PRINCIPLES OF INHERITANCE AND VARIATION

(A) NCERT QUESTIONS & SOLUTIONS

1. Mention the advantages of selecting pea plant for experiment by Mendel.

Ans.
- Annual plant with short life cycle of 2-3 months.
- It has many contrasting trait.
- Pea seeds are large.
- Easy to cultivate.
- Pea plant is naturally self pollinating.
- Artificial cross pollination can be easily performed.

2. Differentiate between the following – [IMP.]

(A) Dominance and Recessive **(B) Homozygous and Heterozygous**

(C) Monohybrid and Dihybrid

Ans. (A) Dominance and Recessive

Dominance	Recessive
Allele which can express itself both in homozygous and heterozygous condition is known as dominant allele.	Allele which can express itself only in homozygous condition is known as recessive allele.

(B) Homozygous and Heterozygous

Homozygous	Heterozygous
☛ In diploid individual, if similar alleles of a gene is present then it is said to be homozygous. ☛ Also termed as Pure /true breeding.	☛ In diploid individual, if dissimilar alleles of a gene is present then it is said to be heterozygous. ☛ Also termed as Impure/Hybrid.

(C) Monohybrid and Dihybrid.

Monohybrid	Dihybrid
☛ Monohybrid involves cross between parents which differs in only one pair of contrasting characters.	☛ Dihybrid involves cross between parents differs in two pairs of contrasting characters.
☛ For example The cross between tall and dwarf pea plant is a monohybrid cross.	☛ For example The cross between pea plants having yellow round seed with those having green wrinkled seeds is a dihybrid cross.

3. A diploid organism is heterozygous for 4 loci, how many types of gametes ?

Ans. A diploid organism heterozygous for 4 loci, will have four different contrasting characters at four different loci.

For example if an organism is heterozygous at four loci with four characters say AaBbCcDd then during meiosis it will segregate to form 16 separate gametes.

Type of gamete = 2^n where n is no of heterozygous pair

So n = 4 so 2^4 so 16 gametes.

4. Explain the Law of Dominance using a monohybrid cross.

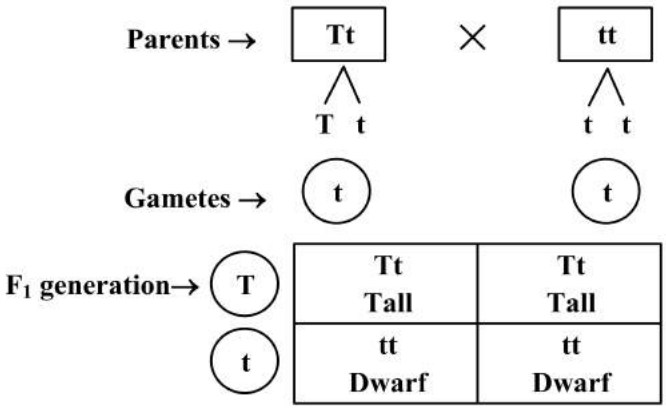
Ans. When two different factors (genes) or a pair of contrasting forms of a character are present in an organism, only one expresses itself in the F_1 generation and is termed as dominant while the other remains unexpressed and called recessive factors (gene).

5. Define a test - cross?

Ans. When an individual is crossed with the homozygous recessive parent. It is called test cross.

6. Using a Punnett Square, workout the distribution of phenotypic features in the first filial generation after a cross between a homozygous female and a heterozygous male for a single locus.

Ans.



Phenotypic Ratio:- 1:1
Genotypic Ratio:- 1:1

7. When a cross in made between tall plant with yellow seeds (TtYy) and tall plant with green seed (Ttyy), what proportions of phenotype in the offspring could be expected to be [IMP.]
(a) Tall and green. (b) Dwarf and green.

Ans.

Tall & Yellow Seeds **Tall & Green Seeds**

TtYy × Ttyy

Ty ty

TY	TTYy (Tall & Yellow)	TtYy (Tall & Yellow)
Ty	Ttyy (Tall & Green)	Ttyy (Tall & Green)
tY	TtYy (Tall & Yellow)	ttYy (Dwarf & Yellow)
ty	Ttyy (Tall & Green)	ttyy (Dwarf & Green)

Phenotype ratio →

(a) Tall and green : 3 (b) Dwarf and green : 1

8. Two heterozygous parents are crossed. If the two loci are linked w e distribution of phenotypic features in F_1 generation for a dihybrid cross?

Ans. The co-existence of two or more genes in the same chromosome is termed as linkage. If the genes are located close to each other and on the same chromosome, they are inherited together and are referred to as linked genes. If two heterozygous parents exhibit linkage, then the outcome is as follows:

BbLl x BbLl

Blue long Blue long

So in F_1 generation the parental combination will comparatively be more than the newer combinations which are less in number.

9. Briefly mention the contribution of T.H. Morgan in genetics.

Ans. Thomas Hunt Morgan is called father of experimental genetics.

- Experimental verification of the chromosomal theory of inheritance was given by Thomas Hunt Morgan and his colleagues, led to discovering the basis for the variation that sexual reproduction produced.
- Morgan worked with the tiny fruit files, *Drosophila melanogaster, which were* found very suitable for such studies.
- Morgan carried out several dihybrid crosses in *Drosophila* to study genes that were sex-linked.
- He stated and established that genes are located on the chromosome.
- He established the principle of linkage, crossing over, sex linked inheritance and discovered the relationship between gene and chromosome.
- He established the technique of chromosome mapping.
- He observed and worked on mutation.

10. What is pedigree analysis? Suggest how such an analysis, can be useful.

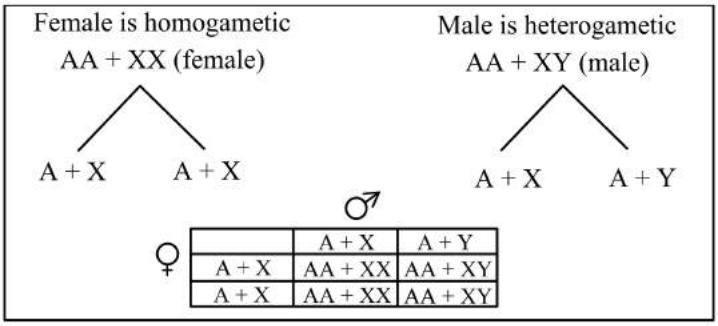
Ans. A pedigree is a record of inheritance of a specific genetic trait for two or more generations which is presented in the form of a diagram or family tree. Pedigree analysis is an analysis of several generations of a family which is used on human beings.

Usefulness of pedigree analysis:

- Serves as a powerful tool which can be used to trace the inheritance of a particular trait, disease or an abnormality
- It is helpful for genetic counsellors to suggest couples about the possibility of having children with genetic abnormalities such as colour blindness, haemophilia, thalassaemia, sickle-cell anaemia etc
- Helpful in reasoning why marriage between close relatives is harmful.

11. How is sex determined in human beings?

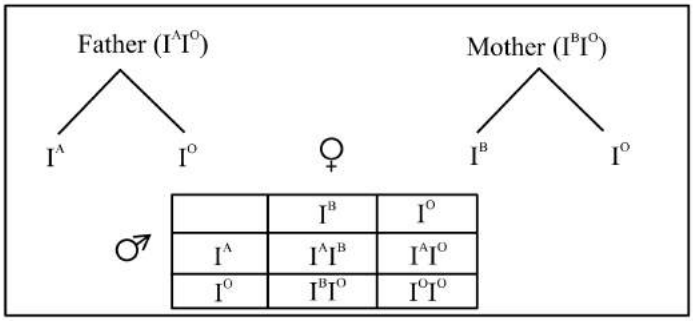
Ans. Sex determination in human is done by XX-XY type method. In humans, females have XX chromosomes and males have two different type sex chromosomes (XY).



