UNIT VII: GENETICS

CHAPTER 2

CLASSICAL GENETICS

Points to Remember

- Genetics – The Science of heredity (Inheritance)
- The term **Genetics** was introduced by **W. Bateson** in 1906.
- Genes – Functional Units of inheritance
- Heredity is the transmission of characters from parents to offsprings.
- The contribution of Mendel to Genetics is called Mendelism.
- Mendel is called as **Father of Genetics.**
- Mendel was born on 22nd July 1822 in Heinzendorf Silesia (now Hyncice, Czechoslovakia), Austria.
- Mendel started his historic studies on pea plants from 1856 to 1863
- Mendel's **"Experiments on Plant Hybrids"** was published in Brunn Society of Natural History in 1866.
- Mendel's experiments rediscovered by, **Hugo de Vries** of Holland, **Carl Correns** of Germany and **Erich von Tschermak** of Austria.
- Alternate forms (versions) for the same trait is called **alleles.**
- An individual has two identical alleles of a gene, it is called as **homozygous(TT)**.
- An individual with two different alleles is called **heterozygous(Tt)**.
- Mendel's first law is The Law of Dominance and the second law is The Law of Segregation.
- The inheritance of two alleles of a single gene is called monohybrid cross.
- The genetic constitution of an individual called **genotype**.
- The observable characteristic of an organism called **phenotype**.
- Punnett's Square named after a British Geneticist Reginald C.Punnett.
- The results of Mendel's monohybrid crosses were not sex dependent.
- Test cross is crossing an individual of unknown genotype with a homozygous recessive.
- Crosses between F1 off-springs with either of the two parents are known as back cross.
- Dihybrid inheritance is the inheritance of two separate genes each with two alleles.
- A cross between parents that differ in three gene pairs is called trihybrid cross.
- A single phenotype is controlled by more than one set of genes, called Gene Interaction.
- The gene interaction concept was introduced and explained by W. Bateson.
- **Incomplete dominance** by Carl Correns's (1905) (German)in 4 O' clock plant, Mirabilis jalapa
- Two alleles are both expressed in the heterozygous individual is known as codominance.
- E. Baur reported a lethal gene in snapdragon (*Antirrhinum sp.*).
- In Pleiotropy, the single gene affects multiple traits and alter the phenotype of the organism.
- The gene that masks the phenotypic expression of a gene at another locus is known as **epistatic**.
- A group of genes that together determine a characteristic of an organism is called polygenic inheritance.
- polygenic inheritance was demonstrated by Swedish Geneticist H. Nilsson - Ehle (1909) in wheat kernels.
- chloroplast and mitochondrion that act as inheritance vectors, are called Cytoplasmic inheritance.
- Male sterility in pearl maize (*Sorgum vulgare*) is the example for mitochondrial cytoplasmic inheritance.

Book Evaluation

PART – A

(1 MARK)

1. Extra nuclear inheritance is a consequence of presence of genes in

a) Mitrochondria and chloroplasts
b) Endoplasmic reticulum and mitrochondria
c) Ribosomes and chloroplast
d) Lysososmes and ribosomes **Ans: a**

2. In order to find out the different types of gametes produced by a pea plant having the genotype AaBb, it should be crossed to a plant with the genotype

a) aaBB b) AaBB c) AABB d) aabb **Ans: d**

3. How many different kinds of gametes will be produced by a plant having the genotype AABbCC?

a) Three b) Four c) Nine d) Two **Ans: d**

4. Which one of the following is an example of polygenic inheritance?

a) Flower colour in *Mirabilis Jalapa*
b) Production of male honey bee
c) Pod shape in garden pea
d) Skin Colour in humans **Ans: d**

5. 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 F2 generation of the cross RRYY x rryy?

a) Only round seeds with green cotyledons
b) Only wrinkled seeds with yellow cotyledons
c) Only wrinkled seeds with green cotyledons
d) Round seeds with yellow cotyledons and wrinkled seeds with yellow cotyledons

Ans: d

6. Test cross involves

a) Crossing between two genotypes with recessive trait
b) Crossing between two F1 hybrids
c) Crossing the F1 hybrid with a double recessive genotype
d) Crossing between two genotypes with dominant trait **Ans: c**

7. In pea plants, yellow seeds are dominant to green. If a heterozygous yellow seed pant is crossed with a green seeded plant, what ratio of yellow and green seeded plants would you expect in F1 generation?

a) 9:1 b) 1:3 b) 3:1 d) 50:50

Ans: d

8. The genotype of a plant showing the dominant phenotype can be determined by

a) Back cross b) Test cross
c) Dihybrid corss d) Pedigree analysis

Ans: b

9. Select the correct statement from the ones given below with respect to dihydrid cross

a) Tightly linked genes on the same chromosomes show very few combinations
b) Tightly linked genes on the same chromosomes show higher combinations
c) Genes far apart on the same chromosomes show very few recombinations
d) Genes loosely linked on the same chromosomes show similar recombinations as the tightly linked ones

Ans: a

10. Which Mendelian idea is depicted by a cross in which the F1 generation resembles both the parents

a) Incomplete dominance
b) Law of dominance
c) Inheritance of one gene
d) Co-dominance **Ans: d**

11. Fruit colour in squash is an example of

a) Recessive epistatsis
b) Dominant epistasis
c) Complementary genes
d) Inhibitory genes **Ans: b**

12. In his classic experiments on Pea plants, Mendel did not use

a) Flowering position b) Seed colour
c) Pod length d) Seed shape **Ans: c**

13. The epistatic effect, in which the dihybrid cross 9:3:3:1 between AaBb Aabb is modified as

a) Dominance of one allele on another allele of both loci

b) Interaction between two alleles of different loci

c) Dominance of one allele to another alleles of same loci

d) Interaction between two alleles of some loci

Ans: d

14. In a test cross involving F1 dihybrid flies, more parental type offspring were produced than the recombination type offspring. This indicates

a) The two genes are located on two different chromosomes

b) Chromosomes failed to separate during meiosis

c) The two genes are linked and present on the some chromosome

d) Both of the characters are controlled by more than one gene

Ans: a

15. The genes controlling the seven pea characters studied by Mendel are known to be located on how many different chromosomes?

