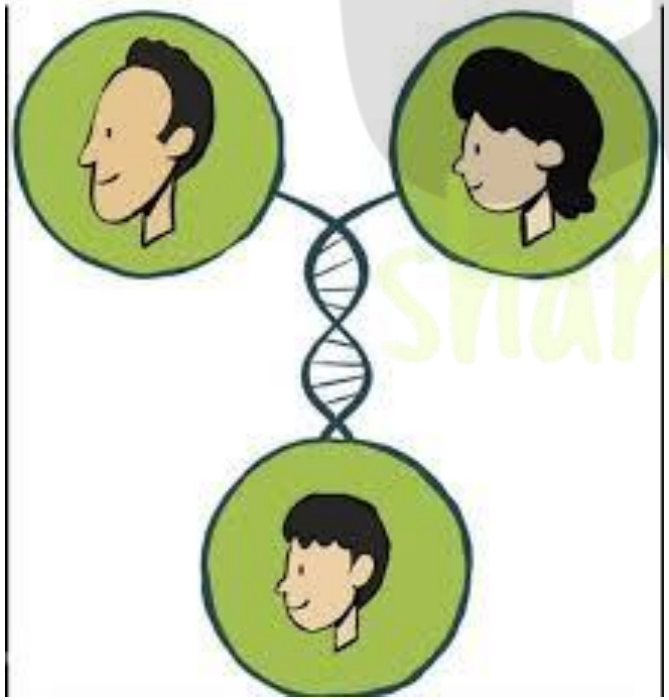
Introduction

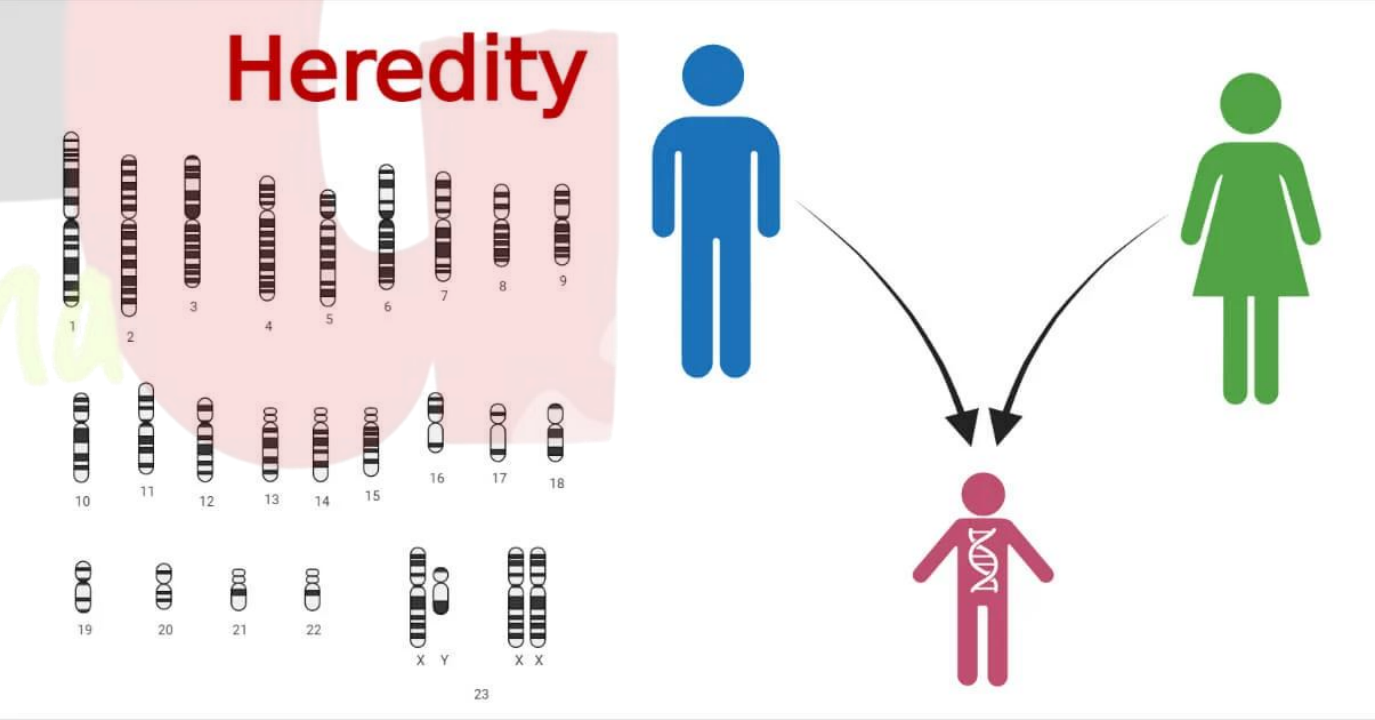
- Genetics deals with the study of Heredity and Variation.

Heredity :- The transmission of characters (or traits) from the parents to their offsprings is called heredity.

These traits can be physical (height, eye colour) or behavioural.

The heredity information is present in the sex cells (or gametes) of the parents.

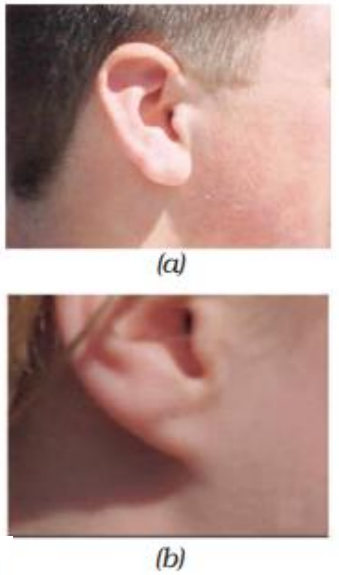




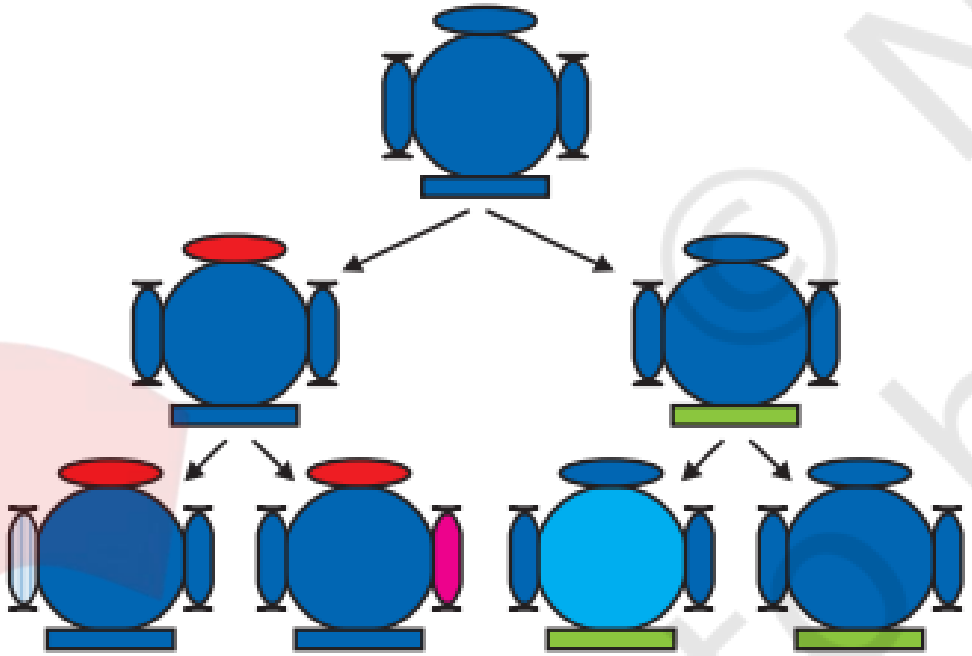
Variation

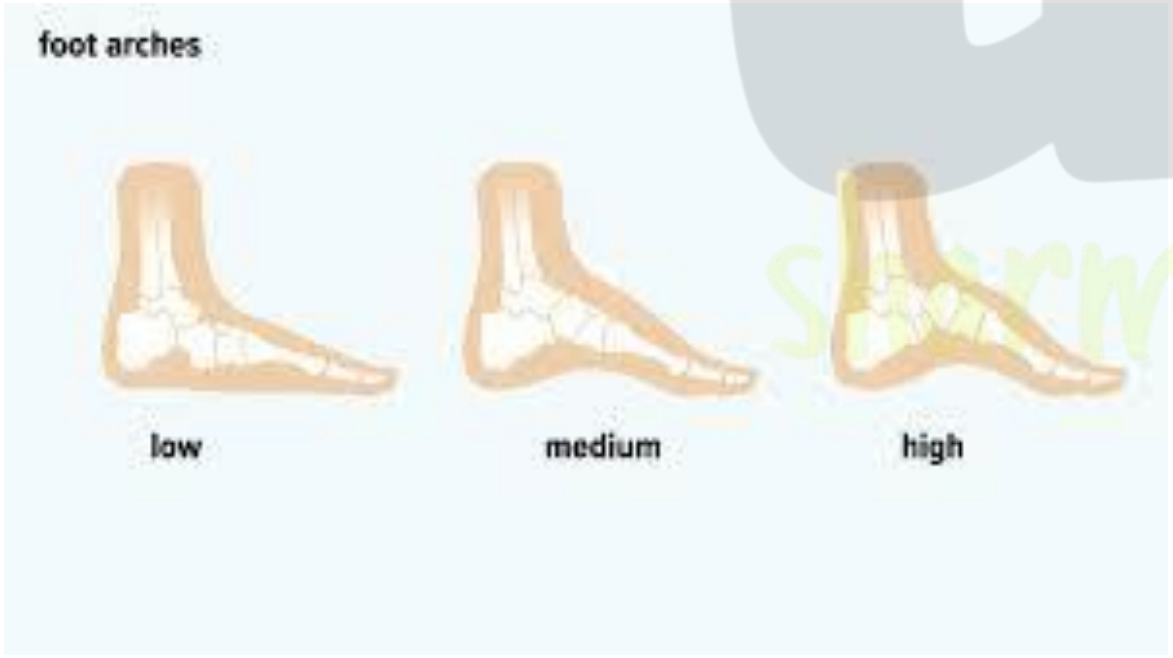
The differences in the characters/traits between the parent and offspring is called Variation.

