03 Inheritance and Variation

Syllabus

3.1 Chromosomes and Mechanism of Inheritance

INTEXT

Q.1 Can you recall ?

i. **Is there a similarity between the parents and offsprings?**

Ans :

Yes, As the offsprings receive their genetic information from parents there is a similarity between them.

ii. **How are hybrid seeds produced?**

Ans : A hybrid plant is produced by crossing two plants having desired characters, these varieties of crop plants need not be closely related. These hybrids grow vigourously and produce more seeds than either parent.

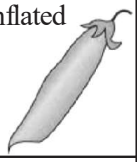
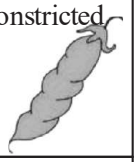
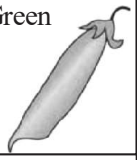
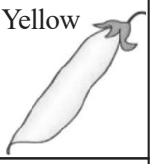
Q.2 Define Heredity/Inheritance.

Ans : The transmission of genetic information from generation to generation is known as heredity or inheritance.

TEXTUAL

★Q.3 Enlist seven fruits of pea plant selected/ studied by Mendel.

Ans :

Plant Traits	Dominant	Recessive
Seed shape	Round 	Wrinkled 
Seed color	Yellow 	Green 
Pod shape	Inflated 	Constricted 
Pod color	Green 	Yellow 
Flower color	Purple 	White 
Flower location	Axial 	Terminal 
Plant height	Tall 	Short (Dwarf) 

★Q.4 What are the reasons for Mendel's success?

Ans : The reasons for Mendel's success are as follows:

i. His experiments were carefully planned and involved large sample.

ii. He carefully recorded the number of plants of each type and expressed his results as ratios.

iii. In the pea plant, contrasting characters can

be easily recognized.

iv. The seven different characters in pea plant were controlled by a single factor each. The factors are located on separate chromosomes and these factors are transmitted from generation to generation.

v. He introduced the concepts of dominance and recessiveness.

MULTIPLE CHOICE QUESTIONS

Entrance Set 1

1. Among the following characters, which one was not considered by Mendel in his experiments on pea?
   (a) Trichomes-Glandular or non-glandular
   (b) Seed-Green or yellow
   (c) Pod-Inflated or constricted
   (d) Stem-Tall or dwarf

   Mendel considered the following characters of pea in his experiments:

	Character	Dominant	Recessive
1	Seed shape	Round (r)	Wrinkled (r)
2	Seed cotyledon	Yellow (Y)	Green (y)
3	Flower colour	Violet (V)	White (v)
4	Pod shape	Inflated (I)	Constricted (i)
5	Pod colour	Green (G)	Yellow (g)
6	Flower position	Axial (A)	Terminal (a)
7	Sten height	Tall (T)	Dwarf (t)

2. Which one from those given below is the period for Mendel's hybridisation experiments?
   (a) 1840-1850 (b) 1857-1869
   (c) 1870-1877 (d) 1856-1863

   Mendel carried out hybridisation experiments on garden pea for 7 years from 1856-1863.

3. In his classic experiments on pea plants, Mendel did not use
   (a) seed shape
   (b) flower position
   (c) seed colour
   (d) pod length.

   Mendel considered the following characters of pea in his experiments:

	Character	Dominant	Recessive
1	Seed shape	Round (r)	Wrinkled (r)
2	Seed cotyledon	Yellow (Y)	Green (y)
3	Flower colour	Violet (V)	White (v)
4	Pod shape	Inflated (I)	Constricted (i)
5	Pod colour	Green (G)	Yellow (g)
6	Flower position	Axial (A)	Terminal (a)
7	Sten height	Tall (T)	Dwarf (t)

4. How many pairs of contrasting characters in pea plants were studied by Mendel in his experiments?
   (a) Eight (b) Seven
   (c) Five (d) Six

   Mendel considered the following characters of pea in his experiments:

	Character	Dominant	Recessive
1	Seed shape	Round (r)	Wrinkled (r)
2	Seed cotyledon	Yellow (Y)	Green (y)
3	Flower colour	Violet (V)	White (v)
4	Pod shape	Inflated (I)	Constricted (i)
5	Pod colour	Green (G)	Yellow (g)
6	Flower position	Axial (A)	Terminal (a)
7	Sten height	Tall (T)	Dwarf (t)

5. Which one of the following traits of garden pea studied by Mendel was a recessive feature?
   (a) Axial flower position
   (b) Green seed colour
   (c) Green pod colour
   (d) Round seed shape

   Mendel considered the following characters of pea in his experiments:

	Character	Dominant	Recessive
1	Seed shape	Round (r)	Wrinkled (r)
2	Seed cotyledon	Yellow (Y)	Green (y)
3	Flower colour	Violet (V)	White (v)
4	Pod shape	Inflated (I)	Constricted (i)
5	Pod colour	Green (G)	Yellow (g)
6	Flower position	Axial (A)	Terminal (a)
7	Sten height	Tall (T)	Dwarf (t)

6. The genes controlling the seven pea characters studied by Mendel are now known to be located on how many different chromosomes?
   (a) Seven (b) Six
   (c) Five (d) Four

   Mendel worked on seven characters. These characters showed complete independent

assortment despite the seven characters chosen by him were present on four chromosomes-1, 4, 5 and 7.

7. How many pairs of contrasting characters in pea plants were studied by Mendel in his experiments?
(a) Five (b) Six
(c) Eight (d) Seven

8. Among the following characters, which one was NOT considered by Mendel in his experiments on pea?
(a) Stem - Tall or Dwarf
(b) Trichomes - Glandular or non-glandular
(c) Seed - Green or Yellow
(d) Pod - Inflated or Constricted

Try yourself

9. Alleles was
(a) different phenotype
(b) true breeding homozygotes
(c) different molecular forms of a gene
(d) heterozygotes

10. Two alternative forms of a gene or alleles are located on _____.
(a) identical loci of the same chromosome
(b) non-identical loci of the same chromosome
(c) identical loci of homologous chromosomes
(d) non-identical loci of homologous chromosomes

11. Multiple alleles are present
(a) an different chromosomes
(b) at different loci on the same chromosome
(c) at the same locus of the chromosome
(d) on non-sister chromatids.

12. A true breeding plant is
(a) always homozygous recessive in its genetic constitution
(b) one that is able to breed on its own
(c) produced due to cross pollination among unrelated plants
(d) near homozygous and produces offspring of its kind

13. Which of the following cross will give recessive progeny in F_1 generation?
(a) TT × tt (b) Tt × TT
(c) tt × tt (d) TT × TT

14. A tall true breeding garden pea plant is crossed with a dwarf true breeding garden pea plant. When the F_1 plants were selfed the resulting genotypes were in the ratio of
(a) 3 : 1 : : Tall : Dwarf
(b) 3 : 1 : : Dwarf : Tall
(c) 1 : 2 : 1 :: Tall homozygous : Tall heterozygous : Dwarf
(d) 1: 2 : 1 :: Tall heterozygous : Tall homozygous : Dwarf

15. What is the possible genotypic ration in F_2 generation if a plant producing red flowers (RR) is crossed with another plant of the same species that produces white flower (rr)?
(a) Red: Pink: White 1: 3: 1 (b) RR: Rr: rr 1: 2: 1
(c) Red: White 3: 1 (d) RR: Rr: rr 2: 6: 4

16. In the first step of Monohybrid cross experiment, Mendel selected pea plants which were
(a) pure tall as male and pure dwarf as female
(b) pure tall as female and pure dwarf as male
(c) heterozygous tall as male and pure dwarf as female
(d) heterozygous tall as female and pure dwarf as male.

3.2 Genetic Terminology

TEXTUAL

★Q.5 Define the following terms:

Ans : i. Dihybrid cross ii. Homozygous iii. Heterozygous iv. Test cross

i. **Dihybrid cross:** A cross between parents differing in two heritable traits, is called dihybrid cross.

ii. **Homozygous:** An individual possessing identical allels for a particular trait, is called homozygous or pure for that trait.

iii. **Heterozygous:** An individual possessing contrasting alleles for a particular trait, is called heterozygous.

iv. **Test cross:** It is a cross of F_1 progeny with homozygous recessive parent (e.g. F_1 tall ×

pure dwarf i.e. Tt × tt). It is used to test the homozygous/ heterozygous nature of hybrid. It is a kind of back cross.

Q.6 Explain the following terms.

i. Character **ii. Trait**
iii. Factor **iv. Gene**
v. Alleles or Allelomorphs
vi. Dominant **vii. Recessive**
viii. Phenotype **ix. Genotype**
x. Homozygous **xi. Heterozygous**
xii. Pure line **xiii. Monohybrid**
xiv. F_1 generation **xv. F_2 generation**
xvi. Punnett square/checker board
xvii. Homologous Chromosomes
xviii. Back cross **xix. Test cross**
xx. Phenotypic ratio
xxi. Genotypic ratio
xxii. Monohybrid cross
xxiii. Dihybrid cross

Ans :

i. **Character:** It is a specific feature of an organism e.g. height of stem.

ii. **Trait:** An inherited character and its detectable variant e.g. Tall or dwarf.

iii. **Factor:** It is a unit of heredity, a particle present in the organism which is responsible for the inheritance and expression of a character. (factor is passed from one generation to the next through gametes). Factor determines a genetical (biological) character of an organism.

iv. **Gene :** It is a particular segment of DNA which is responsible for the inheritance and expression of that character.

v. **Alleles or Allelomorphs:** The two or more alternative forms of a given gene (factor) are called alleles of each other. They occupy identical loci (positions) on homologous chromosomes. Allele is a short form of Allelomorph.

vi. **Dominant:** It is an allele that expresses its trait even in the presence of an alternative allele i.e. in heterozygous condition only. Alternatively, the allele that expresses in F_1 is called dominant. (It is an allele of a pair that masks the expression of other allele in F_1 generation.)

vii. **Recessive:** This allele is not expressed in the presence of an alternative allele (in heterozygous condition). It expresses only in the presence of another identical allele. It is an allele that does not express in F_1 hybrid.

viii. **Phenotype:** The external apperance of an individual for any trait is called phenotype for that trait. It is observable and is determined by different combinations of alleles. e.g. In pea, for the height of stem (plant) tall and dwarf are the two phenotypes (Tall is determined by TT or Tt and dwarf by tt).

ix. **Genotype:** Genetic constitution or genetic make up of an organism with respect to a particular trait. It is representation of the genetic constitution of an individual with respect to a single character or a set of characters. e.g. pea tall plants can have genotype TT or Tt and dwarf has tt.

x. **Homozygous:** An individual possessing identical alleles for a particular trait, is called homozygous or pure for that trait. Homozygous breeds true to the trait and produces only one type of gametes e.g., tall with TT and dwarf with tt.

xi. **Heterozygous:** An individual possessing contrasting alleles for a particular trait, is called heterozygous. Heterozygous does not breed true for that trait and produces two types of gametes e.g. F_1 generation hybrids (Tt). Heterozygous individual is also called hybrid.

xii. **Pure line:** An individual or a group of individuals (population) which is homozygous or true breeding for one or more traits, constitutes pure line i.e. plant which breeds true for a particular character. It is a descendent of a single homozygous parent produced after self fertilization.

xiii. **Monohybrid:** It is heterozygous for one trait and is produced from a cross between two pure parents differing in single pair of contrasting characters e.g. Hybrid tall produced in a cross between pure tall and pure dwarf parents. It is a heterozygote for a single pair of alleles.

xiv. **F_1 generation:** It refers to the first filial generation. It consists of all off-springs produced from a parental cross. Alternatively, it is first generation from a given mating between pure parents having contrasting characters.

xv. **F_2 generation:** The second generation (progeny) produced by selfing (inbreeding) of F_1 generation offsprings is called second filial generation. e.g. Progeny produced from a cross between two F_1 individuals (e.g. Tt × Tt).

xvi. **Punnett square/checker board:** It is a probability table representing different permutations and combination of fertilization between gametes of the opposite mating types. In short, it is a diagrammatic representation of a particular cross to predict the progeny of a cross.

xvii. **Homologous Chromosomes:** The morphologically, genetically and structurally essentially identical chromosomes present in a diploid cell, are called homologous chromosomes. Such chromosomes synapse during meiosis.

xviii. **Back cross:** It is a cross of F_1 progeny with any of the parents (e.g. F_1 tall × pure tall; F_1 tall × pure dwarf i.e. Tt × TT/tt).

xix. **Test cross:** It is a cross of F_1 progeny with homozygous recessive parent (e.g. F_1 tall × pure dwarf i.e. Tt × tt). It is used to test the homozygous/ heterozygous nature of hybrid. It is a kind of back cross.

xx. **Phenotypic ratio:** It is the ratio of the offsprings produced in F_2 and subsequent generation with respect to their physical appearence e.g. 3Tall : 1 dwarf, is F_2 'Phenotypic ratio' in monohybrid cross.

xxi. **Genotypic ratio:** It is the ratio of the offsprings produced in the F_2 and subsequent generation with respect to their genetic make up e.g. 1 TT : 2Tt : 1 tt, is F_2 genotypic ratio in monohybrid cross.

xxii. **Monohybrid cross:** A cross between parents differeing in only one heritable trait is called monohybrid cross. e.g. cross of pure tall and pure dwarf plants. Mendel performed the monohybrid cross between two pea plants with only one pair of contransting character.

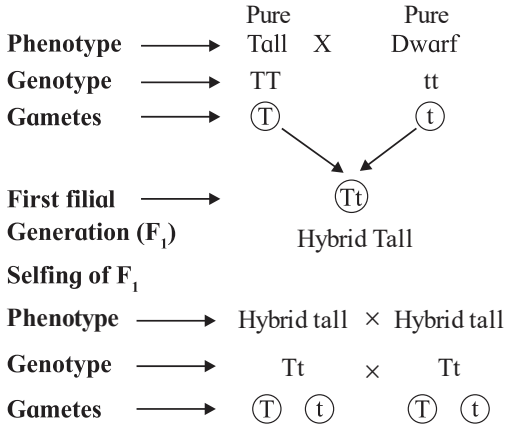
xxii. **Dihybrid cross:** A cross between parents differing in two heritable traits, is called dihybrid cross e.g. cross of pure tall, round seeded plant with dwarf, wrinkled seeded plant. Mendel also performed the dihybrid cross between pea plants that differed in two pairs of contrasting characters.

Q.7 With the help of a suitable example explain monohybrid cross.

Ans :

i. A cross between parents differing in only one heritable trait is called as Monohybrid cross e.g. cross of pure tall and pure dwarf plants.

ii. Parental generation:



F_2 generation:

♀ Female gametes ↓ / ♂ Male gametes →	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Tall

Phenotype ratio → 3 : 1
(Tall : Dwarf)

Genotype ratio → 1 : 2 : 1
(TT : Tt : tt)

TEXTUAL

★Q.8 What is dihybrid cross? Explain with suitable example and checker board method.

Ans :

i. A cross between parents differing in two heritable traits is called dihybrid cross.

eg. Cross between yellow round and green wrinkled plants.

ii. **Parental generation:**

Phenotype → Round, yellow seeds × Wrinkled, green seeds

Genotype → RRYY × rryy

Gametes → RY, ry

First filial generation (F_1) → RrYy

Round, yellow seeds

Selfing of F_1 :

Phenotype → Round, yellow seeds × Round, yellow seeds

Genotype → RrYy × RrYy

Gametes → RY Ry rY ry × Ry Ry rY ry

♀ Female gametes ↓ / ♂ Male gametes →	RY	Ry	rY	ry
RY	RRYY Round, yellow	RRYy Round, yellow	RrYY Round, yellow	RrYy Round, yellow
Ry	RRYy Round, yellow	RRyy Round green	RrYy Round, yellow	Rryy Round green
rY	RrYY Round yellow	RrYy Round yellow	rrYY Wrinkled yellow	rrYy Wrinkled yellow
ry	RrYy Round yellow	Rryy Round green	rrYy Wrinkled yellow	rryy Wrinkled green

Phenotypic Ratio → Round yellow : Wrinkled yellow : Round green : Wrinkled green

9 : 3 : 3 : 1

Genotypic Ratio →

RRYY : RrYY : RRYy : RrYy : rrYY : rryY : RRyy : Rryy : rryy

1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

iii. In dihybrid cross the phenotypic ratio of different types of offsprings (with different combinations) obtained in F_2 generation of dihybrid cross is called dihybrid ratio. It is 9:3:3:1.

INTEXT

Q.9 Activity

i. Complete the chart of monohybrid cross given.

Ans : *Refer Q.7.*

ii. Complete the chart of hybrid cross given

Ans : *Refer Q.8.*

Q.10 Use your brain power.

There are 16 possible individuals in F_2 generation. Try to find out the phenotypes as well as the genotypic and phenotypic ratios.

Ans : *Refer Q.8.*

Q.11 Can you recall?

Why are farmers and gardeners advised to buy new F_1 hybrid seeds every year?

Ans : Farmers and gardeners are advise to buy hybrid seeds every year because the fruits of the plants segregate in the progeny and thus these new progeny plant might not give the desired trait.

Q.12 Workout a cross between homozygous female and heterozygous male.