a) Seven b) Six c) Five d) Four **Ans: d**

16. Which of the following explains how progeny can possess the combinations of traits that none of the parent possessed?

a) Law of segregation b) Chromosome theory

c) Law of independent assortment

d) Polygenic inheritance **Ans: c**

17. "Gametes are never hybrid". This is a statement of

a) Law of dominance

b) Law of independent assortment

c) Law of segregation

d) Law of random fertilization **Ans: c**

18. Gene which suppresses other genes activity but does not lie on the same locus is called as

a) Epistatic b) Supplement only

c) Hypostatic d) Codominant **Ans: a**

19. Pure tall plants are crossed with pure dwarf plants. In the F1 generation, all plants were tall. These tall plants of F1 generation were selfed and the ratio of tall to dwarf plants obtained was 3:1. This is called

a) Dominance b) Inheritance

c) Codominance d) Heredity **Ans:**

20. The dominant epistatis ratio is

a) 9:3:3:1 b) 12:3:1

c) 9:3:4 d) 9:6:1 **Ans: b**

21. Select the period for Mendel's hybridization experiments

a) 1856 – 1863 b) 1850 - 1870

c) 1857 - 1869 d) 1870 - 1877 **Ans: a**

22. Among the following characters which one was not considered by Mendel in his experimentation pea?

a) Stem – Tall or dwarf

b) Trichomal glandular or non-glandular

c) Seed – Green or yellow

d) Pod – Inflated or constricted **Ans: b**

PART – B,C AND D

(2,3 & 5 MARKS)

23. Name the seven contrasting traits of Mendel.

Character	Dominant	Recessive
1. Plant height	Tall	Dwarf
2. Flower position	Axial	Terminal
3. Flower colour	Purple	White
4. Pod form	Inflated	Constricted
5. Pod colour	Green	Yellow
6. Seed shape	Round	Wrinkled
7. Cotyledon colour	Yellow	Green

24. What is meant by true breeding or pure breeding lines / strain?

- Plant has undergone continuous self- pollination.
- It producing stable trait inheritance from parent to offspring is called true breeding lines.
- Pure line breed refers to homozygosity only.

25. Give the names of the scientists who re discovered Mendelism.

- The scientists rediscovered Mendelism by
- Hugo de Vries of Holland,
- Carl Correns of Germany and
- Erich von Tschermak of Austria in 1900.

26. What is back cross?

- F1 hybrid with any one of the parental genotype is called Back cross .
- The back cross is of two types. 1. Dominent back cross 2. Recessive back cross.

27. Define Genetics.

- "Genetics" is the branch of biological science which deals with the transmission of characters from parents to off springs.

28. What are multiple alleles ?

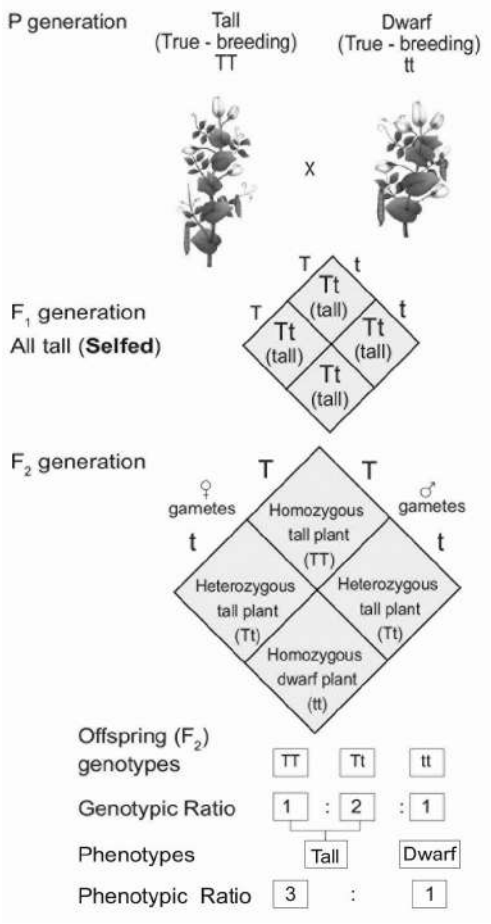
Three or more allelic forms of a gene occupy the same locus in a given pair of homologous chromosomes, they are said to be called **multiple alleles**.

29. What are the reasons for Mendel's successes in his breeding experiment?

- He applied mathematics and statistical methods to biology
- He followed scientific methods
- He kept accurate and detailed data records of the outcome of his crosses.
- His experiments were carefully planned and he used large samples.
- The parents selected by Mendel were pure breed lines.

30. Explain the law of dominance in monohybrid cross.

- Monohybrid cross is the inheritance of a single character (plant height).
- The gene for plant height has two alleles: Tall (T) x Dwarf (t).
- The two alleles of a single gene.
- When the F1 generation was selfed, 787 of 1064 F2 plants were tall and 277 of 1064 were dwarf in the ratio of 3:1
- The dwarf trait disappeared in the F1 generation only to reappear in the F2 generation.



- This law of Dominance gives an explanation to the monohybrid cross
- The expression of only one of the parental characters in F1 generation.
- The expression of both in the F2 generation.
- It also explains the proportion of 3:1 obtained at the F2
- The Law of Dominance and the Law of Segregation give suitable explanation to Mendel's monohybrid cross.