Example :- Hair colour, eye colour, height, shape of feet & earlobes, etc



(a) Free and
(b) attached
earlobes

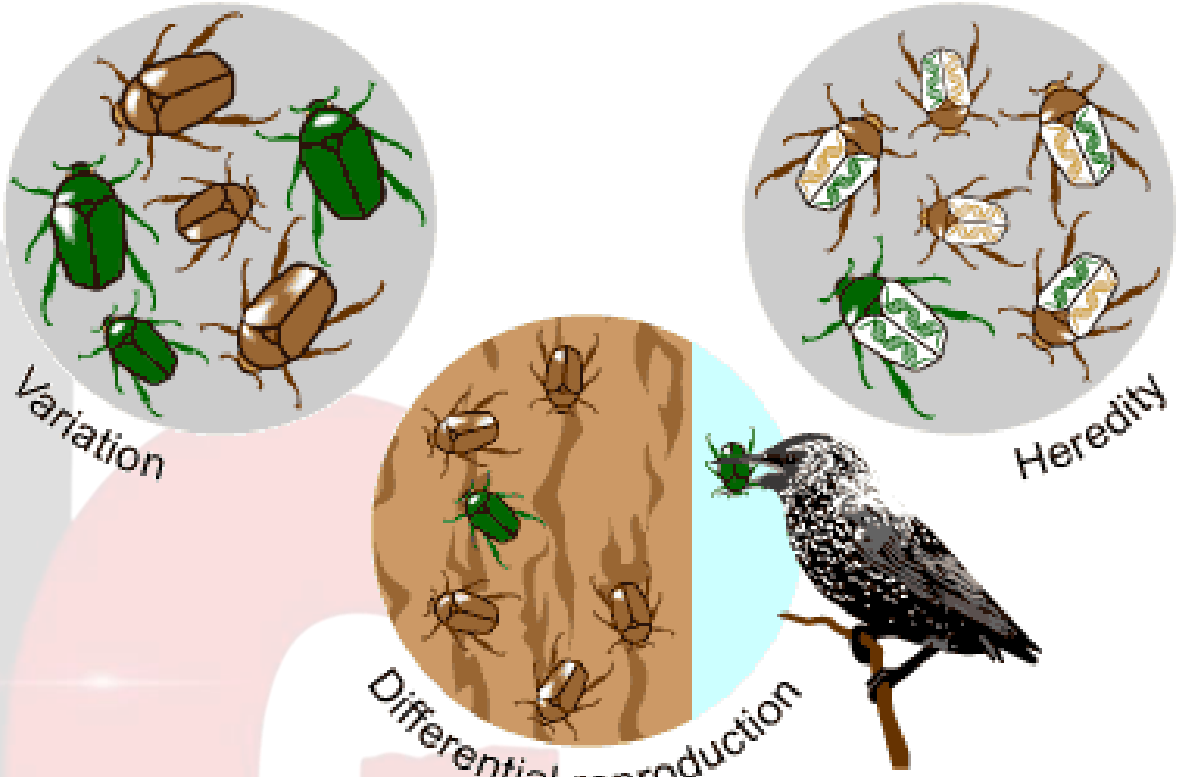



foot arches
low
medium
high


PATHOLOGIES OF FOOT
Flat foot
Normal foot
Hollow foot

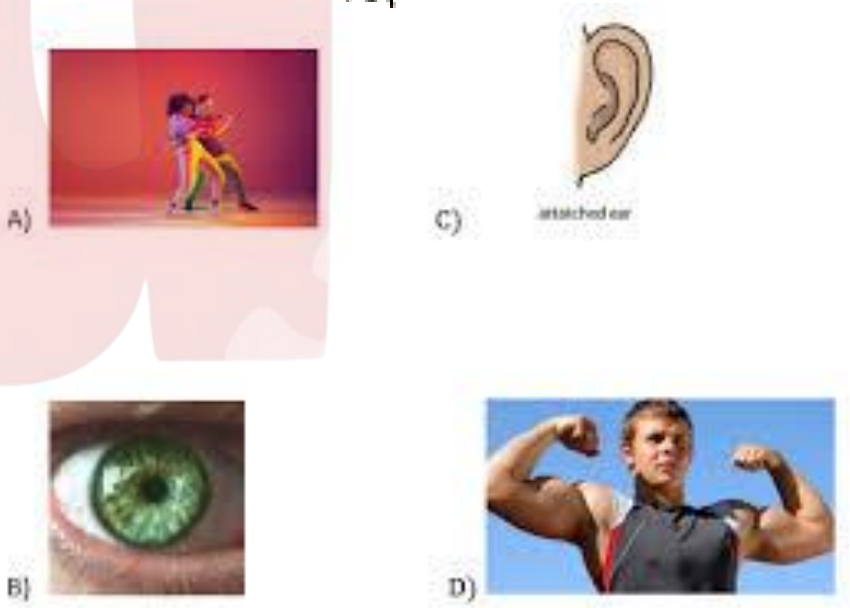
Types of Variations

Variation are of two types:
(i) Somatic Variation
(ii) Gametic Variation



- **Somatic Variation**

→ It takes place in the body cell.
→ It is neither inherited nor transmitted.
→ It is also known as **acquired traits**.
→ Examples: cutting of tails in dogs, boring of pinna etc.



- **Gametic Variation**

→ Takes place in the gametes/Reproductive cells.
→ Inherited as well as transmitted.
→ Also known as **inherited traits**.
→ Example: human height, skin colour.

Accumulation of Variation during Reproduction

→ Variation occurs during reproduction whether organisms multiply sexually or asexually.

Variations in Asexual Reproduction

→ Variations are fewer.
→ Occurs due to small inaccuracies in DNA copying. (Mutation)

Inherited & Acquired Traits

Importance of Variation

Depending upon the nature of variations different individuals would have different kinds of advantage.
Example, Bacteria that can withstand heat will survive better in a heat wave.

Main advantage of variation to species is that it increases the chances of its survival in a changing environment.

Free ear lobes and attached ear lobes are two variants found in human populations.

NOTE :- The great advantage of variation to a species is that it increases the chances of its survival in a changing environment.

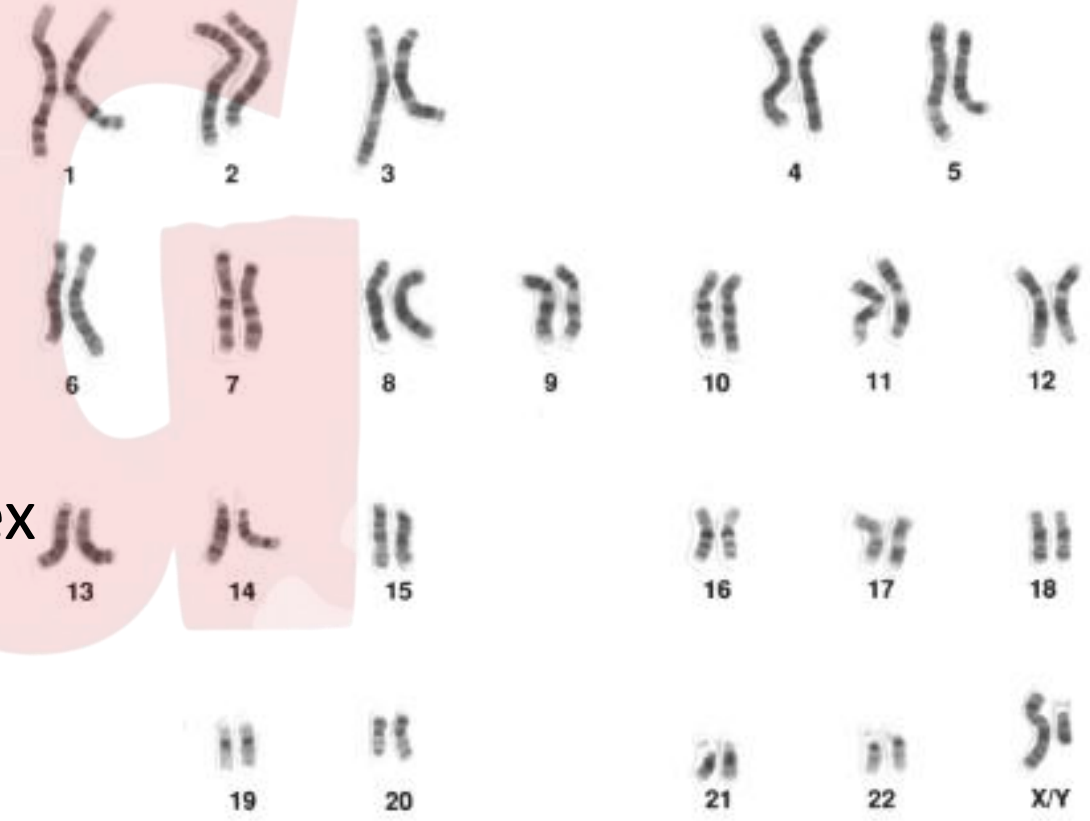
QUESTIONS

1. If a trait A exists in 10% of a population of an asexually reproducing species and a trait B exists in 60% of the same population, which trait is likely to have arisen earlier?
2. How does the creation of variations in a species promote survival?

Terminology related to heredity

Chromosomes :- Chromosomes are thread – like structure in the nucleus of a cell formed of DNA which carries the gene.

- Human have 23 pairs of chromosomes.

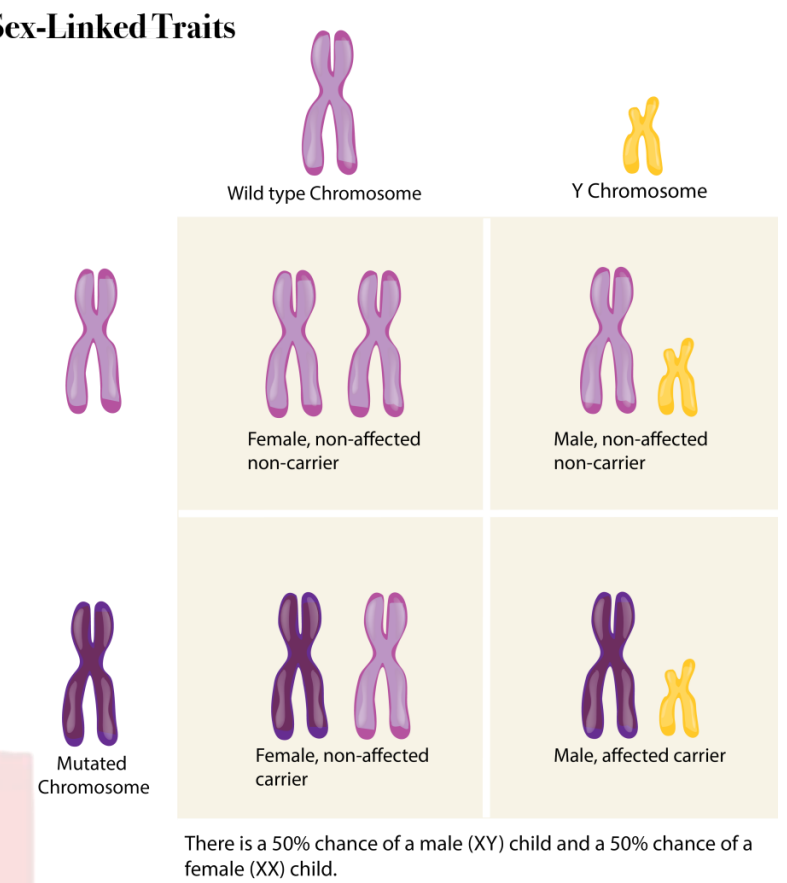


Autosomes :-

- Exist in pairs
- Chromosomes other than the sex chromosomes.
- Control somatic traits (physical characteristics of the body other than sex determination).
- In human, ***22 pairs of autosomes exits***.
- Eg :- Hair colour, eye colour, etc.

Allosomes (or sex Chromosomes) :-

- Chromosomes which determine sex.
- In human, 1 pair of sex chromosome exits (i.e. either XX or XY).



Diploid :- Cell with two complete sets of chromosomes.

Eg :- Somatic cells (other than germ cells).

