Inheritance and Variation

EXERCISES [PAGES 68 - 69]

Exercises | Q 1.1 | Page 68

Multiple choice question.

Phenotypic ratio of incomplete dominance in Mirabilis jalapa.

1. 2 : 1 : 1
2. **1 : 2 : 1**
3. 3 : 1
4. 2 : 2

Solution: 1 : 2 : 1

Exercises | Q 1.2 | Page 68

Multiple choice question.

In a dihybrid cross, F_2 generation offsprings show four different phenotypes while the genotypes are _____.

1. six
2. **nine**
3. eight
4. sixteen

Solution: In a dihybrid cross, F_2 generation offsprings show four different phenotypes while the genotypes are **nine**.

Exercises | Q 1.3 | Page 68

Multiple choice question.

A cross between an individual with an unknown genotype for a trait with recessive plant for that trait is _____.

1. back cross
2. reciprocal cross
3. monohybrid cross
4. **test cross**

Solution: A cross between an individual with an unknown genotype for a trait with a recessive plant for that trait is **test cross.**

Exercises | Q 1.4 | Page 68

Multiple choice question.

When phenotypic and genotypic ratios are the same, then it is an example of _____.

1. **incomplete dominance**
2. complete dominance
3. multiple alleles
4. cytoplasmic inheritance

Solution: When phenotypic and genotypic ratios are the same, then it is an example of **incomplete dominance**.

Exercises | Q 1.5 | Page 68

Multiple choice question.

If the centromere is situated near the end of the chromosome, the chromosome is called _____.

1. metacentric
2. **acrocentric**
3. sub-metacentric
4. telocentric

Solution: If the centromere is situated near the end of the chromosome, the chromosome is called **acrocentric.**

Exercises | Q 1.6 | Page 68

Multiple choice question.

Chromosomal theory of inheritance was proposed by _____.

1. **Sutton and Boveri**
2. Watson and Crick
3. Miller and Urey
4. Oparin and Halden

Solution: Chromosomal theory of inheritance was proposed by **Sutton and Boveri**.

Exercises | Q 1.7 | Page 68

Multiple choice question.

If the genes are located in a chromosome as p-q-r-s-t, which of the following gene pairs will have the least probability of being inherited together?

1. p and q
2. r and s

3. s and t
4. **p and s**

Solution: p and s

Exercises | Q 1.8 | Page 68

Multiple choice question.

Find the mismatch pair:

1. **Down's syndrome = 44 + XY**
2. Turner's syndrome = 44 + XO
3. Klinefelter syndrome = 44 + XXY
4. Super female = 44 + XXX

Solution: Down's syndrome = 44 + XY

Exercises | Q 1.9 | Page 68

Multiple choice question.

A colour-blind man marries a woman, who is homozygous for normal colour vision, the probability of their son being colour blind is –

1. **0%**
2. 25%
3. 50%
4. 100%

Solution: 0%

Exercises | Q 2.1 | Page 68

Very Short Answer Question.

Explain the statement of Test cross is back cross but back cross is not necessarily a test cross.

Solution:

1. In back cross F_1 generation can be crossed with either dominant or recessive parent.
2. But in test cross, F_1 generation is crossed with a recessive parent only.
3. Thus, in the back cross, if F_1 generation is crossed with a 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. Therefore, the test cross is a back cross but the back cross is not necessarily a test cross.

Exercises | Q 2.1 | Page 68

Very Short Answer Question.

Explain the statement of Law of dominance is not universal.

Solution:

1. According to 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.
2. In many cases, the dominance is not complete or absent. This can be explained by two deviations of Mendel's law of dominance: Incomplete dominance and codominance. Thus, law of dominance is significant and true, but it is not universally applicable.

Exercises | Q 2.2 | Page 68

Define the following:

test cross.

Solution:

Test cross: The cross between F_1 hybrid and its homozygous recessive parent is called a test cross.

Exercises | Q 2.2 | Page 68

Define the following:

Homozygous

Solution1:

Homozygous - Diploid condition where both the alleles are identical is called homozygous.

Solution2:

Homozygous (pure): An individual having identical alleles for a particular character is homozygous for that character. It is pure or true breeding for that trait. e.g. TT, tt.

Exercises | Q 2.2 | Page 68

Define the following:

Heterozygous

Solution1:

Heterozygous - Diploid condition where both the alleles are different is called heterozygous.