Male progeny 50% female progeny - 50%

12. A child has blood group O. If the father has blood group A and mother blood group B, work out the genotypes of the parents and the possible genotypes of the other offsprings. [IMP.]

Ans. $I^A I^o \times I^B I^O$



Possible genotype of other offsprings - I^AI^B, I^AI^O, I^BI^O, I^OI^O

13. Explain the following terms with example.

(a) Co-dominance **(b) Incomplete dominance**

Ans. (a) Co-dominance: In this phenomenon both the alleles are able to express themselves independently when found together in a heterozygote. They are termed as co-dominant alleles.

E.g., - ABO blood group

(b) Incomplete dominance: Incomplete dominance may be defined as the partial /expression of both alleles in a heterozygote so that the phenotype is intermediate between those of two homozygotes.

E.g., - (i) Flower colours of *Mirabilis jalapa* (4 o'clock plant) (ii) *Snapdragon*

14. What is point mutation? Give one example.

Ans. Mutations arising due to change in single base pair of DNA is called point mutation. Eg: sickle cell anaemia.

15. Who had proposed the chromosomal theory of the inheritance?

Ans. In 1902 the chromosomal theory of inheritance was proposed by Theodore Boveri and Walter Sutton.

16. Mention any two autosomal genetic disorders with their symptoms. [IMP.]

Ans. Sickle cell anemia -

Symptoms:-

- Shape of RBCs change from biconcave to sickle-shaped(curved) under the influence of low oxygen tension.
- These sickle-shaped RBCs are more rapidly destructed than the normal ones causing anaemia

Phenylketonuria:-

- This inborn error of metabolism is also inherited as the autosomal recessive trait. The affected individual lacks an enzyme that converts the amino acid phenylalanine into tyrosine. As a result of this phenylalanine is accumulated and converted into phenylpyruvic acid and other derivatives.

Symptoms:-

- Accumulation of these in brain results in mental retardation. These are also excreted through urine because of its poor absorption by kidney.

(B) PREVIOUS YEAR QUESTIONS

1. **Assertion (A) :** In Thalassemia an abnormal myoglobin chain is synthesized due to a gene defect.

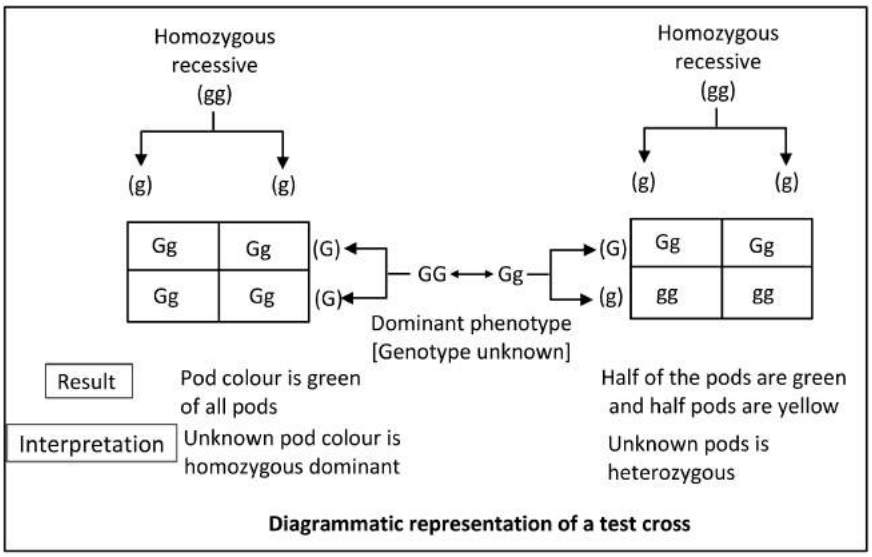
Reason (R) : α–Thalassemia is controlled by genes HBA1 and HBA2 on chromosome 16.

[CBSE 2023]

Ans. (4) Assertion (A) is false but Reason (R) is also true.

2. **By using Punnett square depict the genotypes and phenotypes of test crosses (where green pod colour (G) is dominant over yellow pod colour (g) in Garden pea with unknown genotype.** **[CBSE 2023]**

Ans.

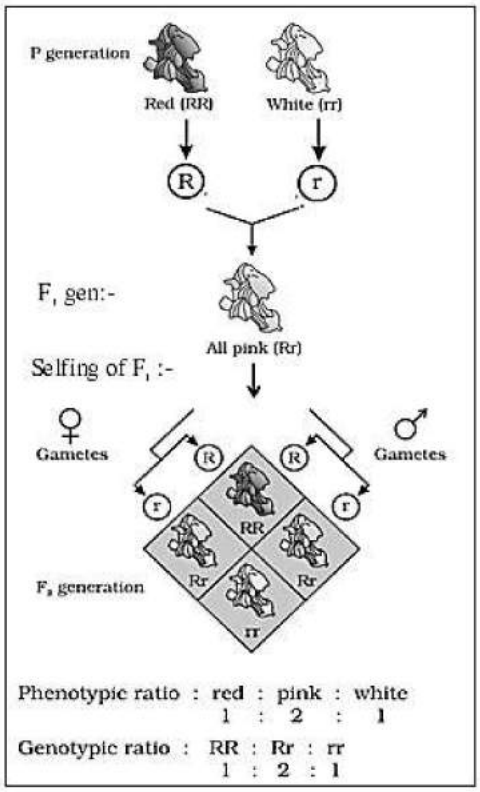


Diagrammatic representation of a test cross

3. **It is sometimes observed that the F_1 progency has a phenotype that does not resemble either of the two parents and has intermediate phenotype. Explain by taking a suitable example and working out the cross upto F_2 progeny.** **[CBSE 2023]**

Ans. When in heterozygous condition, dominant allele cannot express completely over recessive allele this is known as Incomplete dominance.

- It is the exception of law of dominance.
- In case of incomplete dominance the F_1 had a phenotype that did not resemble either of the two parents and was in between the two.
- In heterozygous condition intermediate form appears.
- The inheritance of flower colour in the dog flower (snapdragon or *Antirrhinum majus)* is a good example to understand incomplete dominance.



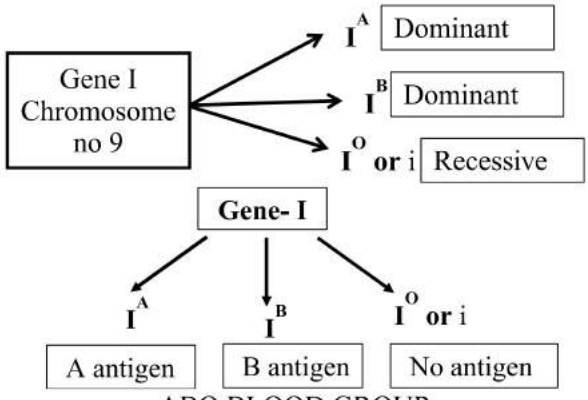
- Incomplete dominance was first discovered by Correns for flower colour in *Mirabilis jalapa*.
- Incomplete dominance is found in Snapdragon is similar to *Mirabilis*.
- Intermediate starch grain size in pea plant is also example of incomplete dominance.

4. "It is sometimes observed that the F_1 progeny shows a phenotype that resembles both the parents." Explain this type of inheritance using the example of A,B,O blood groups in human. [CBSE 2023]

Ans. When both the alleles of a gene express themselves simultaneously in a heterozygote, this condition is known as Co-dominance.

In case of co-dominance the F1 generation resembles both the parents.