Haploid :- Cell with a single set of chromosomes.

Eg :- Gametes

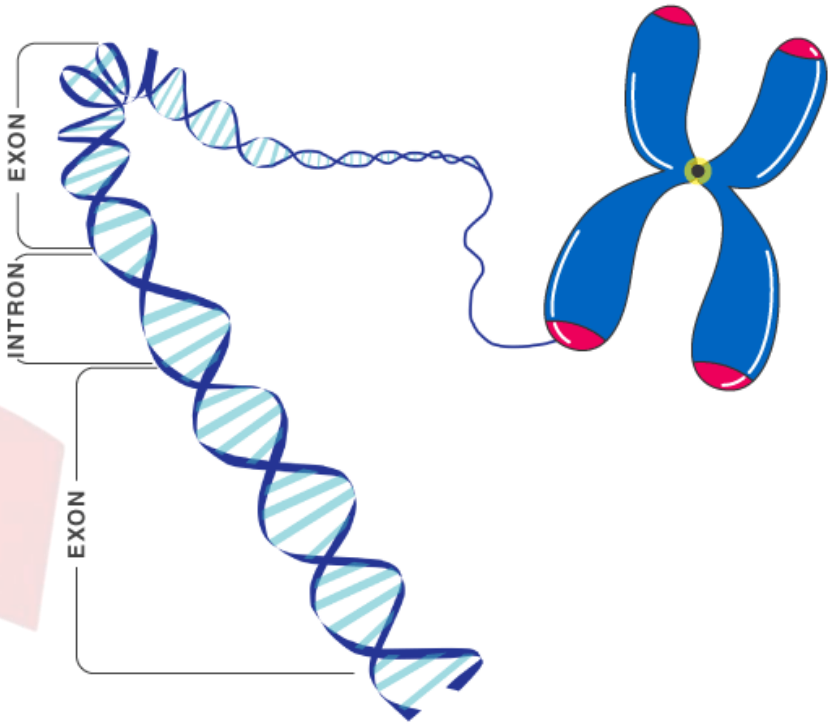
Genes :- A genes is a unit of DNA on a chromosome which governs the synthesis of own protein that controls characteristics or traits of an organism.

Or,

Genes are actually units of heredity which transfer characteristics (or traits) from parents to their offspring during reproduction.

- ***Genes works in pairs***

Genes are two types :-

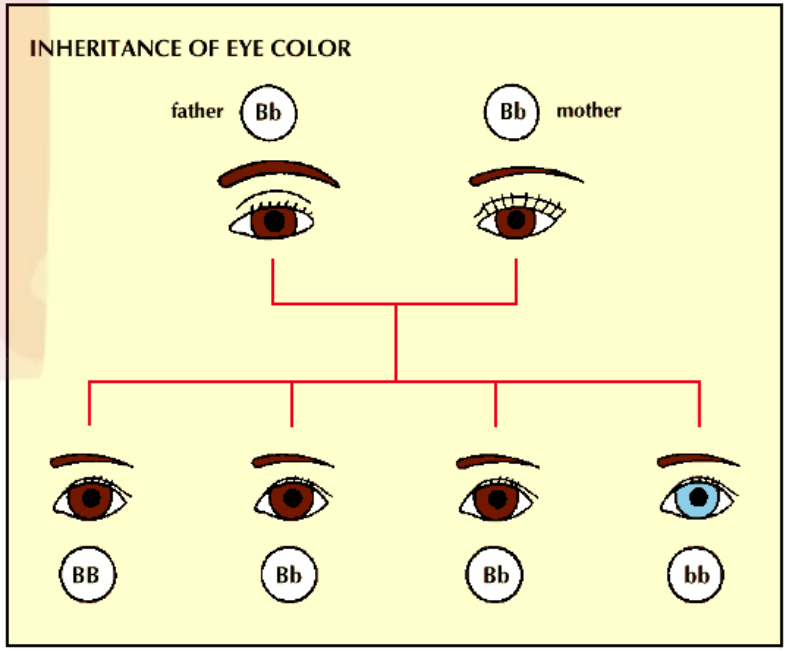


***Dominant gene (Alleles)*:-** Dominant gene is that gene which decide traits even in presence of other gene.

Example :- Black hair, black/ brown eye, etc.

***Recessive gene (Alleles)* :-** Recessive gene is the gene which decides traits only in the presence of identical or same gene.

Example :- Blonde hair, Blue eye, etc.



Dominant gene denoted by capital letter while recessive gene denoted by small letter.

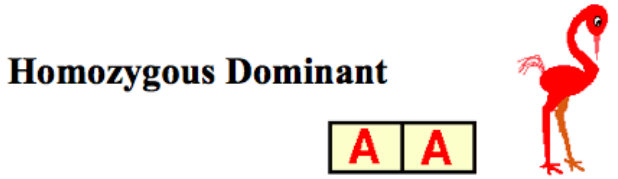
NOTE :- Genes has not been discovered at the time of Mendel experiment.

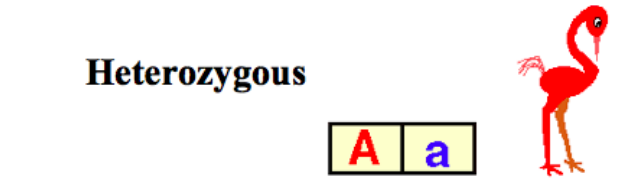
Genotype :- Genotype is the description of genes present in an organism.

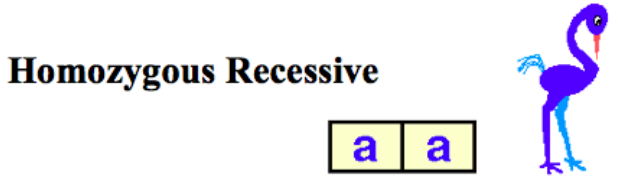
Example :-TT, Tt, Hh, HH, etc.

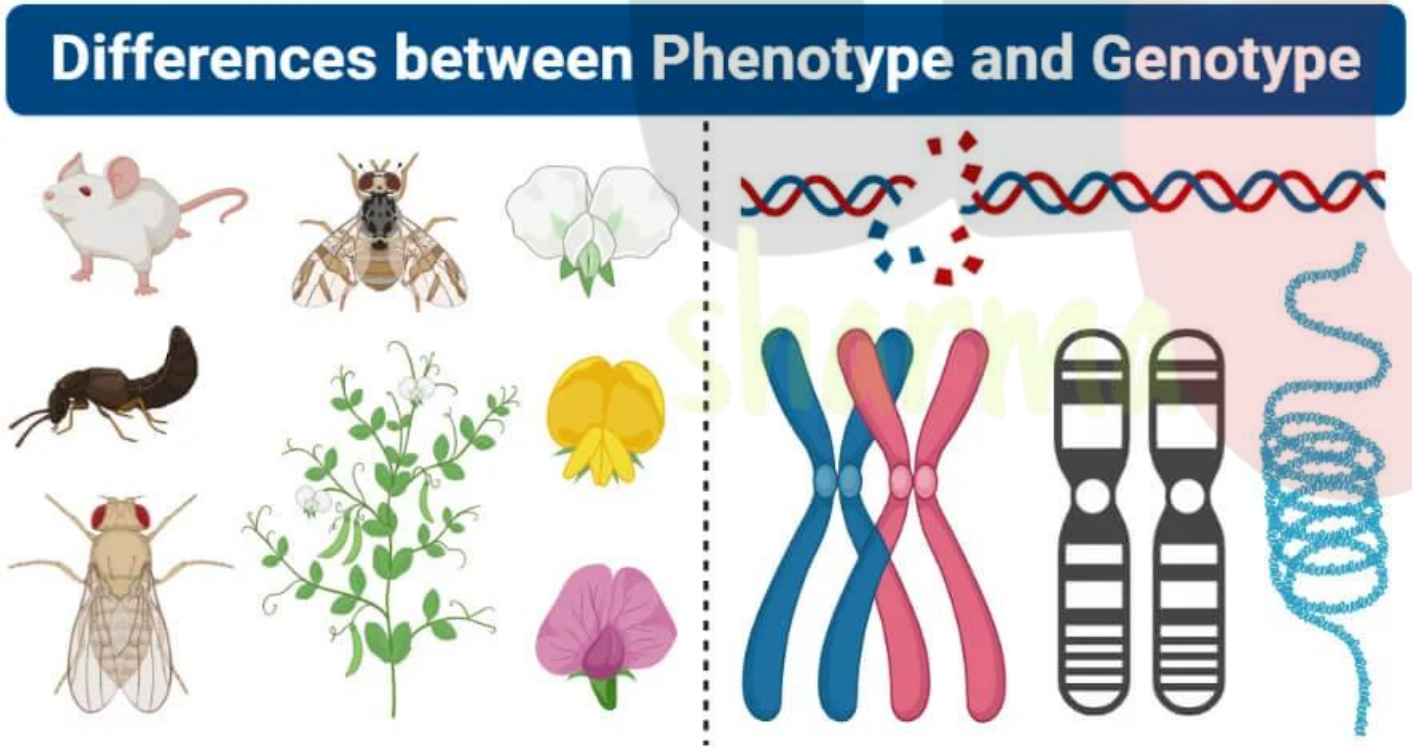
Phenotype :- The characteristics (or traits) which visible in an organism is known as phenotype.

Example :- black hair, blonde hair, blue eye, earlobe, etc









Genotype vs Phenotype

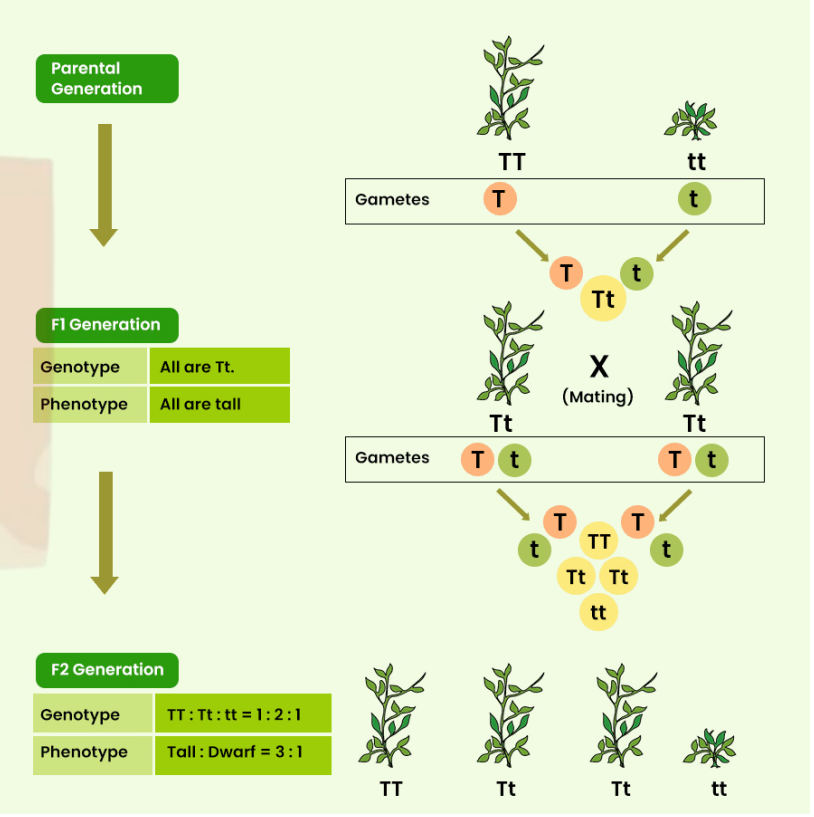
GENOTYPE The genotype is an organism's genetic information.	PHENOTYPE The phenotype is the set of observable physical traits.
BB homozygous dominant	purple
Bb heterozygous	purple
bb homozygous recessive	white