31. Differentiate incomplete dominance and codominance.

	incomplete dominance	codominance
1	The phenotype of F1 hybrid does not resemble either of the parent	The phenotype of F1 hybrid resemble both the parents .
2.	F1 hybrid possess new phenotype	New phenotype is not produced .
3.	*Ex. Mirabilis jalapa*	Ex.Red and white flowers of *Camellia*

32. What is meant by cytoplasmic inheritance ?

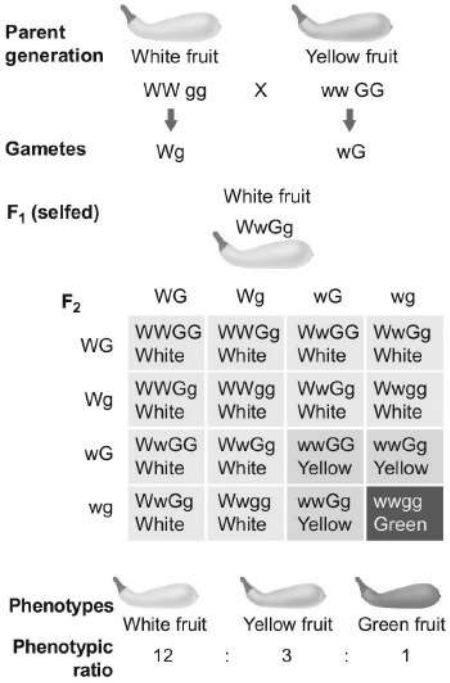
Cytoplasmic organelles such as chloroplast and mitochondrion that act as inheritance vectors,called Cytoplasmic inheritance.

33. Describe dominant epistasis with an example.

- The gene that suppresses or masks the phenotypic expression of a gene at another locus is known as **epistatic**.

Example

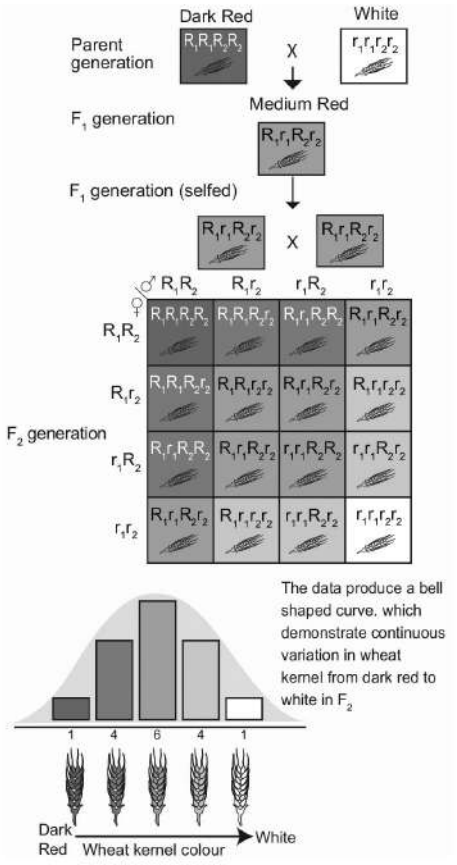
- In summer squash fruit colours maybe white, yellow or green.
- White fruits are produced by a dominant epistatic allele W.
- At another locus G for yellow fruits is dominant to its allele g for green fruits.
- Dominent white hides the effects of yellow or green.
- The white fruit (WWgg) is crossed with yellow fruit (wwGG).
- The F1 plants have white fruit and are heterozygous (WwGg).



- The F1 heterozygous plants are crossed.
- They give rise to F2 with the phenotypic ratio of
- 12 white : 3 yellow : 1 green.
- W is epistatic to the alleles 'G' and 'g'.
- White is dominant which masks the effect of yellow or green.
- Homozygous recessive ww genotypes only give the coloured fruits (4/16).
- Double recessive 'wwgg' will give green fruit (1/16).
- The Plants having only 'G' in its genotype (wwGg or wwGG) will give the yellow fruit(3/16).

34. Explain polygenic inheritance with an example.

- A group of genes that together determine (contribute) a characteristic of an organism is called polygenic inheritance.
- It was first demonstrated by Swedish Geneticist H. Nilsson - Ehle (1909) in wheat kernels.
- Kernel colour is controlled by two genes each with two alleles, one with red kernel colour was dominant to white.



- He crossed the pure breeding dark red (R1R1 R2R2)and a white (r1r1r2r2).
- In the F1 generation medium red were obtained with the genotype R1r1R2r2.
- F1 selfing produces four types of gametes R1R2, R1r2, r1R2, r1r2.

- The intensity of the red colour is determined by the number of R genes in the F2 generation.
- Four R genes: A dark red kernel colour.
- Three R genes: Medium - dark red.
- Two R genes: Medium-red.
- One R gene: Light red.
- Absence of R gene: White kernel colour.

35. Differentiate continuous variation with discontinuous variation.

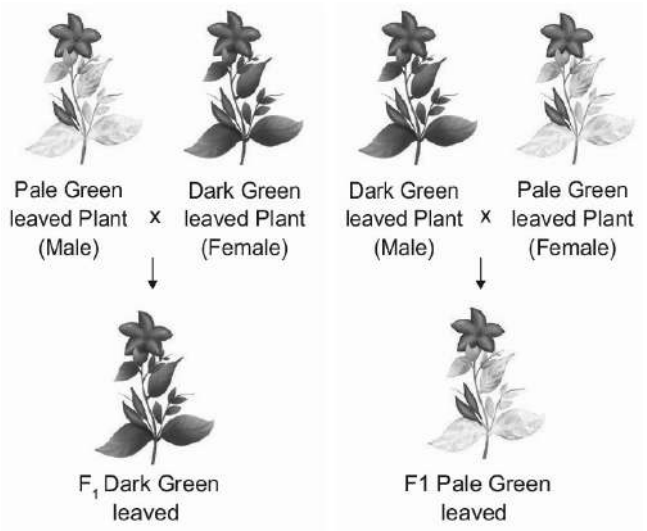
continuous Variation	Discontinuous Variation
This variation due to the combining effects of environmental and genetic factors	This variations are genetically determined by inheritance factors.
In a population most of the characteristics exhibit a complete gradation, from one extreme to the other without any break.	Individuals produced by this variation show without any intermediate form. There is no overlapping between the two phenotypes.
The phenotype is determined by many genes, and environmental factors.	The phenotypic expression is unaffected by environmental conditions.
This is also called as quantitative inheritance.	This is also called as qualitative inheritance.