- ABO blood group in humans beings comprises of four blood groups i.e. A,B,AB,O
- These blood groups are due to the presence of special antigens on the surface of RBC.
- Antigens are controlled by gene I.
- Gene I has three alleles.



ABO BLOOD GROUP

☛ Human is diploid organism so each person possesses any two of the three *I gen*

Genotype	Blood group
I^AI^A	A
I^AI^O	
I^BI^B	B
I^BI^O	
I^AI^B	AB (Codominance)
I^OI^O	O

6 Genotypes **4 Phenotypes**

5. The chromosome number is fixed for all normal organisms leading to species specification whereas any abnormality in the chromosome number of an organism results into abnormal individuals. For example, in humans 46 is the fixed number of chromosomes both in male and female. In male it is '44 + XY' and in female it is '44 + XX'. Thus the human male is heterogametic, in other words produce two different types of gametes one with '22 + X' chromosomes and the other with '22 + Y' chromosomes respectively. Human female, on the other hand is homogametic i.e. produces only on type of gamete with '22 + X' chromosomes only.

Sometimes an error may occur during meiosis of cell cycle, where the sister chromatids fail to segregate called nondisjunction, leading to the production of abnormal gametes with altered chromosome number. On fertilisation such gametes develop into abnormal individuals.

(a) State what is aneuploidy.

(b) If during spermatogenesis, the chromatids of sex chromosomes fail to the segregate during meiosis, write only the different types of gametes with altered chromosome number that could possibly be produced.

(c) A normal human sperm (22 + Y) fertilises an ovum with karyotype '22 + XX'. Name the disorder the offspring thus produced would suffer from and write any two symptoms of the disorder. **[CBSE 2023]**

OR

(c) Name a best known and most common autosomal aneuploid abnormality in human and write any two symptoms.

Ans. (a) Failure of segregation of chromatids during cell division cycle results in t a chromosome(s), called aneuploidy.

(b) 22+XY and 22 + 0

(c) 44+XXY. Klinefelter's Syndrome - This genetic disorder is also caused due to the presence of an additional copy of X-chromosome resulting into a karyotype of 47, XXY. Such an individual has overall masculine development, however, the feminine development (development of breast, i.e., Gynaecomastia) is also expressed such individuals are sterile.

OR

(c) Down's Syndrome : The cause of this genetic disorder is the presence of an additional copy of the chromosome number 21 (trisomy of 21). The affected individual is short statured with small round head, furrowed tongue and partially open mouth. Palm is broad with characteristic palm crease. Physical, psychomotor and mental development is retarded.

6. The case of Down's syndrome in humans is: **[CBSE Term-I 2022]**

(1) Extra copy of an autosome (2) Extra copy of a sex chromosome

(3) Absence of an autosome (4) Absence of a sex chromosome

Ans. (1) Extra copy of an autosome

7. Which of the following features show the mechanism of sex determination in honey-bee? **[CBSE Term-I 2022]**

(1) An offspring formed from the union of a sperm and egg develops as a male.

(2) Males have half the number of chromosomes than that of female.

(3) The females are diploid having 32 chromosomes.

(4) Males have father and can produce sons.

Ans. (2) Males have half the number of chromosomes than that of female.

8. Select the pair that is incorrect: **[CBSE Term-I 2022]**

(1) Sickle-cell anaemia : Autosome liked recessive

(2) Haemophilia : Autosome linked recessive trait

(3) Colour blindness : Sex linked recessive trait

(4)Thalassemia : Autosome linked recessive trait

Ans. (2) Haemophilia : Autosome linked recessive trait

9. An example of a human trait where a single gene can exhibit multiple phenotypic expression is :- **[CBSE Term-I 2022]**

(1) Phenylketonuria (2) Cystic fibrosis

(3) Thalassemia (4) Haemophilia

Ans. (1) Phenylketonuria

10. Life cycle of *Drosophila melanogaster* is completed in :- **[CBSE Term-I 2022]**

(1) 7 days (2) 14 days (3) 21 days (4) 28 days

Ans. (2) 14 days

11. How many types of gametes would develop by an organism with genotype AaBBCcDD? **[CBSE Term-I 2022]**

(1) 1 (2) 2 (3) 3 (4) 4

Ans. (4) 4

12. In Pisum sativum the flower colour may be Violet (V) or White (v). What e offsprings in a cross of VV × vv would be expected to be violet? **[CBSE Term-I 2022]**

(1) 25% (2) 50% (3) 75% (4) 100%

Ans. (4) 100%

13. Which one of the gene pair is expected to give a ratio of 1 : 1 : 1 : 1 in the progeny of a Mendelian Dihybrid cross? **[CBSE Term-I 2022]**

(1) AaBb × AbBb (2) AABB × AaBb

(3) AaBb × aabb (4) AABB × aabb

Ans. (3) AaBb × aabb

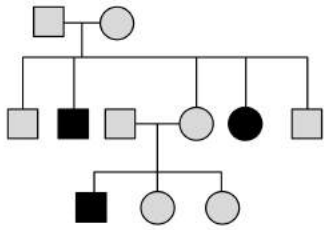
14. The progeny of a cross between two snapdragon plants heterozygous for flower colour, bearing different coloured flower would be: **[CBSE Term-I 2022]**

(1) 50% pink, 50% white (2) 25% red, 50% pink, 25% white

(3) 50% red, 50% white (4) 75% red, 25% white

Ans. (2) 25% red, 50% pink, 25% white

15. Study the given pedigree of a family and select the trait that shows this pattern of inheritance **[CBSE Term-I 2022]**



(1) Autosomal recessive, Phenylketonuria

(2) Sex-linked recessive, Colour blindness

(3) Autosomal dominant, Myotonic dystrophy

(4) Sex-linked dominant, Vitamin D resistant rickets

Ans. (1) Autosomal recessive, Phenylketonuria

16. A child with blood group A has father with blood group B and mother with blood group AB. What would be the possible genotypes of parents and the child? Choose the correct option: **[CBSE Term-I 2022]**

	Father	**Mother**	**Child**
(1)	I^Ai	I^Bi	I^Ai
(2)	I^AI^B	I^Ai	I^AI^A
(3)	I^Bi	I^AI^B	I^Ai
(4)	I^BI^B	I^AI^B	I^AI^A
Ans. (3)	**I^Bi**	**I^AI^B**	**I^Ai**

17. In a dihybrid Mendelian cross, garden pea plants heterozygous for violet flowe s are crossed with homozygous white flowers and wrinkled seeds. The genotypic and phenotypic ratio of F_1 progeny would be: **[CBSE Term-I 2022]**

(1) 9 : 3 : 3 : 1 (2) 1 : 2 : 2 : 1 (3) 1 : 1 : 1 : 1 (4) 3 : 1

Ans. (3) 1 : 1 : 1 : 1

18. Colour blindness is a sex linked recessive trait in humans. A man with normal colour vision marries a women who is colourblind. What would be the possible genotypes of the parents, the son and the daughter of this couple? **[CBSE Term-I 2022]**

	Mother	**Father**	**Daughter**	**Son**
(1)	XX	X^CY	X^CX	XY
(2)	X^CX^C	X^CY	X^CX^C	X^CY
(3)	X^CX	X^CY	X^CX	XY
(4)	X^CX^C	X^CY	X^CX	X^CY
Ans. (4)	**X^CX^C**	**X^CY**	**X^CX**	**X^CY**

19. How many types of gametes can be produced in a diploid organism which is heterozygous for 4 loci? **[CBSE Term-I 2022]**

(1) 4 (2) 8 (3) 16 (4) 32

Ans. (3) 16

20. The recombinant Frequency between the four linked genes is as follows:

(i) between X and Y is 40%. (ii) between Y and Z is 30%.