❖ Generation

F_1 generation **:-** *When two parents cross or breed to produced progeny (child or offspring) then their progeny is called first filial generation or F_1 generation.*

F_2 generation **:-** *When F_1 generation progeny cross to produce second generation progeny, then their progeny is called second filial generation or F_2 generation.*

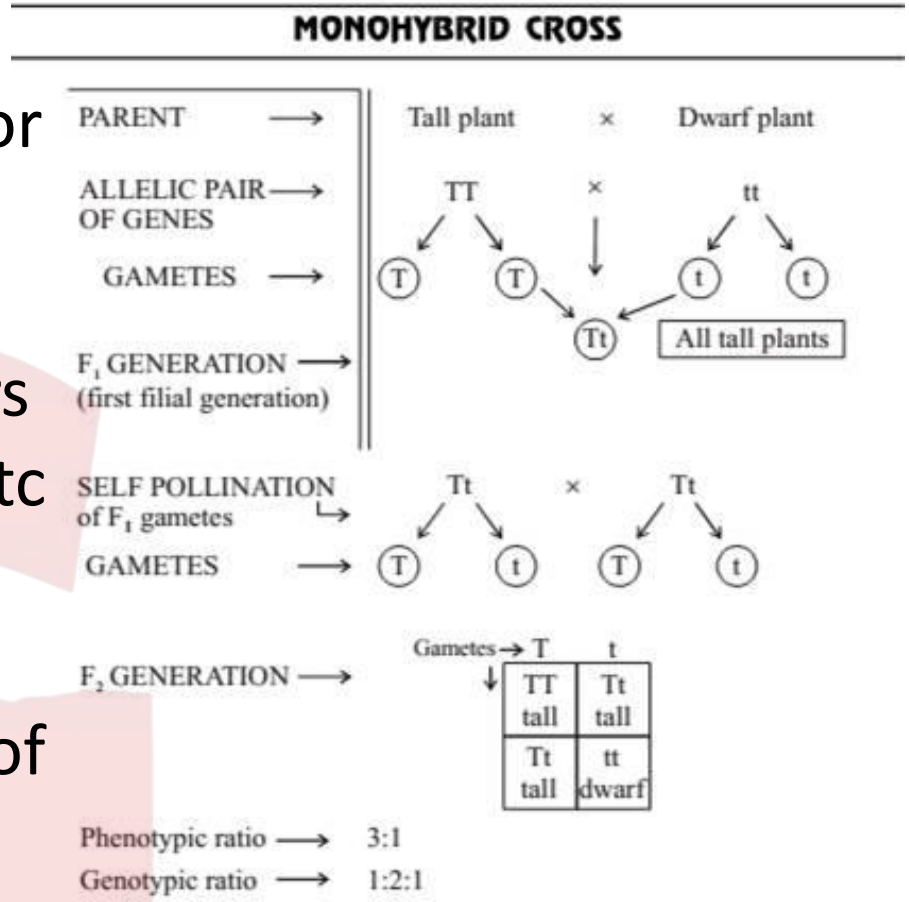
Mother & Father → Parental generation
Their children → F_1 generation
Their grandchildren → F_2 generation



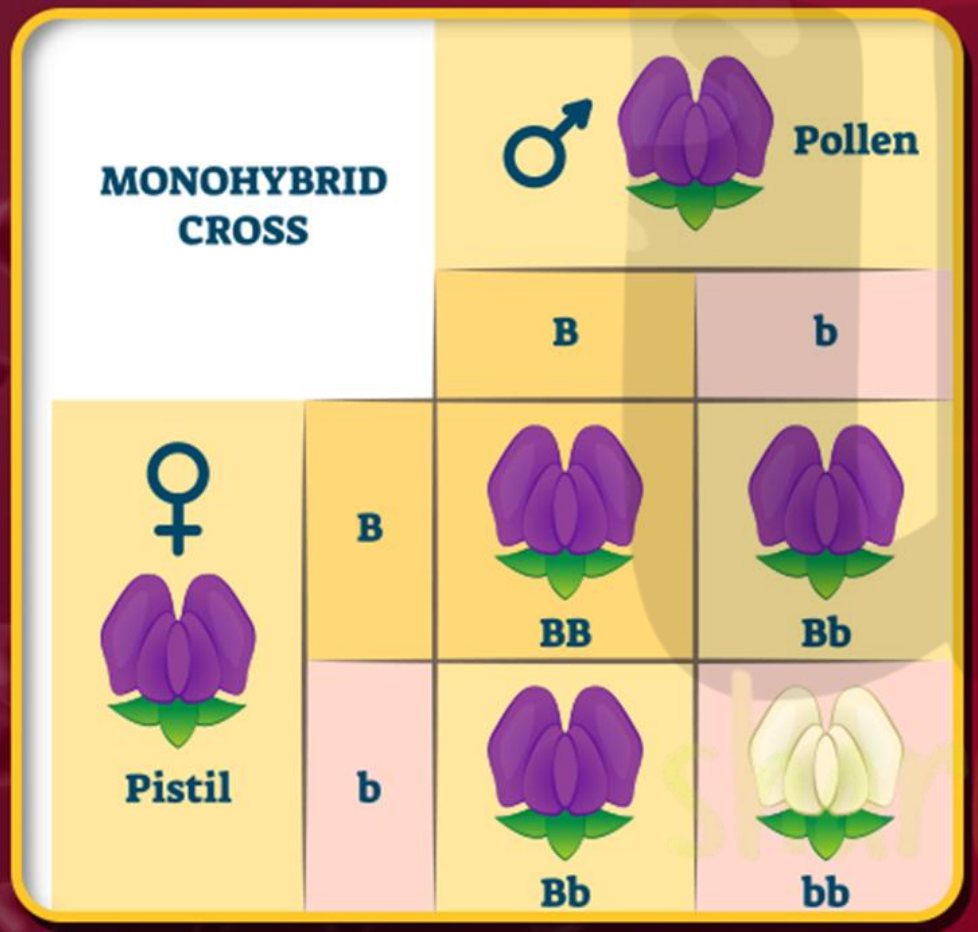
Hybrid :- A new form of plant resulting from across or breeding of different varieties of a plant.

Monohybrid :- Transmission of one pair of characters such as plant height shape of seed, etc is called monohybrid.

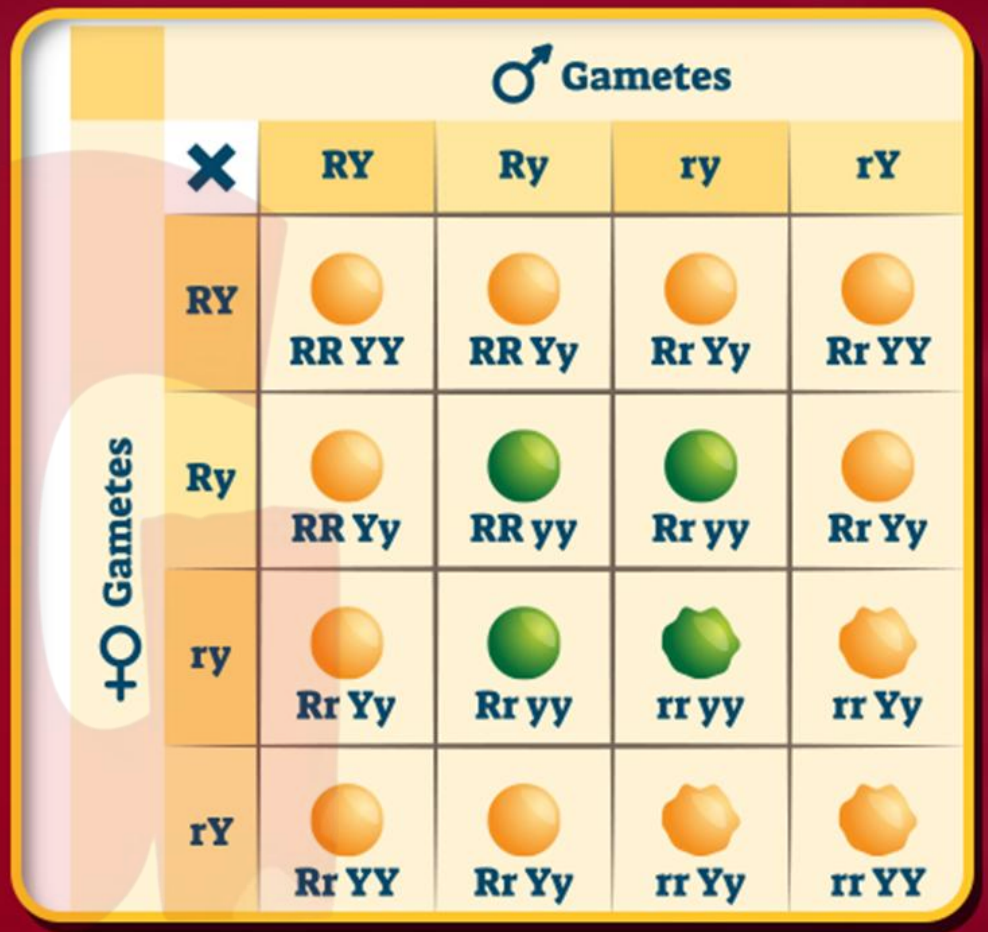
Dihybrid :- Inheritance or transmission of two pairs of contrasting characteristics of pea plants such as round – yellow seeds and wrinkled – green seeds is called dihybrid.



