3	Genetics - Some Basic Fundamentals	Book: Selina

A. MULTIPLE CHOICE TYPE

1. Which one of the following is the phenotypic monohybrid ratio in F_2 generation?
   (a) 3 : 1, (b) 1 : 2 : 1, (c) 2 : 2, (d) 1 : 3
2. If a pure tall plant is crossed with a pure dwarf plant, then offspring will be
   (a) all tall, (b) all dwarf, (c) 3 tall 1 dwarf, (d) 50% tall 50% dwarf
3. The 9:3:3:1 dihybrid ratio is due to
   (a) segregation. (b) crossing over, (c) independent assortment, (d) homologous pairing
4. A plant with green pods and smooth seeds with genotype Ggss will give rise to the following gametes:
   (a) Gg and Ss, (b) Gs and ss, (c) Gs and gs, (d) Gg and gs

B. VERY SHORT ANSWER TYPE

Q – 1 Match the following:

Column 'I' (Term)		Column 'II' (Explanation)		Ans
A	Genetics	1	Chromosomes similar in size and shape	A – 3
B	Autosomes	2	The alternative forms of a gene	B – 5
C	Recessive gene	3	Study of laws of inheritance of characters	C – 4
D	Allele	4	A gene that can express when only in a similar pair	D – 2
E	Homologous chromosomes	5	Chromosomes other than the pair of sex chromosomes	E – 1

Q – 2 Name any two genetic diseases in humans.

Colour-blindness, Thalassaemia, Sickle cell anaemia and Haemophilia (Any two)

Q – 3 Which one of the following genotypes is homozygous dominant and which one homozygous recessive in regard to tongue rolling: Rr, rr, RR?

Homozygous dominant – RR

Homozygous recessive - rr

C. SHORT ANSWER TYPE

Q – 1 Differentiate between:

1. Genotype and Phenotype

Genotype	Phenotype
The set of genes present in the cells of an organism is called its genotype.	The observable characteristic which is genetically controlled is called phenotype.

2. Character and Trait

Character	Trait
Any heritable feature is called a character.	The alternative form of a character is called trait.

3. monohybrid and dihybrid cross (phenotypic ratio)

Monohybrid	Dihybrid cross (phenotypic ratio)
Phenotypic ratio - 3:1	Phenotypic ratio- 9:3:3:1

Q – 2 Among lion, tiger and domestic cat, all the three have the same number of 38 chromosomes, yet they have different appearances. How do you account for such differences?

The characteristics of a species such as physical appearance, body functions and behavior are not only the outcome of chromosome number, but these depend on the genotype of every organism. That means the set of genes present in the organisms may very and therefore lion, tiger and domestic cat have the same number of 38 chromosomes, their characteristics (like different appearances) are the result of the genes located on the chromosomes

Q – 3 List any three features of garden pea with their dominant and recessive traits.

Character	Dominant trait	Recessive trait
Flower Colour	Purple	White
Seed Colour	Yellow	Green
Seed Shape	Round	Wrinkled
Pod Shape	Inflated	Constricted
Flower Position	Axial	Terminal

Q – 4 Explain why generally only the male child suffers from colour blindness and not the female?

Colour-blindness is caused due to recessive genes which occur on the X chromosome.

Males have only one X chromosome. If there is recessive gene present on X chromosome, then the male will suffer from colour-blindness.

Females have two X chromosomes. It is highly impossible that both the X chromosomes carry abnormal gene. Hence, if one gene is abnormal and since it is recessive, its expression will be masked by the normal gene present on the other X chromosome. Females are unlikely to suffer from colour-blindness.

D. DESCRIPTIVE TYPE

Q – 1 Define the terms (1) Pedigree chart, (2) Variations, (3) Mutation, (4) Heterozygous, (5) Homozygous,

1. **Pedigree Chart:** A pedigree chart is a diagram that shows the occurrence and appearance or phenotypes of a particular gene or organism and its ancestors from one generation to the next. In the pedigree chart, males are shown by squares and females by circles.