Solution2:

Heterozygous: An individual possessing contrasting (dissimilar) alleles for a particular trait is called heterozygous. It is a hybrid and does not breed true for that trait. e.g. Tt

Exercises | Q 2.2 | Page 68

Very Short Answer Questions.

Define dihybrid cross

Solution:

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

OR

A cross between two pure (homozygous) parents in which the inheritance pattern of two pairs of contrasting characters is considered simultaneously is called a dihybrid cross.

Exercises | Q 2.3 | Page 68

Very Short Answer Question.

What is allosome?

Solution: The chromosomes which are responsible for the determination of sex are known as Allosomes (sex chromosomes).

Exercises | Q 2.4 | Page 68

Very Short Answer Question.

What is crossing over?

Solution:

1. Crossing over is a process that produces new combinations (recombinations) of genes by interchanging and exchanging of corresponding segments between non-sister chromatids of homologous chromosomes.
2. It occurs during pachytene of prophase I of meiosis.
3. The mechanism of crossing over consists of four sequential steps such as synapsis, tetrad formation, crossing over, and terminalisation.
4. The phenomenon of crossing over is universal and it is necessary for the natural selection because it increases the chances of variation.

Exercises | Q 2.5 | Page 68

Very Short Answer Question.

Give one example of the autosomal recessive disorder.

Solution:

Autosomal recessive traits Phenyl ketonuria (PKU), Cystic fibrosis, and Sickle cell anaemia.

Exercises | Q 2.6 | Page 68

Very Short Answer Question.

What are X-linked genes?

Solution:

The genes which are present on the non-homologous region of X-chromosome are known as X-linked genes.

Exercises | Q 2.7 | Page 68

Very Short Answer Question.

What are holandric traits?

Solution:

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

Exercises | Q 2.8 | Page 68

Very Short Answer Question.

Give an example of a chromosomal disorder caused due to nondisjunction of autosomes.

Solution:

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

Exercises | Q 2.9 | Page 68

Very Short Answer Question.

Give one example of complete sex linkage?

Solution:

Examples of X-linked traits are hemophilia, red-green colour blindness, myopia (near sightedness), and for Y-linked are hypertrichosis, ichthyosis, etc.

Exercises | Q 3.01 | Page 68

Short Answer Question.

Enlist seven traits of pea plant selected/ studied by Mendel.

Solution:

Following are the seven traits of pea plant selected/studied by Mendel:

Character	**Contrasting form / traits**	
	Dominant	**Recessive**
1. Height of stem	Tall	Dwarf
2. Colour of flower	Purple	White

3. Position of flower	Axial	Terminal
4. Pod shape	Inflated	Constricted
5. Pod colour	Green	Yellow
6. Seed shape	Round	Wrinkled
7. Seed colour (cotyledon)	Yellow	Green

Exercises | Q 3.02 | Page 68

Short Answer Question.

Why law of segregation is also called the law of purity of gametes?

Solution:

1. A diploid organism contains two factors for each trait in its diploid cells and the factors segregate during the formation of gametes.
2. The two alleles (contrasting characters) do not mix, alter or dilute each other and the gametes formed are 'pure' for the characters which they carry.
3. A gamete may carry either a dominant or recessive factor but not both.

Hence, this law is also called the law of purity of gametes.

Exercises | Q 3.03 | Page 68

Short Answer Question.

Write a note on pleiotropy.

Solution:

1. When a single gene controls two (or more) different traits it is called pleiotropic gene and the phenomenon is called pleiotropy or pleiotropism.
2. 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.
3. Normal or healthy gene Hb^A is dominant. The carriers (heterozygotes Hb^A /Hb^S) show signs of mild anaemia as their RBCs become sickleshaped i.e. half-moon-shaped only under abnormally low O_2 concentration.
4. The homozygotes with recessive gene HbS die of fatal anaemia.

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

Exercises | Q 3.04 | Page 68

Short Answer Question.

What are the reasons for Mendel's success?

Solution:

Following are the reasons for Mendel's success:

1. His experiments were carefully planned and involved a large sample.
2. He carefully recorded the number of plants of each type and expressed his results as ratios.
3. In the pea plant, contrasting characters can be easily recognized.
4. The seven different characters in the pea plant were controlled by a single factor each.
5. The factors are located on separate chromosomes and these factors are transmitted from generation to generation.