(iii) between Z and W is 10%. (iv) between W and X is 20%.

Select the option that shows the correct order of the position of W, X, Y and Z genes on the chromosome: **[CBSE Term-I 2022]**

(1) Y – X – Z – W (2) Y – W – Z – X (3) X – Y – Z – W (4) Z – X – Y – W

Ans. (2) Y– W – Z – X

21. A snapdragon plant with violet flowers was crossed with another such plant with white flowers. The F1 progeny obtained had pink flowers. Explain, in brief, the inheritance pattern seen in offsprings of F1 generation? [CBSE IMP Question]

Ans. The inheritance is incomplete dominance. In this, a new intermediate phenotype between the two original phenotypes is obtained. One allele for a specific trait is not completely expressed over the other allele for the same trait.

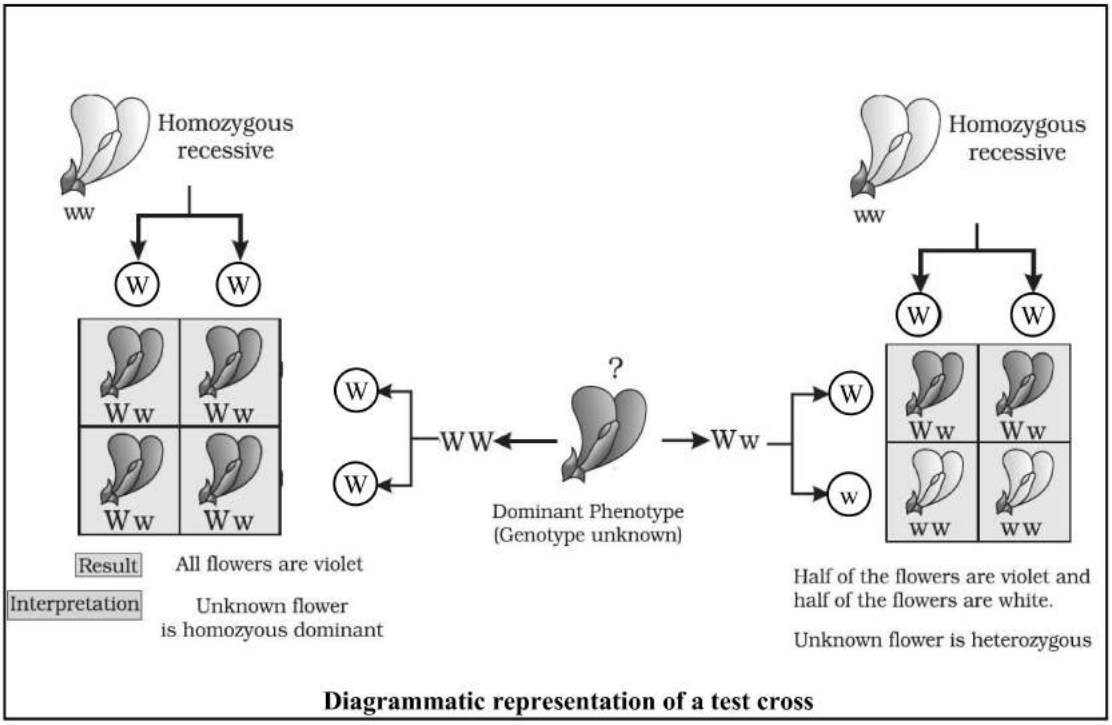
22. Karyotype of a child shows trisomy of chromosome number 21. Identify the disorder and state the symptoms which are likely to be exhibited in this case. [CBSE IMP Question]

Ans. Disorder - Down's Syndrome

Symptoms: The affected individual is short statured with small round head, has furrowed tongue, partially open mouth, Palm is broad with characteristic palm crease, Physical, psychomotor and mental development is retarded (any three symptoms)

23. **How would you find out the genotype of a pea plant with violet flowers? e help of Punnets' square showing crosses.** **[CBSE IMP Question]**

Ans.



Diagrammatic representation of a test cross

24. **What is aneuploidy? Name a chromosomal disorder in humans caused due to (a) gain of an autosome, and (b) loss of a sex chromosome in females.** **[CBSE 2020]**

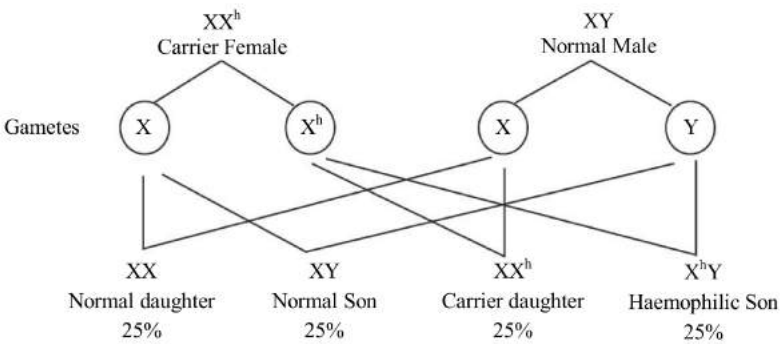
Ans. Aneuploidy is Failure of segregation of chromatids (during cell division), resulting in gain or loss of a chromosome (s)

(a) Gain of an autosome - Down's syndrome

(b) Loss of a sex chromosome - Turner's syndrome

25. **A normal couple has their first child, who is haemophilic. Work out a cross to show how it is possible. State the possibility of the normal and the haemophilic children, along with their sexes, that can be born to them.** **[CBSE 2020]**

Ans.



26. State Mendel's Law of Independent Assortment.

Ans. When two pairs of traits (characters) are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters.

27. Write one example each of organisms exhibiting (i) male heterogamety, and (ii) female heterogamety. [CBSE 2019]

Ans. (i) Human / *Drosophila* / Grasshopper (ii) Birds / Chicken

28. Why is the frequency of red-green colour blindness more in human males than in females? Explain. [CBSE 2019]

Ans. Gene for colour blindness is located on X chromosome in human, it is a recessive gene, since human males have single X chromosome the recessive gene always expresses when present, where as in human females as they have two X chromosomes the trait is expressed only if both the sex chromosomes have this recessive gene.

29. How is polygenic inheritance different from pleiotropy ? Give one example of each.

[CBSE 2019]

Ans.

Polygenic inheritance	Pleiotropy
a) A single trait influenced by many genes	a) A single gene can exhibit multiple phenotypic expression
b) e.g human height/ skin colour in humans controlled by three or more genes.	b) e.g phenylketonuria , characterised by mental retardation / reduction in hairs and / skin pigmentation

30. Write the sex of a human having XXY chromosomes with 22 pairs of autosomes. Name the disorder this human suffers from. [CBSE 2018]