DIFFERENCE BETWEEN



VS



MONOHYBRID

DIHYBRID

MENDEL'S CONTRIBUTION

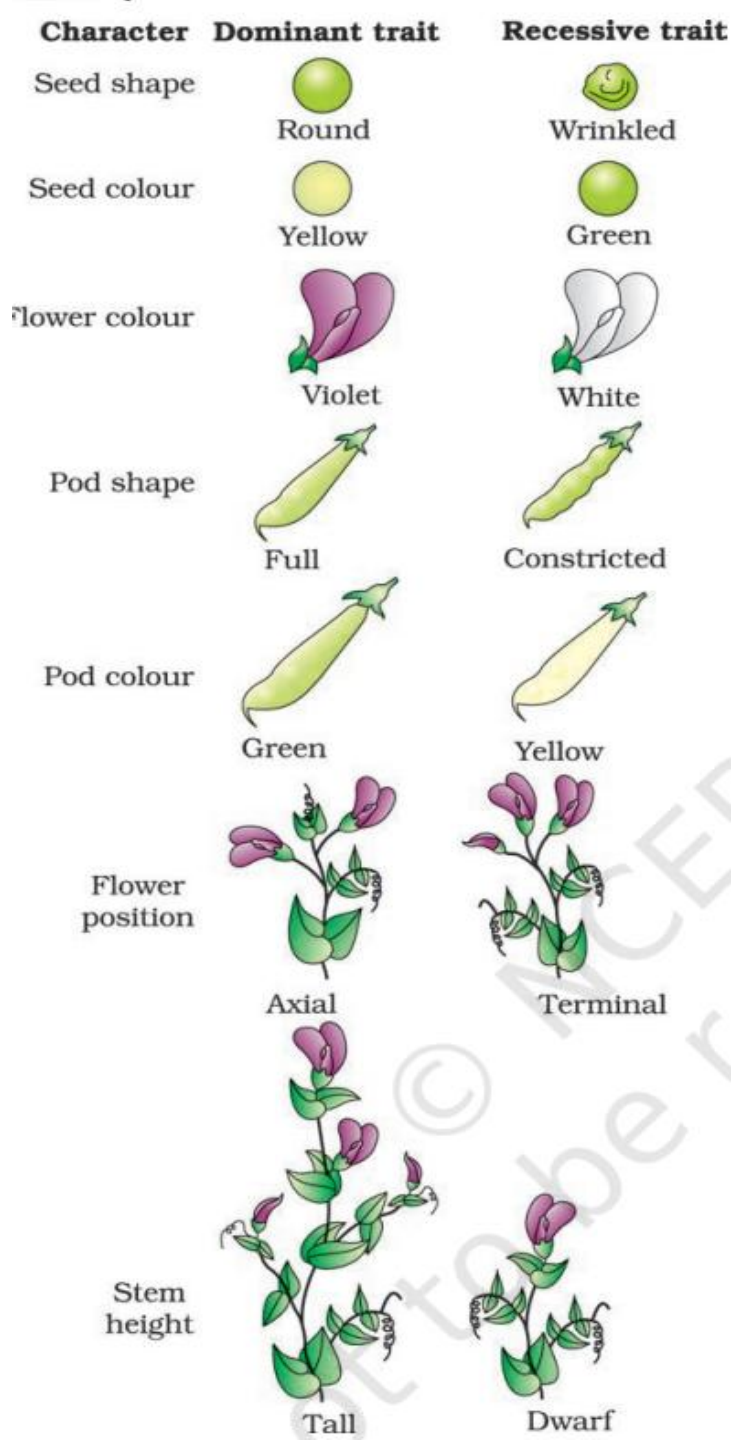
Gregor Johann Mendel (1822 – 1884) was the first scientist to make a systematic study of pattern of inheritance which involved the transfer of characteristics from parents to progeny (children or offspring). This is the reasons he is known as "***Father of Genetic***"

Genetic :- The branch of biology in which we study about heredity and variation is called genetics.

Mendel had chosen pea plants for his experiments because of the following :-

- Pea plant had a number of clean cut differences which were easy to tell apart.
- Pea plants were self – pollinating but cross-fertilisation can also be carried out.
- Pea plants can be produced in a comparatively short life span.
- Large no. of seeds produced.

Seed		Flower	Pod		Stem	
Form	Cotyledon	Color	Form	Color	Place	Size
Round	Yellow	White	Full	Green	Axial pods	Tall
Wrinkled	Green	Violet	Constricted	Yellow	Terminal pods	Short
1	2	3	4	5	6	7



Which of the following is not a reason that Mendel chose pea plants for his experiments?

Pea plants can self-pollinate or be artificially pollinated by humans, so Mendel could investigate the effect of self- and cross-pollination.

Pea plants grow quickly, so Mendel could produce many of them in a short amount of time.

Pea plants have pairs of contrasting traits; for example their pods can be yellow, or they can be green.

Pea plants are very rare, so Mendel knew no one else was doing these experiments.

Mendel's Experiment

• Mendel's Experiments: Mendel conducted a series of experiments in which he crossed the pollinated plants to study one character (at a time).

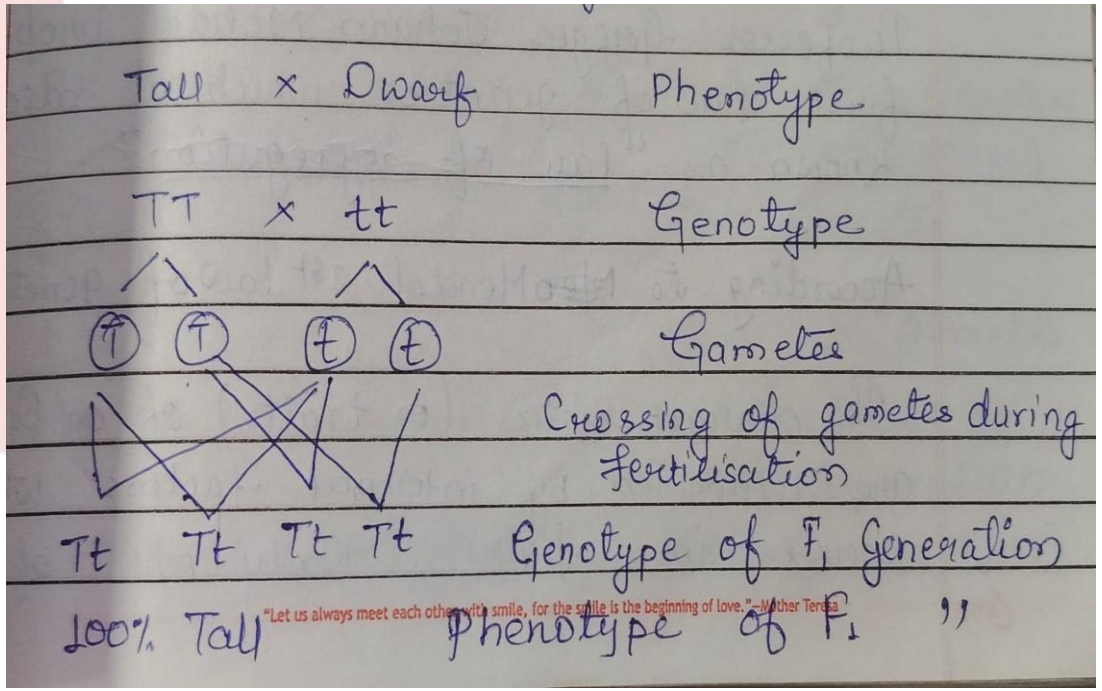
Monohybrid Cross

In a monohybrid cross, Mendel studied one pair of contrasting traits at a time, such as plant height (tall vs. dwarf).

•**Parental (P) Generation:**

He crossed a true-breeding **tall** plant (genotype **TT**) with a true-breeding **dwarf** plant (genotype **tt**).

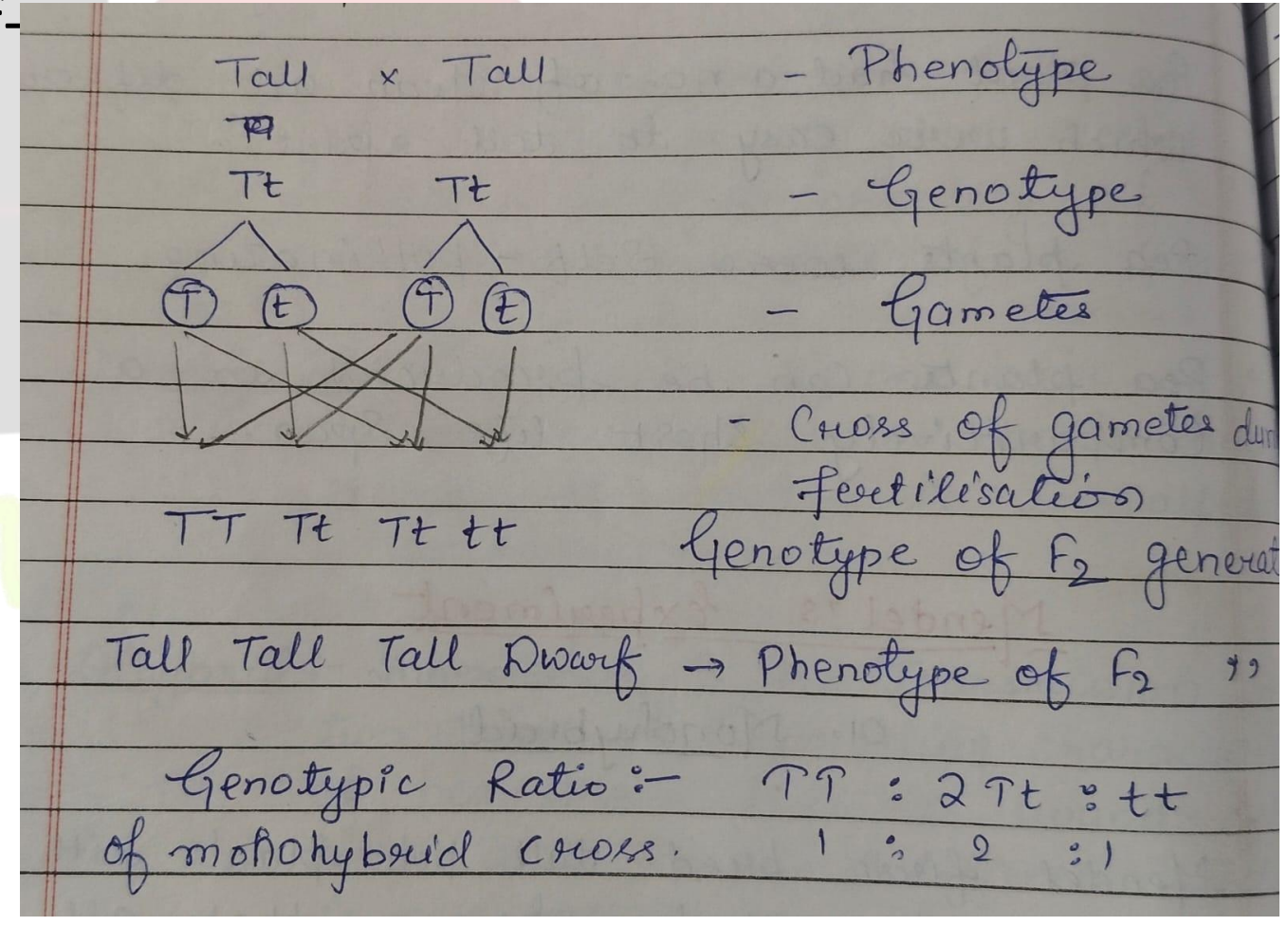
He observed that all plants were produced in F_1 generation were tall.



First Filial (F_1) Generation: All offspring in the F_1 generation were tall (genotype Tt), demonstrating that the allele for tallness was **dominant** over the allele for dwarfness, which was **recessive.**

Second Filial (F_2) Generation: Mendel then allowed the F1 tall plants to self-pollinate. In the F2 generation, he observed that some plants were dwarf again.

Results and Law: The **phenotypic ratio** of tall to dwarf plants in the F_2 generation was approximately **3:1** (three tall for every one dwarf). This led to the **Law of Segregation**



Law of Dominance

•In a pair of contrasting traits, one is **dominant** (expressed) and the other is **recessive** (masked).

•Example: In peas, **Tall (T)** is dominant over **Dwarf (t)**.

Law of Segregation

•Genes separate during gamete formation.