Ans : Let the female be considered to be homozygous tall thus be represented by TT and heterozygous male will be represented by Tt.

Phenotype of parents → Homozygous tall female × Heterozygous tall male

Genotype → TT × Tt

Gametes → T T × T t

F_1 generation →

♀ Female gametes ↓ / ♂ Male gametes →	T	t
T	TT Tall	Tt Tall
T	TT Tall	Tt Tall

In the first fillial generation all the offsprings exhibit the tall phenotype though genetypically 50% will be homozygous tall and 50% will be heterozygous tall.

MULTIPLE CHOICE QUESTIONS

Entrance Set 2

1. The genotypes of a husband and wife are $I^A I^B$ and $I^A i$.
Among the blood types of their children, how many different genotypes and phenotypes are possible?

(a) 3 genotypes; 4 phenotypes
(b) 4 genotypes; 3 phenotypes
(c) 4 genotypes; 4 phenotypes
(d) 3 genotypes; 3 phenotypes

If the genotypes of husband and wife are $I^A I^B$ and $I^A i$ respectively, then the probabilities of genotypes and phenotypes among their children can be worked out as:

2. A tall true breeding garden pea plant is crossed with a dwarf true breeding garden pea plant. When the F_1 plants were selfed the resulting genotypes were in the ratio of
(a) 3 : 1 : : Tall : Dwarf
(b) 3 : 1 : : Dwarf : Tall
(c) 1 : 2 : 1 : : Tall homozygous : Tall heterozygous : Dwarf
(d) 1 : 2 : 1 : : Tall heterozygous : Tall homozygous : Dwarf.

3. A pleiotropic gene
(a) controls a trait only in combination with another gene
(b) controls multiple traits in an individual
(c) is expressed only in primitive plants
(d) is a gene evolved during Pilocene.

4. Select the correct statement from the ones given below with respect to dihybrid cross.
(a) Tightly linked genes on the same chromosomes show higher recombinations.
(b) Genes far apart on the same chromosome show very few recombinations.
(c) Genes loosely linked on the same chromosome show similar recombinations.
(d) Tightly linked genes on the same chromosome show very few recombinations.

5. A human male produces sperms with the genotypes AB, Ab, aB and ab pertaining to two diallelic characters in equal proportions. What is the corresponding genotype of this person?
(a) AaBB (b) AABb
(c) AABB (d) AaBb

6. In Mendel's experiments with garden pea, round seed shape (RR) was dominant over wrinkled seeds (rr), yellow cotyledon (YY) was dominant over green cotyledon (yy). What are the expected phenotypes in the F_2 generation of the cross RRYY x rryy?
(a) pure tall as male
(a) Round seeds with yellow cotyledons, and wrinkled seeds with yellow cotyledons
(b) Only round seeds with green cotyledons
(c) Only wrinkled seeds with yellow cotyledons
(d) Only wrinkled seeds with green cotyledons

7. Phenotype of an organism is the result of
(a) genotype and envrionment interactons
(b) mutationas and linkages
(c) cytoplasmic effects and nutrition
(d) environmental changes and sexual dimorphism.

8. In a plant, red fruit (R) is dominant over yellow fruit (r) and tallness (T) is dominant over shortness (t). If a plant with RRTt genotype is crossed with a plant that is rrtt.
(a) 25% will be tall with red fruit
(b) 50% will be tall with red fruit
(c) 75% will be tall with red fruit.
(d) all the offspring will be tall with red fruit.

9. One of the parents of a cross has a mutation in its mitochondria. In that cross, that parent is taken as a male. During segregation of F_2 progenies that mutation is found in
(a) One -third of the progenies
(b) none of the progenies
(c) all the progenies
(d) fifty percent of the progenies.

10. In Mirabilis jalapa, when red and white varieties are crossed, the hybrid obtained will be _____ pink.
(a) 25% (b) 50%
(c) 75% (d) 100%

11. When two homozygous plants with red and white flowers are crossed, their offsprings show pink flowers. This indicates that the alleles of the gene for flower colour shows _____.
(a) Incomplete dominance
(b) Epistasis
(c) Complete dominance
(d) Co-dominance

12. In a phenomenon where heterozygotes have features of both the homozygotes, that is, an allele is neither dominant nor recessive to the other, Such a phenomenon is termed as
(a) Co-dominance (b) Pleiotropy
(c) Test cross (d) Dominance

13. The genotypes of a husband and wife are I^AI^B and I^Ai. Among the blood types of their children, how many different genotypes and phenotypes are possible?
(a) 3 genotypes; 3 phenotypes
(b) 3 genotypes; 4 phenotypes
(c) 4 genotypes; 3 phenotypes
(d) 4 genotypes; 4 phenotypes

14. If two persons with 'AB' blood group marry and have sufficiently large number of children, these children could be classified as 'A' blood group : 'AB' blood : 'B' blood group in 1:2:1 ratio. Modern technique of protein electrophoresis reveals presence of both 'A' and 'B' type proteins in 'AB' blood group individuals. This is an example of
(a) Co-dominance
(b) Incomplete dominance
(c) Partial dominance
(d) Complete dominance

Try yourself

15. Which of the following characteristics represent 'Inheritance of blood groups' in humans?
i. Dominance
ii. Co-dominance
iii. Multiple allele
iv. Incomplete dominance
v. Polygenic inheritance
(a) i, iv and v (b) i, ii and iii
(b) ii, iii and v (d) i, iii and v

16. ABO blood type in man is an example of
i. pleiotropy
ii. incomplete dominance
iii. co-dominance
iv. multiple allelism
Select the code for the correct answer from the options given below.
(a) i, ii and iii only
(b) i, iii and iv only
(c) iii and iv only
(d) i, ii and iv only

17. **Assertion:** A single gene may be occasionally related to more than one character.
Reason: The above phenomenon cannot be called as pleiotropy since a single gene cannot be related to more than one trait.
Which of the following is true?
(a) Both (A) and (R) are true and (R) is the correct explanation of (A).
(b) Both (A) and (R) are true and (R) is not the correct explanation of (A).
(c) (a) pure tall as male
(A) is true, but (R) is false
(d) (A) is false, but (R) is true.

18. A couple, both carriers for the gene sickle cell anaemia planning to get married, want to know the chances of having anaemic progeny?
(a) 100% (b) 75%
(c) 50% (d) 25%

19. In a person suffering from sickle cell anaemia, the _____ becomes half moon shaped.
(a) RBC (b) Thrombocyte
(c) Monocyte (d) Lymphocyte

3.3 Mendel's Laws of Inheritance

Q.13. Write a brief note on 'Law of Dominance'.

Ans :

i. In monohybrid and dihybrid crosses, the phenotypic characters are controlled by discrete units, called factors.

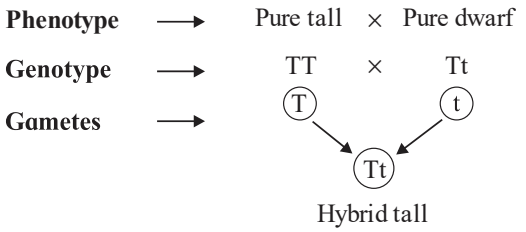
ii. In a dissimilar pair of factors, one member of the pair dominates (i.e. dominant) over the other (i.e. recessive).

iii. The law of dominance is used to explain the expression of only one of the parental characters of a monohybrid cross in F_1 and the expression of both in F_2.

iv. **Statement of Law of Dominance:** "When two homozygous individuals with one or more sets of contrasting characters are crossed, the

alleles (characters) that appear in F_1 are **dominant** and those which do not appear in F_1 are **recessive**".

e.g. Pure tall pea plant is crossed with pure dwarf pea plant.



The F_1 generation shows tall character even though the it is heterozygous thus we could infer that tall character is dominant in pea plant.

Q.14 Write a brief note on 'Law of segregation'.

Ans :

i. The law states that "When hybrid (F_1) forms gametes, the alleles segregate from each other and enter in different gametes".

ii. This law is based on the fact that the alleles do not show any blending/mixing and both the alleles (characters) are recovered as such in the F_2 generation, though one of these is not seen at the F_1 stage.

iii. During formation of gametes, these two alleles (factors) obviously separate or segregate, otherwise recessive type will not appear in F_2.

iv. The gametes which are formed are always pure for a particular character (trait).

v. A gamete may carry either dominant or recessive factor but not both. That's why it is also called as law of purity of gametes.

TEXTUAL

★Q.15 Why law of segregation is also called the law of purity of gametes?

Ans :

a. The gametes which are formed are always pure for a particular character (trait).

b. A gamete may carry either dominant or recessive factor but not both.

c. Thus, it is also called as law of purity of gametes.

Q.16 Explain with suitable example an independent assortment.

Ans :

i. The law states that "When hybrid processing two (or more) pairs of contrasting factors (alleles) forms gametes, the factors in each pair segregate independently of the other pair".

ii. This law is based on dihybrid cross. It is basic principle of genetics developed by a Mendel.

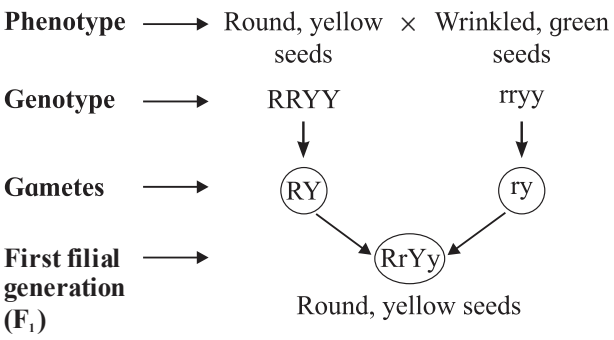
iii. It describes how different genes or alleles present on separate chromosomes independently separate from each other, during formation of gametes.

iv. These alleles are then randomly united in fertilization.

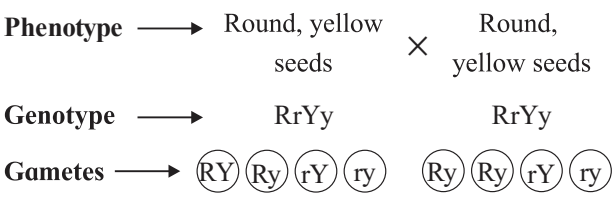
v. In dihybrid cross, F_2 phenotypic ratio 9:3:3:1 indicates that the two pairs of characters behave independent of each other.

vi. It can be concluded that the two characters under consideration are assorted independently giving rise to different combinations.

Parental generation:



Selfing of F_1 :



♀ Female gametes ↓ / ♂ Male gametes →	RY	Ry	rY	ry
RY	RRYY Round, yellow	RRYy Round, yellow	RrYY Round, yellow	RrYy Round, yellow
Ry	RRYy Round, yellow	RRyy Round green	RrYy Round, yellow	Rryy Round green
rY	RrYY Round yellow	RrYy Round yellow	rrYY Wrinkled yellow	rrYy Wrinkled yellow
ry	RrYy Round yellow	Rryy Round green	rrYy Wrinkled yellow	rryy Wrinkled green

Phenotypic Ratio → Round yellow : Wrinkled yellow : Round green : Wrinkled green
9 : 3 : 3 : 1

Genotypic Ratio

RRYY : RrYY : RRYy : RrYy : rrYY : rryY : RRyy : Rryy : rryy
1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

MULTIPLE CHOICE QUESTIONS

Entrance Set 3

1. In Antirrhinum (Snap-dragon), a red flower was crossed with a white flower and in F_1 generation all pink flowers were obtained. When pink flowers were selfed, the F_2 generation showed white, red and pink flowers. Choose the incorrect statements from the following.
   (a) Law of segregation does not apply in this experiment.
   (b) This experiment does not follow the Principle of Dominance.
   (c) Pink colour in F_1 is due to incomplete dominance.
   (d) Ratio of F_2 is $\frac{1}{4}$ (red) : $\frac{2}{4}$ (pink) : $\frac{1}{4}$ (white).
2. Which one of the following cannot be explained on the basis of Mendel's law of dominance?
   (a) The discrete unit controlling a particular character is called a factor.
   (b) Out of one pair of factors one is dominant, and the other recessive.
   (c) Alleles do not show any blending and both the characters recover as such in F_2 generation.
   (d) Factors occur in pairs
3. The _____ is a primary constriction.
   (a) telomere (b) sarcomere
   (c) chromomere (d) centromere

Try yourself

4. The chromosome with centromere near the end is called _____.
   (a) Acrocentric (b) Metacentric
   (c) Sub-metacentric (d) Telocentric
5. The chromosomes in which centromere is situated close to one end are :
   (a) Metacentric (b) Acrocentric
   (c) Telocentric (d) Sub-metacentric
6. In diploid set of chromosomes, deletion or addition of a chromosome leads to
   (a) Aneuploidy (b) Euploidy
   (c) Polyploidy (d) Triploidy

3.4 Back Cross and Test cross

TEXTUAL

★Q.17 Define 'Test cross'.

Ans : The cross of F_1 hybrid with the homozygous recessive parent is known as a **test cross**.

Q.18 Define back cross.

Ans : The cross between F_1 individual obtained in a cross with one of the two parents from which they were derived (either recessive or dominant) is called as a back cross.

Q.19 Explain test cross with the help of a graphical representation.

Ans :

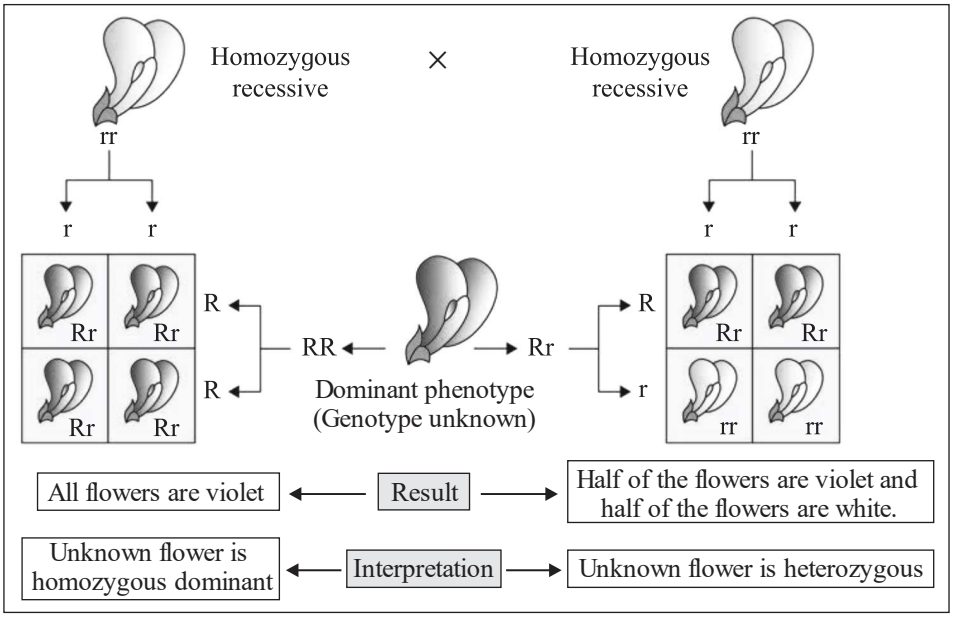
i. Test cross can be used to find out genotype of any plant with dominant expression. But it is not known whether it is homozygous (pure) or heterozygous for that trait.

ii. For example, A pea plant having violet (purple) flowers is crossed with a pea plant with white flowers.

iii. If all flowers produced are violet, we can conclude that plant is pure or homozygous and if we get violet and white flowers in 1:1 ratio, we can conclude that plant is heterozygous.

iv. Test cross is also used to introduce useful recessive traits in the hybrids of self pollinated plants during rapid crop improvement programs.

v. Following is the graphic representation of test cross.



Q.20 Define test cross and explain its significance.

Ans :

i. The cross of F_1 hybrid with the homozygous recessive parent is known as a test cross.

ii. Significance of test cross:

a. Test cross helps us to determine whether individuals exhibiting dominant character are genotypically homozygous or heterozygous.

b. It has wide application in plant breeding experiments.

c. Test cross is also used to introduce useful recessive traits in the hybrids of self pollinated plants during rapid crop improvement programs.

Q.21 Explain the statement.
Test cross is back cross but back cross is not necessarity.

Ans :

i. In back cross F_1 generation can be crossed with either dominant or recessive parent, whereas in test cross the F_1 generation is crossed with the recessive parent only.

ii. It is a back cross, F_1 generation is crossed with recessive parent. It will be a test cross, but if F_1 generation is crossed with a dominant parent it will not be a test cross.

iii. Therefore, test cross is back cross but back cross is not necessarily a test cross.

Q.22 Perform a test cross between a heterozygous tall plant of pea and dwarf plant of pea. Calculate the phenotypic ratio of the progeny.

Ans : The cross can be represented as follows:

Phenotype of parents → Heterozygous Tall × Dwarf

Genotype → Tt × tt

Gametes → T, t × t

F_1 generation:

♀ \ ♂	T	t
t	Tt Heterozygous tall	tt Homozygous dwarf

In this cross, 50% offsprings are tall 50% are dwarf.