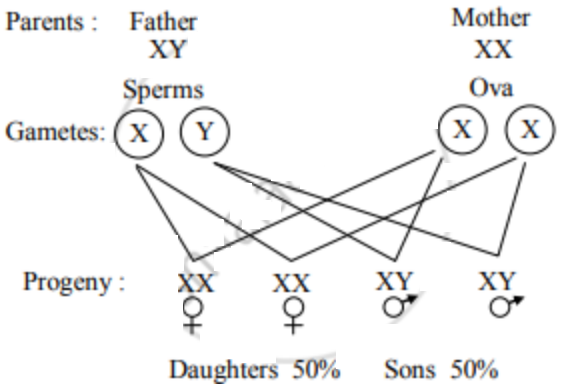
Exercises | Q 3.05 | Page 69

Short Answer Question.

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

Solution:

1. A human male has 44 autosomes + XY sex chromosomes, whereas a female has 44 autosomes + XX sex chromosomes.
2. During gamete formation in male, the diploid germ cells in testis undergo spermatogenesis to produce two types of haploid sperms, 50% sperms contain 22 autosomes and X chromosome while 50% sperms contain 22 autosomes and Y chromosome.
3. In females, the diploid germ cells in ovaries undergo oogenesis to produce only one type of egg. All eggs contain 22 autosomes and the X chromosome.
4. Thus human male is heterogametic and female is homogametic.
5. If a sperm containing X chromosome fertilizes the egg (ovum), the diploid zygote formed after fertilization grows into a female child.
6. If a sperm containing Y chromosome fertilizes the egg, then diploid zygote formed after fertilization grows into a male child.
7. The sex of a child depends on the type of sperm fertilizing the egg and hence the father is responsible for the determination of sex of the child and not the mother



Exercises | Q 3.06 | Page 69

Short Answer Question.

What is a linkage? How many linkage groups do occur in human being?

Solution:

The tendency of two or more genes presents on the same chromosomes to be inherited together is known as linkage. The haploid number of chromosomes in humans is 23 therefore there are 23 linkage groups in humans.

Exercises | Q 3.07 | Page 69

Short Answer Question.

Write note on –PKU.

Solution:

1. Phenylketonuria is an inborn metabolic disorder caused due to deficiency of phenylalanine hydroxylase enzyme.
2. Phenylketonuria is caused due to recessive autosomal genes.
3. When recessive genes are present in homozygous condition, phenylalanine hydroxylase enzyme is not produced.
4. This enzyme is essential for the conversion of amino acid phenylalanine into tyrosine.
5. Due to the absence of this enzyme, phenylalanine is not converted into tyrosine.
6. Hence, phenylalanine and its derivatives are accumulated in blood and cerebrospinal fluid (CSF).
7. It affects development of the brain and causes mental retardation.
8. Excess phenylalanine is excreted in urine, hence this disease is called phenylketonuria.

Exercises | Q 3.08 | Page 69

Short Answer Question.

Compare X chromosome and Y chromosome.

Solution:

X Chromosome	Y Chromosome

1. It is metacentric, hence appears X shaped.	1. It is acrocentric, hence appears Y shaped
2. It is longer than ‘Y’ chromosomes.	2. It is shorter than ‘X’ chromosomes.
3. It contains a large amount of euchromatin and a small amount of heterochromatin.	3. It contains large amount of heterochromatin and small amount of euchromatin.
4. It is found in both males and females.	4. It is found only in males.
5. Non-homologous part of X chromosome shows more genes than Y chromosome.	5. Non-homologous part of Y chromosome contains few genes as compared to X chromosome.
6. X – linked genes are present on the X chromosome.	6. Y-linked genes (Holandric genes) are present on Y chromosome.
7. Genes present on X chromosome show criss–cross inheritance.	7. Genes present on Y chromosome show straight inheritance.

Exercises | Q 3.09 | Page 69

Short Answer Question.

Explain the chromosomal theory of inheritance.

Solution:

The chromosomal theory of inheritance was proposed by Sutton and Boveri.