36. Explain with an example how single genes affect multiple traits and alleles the phenotype of an organism.

- A single gene affects multiple traits and alter the phenotype of the organism is called Pleiotropy.
- The Pleiotropic gene influences a number of characters simultaneously.
- Such genes are called pleiotropic gene.
- Mendel noticed in peas (*Pisum sativum*).
- purple flowers, brown seeds and dark spot on the axils of the leaves crossed with white flowers, light coloured seeds and no spot on the axils of the leaves,
- Flower colour, seed colour and a leaf axil spot all were inherited together as a single unit.
- This is due to the three traits were controlled by a single gene with dominant and recessive alleles.

37. Bring out the inheritance of chloroplast gene with an example.

- Cytoplasmic organelles such as chloroplast and mitochondrion that act as inheritance vectors,called Cytoplasmic inheritance.
- It is found in 4 O' Clock plant (*Mirabilis jalapa*).
- There are two types of variegated leaves 1.dark green leaved plants and 2.pale green leaved plants.



- When the pollen of dark green leaved plant (male) is transferred to the stigma of pale green leaved plant (female) and pollen of pale green leaved plant is transferred to the stigma of dark green leaved plant.
- The F1 generation of both the crosses must be identical as per Mendelian inheritance.
- But in the reciprocal cross the F1 plant differs from each other.
- In each cross, the F1 plant reveals the character of the plant which is used as female plant.
- This inheritance is not through nuclear gene.
- It is due to the chloroplast gene found in the ovum of the female plant.
- It contributes the cytoplasm during fertilization.
- since the male gamete contribute only the nucleus but not cytoplasm.

PART – A

ADDITIONAL QUESTIONS (1 MARK)

1. Haploids are able to express both recessive and dominant alleles/mutations because there are

a) only one allele for each gene in the individual
b) many alleles for each gene
c) only one allele in a gene
d) two alleles for each gene **Ans: a**

2. What contribute to the success of Mendel?

a) His knowledge of biology
b) Qualitative analysis of data
c) Consideration of one character at one time
d) Observation of distinct inherited traits **Ans: c**

3. Triticale has been evolved by intergeneric hybridization between

a) rice and maize
b) wheat and rye
c) wheat and Aegilops
d) wheat and rice **Ans: b**

4. A dihybrid condition is

a) tt rr b) tt Rr c) Tt Rr d) Tt rr **Ans: c**

5. Cross between AaBB and aaBB will form

a) 3 AaBB: 1 aaBB b) 1 AaBB: 1aaBB
c) 1 AaBB: 3 aaBB d) All AaBB **Ans: b**

6. In a genetic cross having recessive epistasis, F2 phenotypic ratio would be

(a)9: 3: 4 (b)9: 6: 1 (c)12: 3: 1 (d)15:1 **Ans: a**

7. ABO blood group system is due to

a) multiple allelism
b) multifactor inheritance
c) epistasis
d) incomplete dominance **Ans: a**

8. tt mates with Tt. What will be characteristic of offspring?

a) 25% recessive b) 75% recessive
c) All dominant d) 50% recessive

Ans: d

9. A normal green male maize is crossed with albino female.The progeny is albino because

a) plastids are inherited from female parent
b) trait for albinism is dominant
c) green plastids of male must have mutated
d) the albinos have biochemical to destroy plastids derived form green male

Ans: a

10. The allele which is unable to express its effect in the presence of another is called

a) complementary b) codominant
c) recessive
d) supplementary **Ans: c**

11. Red (RR) Antirrhinum is crossed with white (WW) one. Offspring RW are pink. This is an example of

a) hybrid b) dominant –recessive
c) supplementary genes
d) incomplete dominance **Ans: d**

12. Multiple alleles control inheritance of

a) sickle cell anaemia b) phenylketonuria
c) blood groups
d) colour blindness **Ans: c**

13. The contrasting pairs of factors in Mendelian crosses are called

a) alloloci b) multiple alleles
c) paramorphs d) allelomorphs **Ans: d**

14. First geneticist/ father of genetics was

a) Darwin b) de Vries
c) Morgan d) Mende **Ans: d**

15. Mendel's last law is

a) independent assortment
b) segregation
c) polygenic inheritance
d) dominance **Ans: a**

16. A gene pair hides the effect of another. The phenomenon is

a) mutation b) epistasis
c) none of the above d) dominance **Ans: b**

17. In a cross between AABB × aabb, the ratio of F2 genotypes between AABB, AaBB, Aabb and aabb would be

a) 1: 2: 2: 1 b) 9: 3: 3: 1
c) 7: 5: 3: 1 d) 2: 1: 1: 2 **Ans: a**

18. Segregation of Mendelian factors (no linkage, no crossing over) occurs during

a) diplotene b) anaphase I
c) metaphase I d) anaphase II **Ans: b**

19. An organism with two identical alleles is

a) heterozygous b) dominant
c) homozygous d) hybrid **Ans: c**

20. An allele is dominant if it is expressed in

a) heterozygous combination
b) both homozygous and heterozygous states
c) homozygous combination
d) second generation **Ans: b**

21. A polygenic inheritance in human beings is

a) Colour blindness b) Skin colour
c) Sickle cell anaemia d) Phenylketonuria

Ans: b

22. Mendel studied inheritance of seven pairs of traits in Pea which can have 21 possible combinations. If you are told that in one of these combinations, independent assortment is not observed in later studies, your reaction will be

a) It is impossible
b) Independent assortment principle may be wrong
c) Later studies may be wrong
d) Mendel might not have studied all the combinations