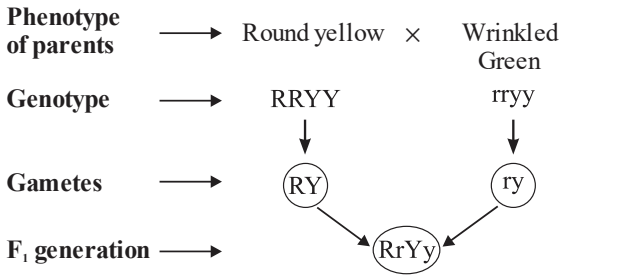
Thus, phenotypic ratio of the progeny = 1 (Tall) : 1 (Dwarf)

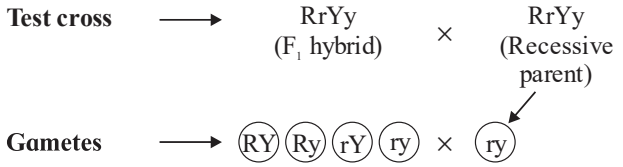
Q.23 Try this.
Find the ratio of dihybrid test crss by using Punnett square.

Ans :

i. A pea plant with Round yellow seeds is crossed with a pea plant having wrinkled green seed.

ii. The F_1 hybrid is crossed with its homozygous recessive plant.





F_2 generation →

♀ \ ♂	RY	Ry	rY	ry
ry	RrYy Round yellow	Rryy Round green	rrYy Wrinkled yellow	rryy Wrinkled green

Test cross Ratio → 1 : 1 : 1 : 1
Round yellow : Wrinkled yellow : Round green : Wrinkled green

MULTIPLE CHOICE QUESTIONS

Entrance Set 4

1. A test cross is carried out to
   (a) determine the genotype of a plant at F_2
   (b) predict whether two traits are linked
   (c) assess the number of alleles of a gene
   (d) determine whether two species or varieties will breed successfully.

2. Which one of the following conditions of the zygotic cell would lead to the birth of a normal human female child?
   (a) Two X chromosomes
   (b) Only one Y chromosomes
   (c) Only one X chromosomes
   (d) One X and one Y chromosome

3. Test cross in plants or in Drosophila involves crossing
   (a) between two genotypes with recessive trait
   (b) between two F_1 hybrids
   (c) the F_1 hybrid with a double recessive genotype
   (d) between two genotypes with dominant trait.

4. The genotype of a plant showing the dominant phenotype can be determined by
   (a) test cross (b) dihybrid cross
   (c) pedigree analysis (d) back cross.

5. A cross in which an organism showing a dominant phenotype is crossed with the recessive parent in order to know its genotype is called
   (a) monohybrid cross (b) back cross
   (c) test cross (d) dihybrid cross.

6. When white eyed and miniature winged *Drosophila malanogaster* is crossed with its wild type, it produces following percentage of recombinants.
   (a) 1.3% (b) 37.2%
   (c) 62.8% (d) 98.7%

7. In Morgan's experiment with *Drosophila*, when yellow bodied white eyed female was crossed with brown bodied red eyed male and their F_1 progeny were intercrossed. What was the percentage of recombinants in F_2 generation?
   (a) 62.8% (b) 98.7%
   (c) 1.3% (d) 37.2%

8. When a white eye *Drosophila* male ($X^r Y$) is crossed to a red eye female ($X^R X^R$), in the F_2 generation all the females are red eyed and 50% males are white eyed. In a criss-cross test, when a white eyed female ($X^r X^r$) is crossed to a red eye male ($X^R Y$), the F_1 generation offspring had red eyes. Instead of crossing of a white eyed female ($X^r X^r$) to a red eyed male ($X^R Y$), white eye female ($X^r X^r$) to white eye male ($X^r Y$) is crossed, the F_1 generation will have the following phenotypes and genotype.
   (a) All females have white eye ($X^r X^r$, $X^r X^r$) and all males have red eye ($X^r Y$, $X^r Y$)

(b) All females have white eye ($X^r X^r$, $X^r X^r$) and 50% males have red eye ($X^R Y$, $X^r Y$)
(c) 50% females have white eye ($X^r X^r$, $X^R X^r$) and all males have white eye ($X^r Y$, $X^r Y$)
(d) All females have white eye ($X^r X^r$, $X^r X^r$) and all males have red eye ($X^r Y$, $X^r Y$)

9. Linkage groups can be separated during ____ in meiosis.
(a) Crossing over (b) Synapsis
(c) Tetrad formation (d) Terminalization

10. The mechanism that causes a gene to move from one linkage group to another is called
(a) Crossing over (b) Inversion
(c) Duplication (d) Translocation

11. Total number of linkage groups in honeybee is _____.
(a) 16 (b) 23
(c) 32 (d) 46

12. The frequency of crossing-over occurring between two genes located on the same chromosome depends on
(a) length of the chromosome
(b) position of the centromere
(c) activities of two genes
(d) distance between two genes.

3.5 Deviations from Mendel's findings

Q.24 Write a note on generalizations mode based on Mendel's experiment.

Ans : Few generalizations were arrived at by Mendel, on the basis of his experiments of garden pea plant- such as,

i. Single trait → Single gene → Two alleles.
ii. Two alleles show interaction in which one is completely dominant.
iii. Factors (genes) for different traits present on different chromosomes assort independently.

Q.25 Write a detailed note on Neo-mendelism

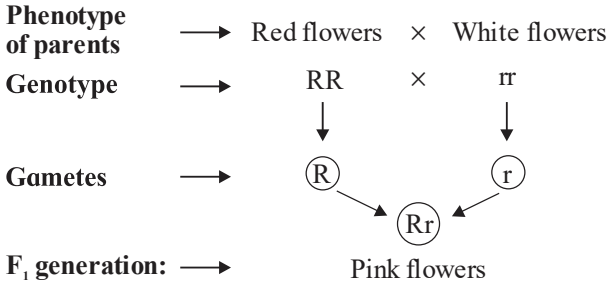
Ans :

i. Number of deviations were observed/ identified in the post-Mendelian era, that gave additional information on the patterns of inheritance.
ii. These deviations are then described as **Neo-Mendelism**.
iii. It was observed that the phenotypic expression of a gene can be modified or influenced by the other gene.
iv. These gene interactions are of two types.
a. Intragenic interactions: Occur between the alleles of same gene e.g. incomplete dominance and co-dominance. It also occurs between the multiple allele series of a gene.
b. Intergenic (non-allelic) interactions: Occur between the allels of different genes present on the same or different chromosomes. e.g. pleiotropy, polygenes, epistasis, supplermetary and complementry genes, etc.

Q.26 Explain incomplete dominance with a suitable example.

Ans :

i. In the incomplete dominance, both the alleles (genes) of an allelomorphic pair express themselves partially.
ii. One allele (gene) cannot supress the expression of the other allele (gene) completely.
iii. In such case, there is an intermediate expression in the F_1 hybrid.
iv. A well-known example is the flower colour of *Mirabilis jalapa*, If a red-flowered (RR) plant is crossed with a white-flowered (rr) plant, then F_1 offsprings have pink (Rr) flowers.
v.



F_2 generation : ⟶ Rr × Rr

Selfing of F_2 generation ⟶

♀ \ ♂	R	r
R	RR Red	Rr Pink
r	Rr Pink	rr White

Result →

Genotypic ratio - 1 RR : 2 Rr : 1rr (1 : 2 : 1)

Phenotypic ratio - 1 red : 2 Pink : 1 white

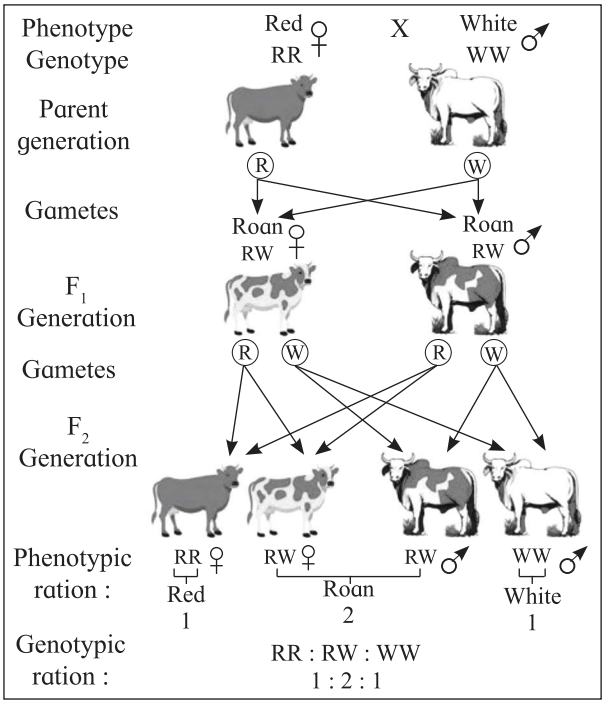
Q.27 Explain co-dominance with a suitable example.

Ans :

i. In co-dominance, both the alleles (genes) of an allelomorphic pair express themselves equally in F_1 hybrids. Such alleles which are able to express themselves equally independently in hybrids, are called co-dominant alleles.

ii. Thus in co-dominance both alleles are expressed.

iii. Classic example of co-dominance is coat colour in cattle.



iv. There are two types one with red coat (with red colour hair) and other with white coat (with white hair).

v. When red cattles (RR) are crossed with white cattles (WW), F_1 hybrids (RW) are roan. Roans have the mixture of red and white colour hair.

vi. Thus both the traits are expressed equally. In F_2 generation red (RR), roans (RW) and white (WW) are produced in the ratio 1:2:1.

vii. Thus in Co-dominance, the genotypic and phenotypic ratios are identical.

TEXTUAL

★Q.28 Explain the statement: Law of dominance is not universal.

Ans :

i. Law of dominance states that, when two homozygous individuals with one or more sets of contrasting characters are crossed, the alleles (characters) that appear in F_1 are dominant and those which do not appear in F_1 are recessive.

ii. We see that dominance might not be complete or absent in some cases.

Thus, law of dominance is significant and true, but it is not universally applicable.

Q.29 Write a brief note on multiple alleles and explain with a suitable example.

Ans :

Phenotype	Genotype
Normal wings 	vg^+
Nicked wings 	vg^{ni}
Notched wings 	vg^{no}
Strap wings 	vg^{st}
Vestigial wings 	vg

i. More than two alternative forms (alleles) of a gene in a population accupying the same locus on a chromosome or its homologue, are known as **multiple alleles**.

ii. Multiple alleles arise by mutations of the wild

type of gene.

iii. A gene can mutate several times producing a series of alternative expression.

iv. Different alleles in a series show dominant-recessive relation or may show co-dominance or incomplete dominance among themselves.

v. Wild type is dominant over all other mutant alleles.

vi. In *Drosophila*, a large number of multiple alleles are known, e.g. The size of wings from normal wings to vestigial (no) wings, i.e., just stumps, is due to one allele (vg) in homozygous condition.

vii. The normal wing is wild type while vestigial wing is recessive type.

TEXTUAL

★Q.30 Write a note on Pleiotropy.

Ans :

i. When a single gene controls two (or more) different traits, it is called pleiotropic gene and the phenomenon is called **pleiotropy** or **pleiotropism**.

ii. The phenotypic ratio is 1:2 instead of 3:1 because of the death of recessive homozygote. The disease, sickle-cell anaemia, is caused by a gene Hb^s.

iii. Normal or healthy gene Hb^A is dominant.

iv. The carriers (heterozygotes Hb^A/Hb^s) show signs of mild anaemia as their RBCs become sickle-shaped i.e. half-moon-shaped only under abnormally low O_2 concentration.

v. The homozygotes with recessive gene Hbs however, die of fatal anaemia.

vi. Thus, the gene for sickle-cell anaemia is lethal in homozygous condition and produces sickle cell trait in heterozygous carrier. Two different expressions are produced by a single gene.

vii. A marriage between two carriers will produce normal, carriers and sickle-cell anaemic children in 1:2:1 ratio. Sickle cell anaemics die leaving carriers and normals in the ratio 1:2.

viii. The heterozygotes or carriers can be identified by microscopic examination of blood.

MULTIPLE CHOICE QUESTIONS

Entrance Set 5

1. Which of the following pairs is wrongly matched?
   (a) Strach synthesis in pea : Multiple allleles
   (b) ABO blood grouping : Co-dominance
   (c) XO type sex determination : Grasshopper
   (d) T.H. Morgan : Linkage

2. Which of the following characteristics represent 'inheritance of blood groups' in humans?
   (i) Dominance
   (ii) Co-dominance
   (iii) Multiple allele
   (iv) Incomplete dominance
   (v) Polygenic inheritance
   (a) (ii); (iii) and (v)
   (b) (i); (ii) and (iii)
   (c) (ii); (iv) and (v)
   (d) (i); (iii) and (v)

3. A tall true breeding garden pea plant is crossed with a dwarf true breeding garden pea plant. When the F_1 plants were selfed the resulting genotypes were in the ratio of
   (a) 3 : 1 : : Tall : Dwarf
   (b) 3 : 1 : : Dwarf : Tall
   (c) 1 : 2 : 1 : : Tall homozygous : Tall heterozygous : Dwarf
   (d) 1 : 2 : 1 : : Tall heterozygous : Tall homozygous : Dwarf.

4. A gene showing codominance has
   (a) alleles that are recessive to each other
   (b) both alleles independently expressed in the heterozygote
   (c) one allele dominant on the other
   (d) alleles tightly on the same chromosome.

5. A pleiotropic gene
   (a) controls a trait only in combination with another gene
   (b) controls multiple traits in an individual
   (c) is expressed only in primitive plants
   (d) is a gene evolved during Pilocene.

6. Multiple alleles are present
   (a) at the same locus of the chromosome
   (b) on non-sister chromatids

(c) on different chromosomes
(d) at different loci on the same chromosome.

7. A man with blood group 'A' marries a woman with blood group 'B'. What are all the possible blood groups of their offsrpings?
(a) A, B, AB and O
(b) O only
(c) A and B only
(d) A, B and AB only

8. If two persons with 'AB' blood marry and have sufficiently large number of children, these children could be classified as 'A' blood group: 'AB' blood group : 'B' blood group in 1 : 2 : 1 ratio. Modern technique of protein electrophoresis reveals presence of both 'A' and 'B' type proteins in 'AB' blood group individuals. This in an example of
(a) partial dominance
(b) complete dominance
(c) codominance
(d) incomplete dominance

9. Which idea is depicted by a cross in which the F_1 generation resembles both the parents?
(a) Inheritance of one gene
(b) Codominance
(c) Incomplete dominance
(d) complete dominance

10. A normal-visioned man whose father was colour-blind, marries a woman whose father was also colour-blind. They have their first child as a daughter. What are the chances that this child would be colour-blind?
(a) 100% (b) Zero percent
(c) 25% (d) 50%

3.6 Chromosomal Theory of Inheritance

★Q.34 Explain chromosomal theory of inheritance.

Ans :

i. **Chromosomal theory of inheritance** was put forth by Sutton and Boveri. This theory identifies chromosomes as the carriers of genetic material.

ii. This theory states that the chromosomes are present in pairs in somatic cells.

iii. During gamete formation homologous chromosomes pair, segregate and assort themselves independently during meiosis. Thus, each gamete contains only one chromosome from a pair.

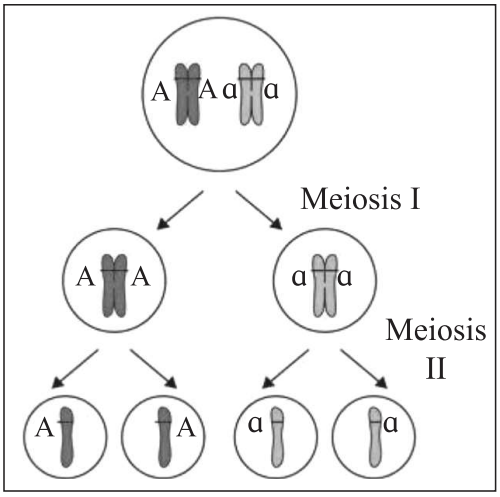
iv. Nucleus of gametes contains chromosomes, which carry all hereditary traits.

v. Male and female gametes (sperms and eggs) carry all the hereditary traits.They are the link between parents and offsprings.

vi. The fusion of haploid male gamete and haplaid female gamete, restores the diploid number of chromosomes of the species.

Q.35 Activity

Observe the following diagram and answer the questions given below:



i. What is homologous chromosome?

ii. In which phase of meiosis-I, homologous chromosomes segregate?

iii. Where are genes located?

iv. Do genes and chromosomes have similar behaviour? Justify.

Ans :

i. The morphologically, genetically and structurally identical chromosome present in a diploid cell, are called homologus chromosomes.

ii. The homologus chromosomes separate in Anaphase I and meiosis I.

iii. Genes are located on chromosomes.

iv. a. Genes are specific segment of DNA which coils to form a chromosome.
b. Genes and chromosomes both occur in

pairs in diploid organisms.

c. They both replicate and both are passed on to offsprings from their parents.

d. Thus they have similar behaviour.