•Each gamete receives only one allele.

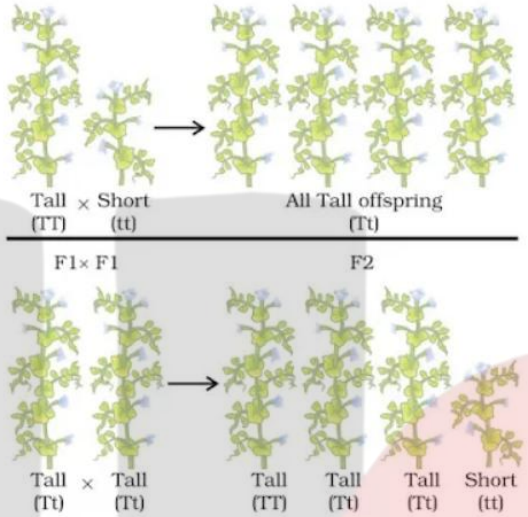
Or,

•**Law of Segregation** states that the two alleles for a trait separate (segregate) during gamete formation, and each gamete receives only one allele.

Generation	Phenotypic Ratio (Tall : Dwarf)	Genotypic Ratio (TT : Tt : tt)
F1	All tall (100%)	All Tt (100%)
F2	3 : 1	1 : 2 : 1

→ Phenotypic ratio → 3 : 1
(Three tall and one short)
→ Genotypic ratio → 1 : 2 : 1
(TT-one, Tt-two, tt-one)

Phenotype means Physical appearance either they are Tall or Short.
Genotype means Genetic make up that are TT, Tt or tt.



P TT x tt

Tall x Dwarf

Gametes (T) (t)

F_1 Tt Monohybrid

Tall (Selfing)

Gametes (T) (t)

F_2

	T	t
T	TT	Tt
t	Tt	tt

TT -1 Homozygous tall

Tt -2 Heterozygous tall

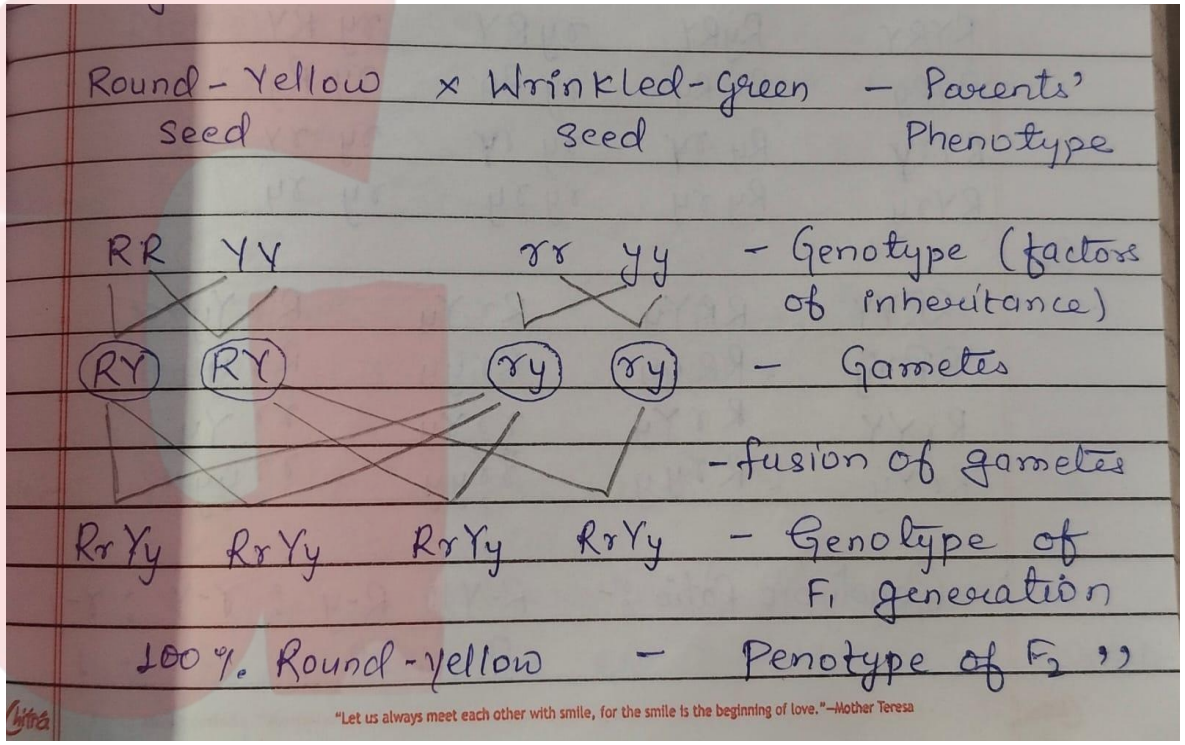
tt -1 Dwarf

Tall : Dwarf = 3:1

Dihybrid Cross

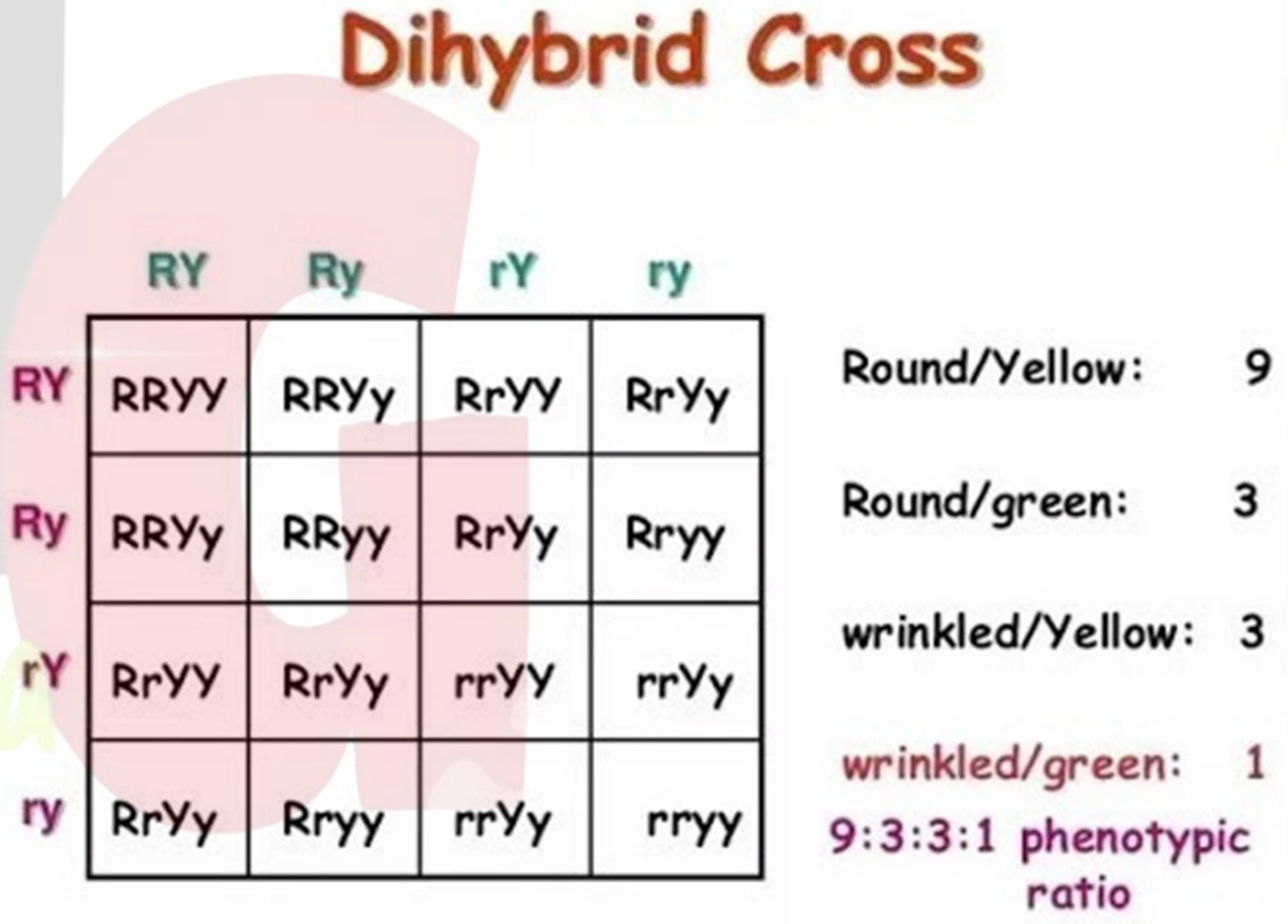
A dihybrid cross studies the simultaneous inheritance of **two different pairs of contrasting traits** (e.g., seed color and seed shape).

- **Parental (P) Generation**: Mendel crossed true-breeding plants with round, yellow seeds (**RRYY**) and wrinkled, green seeds (**rryy**).
- **First Filial (F1) Generation**: All F1 progeny had **round, yellow** seeds (**RrYy**), confirming that round and yellow are dominant traits.



•**Second Filial (F2) Generation**: When the F1 plants were self-pollinated, the F2 generation produced four different combinations of traits.

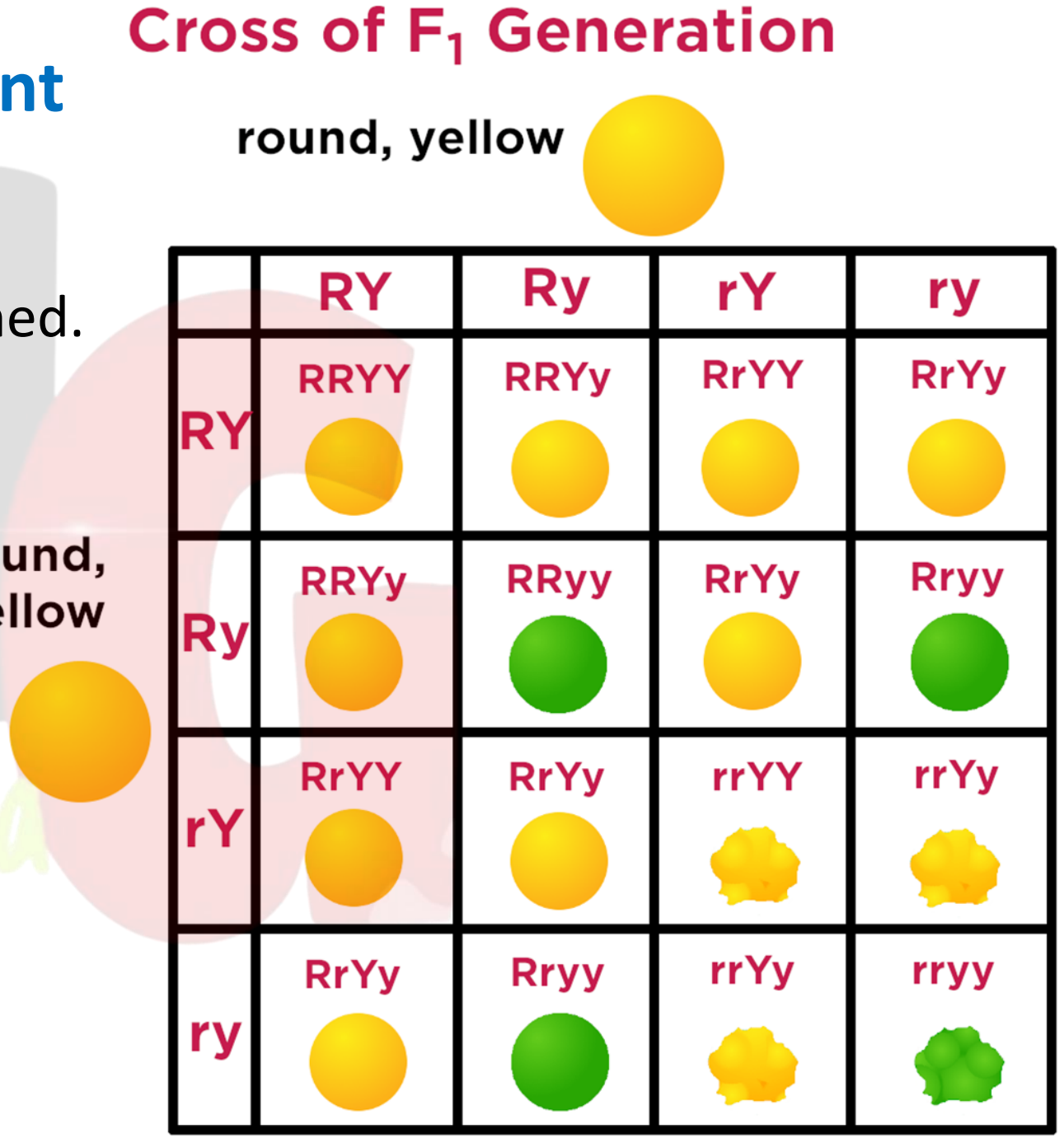
•**Results and Law**: The **phenotypic ratio** in the F2 generation was **9:3:3:1** (9 round-yellow, 3 round-green, 3 wrinkled-yellow, 1 wrinkled-green). This demonstrated that the inheritance of seed color was independent of the inheritance of seed shape, leading to the **Law of Independent Assortment**.