Ans: d

23. When a certain character is inherited only through female parent, it probably represents

a) incomplete dominance
b) multiple plastid inheritance
c) mendelian nuclear inheritance
d) cytoplasmic inheritance **Ans: d**

24. In a dihybrid cross AABB × aabb, F2 progeny of AABB, AABb, AaBB and AaBb occurs in the ratio of

a) 1: 2: 2: 1 b) 1: 1: 1: 1
c) 1 :2: 2: 4 d) 9: 3: 3: 1 **Ans: c**

25. A cross between pure tall Pea plant with green pods and dwarf Pea plant with yellow pods will produce short F2 plants out of 16

a) 4 b) 9 c) 1 d) 3 **Ans: a**

26. The process of mating between closely related individuals is

a) hybridisation b) self breeding
c) heterosis d) inbreeding

Ans: d

27. Alleles that produce independent effects in their heterozygous condition are called

a) complementary alleles
b) codominant alleles
c) supplementary alleles
d) epistatic alleles **Ans: b**

28. After crossing between two plants, the progenies are found to be male-sterile. This phenomenon is found to be maternally inherited and is due to some genes which are present in

a) mitochondrion b) nucleus
c) cytoplasm d) chloroplast **Ans: c**

29. How many different types of genetically different gametes will be produced by a heterozygous plant having the genotype: AABbCc?

a) Six b) Two c) Nine d) Four

Ans: d

30. If Mendel had studied the 7 traits using a plant with 12 chromosomes instead of 14, in what way would his interpretation have been different?

a) He would have discovered sex linkage
b) He would have discovered blending or incomplete dominance
c) He could have mapped the chromosome
d) He would not have discovered the law of independent assortment.

Ans: d

31. How many genome types are present in a typical green plant cell?

a) More than five b) Two
c) More than ten d) Three **Ans: d**

32. In hybridisation Tt × tt gives rise to the progeny of ratio

a) 2 :1 b) 1: 1 c) 1: 2: 1 d) 1 :2 **Ans: b**

33. Which character studied by Mendel in garden pea (Pisum sativum) was dominant

a) Green seed colour
b) Wrinkled seed shape
c) Terminal flower position
d) Green pod colour **Ans: d**

34. Ratio of complementary genes

a) 9: 3: 3: 4 b) 9: 3: 4
c) 9: 7 d) 12: 3: 1 **Ans: c**

35. When dominant and recessive alleles express itself together it is called

a) amphidominace b) codominance
c) pseudodominance d) dominance **Ans: b**

36. Independent assortment of genes does not take place when

a) genes are located on nonhomologous chromosomes
b) genes are located on homologous chromosomes
c) all the above
d) genes are linked and located on same chromosomes

Ans: d

37. In a certain 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 rrtt genotype, what will be the percentage of tall plants with red fruits in the progeny?

a) 75% b) 50%
c) 25% d) 100% **Ans: b**

38. A and B genes are linked what shall be genotype of progeny in a cross between AB/ab and ab/ab?

a) AABB and aabb b) AAbb and aabb
c) None of these d) AaBb and aabb

Ans: d

39. Two non-allelic genes produce new phenotype when present together but fail to do so independently are called?

a) Non- complimentary genes
b) Epistatsis
c) Complimentary genes
d) Polygene **Ans: c**

40. Extranuclear inheritance occurs in

a) mitochondria and ribosome
b) peroxisome and ribosome
c) chloroplast and lysosome
d) chloroplast and mitochondria **Ans: d**

41. A gene is said to be dominant if

a) it expresses its effect both in homozygous and heterozygous condition
b) it expresses its effect only in homozygous state
c) it never expresses its effect in any conditions
d) it expresses its effect only in heterozygous condition

Ans: a

42. Which of the following is an example of pleiotropic effect?

a) Sickle cell anaemia b) Haemophilia
c) Colour blindness d) Thalassemia

Ans: a

43. Genes for cytoplasmic male sterility in plants are generally located in

a) mitochondrial genome
b) cytosol
c) nuclear genome
d) chloroplast genome **Ans: a**

44. There are three genes a, b, c. Percentage of crossing over between a and b is 20%, b and c is 28% an a and c is 8%. What is the sequence of genes on chromosome?

a) a, c, b b) b, a, c
c) none of these d) a, b, c **Ans: b**

45. On selfing a plant of F1 generation with genotype "AABbCC",the genotypic ratio in F2 generation will be

a) 9: 3: 3: 1 b) 3: 1
c) 27: 9: 9: 9: 3: 3: 3: 1 d) 1: 2: 1 **Ans: d**

46. Two crosses between the same pair of genotypes or phenotypes in which the source of the gametes are reversed in one cross, is known as

a) reciprocal cross b) reverse cross
c) dihybrid cross d) test cross **Ans: a**

47. Which one of the following traits of garden pea studied by Mendel was a recessive feature?

a) Green seed colour b) Round seed shape
c) Green pod colour
d) Axial flower position **Ans: a**

48. A self-fertilizing trihybrid plant forms

a) 8 different gametes and 16 different zygotes
b) 8 different gametes and 64 different zygotes
c) 8 different gametes and 32 different zygotes
d) 4 different gametes and 16 different zygotes
Ans: b

49. In order to find out the different types of gametes produced by a pea plant having the genotype AaBb, it should be crossed to a plant with the genotype:

a) aabb b) AABB
c) aaBB d) AaBb **Ans: a**

50. Which one of the following is an example of polygenic inheritance?

a) Skin colour in humans
b) Production of male honey bee
c) Flower colour in Mirabilis jalapa
d) Pod shape in garden pea **Ans: a**