MULTIPLE CHOICE QUESTIONS

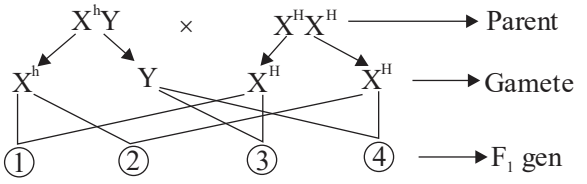
Entrance Set 6

1. A woman has an X-linked condition on one of her X chromosomes. This chromosome can be inherited by
   (a) Only grandchildren
   (b) Only sons
   (c) Only daughters
   (d) Both sons and daughters

2. If a colour blind man marries a woman who is homozygous for normal colour vision, the probability of their son being colour blind is
   (a) 1 (b) 0
   (c) 0.5 (d) 0.75

3. Both male and female have normal vision though their fathers were colour blind, and mothers did not have any gene for colour blindness. The probability of their daughter becoming colour blind is
   (a) 0% (b) 15%
   (c) 25% (d) 50%

4. Select the correct sequence of the F_1 generation.



   (a) ① - X^HX^H, ② - X^hX^H, ③ - X^HY, ④ - X^HY
   (b) ① - X^HX^h, ② - X^HX^h, ③ - X^HY, ④ - X^HY
   (c) ① - X^HX^h, ② - X^hX^H, ③ - X^hY, ④ - X^hY
   (d) ① - X^hX^H, ② - X^HX^h, ③ - X^HY, ④ - X^hY

5. Which of the following most appropriately describes haemophilia?
   (a) Chromosomal disorder
   (b) Dominant gene disorder
   (c) Recessive gene disorder
   (d) X-linked recessive gene disorder

6. The INCORRECT statement with regard to haemophilia is
   (a) it is a sex-linked disease
   (b) it is a recessive disease
   (c) it is a dominant disease
   (d) a single protein involved in the clotting of blood is affected.

3.7 Chromosomes

Q.36 Can you recall?

i. What is Chromosome.

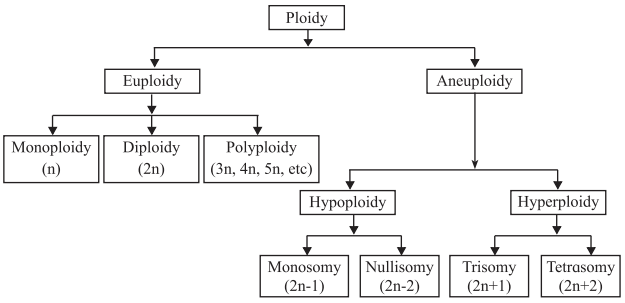
Ans : Chromosomes are filamentous bodies present in the euaryotic nucleus.

ii. How many chromosomes are present in human somatic and reproductive cell?

Ans : Since human somatic cell is diploid (2n) there are 46 chromosomes present whereas reproductive cell (n) has 23 chromosomes.

Q.37 Write a note on Ploidy of chromosomes.

Ans :



i. The term **Ploidy** speaks for the degree of repetition of the primary basic number of chromosomes (i.e. 'x') in a cell.

ii. When the chromosome number in a cell is the exact multiple of the primary basic number, then it is called **euploidy**.

iii. Euploids include monoploid/haploid (with one set of chromosomes where x = n), diploids (2n-two sets of chromosomes), triploids (3n-three sets of chromosomes), tetraploid (4n-four sets of chromosomes) and so on.

iv. When the chromosome number is not the exact multiple of the haploid set, it is described as **Aneuploidy**.

v. Aneuploidy is either addition or deletion of one or more chromosome (s) to the total number of chromosomes in a cell.

INTEXT QUESTION

Q.38 Can you recall?
What are role of chromosomes in living organisms?

Ans :

i. Genes responsible for determining heriditary character are carried by chromosomes.
ii. Chromosome carry genes on them as a linkage group to the next generation.
iii. Chromosomes regulate protein synthesis thus facilitating cell division and cell growth.
iv. Sex chromosomes determine the sex of a person.
v. Chromosomes produce exact copies by replication which are passed onto the daughter cells.

Q.39 State the characteristics of chromosome.

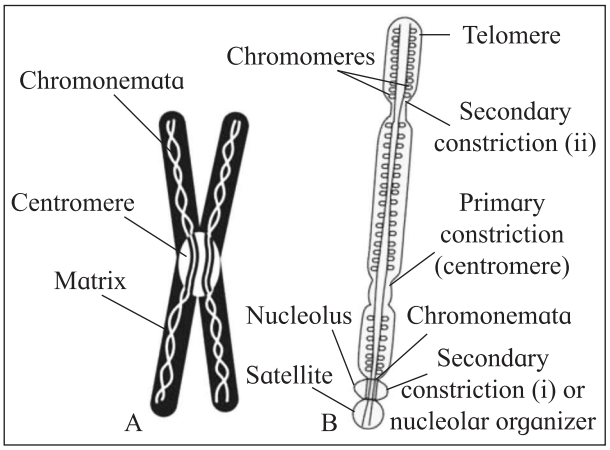
Ans :

i. Chromosomes are filamentous bodies present in the eukaryotic nucleus.
ii. The term chromosomes (Gr., Chromo = colour, soma = body) was coined by W. Waldeyer (1888).
iii. The size of chromosome varies from species to species.
iv. Each metaphase chromosome varies from 0.1 to 33 mm in length and 0.2 to 2 mm in thickness.
v. Chromosomes are visible during cell division.
vi. They are capable of self replication and play vital role in heredity, mutation, variation, and evolutionary devlopment of eukaryotic species.
vii. Chemically eukaryotic chromosomes are made of DNA, histone and non-histone proteins.
viii. **Function:** Chromosomes are carriers of heredity.

Q.40 With the help of neat labelled diagram, describe the structure of chromosome.

Ans :

i. Chromosomes are best visible under microscope, when the cell is at metaphase stage. It is because at this stage chromosomes are highly condensed.
ii. Typical chromosome consists of two chromatides joind together at centromere or primary constriction.



iii. Primary constriction constists of a disk shape plate called **kinetochore**. It is at the kinetochore, spindle fibres get attached during cell division.
iv. Besides primary constriction, some few chromosomes possess additional one or two constrictions called **secondary constriction**.
v. At secondary constriction I, nucleolus becomes organized during interphase.
vi. A satellite body (SAT body) is attached at secondary constriction II, in very few chromosomes.
vii. Each chromatid in turn contains a long, unbranched, slender, highly coiled DNA thread, called Chromonema, extending through the length of chromatid.
viii. Chromatid consists a double stranded DNA molecule which extends from one end of chromosomes to other.
ix. The ends of chromosome (i.e. chromatids) are known as **telomeres**.

Q.41 Activity

Study the types of chromosome according to position of centromere. Observe and complete the following table.

Types of Chromosome	Name of Chromosome	Position of Contromere
	Metacentric	–
	–	–
	Acrocentric	–
	–	At one end

Ans :

Types of Chromosome	Name of Chromosome	Position of Contromere
	Metacentric	**Middle of the chromosome**
	**Sub-metacentric**	**Some distance away from the centre of chromosome**
	Acrocentric	**Near one end of the chromosome**
	**Telocentric**	At one end

TEXTUAL

★Q.42 Describe the different types of chromosomes.

Ans :

i. Depending upon the position of centromere there are four types (shapes) of chromosomes viz. Acrocentric (j shaped), Telocentric (i shaped), Submetacentric (L shaped) and Metacentric (V shaped).

★Q.43 What is allosome?

Ans : The chromosomes which are responsible for the determination of sex are known as **sex chromosomes** or **allosomes**.

Q.44. Write a note on structure of allosomes in human beings.

Ans :

i. Human being and other mammals have X and Y Chromosomes as sex chromosomes.

ii. X chromosome is straight, rod like and longer than Y chromosome.

iii. X chromosome is metacentric, while Y chromosome is acrocentric.

iv. X chromosome has large amount of **euchromatin** (extended region) and small amount of **heterochromatin** (highly condensed region).

v. Euchromatin has large amount of DNA material, hence genetically active.

vi. Y chromosome has small amount of euchromatin and large amount of heterochromatin, hence it is genetically less active or inert.

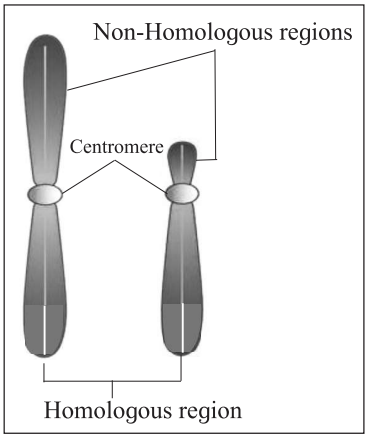
vii. Both X and Y chromosome show homologous and nonhomologous regions.

viii. Homologous regions show similar genes while non-homologous regions show dissimilar genes.

ix. Crossing over occurs only between homologous regions of X and Y chromosomes.

x. Non-homologous region of X chromosome is longer and contains more genes than that of non-homologous region of Y chromosome.

xi. X-linked genes are persent on non-homologous region of X-chromosome while Y linked genes are persent on non-homologous region of Y-chromosome.



★Q.45 Compare X-chromosome and Y-chromosome.

Ans :

	X-chromosome	Y-chromosome
i.	It is metacentric, thus appears X shaped.	It is acrocentric thus appears Y shaped.
ii.	It is comparatively longer.	It is shorter than 'X' chromosomes.
iii.	Large amount of euchromatin and small amount heterochromatin is present.	Large amount of heterochromatin and small amount of euchromatin is present.
iv.	It is present in both male and females.	It is present only in males.
v.	It has X-linked genes present on it.	It has Y-linked jenes present on it.
vi.	Non-homologus parts of X-chromosomes show more genes.	Non-homologus parts of Y chromosomes show fewer genes.

INTEXT

Q.46 Can you tell?

i. What are allosomes.

Ans : *Refer Q.43.*

ii. Compare X and Y chromosomes

Ans : *Refer Q.45.*

MULTIPLE CHOICE QUESTIONS

Entrance Set 7

1. A cell at telophase stage is observed by a student in a plant brought from the field. He tells his teacher that this cell is not like other cells at telophase stage. There is no formation of cell plate and thus the cell is containing more number of chromosomes as compared to other dividing cells. This would result in
   (a) Somaclonal variation
   (b) polyteny
   (c) aneuploidy
   (d) polyploidy.
2. In higher unisexual animals, one pair of chromosomes is not identical in two sexes. It is called as _____.
   (a) Non homologous chromosomes
   (b) Homologous chromosomes
   (c) Autosomes
   (d) Sex chromosomes
3. Peacock shows following genotype
   (a) XX (b) XY
   (c) ZZ (d) ZW
4. The type of sex determination in honey bee is
   (a) Haplo-diploidy (b) Haploidy
   (c) Diploidy (d) ZZ-ZW
5. Select the INCORRECT statement.
   (a) In domesticated fowls, sex of progeny depends on the type of sperm rather than egg.
   (b) Human males have one of their sex - chromosome much shorter than the other.
   (c) Male fruit fly is heterogametic
   (d) In mal grasshoppers, 50% of sperms have no sex-chromosome.
6. From the chromosomal complements given below, identify the one which shows female heterogamety.
   (a) XX - XO (b) XX - XY
   (c) XX - XXY (d) ZZ - ZW

3.8 Linkage and Crossing over

Q.47 Explain the following terms

i. Linked genes ⋆ii. Linkage

Ans :

i. **Linked genes:**
   a. Several genes are present on the chromosome.
   b. As chromosomes are carriers of heredity, these genes have tendency to be inherited together.
   c. Such genes are called **linked genes**.

ii. **Linkage:** This tendency of two or more genes present on the same chromosomes that are inherited together is known as **linkage**.

Q.48. Explain the two kinds of Linkages.

Ans :

i. **Complete linkage:**
   a. The linked genes which are closely located on the chromosome do not separate (no crossing over) and inherit together.
   b. They are called completely linked (strongly linked) genes and the phenomenon of their inheritance is called complete linkage.
   c. Thus the parental traits are inherited in offsprings. e.g. X chromosome of *Drosophila* males-show complete linkage.

ii. **Incomplete linkage:**
   a. The linked genes which are distantly located on the same chromosome and have chances of separation by crossing over, are known as incompletly linked (weakly linked) genes.
   b. The phenomenon of their inheritance, is called incomplete linkage.
   c. Thus, new traits occur in offsprings. e.g. In *Zea mays* - colour and shape of grain show incomplete linkage.

Q.49 Describe Linkage groups in short.

Ans :

i. All the linked genes in a particular chromosome, constitute a linkage group.

ii. The number of linkage groups of a particular species corresponds to its haploid number of

chromosomes.

iii. For e.g. *Drosophila melanogaster* has 4 linkage groups that corrrspond to the 4 pairs of chromosomes.

iv. Garden pea has 7 linkage groups and 7 pairs of chromosomes.

Q.50 Use your brain power
How many Linkage groups are in human brings and maize.

Ans : The haploid number of chromosomes in humans is 23 and in maize is 10 therefore they have 23 and 10 linkage groups in humans and maize repsectively.

Q.51 Write a detailed note on sex linkage and its types in human beings.

Ans :

i. The transmission (inheritance) of X - linked and Y-linked genes from parents to offspring, is called sex-linked inheritance.

ii. Sex-linked inheritance is of three types viz. X-linked, Y-linked and XY-linked. Sex linkage is of two kinds: Complete sex linkage and Incomplete sex linkage

iii **Complete sex linkage:**
   a. It is exhibited by genes located on non-homologous regions of X and Y chromosomes.
   b. They inherit together because crossing over does not occur in this region.
   c. Examples of X-linked traits are haemophilia, red-green colour blindness, myopia (near sightedness) and for Y-linked are hypertrichosis, Ichthyosis, etc.

iv. **Incomplete sex linkage:**
   a. It is exhibited by genes located on homologous regions of X and Y chromosomes.
   b. They do not inherit together because crossing over occurs in this region.
   c. Examples of X-Y linked traits are total colour blindess, nephritis, retinitis pigmentosa, etc.

TEXTUAL

★Q.59 Give one example of complete sex linkage?

Ans : Examples of X-linked traits are haemophilia, red-green colour blindness, myopia (near sightedness) and for Y-linked are hypertrichosis, Ichthyosis, etc.

★Q.60 What is crossing over?

Ans :

i. Crossing over is a process that produces new combinations (recombinations) of genes by interchanging and exhanging of corresponding segments between non-sister chromatids of homologous chromosomes.

ii. It occurs during pachytene of prophase I of meiosis.

iii. The term crossing over was coined by Morgan. The mechanism of crossing over consists four sequential steps such as synapsis, tetrad formation, crossing over and terminalization.

iv. The phenomenon of crossing over is universal and it is necessary for the natural selection, because it increases the chances of variation.

Q.61 Why did Thomas Morgan use *Drosophila melanogaster* for his experiments.

Ans :

i. Morgan used *Drosophila melanogaster* (fruit fly) for his experiments because, Drosophila can easily be cultured in laboratory.

ii. It's life span is short, about two weeks.

iii. More over, it has high rate of reproduction.

Q.62 Explain Morgan's experiments of linkage and recombination.

Ans :

i. Morgan carried out several dihybrid cross experiments in fruit fly to study genes that are sex-linked.

ii. The crosses were similar to dihybrid crosses, as carried out by Mendel in Pea.

iii. For example, Morgan and his group crossed yellow-bodied, white eyed female to the wild type with brown-bodied, red eyed males and intercrossed their F_1 progeny.

iv. He observed that the two genes did not segregate independently of each other and F_2 ratio deviated very signiticantly from 9:3:3:1 ratio.

v. Morgan and his group knew that the genes were located on X chromosome and stated that when two genes in a dihybrid cross are situated on the same chromosome, then the proportion of parental combination is much higher than non-parental type. This occurs due to physical association or linkage of the two genes.