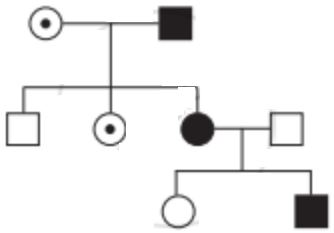
Following are the postulates of chromosomal theory of inheritance:

1. Chromosomes are found in pairs in somatic or diploid cells.
2. During gamete formation, homologous chromosomes pair, segregate and assort independently at meiosis. Due to this, each gamete contains only one chromosome of a pair.
3. Hereditary characters are carried by chromosomes which are present in the nucleus of these gametes.
4. Gametes (sperm and egg) contain all the hereditary characters. They form the link between parents and offsprings.
5. The union of sperm and egg during fertilization restores the diploid number of chromosomes.

Exercises | Q 3.1 | Page 69

Short Answer Question.

Observe the given pedigree chart and answer the following question.



Identify whether the trait is sex-linked or autosomal.

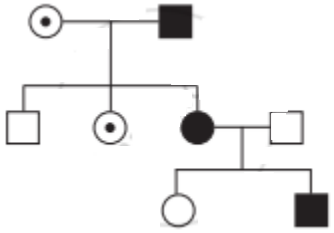
Solution:

The trait represented in given pedigree is sex linked trait.

Exercises | Q 3.1 | Page 69

Short Answer Question.

Observe the given pedigree chart and answer the following question.



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

Solution:

Haemophilia, colour blindness are examples of sex-linked traits in humans.

Exercises | Q 4 | Page 69

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

Column-I	Column-II
1. 21 trisomy	a. Turner’s syndrome
2. X-monosomy	b. Klinefelter’s syndrome
3. Holandric traits	c. Down's syndrome
4. Feminized male	d. Hypertrichosis

Solution:

Column-I	Column-II
1. 21 trisomy	c. Down's syndrome

2. X-monosomy	a. Turner's syndrome
3. Holandric traits	d. Hypertrichosis
4. Feminized male	b. Klinefelter's syndrome

Exercises | Q 5.1 | Page 69

Long answer type question.

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

Solution:

Dihybrid cross:

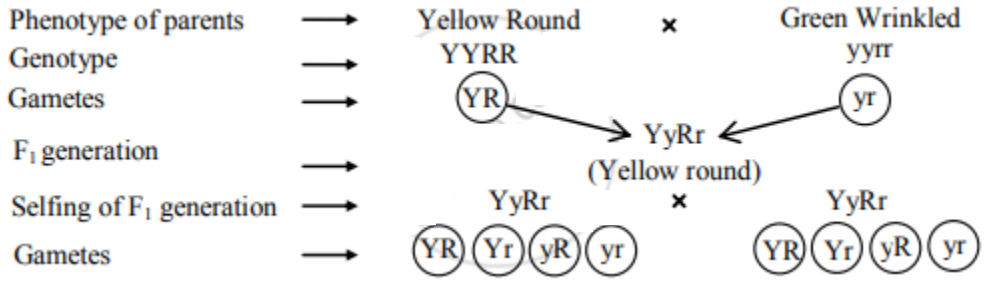
A cross between parents differing in two heritable traits is called a dihybrid cross.

OR

A cross between two pure (homozygous) parents in which the inheritance pattern of two pairs of contrasting characters is considered simultaneously is called a dihybrid cross.

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

For example, when we cross a yellow round seed pea plant with a green wrinkled seed pea plant, we get 9 yellow round, 3 yellow wrinkled, 3 green round and 1 green wrinkled plants in the F_2 generation.



F_2 generation →

♂ → ♀ ↓	YR	Yr	yR	yr
YR	YYRR Yellow round	YYRr Yellow round	YyRR Yellow round	YyRr Yellow round
Yr	YYRr Yellow round	YYrr Yellow wrinkled	YyRr Yellow round	Yyrr Yellow wrinkled

yR	YyRR Yellow round	YyRr Yellow round	yyRR Green round	yyRr Green round
yr	YyRr Yellow round	Yyrr Yellow wrinkled	yyRr Green round	yyrr Green wrinkled

Phenotypic ratio: Yellow round = 9 ;Yellow wrinkled = 3; Green round = 3; Green wrinkled = 1

Dihybrid ratio → 9 : 3 : 3 : 1

Genotypic ratio →

YYRR YYRr YyRR YyRr YYrr Yyrr yyRR yyRr yyrr

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

Exercises | Q 5.2 | Page 69

Long answer type question.

Explain with suitable example an independent assotrment.