2. **Variations:** Variations are the differences shown by individuals of a species or offspring of the same parents.
3. **Mutation:** The sudden change in one or more genes which changes the hereditary materials of cell which in turn changes the character of an organism is called mutation.
4. **Heterozygous:** The condition in which a pair of homologous chromosomes carries dissimilar alleles for a particular character. For example - (i) A daughter (XX^o) from a normal homozygous mother for colour vision (XX) and a colour blind father has one normal and one defective allele (X^oY). (ii) Certain tongue rollers are heterozygous with Rr genotype.
5. **Homozygous:** The condition in which a pair of homologous chromosomes carries similar alleles for a particular character. For example - (i) A colorblind daughter (X^oX^o) will have both the X chromosomes with defective alleles. (ii) A non-roller will have rr (homozygous) genotype.
6. **Monohybrid cross:** A cross between two individuals having one pair of contracting characters is called monohybrid cross.

Q – 2 State the three Mendel's laws of inheritance.

Mendel's laws of inheritance are:

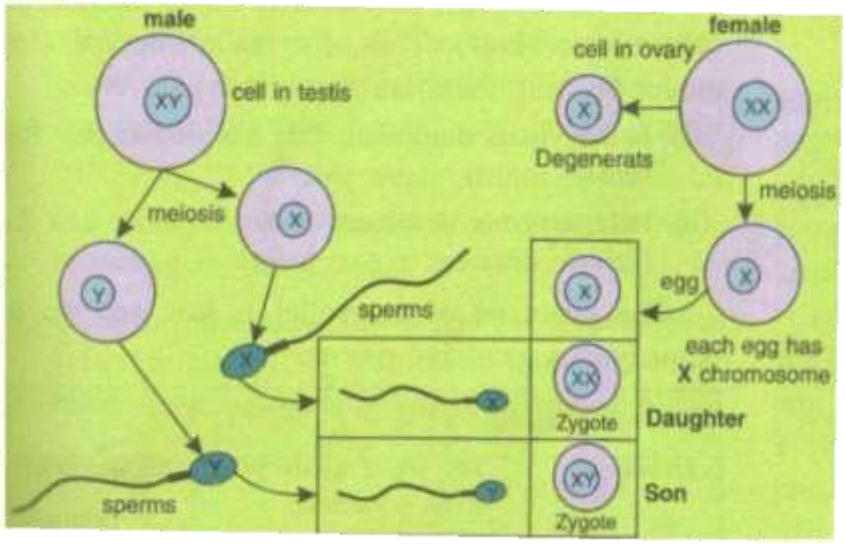
1. **Law of Dominance** Out of a pair of contrasting characters present together, only one is able to express itself while the other remains suppressed. The one that expresses is the dominant character and the one that is unexpressed is the recessive one.
2. **Law of Segregation** : The two members of a pair of factors separate during the formation of gametes. The gametes combine together by random fusion at the time of zygote formation. This law is also known as 'law of purity of gametes'.
3. **Law of Independent Assortment**: When there are two pairs of contrasting characters, the distribution of the members of one pair into the gametes is independent of the distribution of the other pair.

Q – 3 Does the sex of the child depend on the father or is it just a matter of chance? Discuss.

The sex of the child depends on the father. The egg contains only one X chromosome, but half of the sperms contain X-chromosome whereas the other half contains Y-chromosome. It is simply a matter of chance as to which category of sperm fuses with the ovum and this determines whether the child will be male or female.

If the egg fuses with X-bearing sperm, the resulting combination is XX and the resulting child is female.

If the egg fuses with Y-bearing sperm, the resulting combination is XY and the resulting child is male.



Q – 4 Distinguish between the following pairs:

1. Karyotype and Karyokinesis

Karyotype	Karyokinesis
(i) It brings about division from sub-cell to the main cell of cytoplasm	(i) It brings about division from two nuclei to the nucleus
(ii) It is the second stage of meta phase of cell	(ii) It is the first stage of meta phase of cell
(iii) It corresponds to the separation of the daughter nuclei into two daughters cells	(iii) It corresponds to the separation of the daughter to the daughter chromosomes into daughters nuclei
(iv) It distributes organic cell to the nucleus	(iv) It distributes equally to genetic material

2. Autosomes and Sex chromosomes

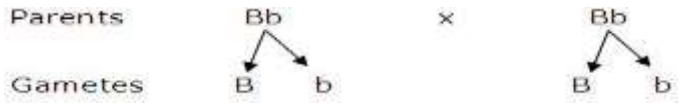
Autosomes	Sex chromosomes
(i) They do not participate in sex determination.	(i) They determine the sex of the an individual.
(ii) They are of one type.	(ii) They are of two types – X and Y

3. Homozygous and Heterozygous

Homozygous	Heterozygous
(i) Homozygous consists of two copies of the same allele that codes for a particular trait.	(i) Heterozygous consists of two different copies of alleles that code for a particular trait.
(ii) Consist of either dominant or recessive allele pairs but not both	(ii) Consist of both dominant and recessive allele pairs
(iii) Produces a single gamete	(iii) Produces two types of gametes

E. STRUCTURED / APPLICATION / SKILL TYPE

Q – 1 In a certain species of animals, black fur (B) is dominant over brown fur (b). Predict the genotype and phenotype of the offspring, when both parents are 'Bb' or have heterozygous black fur.