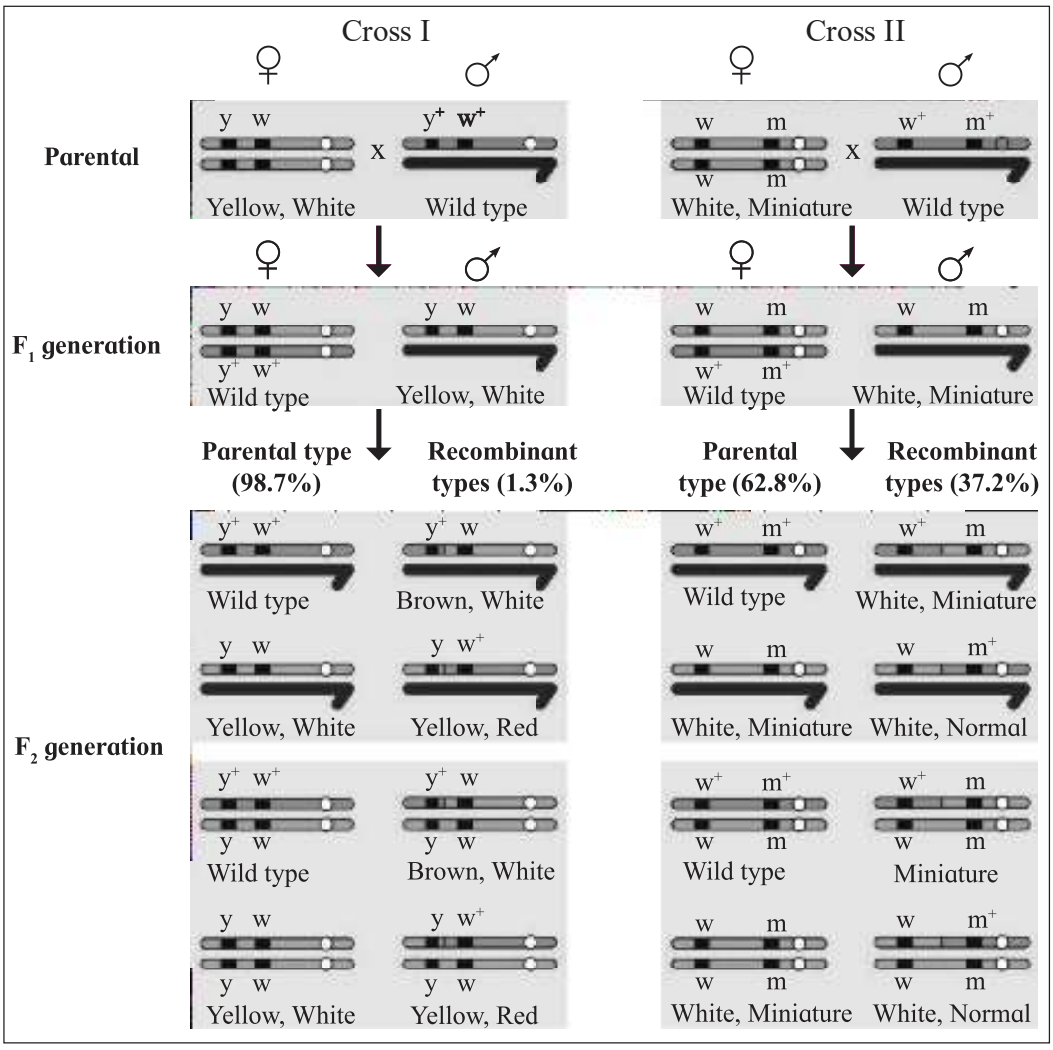
vi. He also found that, when genes are grouped on the same chromosome, some genes are strongly linked. They show very few recombinations (1.3 %).

vii When genes are loosely linked i.e. present far away from each other on chromosome, they show more (higher) recombinations (37.2 %).

viii. For example, the genes for yellow body and white eye were strongly linked and showed only 1.3 percent recombination (in cross-I).

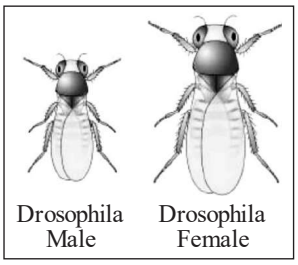
ix. White bodied and miniature wings showed 37.2 percent recombination (in cross-II).

x. Results of two dihybrid crosses conducted by Morgan. Cross I shows crossing between gene (y) and (w); Cross II shows crossing between genes (w) and (m). Here dominant wild type alleles are represented with (+) sign in superscript.



Entrance Corner

The male and female flies are easily distinguishable. Also, it has many types of hereditary variations that can be seen with low power microscopes.



Drosophila Male | Drosophila Female

MULTIPLE CHOICE QUESTIONS

Entrance Set 8

1. The mechanism that causes a gene to move from on linkage group to another is called
   (a) inversion (b) duplication
   (c) translocation (d) crossing-over
2. The term "linkage" was coined by
   (a) G. Mendel (b) W. Sutton
   (c) T.H. Morgan (d) T. Boveri.
3. A human female with Turner syndrome
   (a) has 45 chromosomes with XO
   (b) has one additional X chromosome
   (c) exhibits male characters
   (d) is able to produce children with normal husband.
4. Which of the following is correct match?

	I	II	III
(a)	Thalassemia	XO	Flat nose, simian crease
(b)	Down's syndrome	42 AA + XY	Webbing of neck
(c)	Turner's syndrome	44 AA + XXX	Anaemia, jaundice
(d)	Klinefelter	44 AA+XXY	Tall thin eunuchoid

5. Thalassemia and sickle cell anaemia are caused due to a problem in globin molecule synthesis. Select the correct statement.
   (a) Both are due to a qualitative defect in globin chain synthesis
   (b) Both are due to a quantitative defect in globin chain synthesis
   (c) Thalassemia is due to less synthesis of globin molecules
   (d) Sickle cell anaemia is due to a quantitative problem of globin molecules.
6. A disease caused by an autosomal primary non-disjunction is
   (a) Down syndrome
   (b) Klinefelter syndrome
   (c) Turner syndrome
   (d) Sickle cell anaemia
7. Example for autosomal hyper aneuploidy is
   (a) Down syndrome
   (b) Klinefelter syndrome
   (c) Turner syndrome
   (d) Haemophilia
8. Epicanthal skin fold and simian crease are characteristics of
   (a) Down syndrome
   (b) Klinefelter syndrome
   (c) Thalassemia
   (d) Turner's syndrome
9. An extra sex chromosome is present in ____.
   (a) Turner syndrome
   (b) Thalassemia
   (c) Klinefelter syndrome
   (d) Down syndrome
10. Down syndrome is a condition that causes delays in physical and intellectual development. The cause of this genetic disorder is
   (a) The partial deletion of the short arm of chromosome 5 or 5p monosomy.
   (b) The presence of three copies of 13th chromosome in each cell in the body.
   (c) The presence of an additional copy of the number 21 chromosome (Trisomy 21st)
   (d) The presence of an extra copy of the genetic material on 18th chromosome either in whole (Trisomy 18) or in part (due to translocations).
11. Klinefelter syndrome has the following phenotype and kayotype.
   (a) Male and 47, XXY
   (b) Female and 47, XXX
   (c) Male and 47, XYY
   (d) Female and 46, X.
12. Feminised males have _____ chromosomes.
   (a) 44 (b) 45
   (c) 46 (d) 47

13. In which genetic condition, each cell in the affected person, has three sex chromosomes XXY?
(a) Turner syndrome
(b) Thalassemia
(c) Klinefelter Syndrome
(d) Phenylketonuria

3.9 Autosomal Inheritance

Q.63 What is autosomal inheritance?

Ans :

i. Transmission of body characters other than the sex linked traits from parents to their offsprings through autosomes, is called autosomal inheritance.

Q.64 Give examles of

i. Autosomal dominant traits

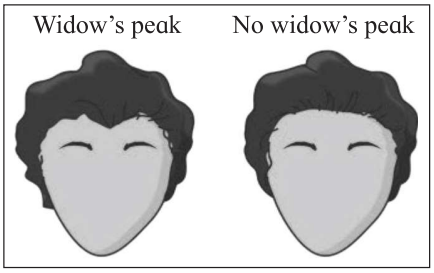
Ans : Widow's peak and Huntington's disease are example of Autosomal dominant traits.

★ii. Autosomal recessive traits.

Ans : Phenylketonuria (PKU), Cystic fibrosis and sickle call anemia are example of Autosomal recessive traits.

Q.65 What is widow's peak?

Ans :



i. A prominent "V" shaped hairline on forehead is described as widow's peak.
ii. It is determined by autosomal dominant gene.
iii. Widow's peak occurs in homozygous dominant (WW) and also heterozygous (Ww) individuals.
iv. Individuals with homozygous recessive (ww) genotype have a straight hair line (no widows peak).
v. Both males and females have equal chance of inheritance.

TEXTUAL

★Q.66 Write note on PKU.

Ans :

i. **Phenylketonuria (PKU)** is an inborn metabolic disorder caused due to recessive autosomal genes.
ii. When recessive genes are present in homozygous condition, phenylalanine hydroxylase enzyme is not produced.
iii. This enzyme is essential for conversion of amino acid phenylalanine into tyrosine.
iv. Due to absence of this enzyme, phenylalanine is not converted into tyrosine.
v. Hence, phenylalanine and its derivatives are accumulated in blood and cerebrospinal fluid (CSF).
vi. It affects development of brain and causes mental retardation.
vii. Excess phenylalanine is excreted in urine, hence this disease is called phenylketonuria.

3.10 Sex Linked Inheritance

Q.67 Define the following terms.

i. Sex linked genes
ii. Sex linked traits
iii. Sex linked inheritance

Ans :

i. Genes located on non-homologous region of sex chromosomes, are called **sex-linked genes**.
ii. The traits that are determined by sex linked genes, are called **sex-linked traits**.
iii. The inheritance of sex linked genes from parents to their offsprings, is called **sex linked inheritance**.

Q.68 Explain types of sex linked genes in details.

Ans :

i. There are two types of sex-linked genes as X-linked genes and Y-linked genes.
ii. **X-linked (sex linked) genes:**
a. The X linked genes are located on non homologous region of X chromosome and these gene do not have corresponding alleles on Y chromosome.
b. Female has two X chromosomes. In

female two recessive sex linked genes are required for expression of sex linked traits.

c. If one X chromosome carries a recessive gene for sexlinked trait (defect) its effect is suppressed by the dominant gene present on other X chromosome.

d. The females with one recessive gene are carriers. The carrier female is physically normal as she does not suffer from the disease (disorder).

e. Male has only one X-chromosome. If X chromosome carries X-linked recessive gene for sex linked trait, then it is expressed phenotypically, because there is no dominant gene on Y chromosome to suppress its effect.

f. Therefore, sex-linked/X-linked traits appear more frequently in males than in the females.

g. Examples of X-linked traits include haemophilia, colour blindness, night blindness, myopia, muscular dystrophy, etc.

iii. **Y-linked (Holandric) genes:**

a. Genes located on non-homologous region of Y chromosome, are called Y linked genes.

b. The Y-linked genes are inherited directly from male to male.

c. In man, the Y-linked genes such as hypertrichosis is responsible for excessive development of hair on pinna of ear. This charater is transmitted directly from father to son.

TEXTUAL

★Q.69 What are X-Linked genes.

Ans : The X linked genes are located on non homologous region of X chromosome and these gene do not have corresponding alleles on Y chromosome.

Q.70. What are holandric traits?

Ans : The traits that are controlled by genes present only on the Y chromosome are known as holandric traits.

INTEXT

Q.71 Internet my friend
Collect information on Ishihara's Test for colour blindness.

Ans :

i. Dr. Shinobu Ishihara introduced in 1917 the most well known colour blindness test.

ii. Each of this consists of a set of colored dotted plates, each of them showing either a number or a path.

iii. Since then this is the most widely used colour vision deficiency test and still used by most optometrists and opthalmologists all around the world.

Q.72 Explain colour blindness in detail.

Ans :

i. Colour blindness is X-linked recessive disorder where person is unable to distinguish between red and green colours as both the colours appear grey.

ii. It is caused due to recessive X-linked genes (X^c) which prevents formation of colour sensitive cells, the cones, in the retina of eye.

iii. The homozygous recessive females ($X^c X^c$) and hemizygous recessive male (X^cY) are unable to distinguish between red and green colours.

iv. The frequency of colour blind women is much less than colour blind men.

v. Dominant X linked gene (X^C) is necessary for formation of colour sensitive cells in the retina of eye.

vi. Thus, genotypes of male and female individuals can be represented as follows:

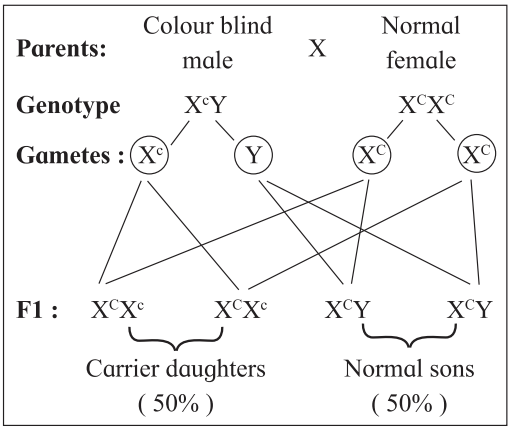
Sex	Normal	Colourblind	Carrier
Male	X^CY	X^cY	——
Female	X^CX^C	X^cX^c	X^CX^c

vii. The inheritance of colourblindness can be studied in the following two types of marriages:

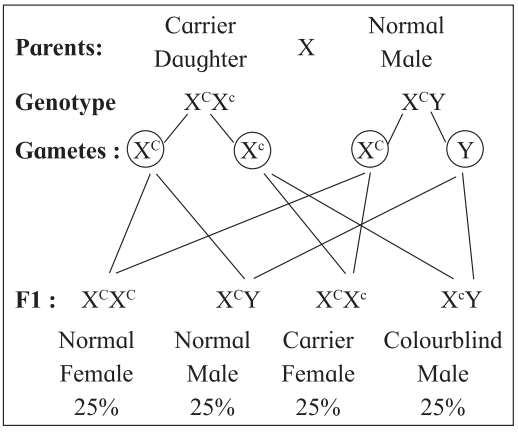
1. a. **Marriage between colour blind male with normal female**, will produce normal visioned male and female offspring in F_1.

b. The sons have normal vision but daughter

will be carrier for the disease.



2. a. **Marriage between carrier female** (daughter) **and normal male** will produce female offsprings with normal vision but half of them will be carriers for the disease.



b. Half of male offsprings will be normal while remaining half will be colour blind.

c. From above example, it is clear that the X linked recessive gene for colour blindness is inherited from colourblind father to his grandson through his daughter.

d. This type of inheritance is called as criss-cross inheritance.

Q.73 What is criss-cross inheritance?

Ans :

i. The inheritance of characters from the father to his grandson through his daughter is called criss-cross inheritance.

ii. Eg. Ref. Q.72 & 74.

Q.74 Explain Haemophilia Bleeder's disease in details.

Ans :

i. Haemophilia is X-linked recessive disorder in which blood fails to clot or coagulates very slowly.

ii. The genes for normal clotting are dominant over the recessive genes for haemophilia.

iii. The person having recessive gene for haemophilia is deficient in clotting factors (VIII or IX) in blood.

iv. Even minor injuries cause continuous bleeding, hence haemophilia is also called as **bleeder's disease**.

v. The recessive gene for haemophilia is located on non homologous region of X chromosome.

vi. As there is no corresponding allele on Y chromosome to suppress its expression, so men suffer from this disease.

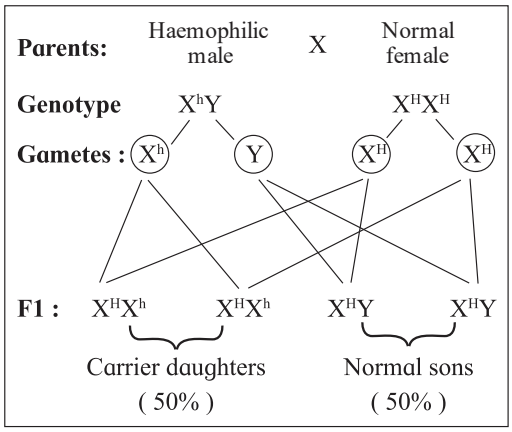
vii. Women suffers only when both X chromosomes have recessive genes (alleles).

viii. The genotype of male and female individuals can be represented as follow:

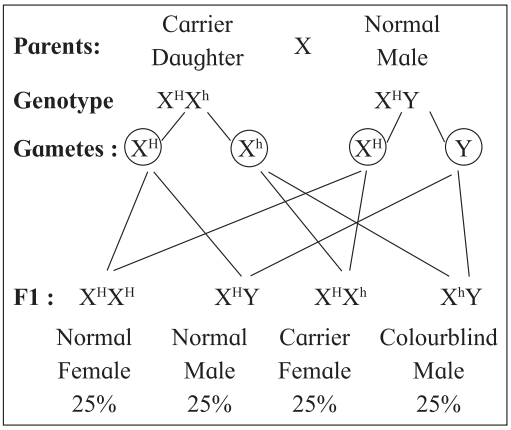
Sex	Normal	Haemophilic	Carrier
Male	X^HY	X^hY	——
Female	X^HX^H	X^hX^h	X^HX^h

Like colour blindness, haemophilia also shows criss-cross inheritance. The inheritance of haemophilia can be studied with the help of following examples:

a. Marriage between the Haemophilic male and normal female.



b. Marriage between carrier female (daughter) and normal male.



Q.75 In the answer for inheritance of X-linked genes, Madhav had shown carrier male. His answer was marked incorrect. Madhav was wondering why his marks were cut. Explain the reason.

Ans : A male has X and Y chromosomes. The X-linked genes do not have their alleles on Y chromosome. Therefore, for males to suffer from disease only one copy of a defective gene is sufficient. In inheritance of X-linked genes females may be carrriers because they have two X chromosomes and may carry one normal and other defective gene. This is not possible in case of males due to presence of single X chromosome.