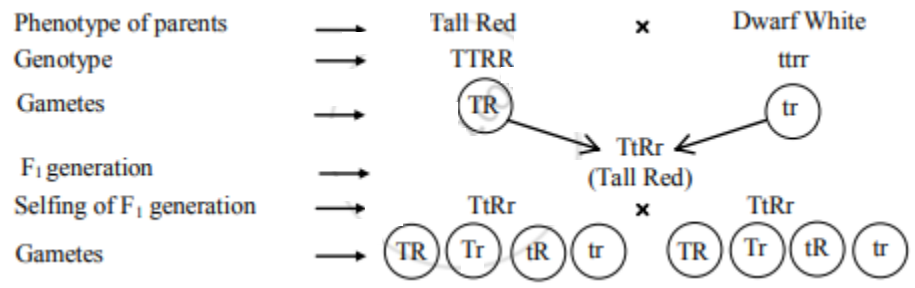
Solution:

Law of independent assortment:
The law states that, when a hybrid possessing two (or more) pairs of contrasting factors (alleles) forms gametes, the factors in each pair segregate independently of the other pair.

OR

The law of independent assortment states that, when two parents differing from each other in two or more pairs of contrasting characters are crossed, then the inheritance of one pair of character is independent of the other pair of character

1. This law is based on a dihybrid cross.
2. It describes how different genes or alleles present on separate chromosomes independently separate from each other, during the formation of gametes. These alleles are then randomly united in fertilization.
3. In dihybrid cross, F2 phenotypic ratio 9:3:3:1 indicates that the two pairs of characters behave independent of each other. It can be concluded that the two characters under consideration are assorted independently giving rise to different combinations.



F_2 generation →

♂ → / ♀ ↓	**TR**	**Tr**	**tR**	**tr**
TR	TTRR Tall red	TTRr Tall red	TtRR Tall red	TtRr Tall red
Tr	TTRr Tall red	TTrr Tall white	TtRr Tall red	Ttrr Tall white
tR	TtRR Tall red	TtRr Tall red	ttRR Dwarf red	ttRr Dwarf red
tr	TtRr Tall red	Ttrr Tall white	ttRr Dwarf red	ttrr Dwarf white

Result: Tall red = 9; Tall white = 3; Dwarf red = 3; Dwarf white = 1

Phenotypic ratio → 9 : 3 : 3 : 1

Genotypic ratio →

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

TTRR TTRr TtRR TtRr ttRR ttRr TTrr Ttrr ttrr

From the above results, it is obvious that the inheritance of character of tallness is not linked with the red colour of the flower. Similarly, the character of dwarfness is not linked with the white colour of the flower. This is due to the fact that in the above cross, the two pairs of characters segregate independently. In other words, there is an independent assortment of characters during inheritance.

Exercises | Q 5.3 | Page 69

Long answer type question.

Define test cross and explain its significance.

Solution:

Definition:

The cross between F_1 hybrid and its homozygous recessive parent is called a test cross.

Significance of test cross:

1. It helps to determine whether individuals exhibiting dominant character are genotypically homozygous or heterozygous.
2. It has wide application in plant breeding experiments.
3. In rapid crop improvement programmes, test cross is used to introduce a useful recessive trait in the hybrids.

Exercises | Q 5.4 | Page 69

Long answer type question.

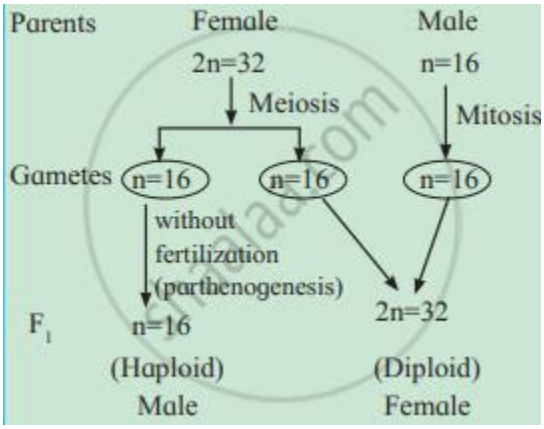
What is parthenogenesis? Explain the haplo-diploid method of sex determination in honey bee.

Solution:

Parthenogenesis:

The process by which a female produces offspring from unfertilized eggs is known as parthenogenesis.