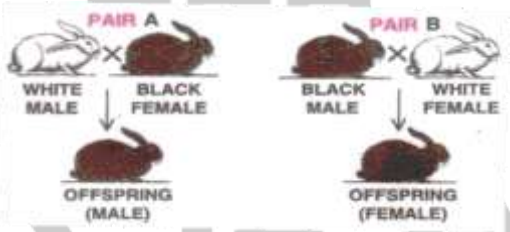


	B	b
B	BB	Bb
b	Bb	bb

Genotype - 1(Homozygous Black Fur) :2 (Heterozygous Black Fur):1 (Homozygous Brown Fur)

Phenotype - 3 (Black Fur) :1(Brown Fur)

Q – 2 Two pairs (A and B) of rabbits were crossed as given below:



1. Can you tell which coat colour (black or white) is dominant?
   Black
2. (b) Is the coat colour sex-linked?
   No

Q – 3 Make a Punnett square and find out the proportion of different genotypes in the progeny of a genetic cross between

1. A **pure tall** (TT) pea plant with a **pure dwarf** (tt) pea plant.

F_2 generation -

Gametes	T	T
T	TT	Tt
t	Tt	Tt

Genotype - 1(Homozygous tall) :2 (Heterozygous tall):1 (Homozygous dwarf)

Phenotype - 3 (Tall) :1(Dwarf)

2. Red flower variety of pea (RR) with white flower variety of pea (rr).

Parents	RR	x	rr
F1 generation		Rr (Hybrid red flower)	
Gametes	R		r

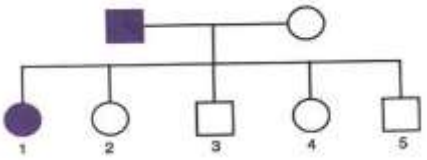
F_2 generation -

Gametes	R	R
R	RR	Rr
r	Rr	rr

Genotype - 1(Homozygous red) :2 (Heterozygous red):1 (Homozygous white)

Phenotype - 3 (Red) :1(White)

Q – 4 A family consists of two parents and their five children and the pedigree chart shown below shows the inheritance of the trait colour blindness in them.



1. Who is colour blind in the parents - the Father or the Mother?
   Father
2. How many daughters and how many sons have been born in the family?
   Two sons and three daughters
3. What does the child 1 indicate about this trait?
   The child 1 (daughter) is colour blind
4. On which chromosome is the gene of this trait located?
   X chromosome
5. Name one other trait in humans which follows a similar pattern of inheritance.
   Haemophilia

Reference Questions:

Q – 1 Short Question Answers

1. **What is a gene ? How is it related to heredity ?**
   Answer: Genes are hereditary units located on a chromosomal thread. A gene can be defined as "ultimate unit of recombination, mutation and self-reproduction". They are responsible for various characteristics externally shown by the plants and animals. A single gene may affect one or more characteristics of offsprings.
2. **Define mutation and give its significance.**

Answer: Any change in genetic composition of an individual brought about by internal or external factors is called mutation. Mutation play a significant role in the evolution and speciation because they cause variability. However, some harmful mutations cause diseases.