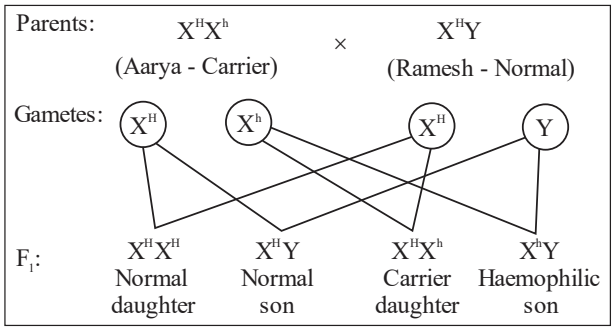
Q.76 Aarya shows normal blood clotting but her mother is haemophilic. Ramesh shows normal blood clotting but his father is haemophilic. If Ramesh and Aarya were to marry, then find out the possible phenotypes of their offsprings.

Ans:

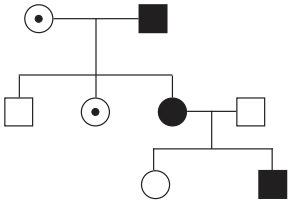
i. Aarya's mother is haemophilic that means her genetic constitution is X^hX^h. As Aarya shows normal blood clotting that means her genetic constitution must be either X^HX^H or X^HX^h. But as Aarya's mother is haemophilic Aarya had received one X^h chromosome (X chromosome carrying defective gene) and one normal X^H chromosome from her father. Therefore, she is carrier (X^HX^h) for haemophilia.

ii. Ramesh's father is haemophilic (X^hY) but Ramesh shows normal blood clotting. Therefore, Ramesh's genetic constitution is X^HY (As males do not receive X chromosome from their father).

iii. If Ramesh and Aarya were to marry, following would be possible phenotypes of their offsprings:



Q.77 Observe the given pedigree chart and answer the following questions.



a. Identify whether the trait is sex linked or autosomal.

b. Give an example of a trait in human beings which shows such a pattern of inheritance.

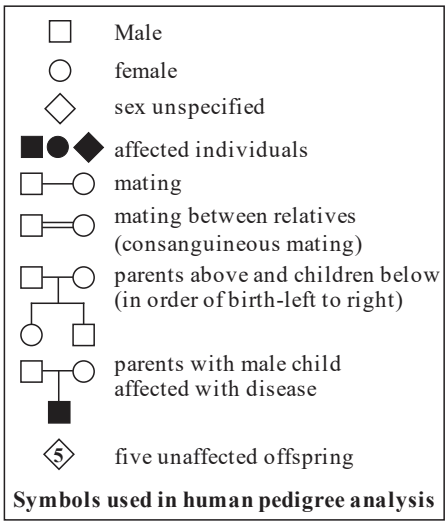
Ans :

a. The trait represented in given pedigree in sex linked trait.

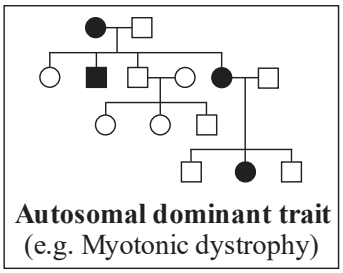
b. Haemophilia, colour blindness are the example of sex linked traits in humans.

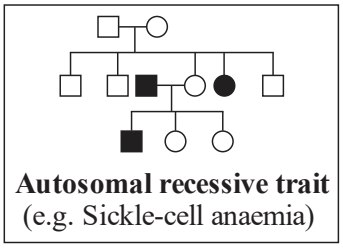
Entrance Corner

The idea that disorders are inherited has been prevailing in the human society since long. This was based on the heritability of certain characteristic features in families. After the rediscovery of Mendel's work the practice of analysing inheritance pattern of traits in human beings began. Since it is evident that control crosses that can be performed in pea plant or some other organisms, are not possible in case of human beings, study of the family history about inheritance of a particular trait provides an alternative. Such an analysis of traits in a several of generations of a family is called the pedigree analysis.



Symbols used in human pedigree analysis

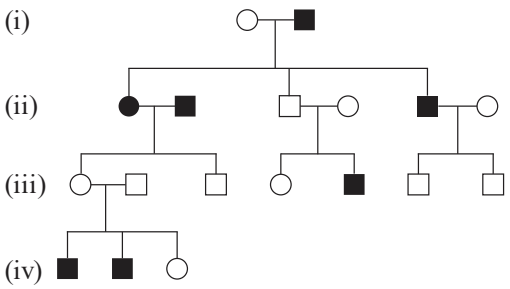

Autosomal dominant trait
(e.g. Myotonic dystrophy)


Autosomal recessive trait
(e.g. Sickle-cell anaemia)

MULTIPLE CHOICE QUESTIONS

Entrance Set 6

1. In the following human pedigree, the filled symbols represent the affected individuals. Identify the type of given pedigree.



(a) Autosomal recessive
(b) X-linked dominant
(c) Autosomal dominant
(d) X-linked recessive

2. A woman has an X-linked condition on one of her X chromosomes. This chromosome can be inherited by
(a) only daughter
(b) only sons
(c) only grandchildren
(d) both sons and daughters.

3. If a colour-blind man marries a woman who is homozygous for normal colour vision, the probability of their son being colour-blind is
(a) 0 (b) 0.5
(c) 0.75 (d) 1

4. Which of the following most appropriately describes haemophilia?
(a) Chromosomal disorder
(b) Dominant gene disorder
(c) Recessive gene disorder
(d) X-linked recessive gene disorder

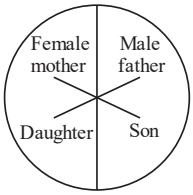
5. A colour blind man marries a woman with normal sight who has no history of colour blindness in her family. What is the probability of their grandson being colour blind?
(a) Nil (b) 0.25
(c) 0.5 (d) 1

6. Fruit colour in squash is an example of
(a) recessive epistasis
(b) dominant epistasis
(c) complementary genes
(d) inhibitory genes.

7. A man whose father was colour blind marries a woman who had a colour blind mother and normal father. What percentage of male children of this couple will be colour blind?
(a) 25% (b) 0%
(c) 50% (d) 75%

8. Select the incorrect statement with regard to haemophilia.
(a) It is a dominant disease.
(b) A single protein involved in the clotting of blood is affected.
(c) It is a sex-linked disease.
(d) It is a recessive disease.

9. Represented below is the inheritance pattern of a certain type of trait in humans. which one of the following conditions could be an example of this pattern?



(a) Phenylketonuria
(b) Sickle cell anaemia
(c) Haemophilia
(d) Thalassemia

10. A man and a woman, who do not show may apparent signs of a certain inherited disease, have seven children (2 daughters and 5 sons). Three of the sons suffer from the given disease but none of the daughters affected. Which of the following mode of inheritance do you suggest for this disease?
(a) Sex-linked dominant
(b) Sex-linked recessive
(c) Sex-limited recessive
(d) Autosomal dominant

11. Haemophilia is more commonly seen in human males than in human females because
(a) a greater proportion of girls die in infancy
(b) this disease is due to Y-linked recessive mutation
(c) this disease is due to an X-linked recessive mutation
(d) this disease is due to an X-linked dominant mutation.

12. Which of the following is not a hereditary disease?
(a) Cystic fibrosis (b) Thalassaemia
(c) Haemophilia (d) Cretinism

13. A woman with normal vision, but whose father was colour blind, marries a colour blind man. Suppose that the fourth child of this couple was a boy. This boy
(a) may be colour blind or may be of normal vision
(b) must be colour blind
(c) must have normal colour vision
(d) will be partially colour blind since he is heterozygous for the colour blind mutant allele.

14. A normal woman, whose father was colour-blind is married to a normal man. The sons would be
(a) 75% colour-blind
(b) 50% colour-blind
(c) all normal
(d) all colour-blind

3.11 Sex Determination

Q.78 Write a detailed note on sex determination in humans?

Ans :

i. The chromosomal mechanism of sex determination in human beings is XX-XY type. In human beings, the nucleus of each somatic cell contains 46 chromosomes or 23 pairs of chromosomes.

ii. Out of these, 22 pairs are **autosomes** and one pair of **sex chromosomes**.

iii. Human female has a pair of XX, homomorphic sex chromosomes while male has XY, heteromorphic sex chromosomes.

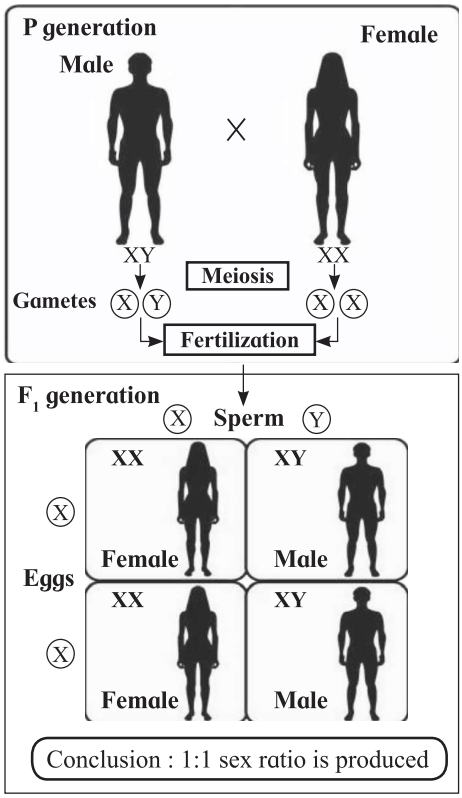
iv. Thus genotype of :
Female = 44 Autosomes + XX
Male = 44 Autosomes + XY

v. During gamete formation in male, the diploid germ cells in testis undergo spermatogenesis to produce two types of haplaid sperms, 50% sperms contain 22 autosomes and X chromosome while, 50% sperms contain 22 autosomes and Y chromosome.

vi. In Female, the diploid germ cells in ovaries undergo oogenesis to produce only one type of egg. All eggs contain 22 autosomes and X chromosome.

vii. Thus human male is heterogametic and female is homogametic.

viii. If sperm containing X chromosome fertilizes egg (ovum), then diploid zygote is formed, that grows into a female child.



ix. If sperm containing Y chromosome fertilizes the egg, then diploid zygote is formed that grows into a male child.

x. This indicates that the sex of a child depends on the type of sperm fertilizing the egg and **hence the father is responsible for determination of sex of child and not the mother**.

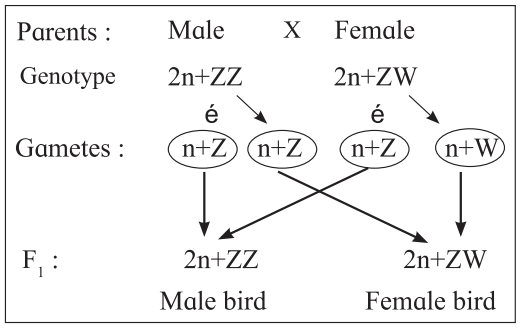
TEXTUAL QUESTION

★Q.79 "Father is responsible for determination of sex of child and not the mother". Justify.

Ans : *Refer Q.78 iii-x.*

Q.80 Explain sex determination in birds with the help of a schematic representation.

Ans :



i. In birds, the chromosomal mechanism of sex determination is ZW-ZZ type.

ii. In this type females are heterogametic and produce two types of eggs; 50% eggs carry Z-chromosome, while 50% eggs carry W-chromosome.

iii. Males are homogametic and produce one type of sperms. Each sperm carries a Zchromosome.

iv. Thus sex of individual depends on the kind of egg (ova) fertilized by the sperm.

Q.81 Explain sex determination in honey bees with the help of schematic representation.

Ans :

i. In honey bees, chromosomal mechanism of sex determination is **haplo-diploid type**.

ii. In this type, sex of individual is determined by the number of set of chromosomes received.

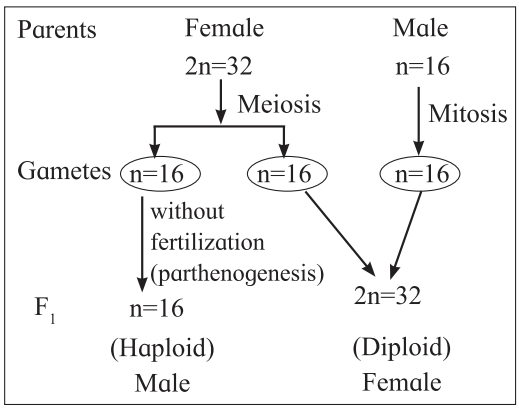
iii. Females are diploid (2n = 32) and males are haploid (n = 16).

iv. The female produces haploid eggs (n = 16) by meiosis and male produces haplaid sperms (n = 16) by mitosis.

v. If the egg is fertilized by sperm, the zygote develops into a diploid female (2n = 32) (queen and worker) and unfertilised egg develops into haploid male (n = 16) (Drone) by way of parthenogenesis.

vi. The diploid female gets differentiated into either worker or queen depending on the food they consume during their development.

vii. Diploid larvae which get royal jelly as food develops into queen (fertile female) and other develops into workers (sterile females).



TEXTUAL QUESTION

★Q.82 What is parthenogenesis? Explain the haplo-diploid method of sex determination in honey bee.

Ans : *Refer Q.81.*

3.12 Genetic disorders

INTEXT QUESTION

Q.83 Can you recall?
Which are the chromosomal disorders?

Ans :

i. Chromosomal disorders are caused due to absence or excess of one or more chromosomes or their abnormal arrangement.

ii. Following are chromosomal disorders:
   a. Down Syndrome/Trisomy of 21st chromosome : 45 + XX or 45 + XY
   b. Turner syndrome (Monosomy of chromosome X : 44 + XD).
   c. Klinefelter's syndrome (44 + XXY)

Q.84 Give classification of genetic disorders.

Ans :

i. Genetic Disorders are broadly grouped into two categories as, Mendelian disorders and chromosomal disorders.

ii. **Mendelian discorders** are mainly caused due to alteration or mutation in the gene. e.g. thalassemia, sicklecell anaemia, colour-blindness, haemophilia, phenylketonuria, etc.

iii. On the other hand, **chromosomal disorders** are caused due to absence or excess of one or more chromosomes or their abnormal arrangment. For e.g. Down syndrome, Turner syndrome, Klinefelter syndrome etc.

Q.85 Write a short note on Thalassemia.

Ans :

i. Thalassemia is an autosomal, inherited recessive disease.

ii. Haemoglobin molecule is made of four polypeptide chains-2 alpha (α) and 2 beta (β) chains.

iii. The synthesis of alpha chains are controlled by two closely linked genes (HBA1 and HBA2) on chromosome 16 while the synthesis of beta chain is controlled by a single gene (HBB) on chromosome 11.

iv. Depending upon which chain of haemoglobin is affected, thalassemia is classified as alpha-thalassemia and beta-thalassemia.

v. It is caused due to deletion or mutation of gene which codes for alpha (α) and beta (β) globin chains that result in abnormal synthesis of haemoglobin.

vi. In Thalassemia, person shows symptoms like anaemia, pale yellow skin, change in size and shape of RBCs, slow growth and development, dark urine, etc.

vii. Massive blood transfusion is needed to these patients.

viii. Thalassemia differs from sickle-cell anaemia. The former is a qualitative problem of synthesising few globin molecule, while the latter is a qualitative problem of synthesising an incorrectly functional globin.

Q.86 Write a short note on Down's Syndrome.

Ans :

i. This Syndrome is caused due to an extra copy of chromosome number 21st.

ii. It shows presence of three copies of 21st chromosome instead of homologous pair.

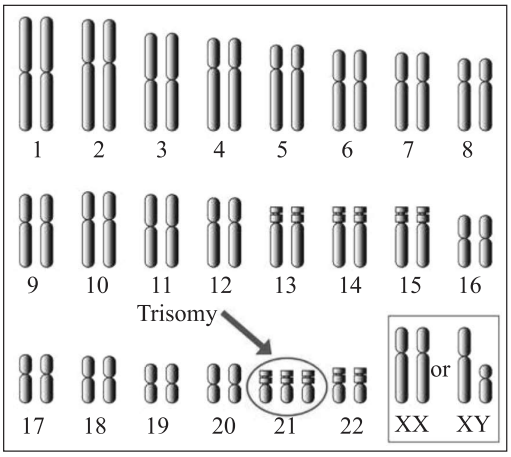
iii. These individuals will have 47 chromosomes instead of the normal number 46.

iv. 21st Trisomy occurs due to non-disjuction or failure of separation of chromosomes **(autosomes)** during gamete formation.

v. The incidence of non-disjunction is distinctly higher in mothers who are over 45 years old.

vi. These patients have mild or moderate mental retardation and skeletal development is poor.

vii. Distinct facial features like small head, ears and mouth, face is typically flat and rounded with flat nose, open mouth and protruding tongue, eyes slant up and out with internal epicanthal folds, flat hands and stubby fingers and palm is broad with single palmer crease.



Q.87 What is Turner's Syndrome?

Ans :

i. Turner's Syndrome (X monosomy / XO females) is sex chromosomal disorder caused due to non-disjunction of chromosome during gamete formation.

ii. Individual born with Turner's syndrome has 44 autosomes with XO.

iii. They are phenotypically female. They have a short stature (height) and webbed neck, lower posterior hair line, broad shield-shaped chest, poorly developed ovaries and breast, and low intelligence.