Haplo-diploid method of sex determination in honey bee:



1. In honey bees, chromosomal mechanism of sex determination is of haplo-diploid type.
2. In this type, sex of the individual is determined by the number of set of chromosomes received.
3. Females are diploid (2n=32) and males are haploid (n=16).
4. The female produces haploid eggs (n=16) by meiosis and male produces haploid sperms (n=16) by mitosis.
5. If the egg is fertilized by sperm, the zygote develops into a diploid female (2n=32) (queen and worker) and an unfertilised egg develops into a haploid male (n=16) (Drone) by way of parthenogenesis.
6. The diploid female gets differentiated into either worker or queen bee depending on the food they consume during their development.
7. Diploid larvae which get royal jelly as food develops into queen (fertile female) and other develops into workers (sterile females).

Exercises | Q 5.5 | Page 69

Long answer type question.

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.

Solution:

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 the inheritance of X-linked genes, females may be carriers because they have two X chromosomes and may carry one normal and another defective gene. This is not possible in the case of males due to the presence of a single X chromosome.

Exercises | Q 5.6 | Page 69

Long answer type question.

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

Solution:

Structure of chromosome:

i. Chromosomes are highly condensed and therefore are clearly visible in metaphase stage of cell division.

ii. A typical chromosome consists of two chromatids joined together at centromere also known as primary constriction.

iii. Primary constriction consists of a disk shape plate called kinetochore. During cell division, spindle fibres get attached to the kinetochore.

iv. Apart from primary constriction, some few chromosomes possess additional one or two constrictions called secondary constriction.

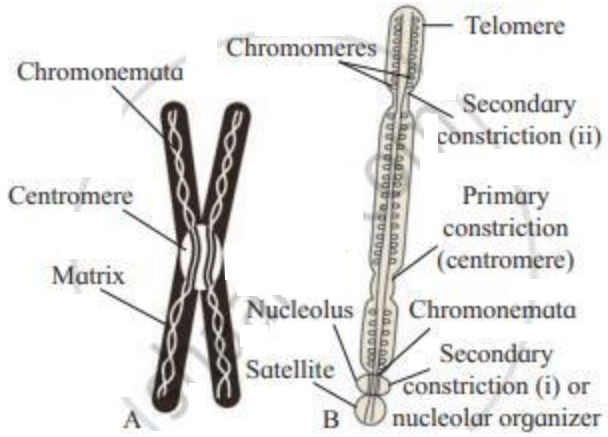
v. At secondary constriction I (nucleolar organizer), the nucleolus becomes organized during interphase.

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 double-stranded DNA thread, called chromonema, extending through the length of the chromatid.

viii. The ends of the chromosome (i.e. chromatids) are known as telomeres.

Structure of Chromosome-



A : Parts of chromosomes B : Showing secondary constrictions and details

Exercises | Q 5.7 | Page 69

Long answer type question.

What is cris-cross inheritance? Explain with suitable example.

Solution:

Criss-cross inheritance:

The inheritance of characters from the father to his grandson through his daughter is called criss-cross inheritance. Criss-cross inheritance can be explained with the help of two examples: colour blindness and haemophilia.

i. Colour blindness:

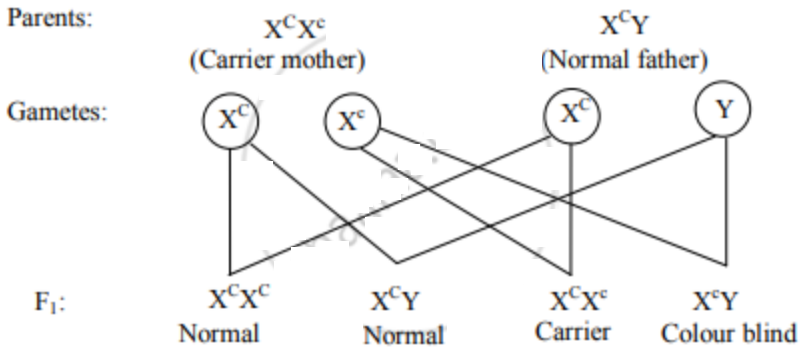
a. A person suffering from colour blindness cannot differentiate between red and green colours. Both these colours appear grey to the colour blind person.

b. It is caused due to recessive X-linked genes (X^c) which prevent the formation of colour sensitive cells in the retina that are necessary for distinguishing red and green colours.