Ans. Male, Klinefelter's syndrome

C) MULTIPLE CHOICE QUESTIONS

1. An organism's genetic constitution is called its

(1) Genotype (2) Phenotype (3) Holotype (4) None of these

Ans. (1) Genotype

2. An organism with two identical alleles for a given trait is

(1) Homozygous (2) Segregating (3) Dominant (4) A hermaphrodite

Ans. (1) Homozygous

3. What type of gametes will be formed by genotype RrYy?

(1) RY, Ry, YY, ry (2) RY, Ry, ry, ry (3) RY, Ry, rY, ry (4) Rr, RR, Yy, YY

Ans. (3) RY, Ry, rY, ry

4. Which genotype characterizes an organism that is heterozygous for two genes?

(1) RRYy (2) RrYY (3) RRYY (4) RrYy

Ans. (4) RrYy

5. Which of the following is the dominant character according to Mendel?

(1) Dwarf plant and yellow fruit (2) Terminal fruit and wrinkled seed

(3) White testa and yellow pericarp (4) Green coloured pod and rounded seed

Ans. (4) Green coloured pod and rounded seed

6. Self-pollination between Tt and Tt plants results into the genotype ratio of

(1) 3 : 1 (2) 1 : 2 : 1 (3) 1 : 3 (4) 4 : 0

Ans. (2) 1 : 2 : 1

7. Mendel's law of heredity can be explained with the help of

(1) Mitosis (2) Meiosis

(3) Both mitosis and meiosis (4) None of these

Ans. (2) Meiosis

8. Genes do not occur in pair in :-

(1) Gametes (2) Embryo (3) Zygote (4) Somatic Cell

Ans. (1) Gametes

9. When heterozygous tall plants are self-pollinated, then tall and dwarf plants are obtained. This explains

(1) Law of purity of gamete (2) Law of segregation

(3) Division in spores (4) Independent assortment

Ans. (2) Law of segregation

10. Mendel's principle of segregation was based on the separation of alleles in the

(1) Pollination (2) Embryonic development

(3) Seed formation (4) Gamete formation

Ans. (4) Gamete formation

11. A cross between a homozygous recessive and a heterozygous plant is called

(1) Monohybrid cross (2) Dihybrid cross (3) Test cross (4) Back cross

Ans. (3) Test cross

12. Cross between F_1 plant and recessive female plant is called

(1) Back cross (2) Test cross (3) Out cross (4) Mutation

Ans. (2) Test cross

13. In F_2 generation, a phenotypic ratio of 1 : 1 : 1 : 1 exhibits

(1) Back cross (2) Monohybrid test cross

(3) Lethality (4) Dihybrid test cross

Ans. (4) Dihybrid test cross

14. Which of the following depicts the Mendel's dihybrid ratio?

(1) 3 : 1 (2) 9 : 3 : 3 : 1 (3) 9 : 7 (4) 15 : 1

Ans. (2) 9 : 3 : 3 : 1

15. Inheritance of ABO blood group system is an example of

(1) Multiple allelism (2) Partial dominance (3) Epistasis (4) Dominance

Ans. (1) Multiple allelism

16. Genotype of blood group 'A' will be

(1) I^AI^A (2) I^BI^B (3) I^AI^A or I^AI^O (4) I^AI^O

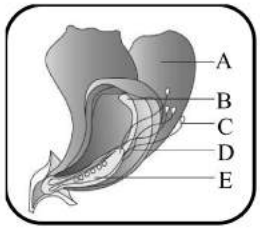
Ans. (3) I^AI^A or I^AI^O

17. Blood group 'B' will have alleles

(1) ii (2) I^AI^A (3) I^BI^B (4) I^AI^B

Ans. (3) I^BI^B

18. Identify A to E in this figure.



(1) A: Petal; B: Stigma; C: Anther; D: Stamen; E: Carpel

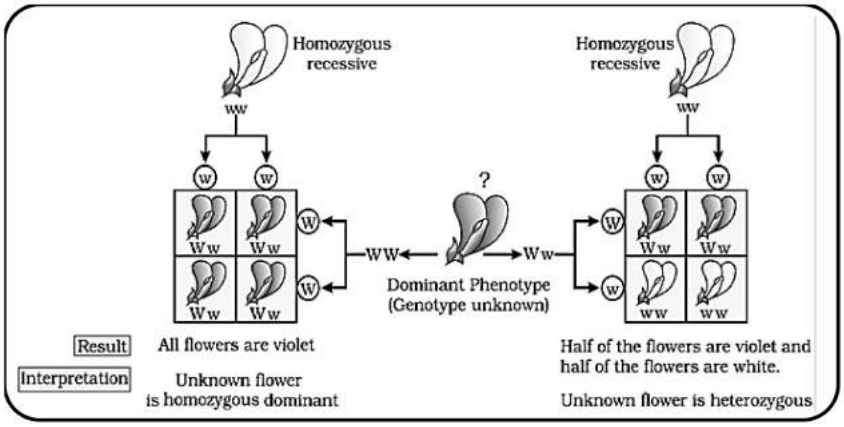
(2) A: Anther; B: Petal; C: Stigma; D: Carpel; E: Stamen

(3) A: Carpel; B: Stamen; C: Anther; D: Stigma; E: Petal

(4) A: Stigma; B: Petal; C: Stamen; D: Anther; E: Carpel

Ans. (1) A: Petal; B: Stigma; C: Anther; D: Stamen; E: Carpel

19. The below diagram represents



(1) Back cross (2) Out cross (3) Test cross (4) Dihybrid cross

Ans. (3) Test cross

20. If in a dihybrid cross, Mendel had used two such characters which have linked, he would have faced difficulty in explaining the results on the basis of

(1) Law of segregation (2) Law of multiple factor hypothesis

(3) Law of independent assortment (4) Law of dominance

Ans. (3) Law of independent assortment

(D) ASSERTION & REASON QUESTIONS

Directions: In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:

(1) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
(2) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
(3) If Assertion is true but Reason is false.
(4) If both Assertion and Reason are false.

1. **Assertion:** A good example of multiple alleles is ABO blood group system.
Reason: When I^A and I^B alleles are present together in ABO blood group system, they both express their own types of sugar.
Ans. (2)

2. **Assertion :** In *Mirabilis*, selfing of F_1 pink flower plants produces same phenotypic & genotypic ratio.
Reason : Flower colour gene shows incomplete dominance.
Ans. (1)

3. **Assertion:** By means of dihybrid cross, the law of independent assortment can be studied.
Reason: The law of independent assortment is applicable only to linked genes.
Ans. (3)

4. **Assertion :** In case of incomplete linkage, linked gene show new combination along with parental combination.
Reason : In case of incomplete linkage, linked genes are separated by crossing over.
Ans. (1)

5. **Assertion:** When white eyed, yellow bodied *Drosophila* females were hybridized with red eyed, brown-bodied males; and F1 progeny was intercrossed, F2 ratio deviated from 9 : 3 : 3 : 1.
Reason: When two genes in a dihybrid are on the same chromosome, the proportion of parental gene combinations are much higher than the non parental type.
Ans. (1)

6. **Assertion:** The maximum frequency of recombination, that can result from crossing over between linked genes, is 50 percent.
Reason: Higher frequency of crossing over is shown in linked genes if distance between them is longer.
Ans. (2)

7. **Assertion :** The linked genes tend to get inherited together.
Reason : The link between them fails to break.
Ans. (1)

8. **Assertion :** The females are diploid having 32 chromosomes in honeybee.
Reason : The male are haploid having 16 chromosomes in honeybee.
Ans. (2)

9. **Assertion :** Most of experiments regarding sex determination were done on *Drosophila*.
Reason : It is fruit fly.
Ans. (2)

10. **Assertion :** In birds, the chromosome composition of the egg determines the sex.
Reason : Female birds are heterogametic.
Ans. (1)

(E) VERY SHORT ANSWER QUESTIONS

1. **How many type of gametes produced by the individual with genotype AABBCCDD and AaBbCcDd?**

Ans. One type of gamete by individual AABBCCDD and sixteen ($2^4 = 16$) type of gametes by individual AaBbCcDd.

2. **Mention the type of allele that expresses itself only in homozygous state in an organism.**

Ans. Recessive allele.

3. **Write the percentage of F_2 homozygous and heterozygous populations in a typical monohybrid cross.**

Ans. The ratio of a typical monohybrid cross is 1 : 2 : 1 where 50% are homozygous and 50% are heterozygous populations. (25% homozygous dominant, 25% homozygous recessive).

4. **Name the type of cross that would help to find the genotype of a pea plant bearing violet flowers.**

Ans. Test cross.