51. In pea plants, yellow seeds are dominant to green. If a heterozygous yellow seeded plant is crossed with a green seeded plant, what ratio of yellow and green seeded plants would you expect in F1 generation?

a) 3: 1 b) 9: 1 c) 50 :50 d) 1: 3 **Ans: c**

52. Two genes R and Y are located very close on the chromosomal linkage map of maize plant. When RRYY and rryy genotypes are hybridized, the F2 segregation will show

a) higher number of the parental types
b) segregation in the expected 9: 3: 3: 1 ratio
c) higher number of the recombinant types.
d) segregation in 3: 1 ratio **Ans: a**

53. A common test to find the genotype of a hybrid is by

a) crossing of one F1 progeny with male parent
b) crossing of one F2 progeny with female parent
c) crossing of one F2 progeny with male parent.
d) studying the sexual behaviour of F1 progenies
Ans: a

54. Phenotype of an organism is the result of

a) genotype and environment interactions
b) cytoplasmic effects and nutrition
c) mutations and linkages
d) environmental changes and sexual dimorphism
Ans: a

55. Inheritances of skin colour in humans is an example of

a) codominance
b) point mutation
c) chromosomal aberration.
d) polygenic inheritance **Ans: d**

56. Which one of the following cannot be explained on the basis of Mendel's Law of Dominance?

a) Alleles do not show any blending and both the characters recover as such in F2 generation.
b) The discrete unit controlling a particular character is called a factor
c) Factors occur in pairs
d) Out of one pair of factors one is dominant, and the other recessive **Ans: a**

57. The genotype of a plant showing the dominant phenotype can be determined by:

a) pedigree analysis b) test cross
c) back cross d) dihybrid cross **Ans: b**

58. When two unrelated individuals or lines are crossed, the performance of F1 hybrid is often superior to both parents. This phenomenon is called:

a) splicing b) heterosis
c) metamorphosis d) transformation **Ans: b**

59. A test cross is carried out to

a) assess the number of alleles of a gene.
b) determine the genotype of a plant at F2.
c) determine whether two species or varieties will breed successfully.
d) predict whether two traits are linked. **Ans: b**

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

Mark the correct choice as:

a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

c) If Assertion is true but Reason is false.

d) If both Assertion and Reason are false.

60. Assertion : Cross of F1 individual with recessive homozygous parent is test cross.

Reason : No recessive individual are obtained in the monohybrid test cross progeny. Ans: c

61. Assertion : In a monohybrid cross, F1 generation indicate dominant characters.

Reason : Dominance occurs only in heterozygous state. Ans: c

62. Assertion : In *Mirabilis*, selfing of F1 pink flower plants produces same phenotypic & genotypic ratio.

Reason : Flower colour gene shows incomplete dominance. Ans: a

63. Assertion : The genetic complement of an organism is called genotype.

Reason : Genotype is the type of hereditary properties of an organism. Ans: a

64. Assertion: In *Cucurbita pepo,* variety of fruit is result of recessive epistasis.

Reason: In recessive epistatsis, a recessive gene at one locus enhances the expression of another gene, at a different locus. Ans: d

65. Match the given Column I and Column II identify the Correct Option given below

Column I		Column II	
1.	Monohybrid Cross	i	Codominants
2.	AB. Blood Group	ii	Correns
3.	Dihybrid Cross	iii	Dominant
4.	Incomplete Deminants	iv	Independent assortment

1 2 3 4

a) iii i iv ii

b) iii i ii iv

c) iii ii i iv

d) iv I ii i **Ans: a**

66.

Column I		Column II	
1.	Dominant Epistasis	i.	15 :1
2.	Complementary genes	ii	9:7
3.	Duplicate genes	iii	12:3:1
4.	Recessive epistasis	iv	9:3:4

1 2 3 4

a) iii i iv ii

b) iii i ii iv

c) iii ii i iv

d) iv i ii i **Ans: c**

True or False

67. Male sterility found in sorghum is the best example for mitochondrial cytoplasmic inheritance- True

68. Polygenic inheritance was demonstrated by Swedish H. Nilsson Ehle. - True

69. T.H. Morgan reported a lethal gene in Snap dragon - False

70. The recessive back cross helps to identify the Homozygosity of the hybrid – False

71. The allele which is not expressed is called

a) Dominant gene b) Recessive genes

c) Homozygous gene d) Co-dominant /gene

Ans: b

72. The results obtained from self-fertilization among F1 individuals in Mendel's Monohybrid cross is-

a) ¼ Dominant and ¾ Recessive

b) ¼ Dominant and 4/4 Recessive

c) ¾ Dominant and ¼ Recessive

d) ¼ Dominant and ¼ Recessive **Ans: C**

73. What type of gametes will from by Genotype Rr Yy?

a) RY, Ry, rY, ry b) RY, Ry, ry, ry

c) Ry, Ry,rY,ry d) Ry RR,Yy, yY

Ans: a

74. One Character is Controlled by one pair of genes. This statement is incorrect for..

a) Polygenic Inheritance

b) Co dominance

c) Sex linked Inheritance

d) Incomplete dominance **Ans: a**

75. What is genotypic ratio of Co-Dominance?

a) 3:1 b) 1:2:1 c) 1:1 d) 2:1:2

Ans: b

76. The effect of a single gene upon two or more character is

a) Pleiotropism
b) Multiple Alleles
c) Polygenic inheritance
d) Incomplete dominance **Ans: a**

77. The scientist who rediscovered Mendel's results on the inheritance of characters are---

a) Bateson and Punnet
b) Sutton and Biveri
c) Morgan and Bateson
d) De viries, Carrens and Tschermak

Ans: d

78. Nilsson Ehle found red: white ratio in kernel colour of wheat in F2 generation of polygenic inheritance is

a) 60:1 b) 61:1 c) 62:1 d) 63:1

Ans: d

79. The Ratio 1:2:1 is found in

a) Incomplete dominance
b) Codominance
c) A and B
d) None of these **Ans: C**

80. A self fertilized tri hybrid plant forms

a) 6 different gametes and 64 different zygotes
b) 8 different gametes and 64 different zygotes
c) 8 different gametes and 68 different zygotes
d) 6 different gametes and 66 different zygotes