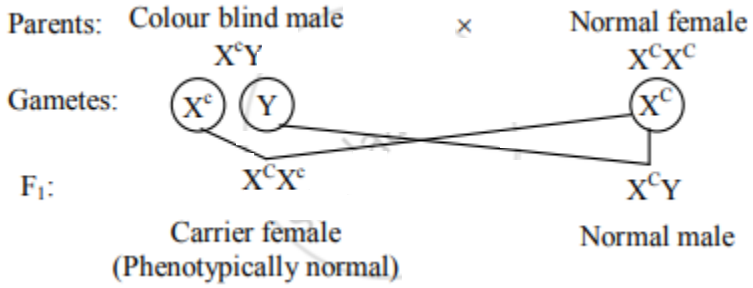
c. Dominant X linked gene (X^C) is necessary for the formation of colour sensitive cells in the retina of eye.

d. The homozygous recessive females (X^cX^c) and hemizygous recessive male (X^cY) are unable to distinguish between red and green colours. The frequency of colour blind women is much less than colour blind men.

e. When a normal man marries a carrier woman, half of their sons may be colour blind, while the remaining half will have normal vision. All their daughters will have normal vision and half of them will be carriers for the disease.



f. If a colour blind male (X^cY) marries a female with normal vision (X^CX^C), then all the offsprings will have normal vision. The sons will have normal vision but daughters will be carriers for the disease. The carriers have normal vision.



ii. Haemophilia (Bleeder's disease):

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

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

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

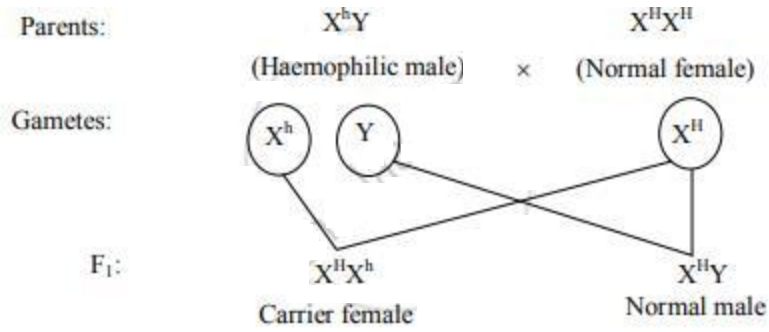
d. Even minor injuries cause continuous bleeding, hence haemophilia is also called as bleeder's disease.

e. The recessive gene for haemophilia is located on a nonhomologous region of X chromosome.

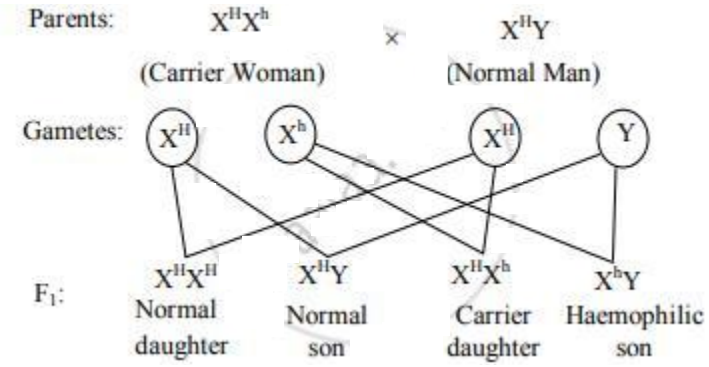
f. As there is no corresponding allele on Y chromosome to suppress its expression, so men suffer from this disease.

g. Women suffer only when both X chromosomes have recessive genes (alleles).

1. If a haemophilic male (X^hY) marries a female with normal clotting of blood (XX), then all the offsprings will show normal clotting of blood. The sons will have normal clotting of blood, but daughters will be carriers for the disease. The carriers have normal clotting of blood.



2. When carrier woman (X^HX^h) marries a normal man (X^HY), then all the daughters will have normal clotting of blood but half of them will be carriers for the disease. Half the sons will be haemophilic while the remaining will have normal clotting of blood.



Exercises | Q 5.8 | Page 69

Long answer type question.

Describe the different types of chromosomes.

Solution:

Following are the four types of chromosomes with respect to the position of the centromere: Acrocentric (j shaped), Telocentric (i shaped), Sub-metacentric (L shaped) and Metacentric (V-shaped).

Type of chromosome	Name of chromosome	Position of centromere
	Metacentric	Middle of the chromosome
	Sub-metacentric	Some distance away from the centre of chromosomes
	Acrocentric	Near one end of the chromosome
	Telocentric	At one end