Law of Independent Assortment

•Genes for different traits assort independently when gametes are formed.
Or,

The law of independent assortment states that the alleles for different traits segregate independently of each other during gamete formation. This means that the inheritance of one trait, like seed color, does not influence the inheritance of another trait, such as seed shape



DIHYBRID CROSS

F2 GENERATION

RrYy
Round Yellow

RrYy
Round Yellow

	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

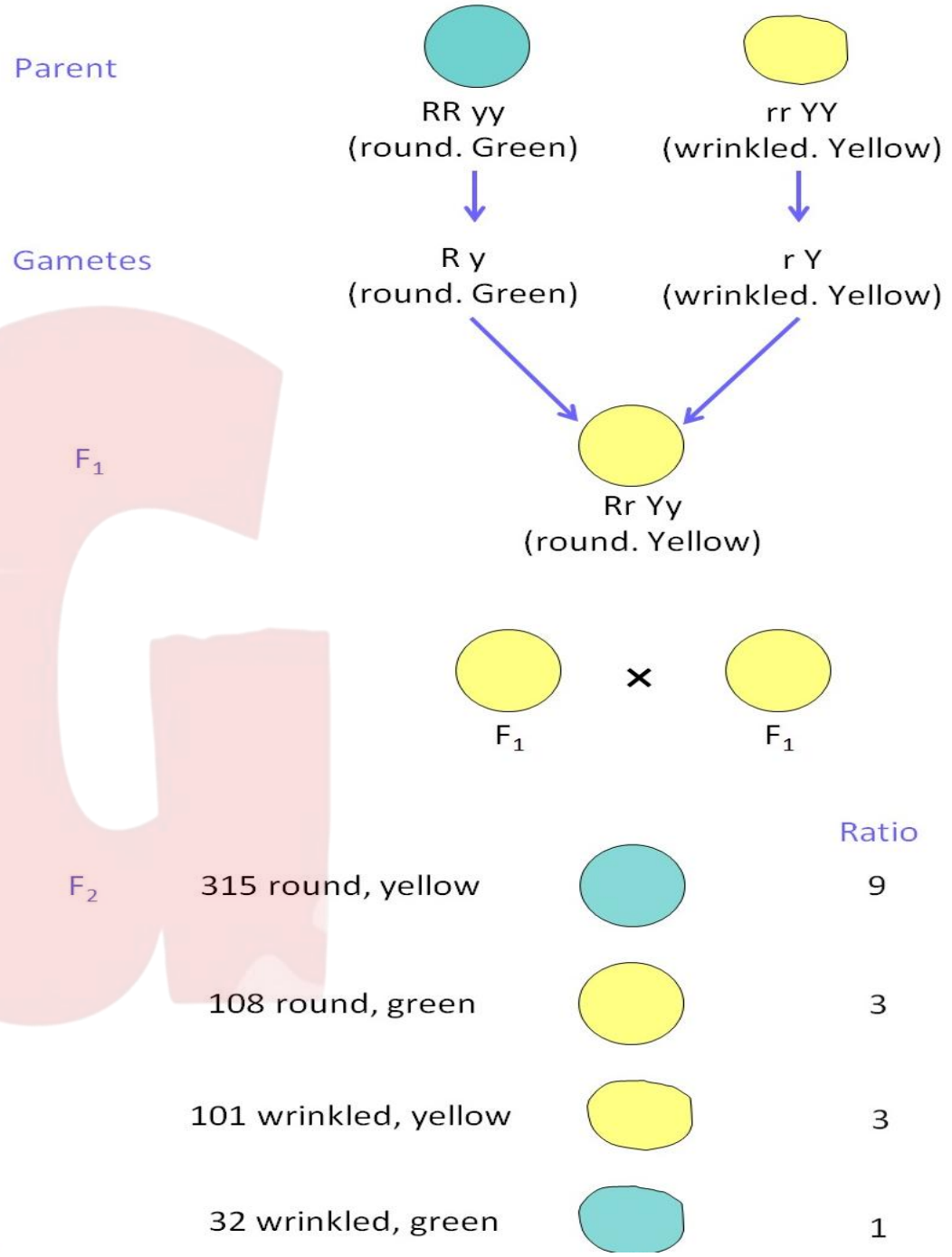
PHENOTYPIC RATIO – 9:3:3:1

GENOTYPIC RATIO – 1:2:2:4:1:2:1:2:1

Conclusions

→ Round and yellow seeds are Dominant characters.

→ Occurrence of new phenotype combinations show that genes for round and yellow seeds are inherited independently of each other.

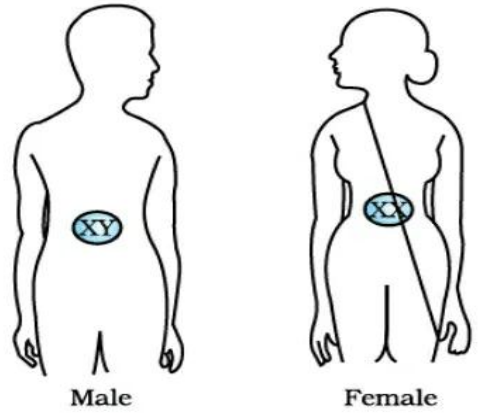


Sex Determination

- Determination of sex of an offspring is known as Sex Determination.
- **Environmental** and **Genetic** factors are responsible for sex determination.

Genetic (In human)

- Humans have **46 chromosomes** (23 pairs).
- **22 pairs** = autosomes, **1 pair** = sex chromosomes.

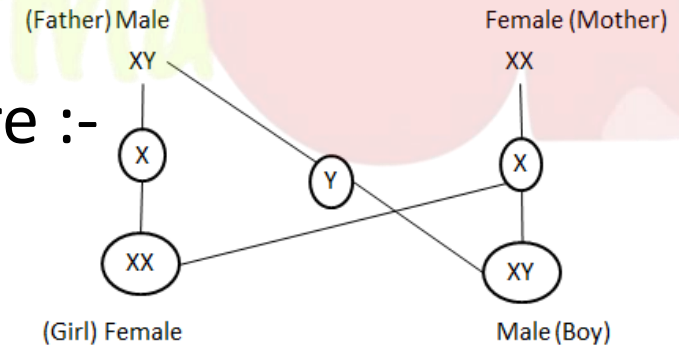


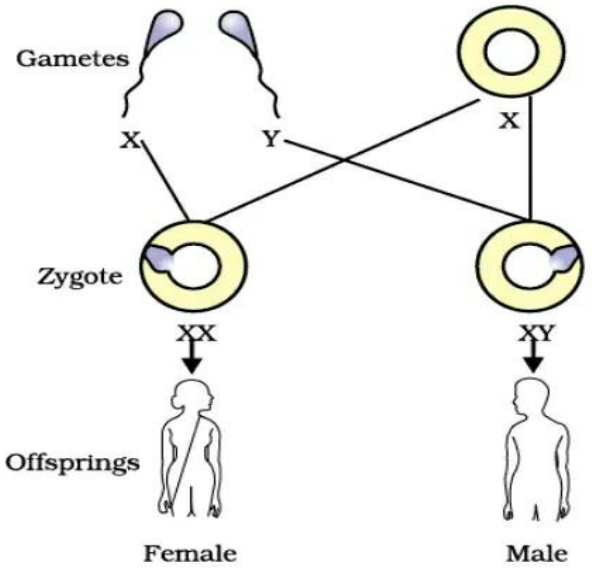
- The chromosomes which determine the sex of a person a is called “sex chromosomes”.
- There are two types of chromosomes, one is X and other is Y chromosomes.

The pair of sex chromosomes are :-

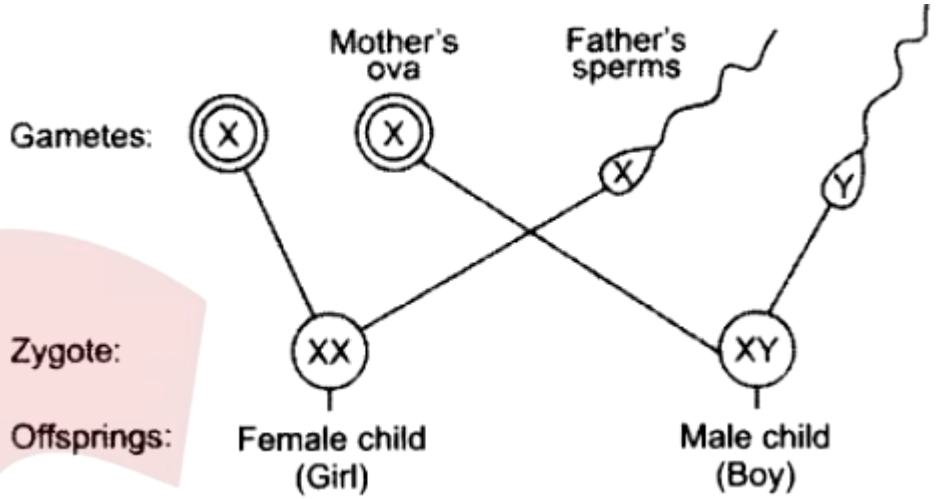
XX for a girl or female

XY for a boy or male





NOTE :- Father (man or husband) determines the sex of the child, because he produces two types of sperms — X and Y.