Ans: b

81. Which of the following statement in incorrect

a) The results of the reciprocal cross area same
b) The trait is not sex dependent
c) The Phenotype of Monohybrid ratio is 3:1
d) Test cross is crossing homozygous tall with homozygous Dwarf

Ans: d

82. Read the following statement carefully and select the wrong one of the following

a) Mendel born in Silesia
b) He select sweet pea plant for his experiment
c) He studied Maths, Physics, and Botany
d) He started experiments in pea plant from 1856 to 1863

Ans: b

83. Read the following and odd one out

a) Law of Dominance
b) Law of recessive
c) Law of Purity of gametes
d) Law of independent assortment

Ans: b

84. A Cross made between F1 hybrid with any one of the parental genotype is called

a) Back Cross b) Test Cross
c) Both A and B d) none of these

Ans: a

85. Match the terms in Column I with their description in Column II and choose the correct option.

Column I	Column II
a) Dominance	i) Many genes govern a single character
b) Co-dominance	ii) In a heterozygous organism only me allele expresses itself
c) Pleiotropy	ii) In a heterozygous organism both alleles express themselves fully
d) Polygenic	iv) A single gone influences Inheritance many characters

	a	b	c	d
a	ii	i	iv	iii
b	ii	iii	iv	i
c	iv	I	ii	iii
d	iv	iii	I	ii

Ans: b

86. The term genetics was introduced by

a) Morgan b) Punnet
c) Menta d) W. Bateson **Ans: d**

87. The transmission of characters from Parents to off springs is

a) Linkage b) Heredity
c) Mutation d) Variation **Ans: b**

88. Experiments on plant hybrids' was presented by

a) Mende b) Bateson
c) Morgan d) Punnet **Ans: a**

89. The Scientist Hugo de varies belongs to the country

a) Austria b) Holland
c) Germany d) France **Ans: b**

90.Alternative forms for the same trait is called

a) Genes b) Chromosomes
c) Alletes d) Heredity **Ans: c**

91. Read the Statement carefully and identify the wrong statement

a) Back cross is a cross of F1 hybrid with any one of the parent
b) The recessive back cross helps to identify the hetero zygosity of the hybrid
c) Gene interaction concept was introduced by W. Bateson
d) Several genes combine to abstract multiple traits

Ans: d

92. Match the following columns

Column I	Column II
I Test Cross	a) 9:3:3:1
II Monohybrid Cross	b) Tt x tt
III Back Cross	c) Tt x TT
IV Di hybrid Cross	d) 3:1

Codes

	I	II	III	IV
a)	I b	II d	III c	a
b)	I c	II d	III a	b
c)	I b	II c	III a	d
d)	I b	II d	III a	c

	I	II	III	IV	
a)	b	d	c	a	
b)	c	d	a	a	
c)	b	c	a	d	
d)	b	d	a	c	**Ans: a**

93. The main reason for the success of Mendel was that he

a) Applied mathematical and statistical methods
b) First took only one character at time in his crosses
c) Selected Pea plant
d) Kept accurate and defaulted records **Ans: b**

94. Mendal conducted the following experiments on garden pea plant

a) Quantitative b) Qualitative
c) Hybridisation d) All of these **Ans: c**

95.A gene which gives multiple phenotypic effects

a) Complementary genes
b) Pleiotropic genes
c) Lethal genes
d) Holandric genes **Ans: b**

96. Match the Characters given in Column I withColumn II choose the answer with correct combination

Column I		Column II
A	Monohybrid Cross	i T and t
B	Test Cross	ii TT
C	Alleles	iii Tt x Tt
D	Homozygous tall	iv tt
		Tt x tt

	A	B	C	D
a)	III	V	IV	II
b)	III	V	I	II
c)	V	III	II	IV
d)	III	I	V	II

PART – B

ADDITIONAL QUESTIONS (2 MARKS)

1. Who interduced the term genetics ?

The term **Genetics** was introduced by **W. Bateson** in 1906.

2. Describe Transmission Genetics / Classical Genetics

Deals with the transmission of genes from parents to off springs. The foundation of classical genetics came from Gregor Mendel.

3. Define Molecular Genetics

Deals with the structure and function of a gene at molecular level.

4. Define Population Genetics

Deals with heredity in groups of individuals for traits which is determined by a few genes.

5. Describe Quantitative Genetics

Deals with heredity of traits in groups of individuals where the traits are governed by many genes simultaneously.

6. What is the reason for similarities, differences of appearance and skipping of generations?

Functional Units of inheritance is genes

The basic unit of heredity which transmits biochemical, anatomical and behavioural traits from parents to off springs.

7. Describe genetics

Genetics is a science which deals with heredity and variation.

8. Define heredity

Heredity is the transmission of characters from parents to offsprings.

9. What is variation ?

The organisms belonging to the same species that shows a difference in the characteristics is called variation.

10. Name the types of variation

There are two types of variation are i) Discontinuous variation and ii) Continuous variation

11. Define Mendelism.

The contribution of Mendel to Genetics is called Mendelism.

12. Why Mendel is called Father of Genetics ?

Mendelian genetic concepts are basic to modern genetics. Therefore, Mendel is called as **Father of Genetics.**

13. Define genes

Hereditary units or factors, which are called as **genes**

14. What is Emasculation ?

Remove the anthers from the bisexual flower before fertilization is called Emasculation

15. Describe self-fertilization.

Fusion of male and female gametes produced by the same individual i.e pollen and egg are derived from the same plant is known as self-fertilization.

16. What is an alleles ?

Alternate forms (versions) for the same trait..