5. **A cross was carried out between two pea plants showing the contrasting traits of height of the plant. The result of the cross showed 50% of parental characters. Name the type of cross.**

Ans. Test cross

6. **Why, in a test cross, did Mendel cross a tall pea plant with a dwarf pea plant only?**

Ans. To determine the genotype of the tall plant, whether it is homozygous dominant or heterozygous, as dwarfness is a recessive trait which is expressed only in homozygous condition and he was sure of genotype of dwarf plant.

7. **Name the stage of cell division where segregation of an independent pair of chromosomes occurs.**

Ans. Anaphase-I of Meiosis-I.

8. **In a dihybrid cross, when would the proportion of parental gene combinations be much higher than non-parental types, as experimentally shown by Morgan and his group?**

Ans. When the genes are linked.

9. **If the frequency of a parental form is higher than 25% in dihybrid test cross, what does that indicate about the two genes involved?**

Ans. It shows that the two genes are linked.

10. **If two genes are located far apart from each other on a chromosome, how the frequency of recombination will get affected?**

Ans. Frequency of recombination will be higher.

(F) SHORT ANSWER QUESTIONS

1. Name the base change and the amino acid change, responsible for sickle cell anaemia.

Ans. AG changes as GUG, Glutamic acid is substituted by Valine.

2. Name any one plant that shows the phenomenon of incomplete dominance during the inheritance of its flower colour.

Ans. Snapdragon or *Antirrhinum sp.*

3. What is point mutation and frame shift mutation ?

Ans. Point Mutation : Arises due to change in a single base pair of DNA e.g., sickle cell anaemia.

Frame shift mutation : Deletion or insertion/ duplication/addition of one or two bases in DNA.

4. What is pedigree analysis?

Ans. A pedigree is a record of inheritance of a specific genetic trait for two or more generations which is presented in the form of a diagram or family tree. Pedigree analysis is an analysis of several generations of a family which is used on human beings.

5. Write the sex of a human having XXY chromosomes with 22 pairs of autosomes. Name the disorder this human suffers from.

Ans. Male, Klinefelter's syndrome

6. A haemophilic father can never pass the gene for haemophilia to his son. Explain.

Ans. It is a sex linked recessive disorder in which X-chromosome has the haemophilic gene.

- Son inherits a Y chromosome from father and gene for haemophilia is not present on Y chromosome

7. A colour blind boy is born to a couple with a normal colour vision. Write the genotype of the parents.

Ans. Father - XY, Mother -XX^C

8. What is a test cross ? How can it decipher the heterozygosity of a plant?

Ans. A cross to analyse whether genotype of dominant individual is homozygous or heterozygous

On crossing with a recessive parent, if 50% of progeny have dominant trait and 50% have recessive trait then the plant is said to be heterozygous

9. What happens when chromatids fail to segregate during cell division cycle? Explain your answer with an example.

Ans. Failure of segregation of chromatids during cell division cycle results in the gain or loss of chromosome called aneuploidy.

E.g. (i) Down' syndrome results in the gain of extra copy of chromosome 21

(ii) Turner's syndrome results due to loss of an X-chromosome in human female.

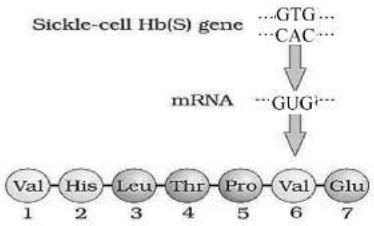
10. ABO blood groups is a good example of co-dominance. Justify.

Ans. – ABO blood group in humans is contributed by gene 'I' that has 3 alleles 'I^A' 'I^B' and 'i'.

- Because human beings are diploid each person has two of the three alleles.
- I^A and I^B produce two different types of sugar while allele **i** does not produce sugar on the plasma membrane of RBC.
- When I^A and I^B are present they both express their own type of sugar- this is codominance

(G) LONG ANSWER QUESTIONS

1. Given below is the representation of a relevant part of amino acid composition of the β-chain of haemoglobin, related to the shape of human red blood cells.



Hbs peptide

(a) Is this representation of the sequence of amino acids indicating a normal human or a sufferer from a certain blood related genetic disease? Give reason in Support of your answer.

(b) Why is the disease referred to as a Mendelian disorder? Explain.

Ans. (a) Suffered human, because at 6th position of the chain Valine is present.

(b) Alteration / mutation occurs in a single gene, at 6th position Glutamic acid replaces Valine.

2. (a) How would you find out whether a given tall garden pea plant is homozygous or heterozygous?

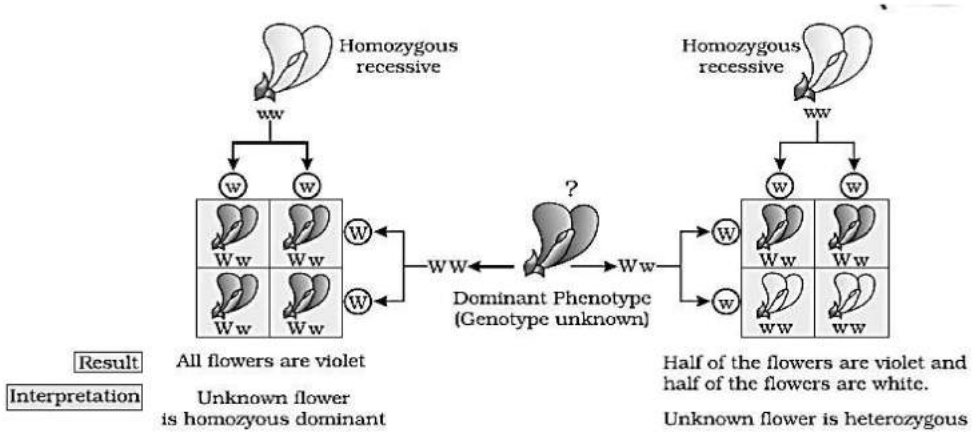
Substantiate your answer with the help of Punnett squares.

(b) Given below are the F2-phenotypic ratios of two independently carried Monohybrid crosses:

(i) 1 : 2 : 1 **(ii) 3 : 1**

Mention what does each ratio suggest.

Ans. (a) By Test Cross / crossing the organism with dominant phenotype (but unknown genotype) with the recessive individual.



(b) (i) Incomplete Dominance **(ii)** Dominance

3. Give the answer of following questions.

(a) Why are thalassemia and haemophilia categorized as Mendelian disorders ? Write the symptoms of these diseases. Explain their pattern of inheritance in humans.

(b) Write the genotypes of the normal parents producing a haemophilic son.

Ans. (a) The thalassemia and haemophilia categorized as Mendelian disorder becau d due to alteration or mutation in single gene.

S.No.	Haemophilia	Thalassemia
1	Single protein involve in the clotting of blood is affected	Defects in the synthesis of globin leading to formation of abnormal haemoglobin
2	Sex linked recessive disorder	Autosomal recessive disorder
3	Blood does not clot	Results in anaemia

Inheritance pattern:

- The thalassemia is autosomal recessive disorder which inheritate like non criss-cross form both heterozygous parents to any progeny or both recessive parents to all progeny.
- The haemophilia is Sex linked recessive disorder so that inheritate like criss-cross, from carrier mother to affected son to carrier daughter. In haemophilia the the female are carrier while male are patient, female may be patient in case of their parents (both male and female) carry gene for haemophilia

(b) The genotype of parents of haemophilic son is that father is normal (XY) and mother is carrier($X^C X$).

4. (a) Compare in any three ways the chromosomal theory of inheritance as proposed by Sutton and Bovery with that of experimental results on pea plant presented by Mendel.