Q.88 Explain Klinefelter's syndrome

Ans :

i. Klinefelter's syndrome (XXY males) is chromosomal disorder caused due to extra X chromosome in males.

ii. Thus genotype of individuals is 44 + XXY.

iii. They are described as feminized males.

iv. Extra chromosome is a result of non-disjunction of X-chromosome during meiosis.

v. Individual is male and has over all masculine development.

vi. Voice pitch is harsh and have under developed testis. They are tall with long arms, feminine development (development of breast i.e. Gynaecomastia) and no spermatogenesis, therefore, individuals are sterile.

★Q.89 Give an example of chromosomal disorder caused due to non-disjunction of autosomes.

Ans : Down syndrome is an example of chromosomal disorder caused due to non-disjunction of autosomes.

★Q.90 Match the column-I with column-II and re-write the matching pairs.

	Column I		Column II
i.	21 Trisomy	a.	Turner syndrome
ii.	X Monosomy	b.	Klinefelter syndrome
iii.	Holandric traits	c.	Down syndrome
iv.	Feminized male	d.	Hypertrichosis

Ans :

	Column I		Column II
i.	21 Trisomy	c.	Down syndrome
ii.	X Monosomy	a.	Turner syndrome
iii.	Holandric traits	d.	Hypertrichosis
iv.	Feminized male	b.	Klinefelter syndrome

MULTIPLE CHOICE QUESTIONS

Entrance Set 7

1. Select the incorrect statement.
   (a) Human males have one of their sex-chromosome much shorter than other.
   (b) Male fruit fly is heterogametic.
   (c) In male grasshoppers, 50% of sperms
   (d) In domesticated fowls sex of progeny depends on the type of sperm rather than egg.

2. A cell at telophase stage is observed by a student in a plant brought from the field. He tells his teacher that this cell is not like other cells at telophase stage. There is no formation of cell plate and thus the cell is containing more number of chromosomes as compared to other dividing cells. This would result in
   (a) Somaclonal variation
   (b) polyteny
   (c) aneuploidy
   (d) polyploidy.

3. In Drosophila, the sex is determinedby
   (a) the ratio of number of X-chromosome to the sets of automsomes
   (b) X and Y chromosomes
   (c) the ratio of pairs of X-chromosomes to the pairs of autosomes
   (d) whether the egg is fertilized or develops parthenogenetically.

4. What is the genetic disorder in which an individual has an overall masculine development, gynaecomastia, and is sterile?
   (a) Down's syndrome
   (b) Turner's syndrome
   (c) Klinefelter's syndrome
   (d) Edward syndrome
5. Thalassemia and sickle cell anemia are caused due to a problem in globin molecule synthesis. Select the correct statement.
   (a) Both are due to a quantitative defect in globin chain synthesis.
   (b) Thalassemia is due to less synthesis of globin molecules.
   (c) Sickle cell anaemia is due to a quantitative problem of globin molecules.
   (d) Both are due to a qualitative defect in globin chain synthesis.
6. A disease caused by an autosomal primary nondisjunction is
   (a) Klinefelter's syndrome
   (b) Turner's syndrome
   (c) sickle cell anaemia
   (d) Down's syndrome.
7. An abnormal human body with 'XXX' sex chromosomes was born due to
   (a) fusion of two ova and one sperm
   (b) fusion of two sperms and one ovum
   (c) formation of abnormal sperms in the father
   (d) formation of abnormal ova in the mother.
8. A human female with Turner's syndrome
   (a) has 45 chromosomes with XO
   (b) has one additional X chromosome
   (c) exhibits male characters
   (d) is able to produce children with noraml husband.
9. Which of the following cannot be detected in a developing fetus by amniocentesis?
   (a) Down's syndrome
   (b) Jaundice
   (c) Klinefelter's syndrome
   (d) Sex of the fetus
10. If both parents are carriers for thalassaemia, which is an autosomal recessive disorder, what are the chances of pregnancy resulting in an affected child?
   (a) 25% (b) 100%
   (c) No chance (d) 50%
11. Down's syndrome in humans is due to
   (a) three 'X' chromosomes
   (b) three copies of chromosome 21
   (c) monosomy
   (d) two 'Y' chromosomes.
12. Sickle-cell anaemia is
   (a) caused by substitution of valine by glutamic acid in the beta globin chain of haemoglobin
   (b) caused by a change in a single base pair of DNA
   (c) characterized by elongated sickle like RBCs with a nucleus
   (d) an autosomal linked dominant trait.
13. Which one of the following conditions in humans is correctly matched with its chromosomal abnormality/linkage?
   (a) Erythroblastosis fetalis - X-linked
   (b) Down's syndrome - 44 automsomes + XO
   (c) Klinefelter's syndrome - 44 autosomes + XXY
   (d) Colour blindness - Y linked
14. A woman with 47 chromosomes due to three copies of chromosome 21 is characterized by
   (a) Superfemaleness
   (b) triploidy
   (c) Turner's syndrome
   (d) Down's syndrome
15. Down's syndrome is caused by an extra copy of chromosome number 21. What percentage of offspring produced by an affected mother and a normal father would be affected by this disorder?
   (a) 100% (b) 75%
   (c) 50% (d) 25%

❑❑❑

ANSWER KEY

Entrance Corner Set-1

3.1

1. (a) 2. (d) 3. (d) 4. (b) 5. (b)
6. (d) 7. (d) 8. (b) 9. (c) 10. (c)
11. (c) 12. (d) 13. (c) 14. (c) 15. (b)
16. (b)

Solution:

1-(a) Mendel considered the following characters of pea in his experiments:

	Character	Dominant	Recessive
1	Seed shape	Round (r)	Wrinkled (r)
2	Seed cotyledon	Yellow (Y)	Green (y)
3	Flower colour	Violet (V)	White (v)
4	Pod shape	Inflated (I)	Constricted (i)
5	Pod colour	Green (G)	Yellow (g)
6	Flower position	Axial (A)	Terminal (a)
7	Sten height	Tall (T)	Dwarf (t)

2-(d)

3-(d)

4-(b)

5-(b)

Mendel considered the following characters of pea in his experiments:

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5	Pod colour	Green (G)	Yellow (g)
6	Flower position	Axial (A)	Terminal (a)
7	Sten height	Tall (T)	Dwarf (t)

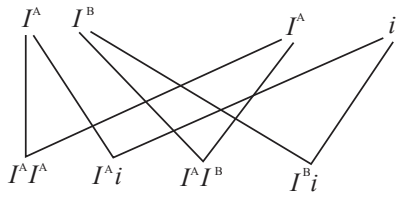
6-(d) Mendel worked on seven characters. These characters showed complete independent assortment despite the seven characters chosen by him were present on four chromosomes-1, 4, 5 and 7.

3.2

1. (d) 2. (a) 3. (a) 4. (c) 5. (a)
6. (b) 7. (c) 8. (c) 9. (d) 10. (d)
11. (a) 12. (a) 13. (c) 14. (a) 15. (b)
16. (c) 17. (c) 18. (d) 19. (a)

Solution:

1-(b) If the genotypes of husband and wife are $I^A I^B$ and $I^A i$ respectively, then the probabilities of genotypes and phenotypes among their children can be worked out as:



Genotype: I^AI^A I^Ai I^AI^B I^Bi

Phenotype: A A AB B

Thus there are four possible genotypes, *viz.*, I^AI^A, I^Ai, I^AI^B and I^Bi and three possible phenotypes, *viz.*, A, AB and B among the children.

2-(c) When a tall true breeding garden pea plant is crossed with a dwarf true breeding garden pea plant and the F_1 plants were selfed the resulting genotypes were in the ratio of 1 : 2 : 1 i.e., Tall homozygous: Tall heterozygous : Dwarf

It can be illustrated as given below:

Tall × Dwarf
TT × tt — Parent generation
T, t — Gametes
Tt — F_1 generation
Tall heterozygous
TT × Tt — Selfing

Female gametes \ Male gametes	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Dwarf

F_2 generation

Phenotypic ratio : 3 : 1 : : Tall : Dwarf

Genotypic ratio - 1 : 2 : 1 : : TT : Tt : tt

3-(b) The ability of a gene to have multiple phenotypic effects because it influences a number of characters simultaneously is known as pleiotropy. The gene having a multiple phenotypic effect because of its ability to control expression of two or more characters is called pleiotropic gene. In human beings pleiotropy is exhibited by syndromes called sickle cell anaemia and phenylketonuria.

4-(d) Linkage is the phenomenon of certain genes stayign together during inheritance through generation without any change or separation due to their being present on the same chromosome. Linked genes occur in the same chromosome. Strenght of the linkage between two genes is inversely proportional to the distance between the two i.e., two linked genes show higher frequency of crossing over (recombination) if the distance between them is higher and lower frequency if the distance is small.

5-(d) As sperms produced are with genotypes AB, Ab, aB, ab (two diallelic character) the person must be heterozygous for both genes. So his genotype will be AaBb.

6-(a) Since round seed shape is dominant over wrinkled seed shape and yellow cotyledon is dominant over green cotyledon so RRYY individuals is round yellow and rryy is wrinkled green.

Round yellow seeds × Wrinkled green seeds

RRYY × rryy

↓

F_1 generation RrYy

F_2 generation is obtained by selfing F_1.

Female gametes ↓ / Male gametes →	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

Expected phenotypes in F_2 generation

Round yellow seed	Wrinkled yellow seed
9	3
Round green seed	Wrinkled green seed
3	1

7-(a) The external manifestation, morpholigical or physiological expression of an individual with regard to one or more characters is called phenotype. For recessive genes, the phenotype and genotype are similar. For dominant genes, the phenotype is same for both homozygous states. Phenotype is influenced by environment as well as age. A child definitely differs from adolescent, the latter from adult and an adult from aged one. Many phenotypes are determined by multiple genes. Thus, the identity of phenotype is determined by genotype and environment.

8-(b) Since red fruit colour is dominant over yellow fruit colour and tallness is dominant over shortness.

RRTt × rrtt .... Parent
Red Tall Yellow Short
↓
RT Rt rt .... Gametes
RrTt Rrtt .... F_1
Red Tall Red Short

These are produced in 1 : 1 ratio.

9-(b) Mutation is a sudden alteration of the chemical structure of a gene or the alternative of its position on the chromosome by breaking and rejoining of the chromosome. It has occured in male parent. But organelles like mitochondria, chloroplast etc., are a part of cytoplasmic inheritance.

Cytoplasmic inheritance is the passage of traits from parents to offspring through structures present inside the cytoplasm of contributing gametes. Plasma genes occur in plastids, mitochondria, plasmids and some special particles like kappa particles, sigma particles, etc. In higher organisms cytoplasmic inheritance is called maternal inheritance because the zygote receives most of its cytoplasm from the ovum. Therefore, cytoplasmic inheritance is usually unparental. So none of the progeny will show mutation.

3.3

1. (a) 2. (c) 3. (d) 4. (a) 5. (b)
6. (a)

Solution:

1-(a) Law of segregation applies in this case as when pink flowers obtained in F_1 are selfed then red and white flowers are obtained in F_2 which indicates that there is no mixing of gametes.

2-(c) According to Mendel's law of dominance, in heterozygous individuals a character is represented by two contrasting factors called alleles or allelomorphs which occur in pairs.

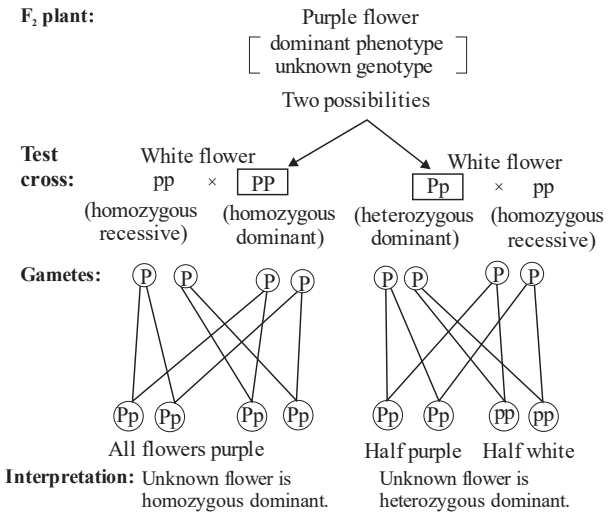
Out of the two contrasting alleles, only one is able to express its effect in the individual. It is called dominant factor or dominant allele. The other allele which does not show its effect in the heterozygous individual is called recessive factor or recessive allele. The option (c) in the given question cannot be explained on the basis of law of dominance. It can only be explainedon the basis of Mendel's law of independent assortment, according to which in a dihybrid cross, the two alleles of each character assort independently (do not show any blending) of the alleles of other character and separate at tht time of gamete formation. Both the characters are recovered as such in F_2 generation producing both parental and new combinations of traits.

3.4

1. (a) 2. (a) 3. (c) 4. (a) 5. (c)
6. (b) 7. (c) 8. (d) 9. (a) 10. (d)
11. (a) 12. (d)

Solution:

1-(a) Test cross is performed to determine the genotype of F_2 plant. In a typical test cross an organism showing dominant phenotype and whose genotype is to be determined is crossed with one that is homozygous recessive for the allele being investigated, instead of self-crossing. The progenies of such a cross can easily be analysed to predict the genotype of the test organism. Given below is an illustration of test cross.



2-(a) In humans, the female has a pair of X chromosome (homogametic composition) and the male has XY chromosomes (heterogametic composition). Therefore, two normal X chromosomes in zygotic cell lead to the birth of a normal human female child.

3-(c) Test cross is performed to determine the genotype of F_2 plant. In a typical test cross an organism showing dominant phenotype and whose genotype is to be determined is crossed with one that is homozygous recessive for the allele being investigated, instead of self-crossing. The progenies of such a cross can easily be analysed to predict the genotype of the test organism. Given below is an illustration of test cross.

[Dig,] [Refer to answer 1]

4-(a) Test cross is performed to determine the genotype of F_2 plant. In a typical test cross an organism showing dominant phenotype and whose genotype is to be determined is crossed with one that is homozygous recessive for the allele being investigated, instead of self-crossing. The progenies of such a cross can easily be analysed to predict the genotype of the test organism. Given below is an illustration of test cross.

[Dig,] (Refer to answer 1).

5-(c) Test cross is performed to determine the genotype of F_2 plant. In a typical test cross an organism showing dominant phenotype and whose genotype is to be determined is crossed with one that is homozygous recessive for the allele being investigated, instead of self-crossing. The progenies of such a cross can easily be analysed to predict the genotype of the test organism. Given below is an illustration of test cross.

[Refer to answer 1]

3.5

1. (a) 2. (b) 3. (c) 4. (b) 5. (b)
6. (a) 7. (a) 8. (c) 9. (b) 10. (b)
11. (a) 12. (d)

Solution:

1-(a) The gene for starch synthesis in pea seeds can produce more than one effect which implies

it is a pleiotropic gene.

2-(b) ABO blood group system in human beings is an example of dominance, co-dominance and multiple allelism.

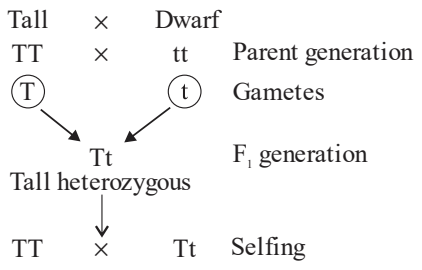
$I^A\ I^O$, $I^B\ I^O$ or i - Alleles shows dominant-recessive relationship.

$I^A\ I^B$ - Codominance is a phenomenon in which alleles of a gene do not show dominant recessive relationship and express themselves independently when present together.

$I^A, I^B\ I^O$ or *i* - More than two alternate forms of a gene present on the same locus are called as multiple alleles and the mode of inheritance in the alleles is called multiple allelism.

3-(c) When a tall true breeding garden pea plant is crossed with a dwarf true breeding garden pea plant and the F_1 plants were selfed the resulting genotypes were in the ratio of 1 : 2 : 1 i.e., Tall homozygous: Tall heterozygous : Dwarf

It can be illustrated as given below:



Male gametes → / Female gametes ↓	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Dwarf

F_2 generation

Phenotypic ratio : 3 : 1 : : Tall : Dwarf

Genotypic ratio - 1 : 2 : 1 : : TT : Tt : tt

4-(b) The phenomenon of expression of both the alleles in a heterozygote is called codominance. The alleles which do not show dominance-recessive relationship and are able to express themselves independently when present together are called codominant alleles. As a result the heterozygous condition has a phenotype different from either of homozygous genotypes, e.g., alleles for blood group A(I^A) and for blood group B (I^B) are codominant so that when they come together in an individual, they produce blood group AB.

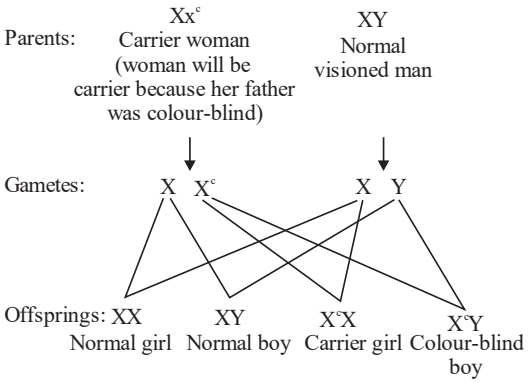
5-(b) The ability of a gene to have multiple phenotypic effects because it influences a number of characters simultaneously is known as pleiotropy. The gene having a multiple phenotypic effect because of its ability to control expression of two or more characters is called pleiotropic gene. In human beings pleiotropy is exhibited by syndromes called sickle cell anaemia and phenylketonuria.