3. **What is crossing-over ? What are the factors affecting it ?**
   Answer: Crossing-over is the interchange of the parts of the chromatid of a pair of chromosomes. High temperature, X-rays and radiation treatment are the factors affecting crossing-over.
4. **Why did Mendel selected pea plants for his experiment ?**
   Answer: Mendel selected pea plants for his experiment because of the following reasons :
   A pea plant has many contrasting characters.
   Self-fertilization takes place in pea plants and so it is possible to get a pure line of traits.
   Flowers are bisexual and hermaphrodite. Therefore, cross pollination is achieved easily.
5. **Define Mendel's law of segregation.**
   Answer: Law of Segregation or the law of purity of gametes : The two members of a pair of factors separate during the formation of gametes. They do not blend but segregate or separate into different gametes. The gametes combine together by random fusion at the time of zygote formation.
6. **What is monohybrid cross ? How did Mendel performed this cross ?**
   Answer: Monohybrid cross : It is a cross where two forms of a single trait are crossed or hybridized. Mendel performed this experiment on pea plant. He crossed the true breeding forms of tall and dwarf plants and obtained the hybrid progeny. This is called as first generation (F1) offspring plant to self-pollinate and produced the second generation (F2).
7. **A certain couple got four daughters in a sequence and no son. Does it mean that the husband does not produce Y-chromosome bearing sperms ? Explain. What is the chance of this couple having a daughter ?**
   Answer: Daughter or son is a matter of chance for Y- or X-chromosome carrying sperm to fertilize the egg. It is always 50% The couple got four daughters as a matter of chance encounter of the X-chromosome carrying sperm fertilizing the eggs. The chance of the couple getting another daughter is again 50% (so is for the son).
8. **Mutation alerts the hereditary material. Give reasons.**
   Answer: Mutation alerts the hereditary materiel of an organisms cell and result into change in certain characters of traits. For example:
   (a) Sickle-cell anemia, is a blood disease caused by gene mutation. The mutation causes change in the DNA which controls productivity of RBCs.
   (b) Radioactive radiations also alter the gene structure and their effects can be seen generation after generation.
9. **Why do men suffer from haemophilia and colour blindness? Under what conditions do women suffer from these disorders?**

Answer: Haemophilia and colour blindness are sex-linked disorders, caused by recessive genes located on X-chromosome. These disorders occur more frequently in men because males are heterozygous for the defect. They have one X-chromosome and one Y-chromosome. Y- chromosome does not carry alleles for these traits, therefore the recessive genes are able to express even in single dose.

Females have two X-chromosomes therefore both the alleles have to be present in recessive form to be able to be expressed. Thus, females suffer only if they are homozygous for the trait which is possible only when a carrier or sufferer female marries a sufferer male.

Q – 2 Give Reasons

1. **Law of independent assortment holds good for the gene pairs that occur in different pairs of chromosomes.**
   Answer: It is chromosome and not the individual gene which segregate during gamete formation.
2. **Heritable variations are called genetic variations.**
   Answer: Because these variations arise due to change in the genetic material of germplasm or gametes.
3. **Discontinuous variations are inheritable.**
   Answer: Because these are produced by the effects of environment.
4. **Why X-linked recessive diseases are more common among males than females.**
   Answer: Because females have two copies of the X-Chromosome and males have only one X-chromosome.
5. **In honey bee, female is diploid and male is haploid.**
   Answer: Because in honey bee the fertilized diploid egg develops into a female but on unfertilized haploid egg develops into male.
6. **Haemophilia shows criss-cross inheritance.**
   Answer: The gene that causes haemophilia is recessive and lies in the X-chromosomes.

Q – 3 Explain the terms

1. Heredity: The process of transmission of parental characters to the progeny through the generations.
2. Variation: Occurrence of differences in progeny of same parents and individuals of same species.
3. Dominance: The character expressed in first generation when any two individuals of contrasting characters breed is dominant and the phenomenon is called dominance.
4. Linkage: The phenomenon of inheritance of a group of genes together through some generations.
5. Mutation: Any change brought about into the genetic composition through external or internal factors.
6. Crossing-over: The phenomenon of the exchange of genetic material between two non¬sister chromatids.

7. Heterosome: Chromosome found in reproductive cell and which are responsible for the sex of a child.
8. Recessive character: The character which remains hidden in F1 generation and expressed in the second-generation in the ratio of 1:2:1.
9. Genotype: The genetic composition of any organism is called genotype.
10. Alleles: Alleles are the alternative forms of the same gene. For example, tallness and dwarfness are the two alternative forms of a gene for height and are called alleles. Similarly, attached ear lobes and free ear lobes are alleles for the type of ear lobes.