(b) Mendel published his work on inheritance of characters in 1865 but it remained unrecognized till 1900. What are the reasons behind this.

Ans. (a)

S.No.	Sutton And Bovery	Mendel
1	Chromosomes occur in pairs	Factors occur in pairs
2	Chromosomes segregate at the time of gamete formation such that only one of each pair is transmitted to a gametes	Factors segregate at gamete formation stage and only one of each pair is transmitted to a gamete
3	Independent pairs of chromosomes segregate independently of each other	One pair of factors segregate independently of another pairs

(b) There are following reasons behind unrecognization of Mendel work.

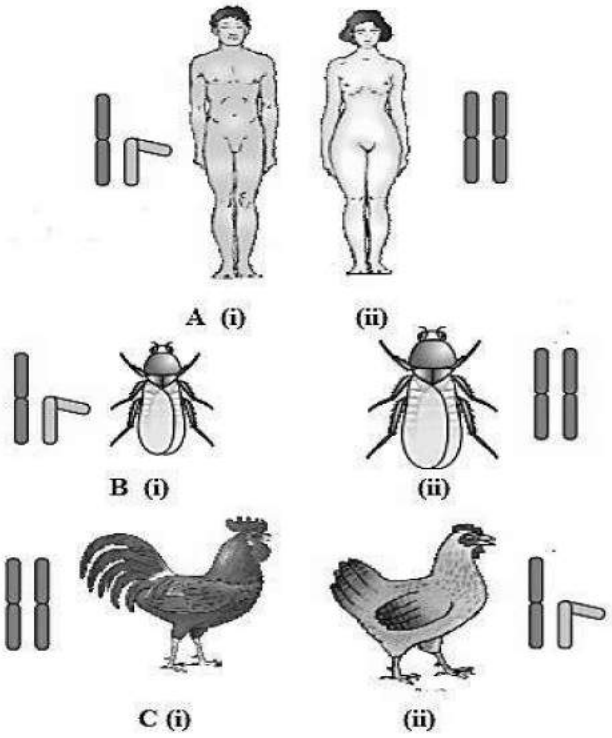
(i) The communication was not easy in those days and his work could not be widely published.

(ii) His concept of genes or factor as stable and discrete unit that control the expression of traits and, of the pair of allele which did not blend each other, was not accepted by his contemporaries as an explanation for the apparently continuous variations seen in nature.

(iii) Mendel's approach of using mathematics to explain biological phenomena was totally new and unacceptable to many of the biologists of his time.

(iv) Finally, though Mendel's work suggested that factors (genes) were discrete units, he could not provide any physical proof for the existence of factor.

5. **The given below is the figure of sex determination into three (A ,B and C). Observe it and give the answer of question that follow.** 1



(a) Which of the animal show male heterogamety?

(b) Is the sperm or egg responsible for the sex of the chicks?

(c) In our society the women are often blamed for giving birth to daughters. Can you explain why this is not correct?

Ans. **(a)** The male parent of both A and B show male haterogamety that they formed two type of gametes.

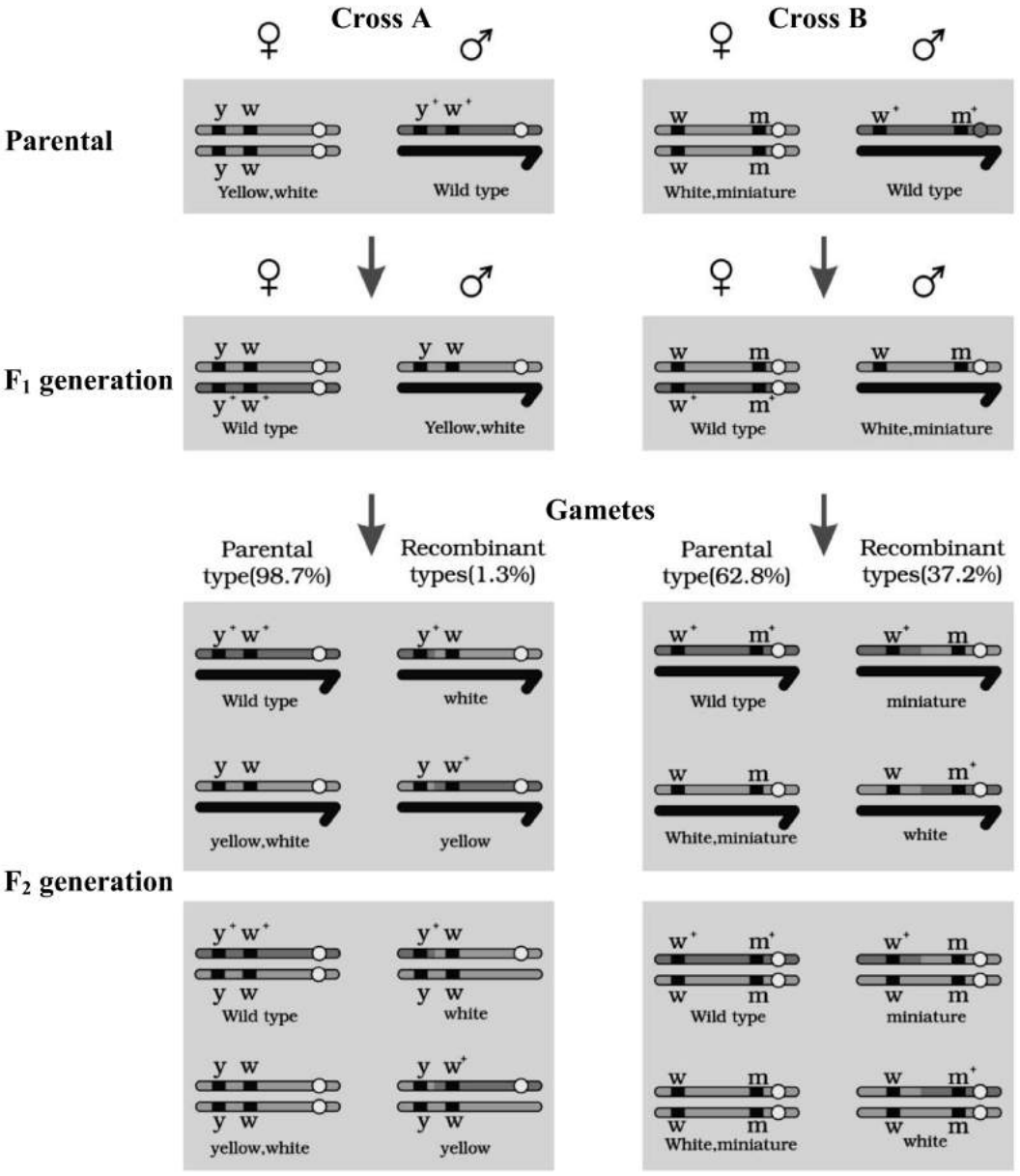
(b) The egg is responsible for the sex of chicks because the female is heterogametic which formed two different type of gametes with sex chromosome (Z and W) while male formed only one type of gametes (Z).The combination of W from female with Z of male formed the female progeny.

(c) This is not correct to blame women for giving birth to daughter. The male sperm contain either X or Y chromosome whereas the female egg contain only X chromosome. At the time of fertilization, sperm with Y chromosome combine with egg containing X chromosome formed which would be male. Thus scientifically sex of the baby is determined by the father and not by the mother as blamed in our society.

(H) CASE-STUDY BASED QUESTIONS

1. Study the following and answer the questions given below :

During a study of inheritance of two genes, teacher asked students to perform an experiment. The students crossed white eyed, yellow bodied female *Drosophila* with a red eyed, brown bodied male *Drosophila* (i.e., wild). They observed that progenies in F_2 generation had 1.3 percent recombinants and 98.7 percent parental type combinations. The experimental cross with results is shown in the given figure.