7-(a) The man has blood group. A, thus its genotype can either be $I^A\ I^B$ or $I^A\ I^O$. Similarly, woman can either have $I^B\ I^B$, or $I^A\ I^O$ genotype. Thus, their offspring can have any of the blood groups A($I^A\ I^A$ or $I^A\ I^O$), B ($I^B\ I^B$ or $I^B\ I^O$), AB ($I^A\ I^B$) or O ($I^O\ I^O$).

8-(c) The phenomenon of expression of both the alleles in a heterozygote is called codominance. The alleles which do not show dominance-recessive relationship and are able to express themselves independently when present together are called codominant alleles. As a result the heterozygous condition has a phenotype different from either of homozygous genotypes, e.g., alleles for blood group A(I^A) and for blood group B (I^B) are codominant so that when they come together in an individual, they produce blood group AB.

9-(b) In codominance, both the alleles are able to express themselves independently when present together resulting in a phenotype that is intermediate between both the parental homozygous phenotypes, thereby resembling both of them. E.g., roan coat colour in cattle is a result of codominance of alleles for white and red coat colour.

10-(b) In the given condition the chances of child to be colour-blind is zero percent. It can be understood by the given cross:



3.6

1. (d) 2. (b) 3. (a) 4. (b) 5. (d)
6. (c)

3.7

1. (d) 2. (d) 3. (c) 4. (a) 5. (a)
6. (d)

3.8

1. (c) 2. (c) 3. (a) 4. (d) 5. (c)
6. (a) 7. (a) 8. (a) 9. (c) 10. (c)
11. (a) 12. (d) 13. (c)

Solution:

1-(c) Translocation is a chromosomal abnormality caused by rearrangement of parts between non-homologous chromosomes. It may cause a gene to move from one linkage group to another.

2-(c) Linkage is the phenomenon of certain genes staying together during inheritance through generations without any change or separation due to their being present on the same chromosome. Linkage was first suggested by Sutton and Boveri (1902-1903) when they propounded the famous "chromosomal theory of inheritance." Bateson and Punnett (1906) while working sweet pea found that the factors for certain characters do not show independent assortment. However, it was Morgan (1910) who clearly proved and defined linkage on the basis of his breeding expriment in fruit fly (Drosophila melanogaster).

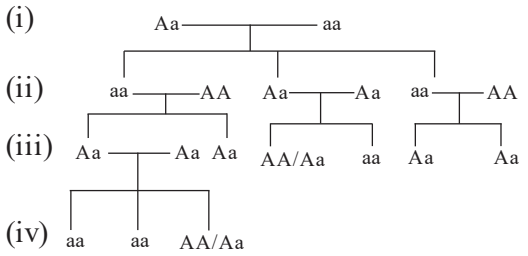
Entrance 6

3.9

1. (a) 2. (d) 3. (a) 4. (d) 5. (b)
6. (b) 7. (c) 8. (a) 9. (c) 10. (b)
11. (c) 12. (d) 13. (a) 14. (b)

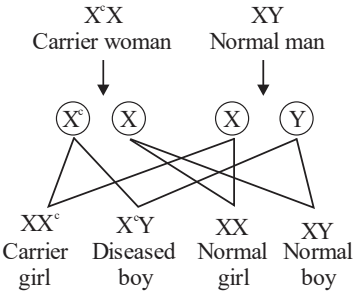
Solution:

1-(a) Autosomal recessive traits are the traits which are caused by recessive autosomal genes when present in homozygous condition. The given pedigree can be explained as:



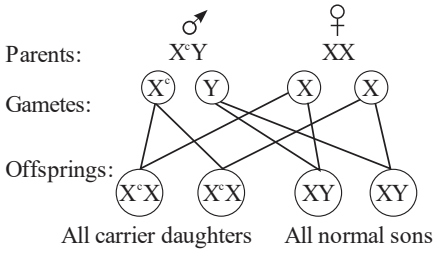
As the trait appears only in homozygous recessive individuals (aa), therefore it is an autosomal recessive trait.

2-(d) Women acts as a carrier when she has the X-linked condition on one of her X-chromosomes. Both son and daughter inherit X chromosome from mother. Hence, one of the two daughters will be carrier and one of the two daughters will be carrier and one of the two sons will be diseased. It can be explained by the given cross:



where X^c is the X-chromosome carrying the gene for the condition.

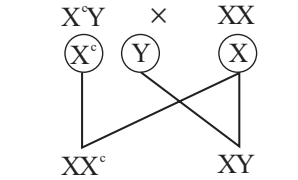
3-(a) Geneotype of colour blind man - X^cY
Geneotype of women homozygous - XX for normal woman.



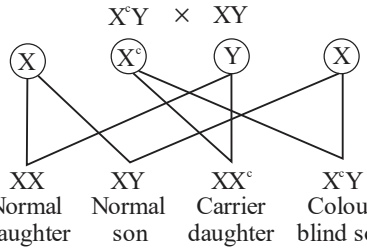
Hence, there is zero (0) probability of their son to be colour-blind.

4-(d) Haemophilia is a sex-linked disease. It ocurs due to the presence of a recessive sex linked gene h, which is carried by X-chromosome.

5-(b) When a colour blind man (X^cY) marries a normal woman (XX), all of their daughters are carriers and all of their sons are normal, as shown in following figure:



When the carrier daughter (XX^c) is married to a normal man, the probability of their son being colour blind is 0.25, as shown in the following figure:



From above crosses, it is clear that the probability of occurence of colour blindness in the grandson of a colour blind man and a normal woman in 0.25.

6-(b) A dominant epistatic allele suppresses the expression of a non-allelic gene whether the latter is dominant or recessive. The gene which suppresses the expression of a non-allelic gene is known as epistatic gene. The gene or locus which is suppressed by the presence of non-allelic gene is known as epistatic gene. The gene or locus which is suppressed by the presence of non-allelic gene is termed as hypostatic gene. In summer squash or *Cucurbita pepo*, there are three types of fruit colour- yellow, green and white. White colour is dominant orver other colours while yellow is dominant over green. Yellow colour is formed only when the dominant over green. Yellow colour is formed only when the dominant epistatic gene is represented by its recessive allele (w). When the hypostatic gene is also recessive (y), the colour of the fruit is green, *i.e.*,

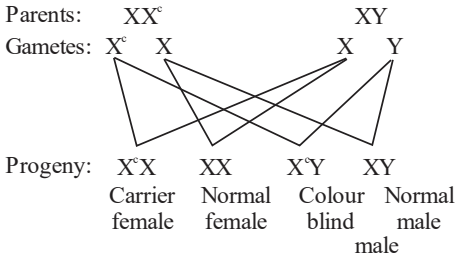
W – Yy, W – yy → White

wwY → Yellow

wwyy → Green

7-(c) It is given that the man had colour blind father, i.e., man's genotype would be XY.

Now, the woman had a colourblind mother and normal father, thus her genotype would be X^cX. A cross between them can be represented as below.



Therefore, 50% of male children of this couple will be colour blind.

8-(a) Haemophilia is sex-linked diesease 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 posses the natural phenomenon of blood clotting due to absence of antihaemophiliac globulin or factor VIII (haemophilia - A) and plasma thromboplastin factor IX (haemophilia-B, Christmas disease) essential for it. As a result of continuous bleeding the patient may die of blood loss. It is genetically due to the presence of a recessive sex linked gene h, carried by X-chromosome. A female becomes haemophiliac only when both of her X-chromosomes carry the gene (X^hX^h). However, such females generally die before birth because the combination of these two recessive allele for normal (XX^h) appears normal because the allele for normal blood clotting present on the other X-chromosome is dominant. Such females are known as carriers. In case of males, a single gene for the defect is able to express itself as the Y-chromosome is devoid of any corresponding allele (X^hY).

10-(b) Traits governed by sex-linked recessive genes are: (a) produced disorders in males more often than in females, (b) express themselves in males even when represented by a single allele becuase Y-chromosome does not carry any corresponding alleles, (c) seldom appear in both father and son, (d) fail to appear in females unless their father also possesses the same and the mother is a carrier, (e) female heterozygous for the trait function as carrier and (f) female homozygous for the recessive trait transfer the trait to all the sons.

Take the example of colour blindness which is a recessive sex-linked trait. In the question, as man and woman do not show any signs of disease, so man must be normal and woman must be carrier.

11-(c) Haemophilia is sex-linked diesease 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 posses the natural phenomenon of blood clotting due to absence ofantihaemophiliac globulin or factor VIII (haemophilia - A) and plasma thromboplastin factor IX (haemophilia-B, Christmas disease) essential for it. As a result of continuous bleeding the patient may die of blood loss. It is genetically due to the presence of a recessive sex linked gene h, carried by X-chromosome. A female becomes haemophiliac only when both of her X-chromosomes carry the gene (X^hX^h). However, such females generally die before birth because the combination of these two recessive allele for normal (XX^h) appears normal because the allele for normal blood clotting present on the other X-chromosome is dominant. Such females are known as carriers. In case of males, a single gene for the defect is able to express itself as the Y-chromosome is devoid of any corresponding allele (X^hY).

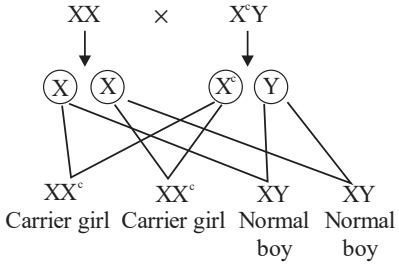
12-(d) Cretinism occurs due to hyposecretion of thyroid hormones. Haemophilia is a sex linked recessive trait. Cystic fibrosis is also a recessive autosomal disorder resulting in mucus clogging in lungs. Thalassemia involves a gene mutation in the polypeptide chains of haemoglobin.

13-(a) Colour blindness is a recessive sex-linked trait. Since the woman's father was colour blind, she should be carrier of the colour blind gene (XCX). When she marries to colour blind man their progency could be

Parent	X^cX Carrier woman		×	X^cY Colourblind man			
Progeny	X^cX^c Colour blind girl		X^cX Carrier girl		X^cY Colour blind son		XY Normal son

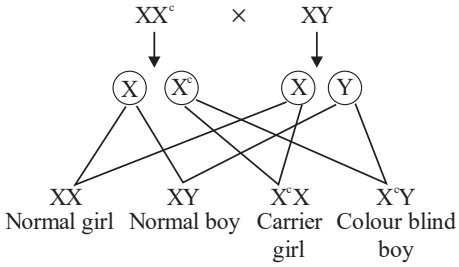
14-(b) In question, where the genotype of the other parent is not mentioned then that should be considered normal. Colour blindness is a recessive sex-linked trait

(i) To find out the genotype of a woman. Her father is colour-blind or his genotype is X^cY and her mother is normal so her genotype is XX.



So, woman is carrier.

(ii) When this woman marries normal man 50% of the sons would be colour blind.



Set 7

3.11

1. (d) 2. (d) 3. (c) 4. (c) 5. (b)
6. (d) 7. (d) 8. (a) 9. (b) 10. (a)
11. (b) 12. (b) 13. (c) 14. (d) 15. (c)

Solution:

1-(d) In birds, e.g., fowls, male have homomorphic sex chromosomes (AA + ZZ) and females have heteromorphic sex chromosomes (AA +

ZW). So, males produce only one type of sperms containing (A + Z) whereas females produce two types of eggs (A + Z and A + W). Therefore, the sex of the progeny depends on the type of the egg which is fertilised by the sperm.

2-(d) Polyploidy is the phenomenon of occurrence of more than two sets of chromosomes in the nucleus of a cell. Polyploidy is more common in plants. Polyploidy arises as a result of total non-disjunction of chromosomes during mitosis or meiosis.

3-(c) According to genic balance theory of sex dertermination the ratio between the number of X-chromosomes and number of complete sets of automsomes carry male tendency genes. Both these sets of genes start functioning and there has to be a balance between them for an individual to become male or female. If the ratio between X and A is 1.0 it will be a female individual and when it is 0.5, it would be male.

4-(c) Klinefelter's syndrome occurs by the union of an abnormal XX egg and a normal Y sperm or a normal X egg and abnormal XY sperm. The individual has 47 chromosomes (44 + XXY). Such persons are sterile males with undeveloped testes, mental retardation, sparse body hair, long limbs and with some female characteristics such as enlarged breast, i.e., gynaecomastia.

5-(b) Sickle cell anaemia is caused due to point mutation in which at the 6th position of beta globin chain, glutamic acid is replaced by valine. Thus, it is a qualitative defect in functioning of globin molecules.

Thalassemia is caused due to either mutation or deletion which ultimately results in reduced rate for synthesis of one of the globin chains that make up haemoglobin. Hence, it is a quantitative defect in functioning of globin molecules.

6-(d) Down's syndrome is an autosomal aneuploidy, caused by the presence of an extra-chromosome number 21. Both the chromosomes of the pair 21 pass into a single egg due to non disjunction during oogenesis.

7-(d) The abnormal baby has an extra X chromosome, thus it must have been produced by fusion of abnormal XX ovum with a normal X sperm. Abnormal XX sperm is not possible because, males have XY genotype, and if produce abnormal sperms, then XY sperms and O sperms will be produced. If fusion of multiple gametes have occured (either two ova with one sperm or two sperm with one ovum), then the baby will have triploid genotype not the trisomy of sex chromosomes.

8-(a) A human female with Turner's syndrome has single sex chromosome i.e., 44 + X0 (45). Such females are called sterile females with rudimentary ovaries. Other associated phenotypes of this condition are short stature, webbed-neck, broad chest, lack of secondary sexual characteristics and sterility. Thus, any imbalance in the copies of the sex chromosomes may disrupt the genetic information necessary for normal sexual development.

9-(b) Amniocentesis is a fetal sex determination test in which amniotic fluid containing fetal cells which surrounds the developing embryo is extracted and cells are tested for chromosomal pattern to identify genetic disorders, if any. Jaundice is not a chromosomal disorder thus cannot be tested by amniocentesis.

10-(a) Thalassaemia is an autosomal recessive blood disorder. In the given case, both the partners are unaffected carriers for the gene i.e., have heterozygous genotype Tt. Persons homozygous for the autosomal recessive gene of β–thalassaemia suffer from severe haemolytic anaemia. Heterozygous persons are also not normal, but show the defect in a less severe form (thalassaemia mirror).

Parents genotype: Tt × Tt

↓

Offspring genotype: TT : Tt : tt

1 : 2 : 1

Normal 25% | Carriers 50% | Affected 25%

11-(b) Down's syndrome is the trisomy of 21st chromosome in man. Down's syndrome is characterised by short stature, warty skin, protruding tongue, slanting eyes, with folded eyelids. The affected person's face presents a typical monogoloid look. Hence, it is also called as mongoloid idiocy. It occurs due to the phenomenon of non-disjunction. Non-disjunction occurs when a pair of homologous chromosomes do not separate in meiosis but migrate to the same pole of the cell resulting in an uneven number of chromosomes in the daughter cells (45 in one and 47 in other). This numberical abnormality results in trisomy (2n + 1) and monosomy (2n - 1). Non-disjunction is more common in sex chromosomes.

12-(b) Sickle-cell anaemia is an autosomal hereditary disorder in which erythrocytes becomes sickle shaped. It is caused by the formation of abnormal haemoglobin called haemoglobin-S. Haemoglobin-S is formed when 6th amino acid of β-chain, i.e., glutamic acid is replaced by valin due to substitution. It occurs due to a single nucleotide change (A $\rightarrow$ T) in the β-globin gene of coding strand. In the normal β-globin gene the DNA sequence is CCTGAGGAG, while in sickle-cell anaemia, the sequence is CCTGTGGAG.

13-(c) Klinefelter's syndrome is a genetic disorder in which there are three sex chromosomes, XXY, rather than the normal XX or XY. The number of autosomes are normal i.e., 44. Affected individuals are apparently male but are tall and thin, with small testes, failure of normal sperm production (azoospermia), enlargement of the breasts (gynaecomastia) and absence of facial and body hairs.

14-(d) Down's syndrome is caused by the presence of an extra chromosome number 21. Both the chromosomes of the pair 21 pass into a single egg. Thus, the egg possesses 24 chromosomes instead of 23 and offspring has 47 chromosomes (45 + XY in males, 45 + XX in males) instead of 46. Turner's syndrome is formed by the union of an abnormal 0 egg and a normal X sperm or a normal X sperm. The individual has 45 chromosomes (44 + X) instead of 46. Female with more than two X chromosomes is called superfemale. Triploidy is a condition in which an organism has three times (3n) the haploid number (n) of chromosomes.

15-(c) Down's syndrome is the example of autosomal aneuploidy. Here, an extra copy of chromosome 21 occurs. As it is an autosomal disease, the offsprings produced from affected mother and normal father should be 50%.

❑❑❑