Environmental

In some animals as reptile, the **temperature** at which the fertilized eggs are kept decides the gender.

Example: Turtle

Important Questions – Heredity

1. Define heredity. How does it differ from variation?
2. State Mendel's Law of Segregation with a suitable example.
3. In a monohybrid cross between a pure tall (TT) plant and a pure dwarf (tt) plant, what will be the phenotype and genotype ratios in F_2 generation? Show with Punnett square.
4. What are dominant and recessive traits? Give one example of each from Mendel's experiments.
5. Explain how the sex of a child is determined in humans. Why is the father responsible for determining the sex?
6. What is a gene? How are traits transmitted from parents to offspring?
**7. Distinguish between:
(a) Homozygous and Heterozygous
(b) Genotype and Phenotype**
8. What is the role of DNA in inheritance?
9. State the phenotypic ratio obtained in a dihybrid cross. Name the law explained by this experiment.
10. Why are acquired traits not inherited? Explain with an example.

QUESTIONS

1. How do Mendel's experiments show that traits may be dominant or recessive?
2. How do Mendel's experiments show that traits are inherited independently?
3. A man with blood group A marries a woman with blood group O and their daughter has blood group O. Is this information enough to tell you which of the traits – blood group A or O – is dominant? Why or why not?
4. How is the sex of the child determined in human beings?

EXERCISES

1. A Mendelian experiment consisted of breeding tall pea plants bearing violet flowers with short pea plants bearing white flowers. The progeny all bore violet flowers, but almost half of them were short. This suggests that the genetic make-up of the tall parent can be depicted as
   (a) TTWW
   (b) TTww
   (c) TtWW
   (d) TtWw
2. A study found that children with light-coloured eyes are likely to have parents with light-coloured eyes. On this basis, can we say anything about whether the light eye colour trait is dominant or recessive? Why or why not?
3. Outline a project which aims to find the dominant coat colour in dogs.
4. How is the equal genetic contribution of male and female parents ensured in the progeny?

MCQs

1. The transmission of traits from parents to offspring is called:

A. Variation
B. Evolution
C. Heredity
D. Speciation

Answer: C

2. The trait that gets expressed in a heterozygous condition is called:

A. Recessive
B. Dominant
C. Hybrid
D. Mutant

Answer: B

3. Which term represents the genetic makeup of an organism?

A. Phenotype
B. Genotype
C. Trait
D. Chromosome

Answer: B

4. Father determines the sex of the child because:

A. He has XX chromosomes
B. He produces only X chromosomes
C. He produces both X and Y sperms
D. Mother produces Y eggs

Answer: C

5. In pea plants, tallness (T) is dominant over dwarfness (t). The genotype Tt is:

A. Homozygous dominant
B. Homozygous recessive
C. Heterozygous
D. Pure line

Answer: C

6. The physical expression of a trait is known as:

A. Genotype
B. Phenotype
C. Gene
D. Chromosome

Answer: B

7. The ratio obtained in F_2 generation of a monohybrid cross is:

A. 9:3:3:1

B. 3:1

C. 1:2:1

D. 1:3

Answer: B

8. The number of chromosomes in human gametes is:

A. 23

B. 46

C. 44

D. 22

Answer: A

9. Genes are located on:

A. Ribosomes

B. Chromosomes

C. Mitochondria

D. Cell membrane

Answer: B

10. Which of the following is an acquired trait and not inherited?

A. Eye colour

B. Hair type

C. Scar on skin

D. Blood group

Answer: C

Previous Year Questions 2025

Q1: If pea plants with round and green seeds (RRyy) are crossed with pea plants having wrinkled and yellow seeds (rrYY), the seeds developed by the plants of F_1 generation will be: (1 Mark)

(A) 50% round and green

(B) 75% wrinkled and green

(C) 100% round and yellow

(D) 75% wrinkled and yellow

Ans: (C) 100% round and yellow

Q2: Question consist of two statements are given — one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below. (1 Mark)

Assertion (A): A human child bears all the basic features of human beings.

Reason (R): It looks exactly like its parents, showing very little variations.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, but R is not the correct explanation of A.

(C) A is true, but R is false.

(D) A is false, but R is true.

Ans: (C) A is true, but R is false.

Q3: Question consist of two statements are given — one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below. (1 Mark)

Assertion (A): A mango seed will germinate to form a mango tree.

Reason (R): Heredity determines the process by which traits and characteristics are reliably inherited from parents to offspring.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, but R is not the correct explanation of A.

(C) A is true, but R is false.

(D) A is false, but R is true.

Ans: (A) Both A and R are true, and R is the correct explanation of A.

Q4: When a pure-tall pea plant is crossed with a pure-dwarf pea plant, the percentage of tall pea plants in F_1 and F_2 generation pea plants will be respectively: (1 Mark)

(a) (100% ; 25%)

(b) (100% ; 50%)

(c) (100% ; 75%)

(d) (100% ; 100%)

Ans: (c) (100% ; 75%)

Q5: A tall pea plant with round seeds (TTRR) is crossed with a short pea plant with wrinkled seeds (ttrr). The F_1 generation will be: (1 Mark)

(A) 25% tall with round seeds

(B) 50% tall with wrinkled seeds

(C) 75% tall with wrinkled seeds

(D) 100% tall with round seeds

Ans: (D) 100% tall with round seeds

Q6: Mendel obtained F_2 generation by: (1 Mark)

(A) Self-pollinating F_1 generation plants

(B) Cross-pollinating F_1 generation plants with plants having dominant trait

(C) Cross-pollinating F_1 generation plants with plants having recessive trait

(D) Cross-pollinating both the parents

Ans: (A) Self-pollinating F_1 generation plants

Q7: (a) Explain how the proteins control the 'characteristics' in an organism with the help of an example of 'short height' trait in pea plant.

(b) Name the information source of making proteins in a cell. (2 Marks)

Q8: Pure-tall (TT) pea plants are crossed with pure-dwarf (tt) pea plants. The pea plants obtained in F_1 generation are then self-pollinated to produce F_2 generation. (2 Marks)

(i) What do the plants of F_1 generation look like? Justify your answer.

(ii) What is the ratio of pure-tall plants to pure-dwarf plants in F_2 generation?

Q9: "Proteins control the expression of various characters." Explain this statement by taking an example of "tallness" as a characteristic in plants. (2 Marks)

Q10:(a) What are chromosomes?

(b) Explain in brief how stability of DNA content of a species is ensured in sexually reproducing organisms?

or

Explain the mechanism of inheritance used by sexually reproducing organisms to ensure the stability of DNA of the species. (3 Marks)

Q11: In one of Mendelian experiments, when F_1 generation pea plants with round yellow seeds were self-pollinated, pea seeds with the following combinations were obtained in F_2 generation: (3 Marks)

Seeds	Round yellow	Round green	Wrinkled yellow	Wrinkled green
Number	800	275	268	90

Q12: (a) How many chromosomes are present in human beings? Out of these how many are sex chromosomes?

(b) Explain how, in sexually reproducing organisms, the number of chromosomes in the progeny is maintained. (3 Marks)

Q13: The lowest part of the ear called earlobe, is closely attached to the side of the head in some of us (Figure 'X'), and not in others, called free earlobe (Figure 'Y'). Attached and free earlobes are two variants found in human populations. The gene for free earlobe is dominant over attached earlobes. (3 Marks)

Figure 'X'

Figure 'Y'

(a) A man with attached earlobes marries a woman having free earlobes. 50% of their children have free earlobes and 50% have attached earlobes. Explain the inheritance of this trait and write the trait combinations of the progeny.

(b) Write the gene combinations of the father and the mother in the above case.

Q14: A pure pea plant bearing terminal flowers was cross-pollinated with a pure plant having terminal flowers. In the F_1 generation, plants with axial flowers only were obtained. F_1 generation plants are self-pollinated and F_2 generation is obtained.

(3 Marks)

(a) Work out the pattern of inheritance in this case.

(b) What will be the ratio of plants obtained in F_2 generation?

Q15: A pure pea plant having round (R), yellow (Y) seeds is crossed with another pure pea plant having wrinkled (r), green (y) seeds. Subsequently F_1 progeny is self-pollinated to obtain F_2 progeny.

(a) What do the seeds of F_1 generation look like?

(b) Give the possible combinations of traits in seeds of F_2 generation. Also give their ratio.

(c) State the reason of obtaining seeds of new combination of traits in F_2 generation.

(3 Marks)Ans:

Q16: The gene combination of purple flowered pea plants is denoted as (WW) and that of white flowered pea plants as (ww), when these two plants are crossed F_1 generation is obtained.

(a) List two observations made by Mendel in F_1 generation plants.

(b) Give the (i) percentage of white flowered plants in F_2 generation and

(ii) ratio of the gene combinations WW, Ww, and ww in F_2 generation.

(c) Write one difference between dominant and recessive trait. (3 Marks)

Q17: Question is Case/data-based question with 2 or 3 subparts. Internal choice is provided in one of these sub parts.

In human beings, there are 23 pairs of chromosomes. Out of these 23 pairs of chromosomes (i.e. 46 chromosomes), 22 pairs of chromosomes are called autosomes, and one pair of chromosomes, i.e. two chromosomes, are called sex chromosomes. The sex chromosomes are of two types - 'X' chromosomes and 'Y' chromosomes. The sex of a child (i.e. progeny) is decided at the time of fertilisation. In other words, at the time of zygote formation, the sex chromosomes inherited from the parents of a child decide whether the newborn will be a boy or a girl. (4 Marks)

(a) What are chromosomes?

(b) Why is the pair of sex chromosomes in human males called mismatched pair?

(c) (A) Show with the help of a flow chart that the statistical probability of getting a boy or a girl is 50:50.

Previous Year Questions 2024

Q1: Consider the following statements:

(i) The sex of a child is determined by what it inherits from the mother.

(ii) The sex of a child is determined by what it inherits from the father.

(iii) The probability of having a male child is more than that of a female child.

(iv) The sex of a child is determined at the time of fertilisation when male and female gametes fuse to form a zygote. (2 Marks) (2024)(2024)

The correct statements are:

(a) (i) and (iii)

(b) (ii) and (iv)

(c) (iii) and (iv)

(d) (i), (iii) and (iv)

Q2: Source-based/case-based questions with 2 to 3 short subparts. Internal choice is provided in one of these sub-parts: Mendel worked out the rules of heredity by working on garden pea using a number of visible contrasting characters. He conducted several experiments by making a cross with one or two pairs of contrasting characters of pea plant. On the basis of his observations, he gave s ome interpretations which helped to study the mechanism of inheritance.

(i) When Mendel crossed pea plants with pure tall and pure short characteristics to produce progeny, which two observations were made by him in F_1 plants?

(ii) Write one difference between dominant and recessive traits.

(iii) (A) In a cross with two pairs of contrasting characters

RRYY × rryy

(Round Yellow) (Wrinkled Green)

Mendel observed 4 types of combinations in F2 generation. By which method did he obtain F2 generation? Write the ratio of the parental combinations obtained and what conclusions were drawn from this experiment.

OR

(iii) (B) Justify the statement: "It is possible that a trait is inherited but may not be expressed." (4 to 5 Marks) (2024)