Q – 4 Name the following

1. The study of heredity and variation.
   Genetics
2. Cells having a single set of chromosomes.
   Haploid
3. The genetic composition of an organism.
   Genotype
4. Pairs of chromosomes, present in human egg cells.
   23
5. Number of chromosomes present in human gametes.
   23
6. The diploid number for cell of man.
   46
7. Chromatids where Recombination of characters occurs.
   Non-sister chromatids
8. A specific part of chromosome that determine hereditary characteristics.
   Gene
9. The pattern of arrangement of genes along a chromosome.
   Linearly
10. Pair of genes responsible for a particular characteristic.
    Alleles
11. The type of gene, which in the presence of a contrasting allele is not expressed.
    Recessive

Q – 5 Give technical terms

1. Transmission pf characters through generations.
   Heredity
2. Differences occurring within offsprings of the same progeny.
   Variation
3. Cell organelle directly involved in genetics.

Nucleus

4. Cell which determines the sex of a baby.
   Sperm cell
5. A virus with DNA as heredity material.
   Retro virus e.g. HIV
6. The hereditary unit, which is responsible for inheritance.
   Gene
7. Transmits characteristics from parents to offsprings.
   Genes
8. The individual having similar pair of genes.
   Homozygous
9. The individuals having dissimilar pair of genes.
   Heterozygous
10. The ratio of offspring on F2 generation in a dihybrid cross.
    9 : 3 : 3 : 1
11. A single egg was fertilized by a single sperm. But twins derived from that egg were born. What is the name of such type of twins ?
    Identical or monozygotic twins
12. A twin consisting of a brother and a sister were bom to a lady. What is the name of such a type of twins?
    Non-identical or fraternal twins
13. Name a genetic disease in which a person cannot distinguish red and green colour.
    Colour blindness

Q – 6 Fill in the blanks

1. The chromosomal theory of inheritance was proposed by Sutton and Boveri in 1902.
2. Gene is the hereditary unit.
3. In mammals, the female is homozygous while the male is Heterozygous.
4. A chromosome is composed of 50 % DNA and 50% histone.
5. Gregor John Mendel is the Father of Genetics.
6. The number of chromosomes in human is pairs/46.
7. The physical expression of genes is called Phenotype.
8. The small differences among individuals are called Variations.
9. The dissimilar pairs of genes present in an individual are known as Heterozygous.
10. Autosomes chromosomes do not take part in sex determination.
11. Alleles are the alternative forms of a gene producing different effects.
12. 9 : 3 : 3 : 1 is the ratio of dihybrid cross.

13. A character that is supressed is Recessive.
14. Upon Fertilization the diploid condition is restored.

Q – 7 Mention, if the following statements are True or False. If false rewrite the wrong statement in its correct form:

1. Most genetic diseases in man are recessive in character. (True)
2. DNA has a double helical structure. (True)
3. Genes are responsible for genetic characters. (True)
4. Linkage is a permanent feature of few genes. (True)
5. Mutation can be brought about artificially. (True)
6. A female is responsible for the sex of the progeny. (False, Male is responsible for the sex of progeny.)
7. Mendel experimented upon plants of Oryza sativa. (False, Mendel experimented plants of Pisum sativum.)
8. Male act as carrier for colourblindness. (False, Female acts as carrier for colour blindness.)
9. Females are more affected by sex-linked genetic disorders. (False, Males are more affected by sex linked genetic disorders.)
10. Colour blindness is a Y-linked character. (False, Colour blindness is a X-linked character.)
11. Haemophilia exhibits X linked inheritance. (True)
12. A colourblind male cannot distinguish any colour. (False, A colour blind male cannot distinguish red and green colour.)
13. Cancer is a genetic disorder. (False, Cancer is not a genetic disorder.)

Q – 8 Diagram Based Questions

1. Question 1:

(1) State Mendel's Law of Dominance.
(2) A pure tall plant (TT) is crossed with a pure dwarf plant (tt). Draw Punnet squares to show (1) F2 generation (2) F2 generation.
(3) Give the Phenotype of the F2 generation.
(4) Give the Phenotyic and Genotypic ratio of the F2 and F2 generation.
(5) Name any one X-linked disease found in humans.

Answer:

(1) Law of Dominance: Out of a pair of contrasting characters present together, one is able to express itself while the other remains suppressed.
(2)

(ii) Parents tall plant × dwarf plant

TT × tt

(1) F_1 generation

	t	t
T	Tt	Tt
T	Tt	Tt

(2) F_2 generation Tt × tt

	T	t
T	TT	Tt
t	Tt	tt

(3) In F2 generation 75% plants will be tall and 25% dwarf.

(4) F1: Phenotypic ratio—all tall plants. Genotypic ratio—all hybrids. F2: Phenotypic ratio—3:1 Genotypic ratio—1:2:1

(5) Haemophilia.