(i) Identify in which of the crosses, the strength of linkage between the ge e reasons in support of your Answer?

Ans. The strength of linkage is higher in the cross A than in cross B because linkage is higher when two genes are present closely on the same chromosome than those gene which are far a part. In cross B the chance of crossing over or recombination are higher because the genes are lossely linked.

(ii) Write the scientific name of fruitfly?

Ans. *Drosophila melanogaster*

(iii) Why did morgan prefer to work with fruit flies for his experiments? State any two reasons.

Ans. (i) It complete its life cycle in about two weeks. (ii) a single mating could produce a large number of progeny flies.

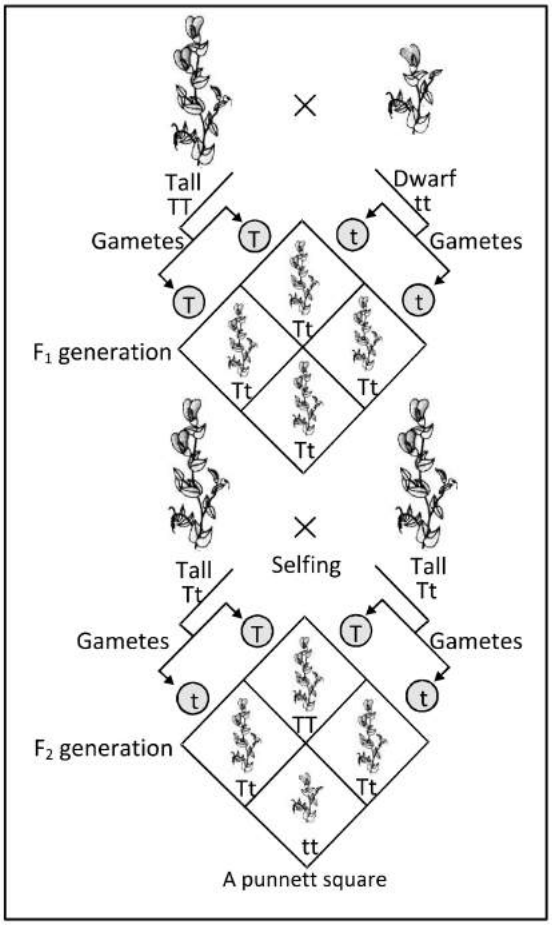
(iv) How did morgan show the deviation in inheritance - Pattern in Drosophila with respect to this law.

Ans. Morgan found that linkage is an exception to the law of Independent assortment.

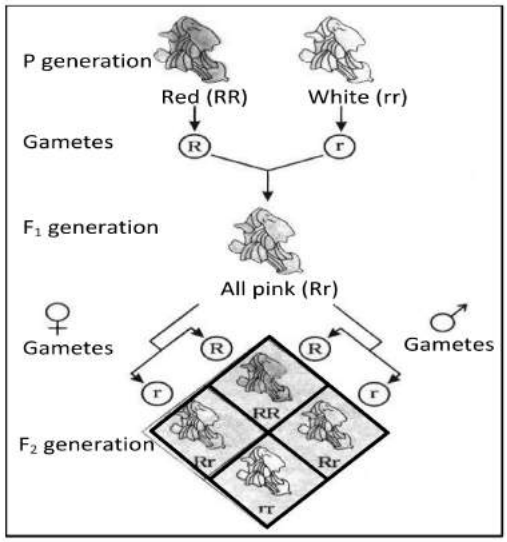
2. Study the following and answer the questions given below:

The given below is inheritance pattern of plant height (Subject-1) and flower colour in snapdragon plant (Subject-2) study it give the answer of asked questions.

Subject-1



Subject-2



(i) What type of cross represented by subject - 1 and subject - 2 respectively?

Ans. Subject-1 → Monohybrid cross

Subject-2 → Incomplete Dominance

(ii) What are genotype and phenotype ratio of F_2 generation of subject - 1?

Ans. Genotype = 1 : 2 : 1

Phenotype = 3 : 1

(iii) The appearance of pink flowers is not known as blending why? (Subject-2)

Ans. Blending is the mixing of two colours but in this example red and white colours appear indepently at cellular level. Thus no blending occurs. The red and white colours reappear in F_2 generation.

(iv) Phenotypic and genotypic ratio is similar in case of -

Ans. Incomplete dominance (Subject-2)

3. Read the following and answer the questions given below:

Haemophilia is a sex linked disease which is also known as bleeder's disease as the patient will continue to bleed even from a minor cut since he or she does not possess the natural phenomenon of blood clotting due to absence of anti-haemophilic globulin or factor VIII and plasma thromboplastin factor IX essential for it. As a result of continuous bleeding the patient may die of blood loss. Colour blindness is another type of sex linked trait in which the eye fails to distinguish red and green colours. Vision is however, not affected and the colour blind can, lead a normal life, reading, writing and driving (distinguishing traffic lights by their position).

(i) Which of the blood clotting factors are absent in the patient who suffered from haemophilia?

Ans. Anti-haemophilic globulin or factor VIII and plasma thromboplastin factor IX essential for it.

(ii) A man whose father was colour blind and mother was normal marries a woman whose father was haemophilic and mother was normal . Write the ration of possible progenies.

Ans. 25% male progenies and 25% female progenies carry the gene of haemophilia.

(iii) If a haemophilic man marries a woman whose father was haemophilic and mother was normal then what will be normal, carrier and haemphilic in female progenies.?

Ans. Of the total number of daughters,0% daughter are normal 50% daughters are carriers and 50% are haemophilic.

(iv) A hemophilic father can never pass the gene for hemophilia to his son. Explain.

Ans. The hemophilia is X-linked recessive disorder where female is carrier while male is patient in case of present of single X chromosome. The X chromosome of male only passed to daughter and Y to son. So that the son of hemophilic father is never be a patient.

(v) About 8% male the human population are colourblind whereas only 0.4 e colour – blind. Write an explanation to show how it is possible.

Ans. Colour blind is a X linked recessive disorder. Male have higher chances of getting affected in comparison to females because male have only one X with Y chromosome and female have XX chromosome Thus for a female to get affected by colour blindness,she has to have the mutate gene on both the X chromosome while male can be affected, if they carry it on the single X chromosome.

4. Read the following and answer the questions given below:

Turner's syndrome is an example of monosomy. It is formed by the union of an allosome free egg and a normal 'X' containing sperm or a normal egg and an allosome free sperm. The individual has 2n = 45 chromosomes = (44 + X0) instead of 46. Such individuals are sterile females who have rudimentary ovaries, under developed breasts, small uterus, short stature, webbed neck and abnormal intelligence. They may not menstruate or ovulate . This disorder can be treated by giving female sex hormone to the women from the age of puberty to make them develop breasts and have menstruation. This makes them feel more normal.

(i) Write the karyotype of Turner's syndrome.

Ans. 44+ XO

(ii) Write the number of Bar body present in a female with Turner's syndrome.

Ans. 0 Bar Body.

(iii) What is the reason behind a person to be Turner's syndrome?

Ans. It is due to the union of an allosome free egg and a normal 'X' containing sperm or a normal egg and an allosome free sperm.

(iv) Write the symptoms of Turner's syndrome.

Ans. Such individuals are sterile females who have rudimentary ovaries, under developed breasts, small uterus, short stature, webbed neck and abnormal intelligence. They may not menstruate or ovulate.

(v) Write the treatment for Turner's syndrome.

Ans. This disorder can be treated by giving female sex hormone to the women from the age of puberty to make them develop breasts and have menstruation. This makes them feel more normal.