17. Define homozygous

An individual has two identical alleles of a gene are called **homozygous (TT)** .

18. Define heterozygous

An individual with two different alleles of a gene are called **heterozygous (Tt)**.

19. What is hybrids?

Non-true breeding plants are heterozygous are called hybrids.

20. How to symbolized dominant and recessive alleles ?

The dominant allele is symbolized with capital letter.

The recessive allele is symbolized with small letter.

21. Describe homozygous recessive

Both alleles are recessive the individual is called **homozygous recessive** (tt) Example : Dwarf pea plants.

22. Describe homozygous dominant

Both alleles are dominant the individual is called **homozygous dominant** (TT) Example : Tall pea plants.

23. Describe heterozygous tall

One dominant allele and one recessive allele is called **heterozygous tall** (Tt) Example : Non-true breeding tall pea plants**.**

24. What is meant by genotype ?

The genetic constitution of an individual is called **genotype**.

25. What is meant by phenotype ?

The term refers to the observable characteristic of an organism is called **phenotype**.

26. What is Punnett's Square ?

The genetic cross can be easily understood by Punnett's Square .

Punnett's Square named after a British Geneticist Reginald C.Punnett.

27. The Law of Segregation (Law of Purity of gametes):

- Alleles do not show any blending
- Both characters are seen in the F2 generation although one of the characters is not seen in the F1 generation

28. A garden pea plant produced axial white flowers ,another of the same species produced terminal violet flowers . identify the dominant traits.

Axial, violet flower.

29. What is test cross? Mention their uses.

Crossing an individual of unknown genotype with a homozygous recessive is called Test cross.

Test cross is used to identify whether an individual is homozygous or heterozygous for dominant character

30. What is dihybrid cross?

The crossing of two plants differing in two pairs of contrasting traits is called dihybrid cross..

31. State the principle of law of independent assortment

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

32. What is gene interaction ?

A single phenotype is controlled by more than one set of genes, each of which has two or more alleles. This phenomenon is called Gene Interaction.

33. Define intragenic gene interactions

Interactions take place between the alleles of the same gene (alleles at the same locus) is called intragenic or intralocus gene interaction.

34. Write the possible genotypes, Mendel got when he crossed F1tall pea plants with a dwarf pea pant .

Possible genotypes. Tt and tt.

35. Classify the factor hypothesis or bateson's factor hypothesis

- Intragenic gene interactions or Intra allelic or allelic interactions.
- Intergenic gene interactions or inter allelic or non-allelic interactions.

PART – C

ADDITIONAL QUESTIONS (3 MARKS)

1. Name the four major subdisciplines of genetics.

1. Transmission Genetics / Classical Genetics
2. Molecular Genetics
3. Population Genetics
4. Quantitative Genetics

2. Write the advantages of selecting pea plant for experiment by mendel.

- It is an annual plant.
- It has clear contrasting characters that are controlled by a single gene separately.
- Both self-fertilization and cross-fertilization is made easy.
- Emasculation and pollination are very easy for hybridization.

3. Describe the mendel's experiments on pea plant

- He performed artificial pollination or cross pollination in pea plants.
- Self-pollination takes place in Mendel's peas.
- The experimenter can remove the anthers (Emasculation) before fertilization .
- Now transfer the pollen from another variety of pea to the stigma where the anthers are removed.
- This results in cross-fertilization, which leads of hybrid varieties with different traits.

4. Write the proceses of the following charts .

Removal of anthers -1 Transfer the pollen -2 Fusion of male and female gametes-3

1. Emasculation 2. Pollination 3. Fertilization

5. Importance of variations

- They make some individuals better fitted in the struggle for existence.

- They help the individuals to adapt themselves to the changing environment.
- It provides the genetic material for natural selection
- They allow breeders to improve better yield, quicker growth, increased resistance and lesser input.
- They constitute the raw materials for evolution.

6. Name the mendel's laws of Heredity

The law of dominance

The law of segregation.

The law of independent assortment

7. Gametes are never hybrid-justify your answer.

- It is the Law of Segregation (Law of Purity of gametes).
- During the formation of gametes, the alleles of a pair separate and segregate from each other.
- Each gamete receives only one of the two factors.
- A homozygous parent produces similar gametes and a heterozygous parent produces two kinds of gametes each having one allele with equal proportion.
- Gametes are never hybrid.

9. What is reciprocal cross

- Tall (male) x Dwarf (female) and Tall (female) x Dwarf (male) mating are done in both ways which are called reciprocal crosses.
- The results of the reciprocal crosses are the same. So it was concluded that the trait is not sex dependent.

10. Describe back cross

- In Dominent back cross all the F2 develop dominant characters only.
- In Recessive back cross individuals of both the phenotypes appear in equal proportion.
- The recessive back cross helps to identify the heterozygosity of the hybrid.

11. What are the significance of independent assortment

- Genes that are located in different chromosomes assort independently during meiosis.
- Many possible combinations of factors can occur in the gametes.
- It leads to genetic diversity.
- It is important in the process of evolution.

12. A pea plant with purple flowers was crossed with white flowers producing 50 plants with only purple flowers on selfings , these plants produced 482 plants with purple flowers and 162 with white flowers. What genetic mechanism accounts for these results ? explain.

- A pea plant with purple flowers was crossed with white flowers.
- The purple flowers are dominant over that of white flowers.
- When two pure varieties are crossed, the f1 generation produce only purple flowers and selfing, the flowers are produced in a 3:1 ratio. (482:162 =3:1)

13. Describe factor hypothesis

- Mendelian experiments prove that a single gene controls one character.
- Various exception have been noticed, in mendelian experiments.
- The different types of interactions are possible between the genes.
- It was introduced and explained by W. Bateson.
- This concept is known as Factor hypothesis or Bateson's factor hypothesis.

14. Classify the factor hypothesis or bateson's factor hypothesis

- Intragenic gene interactions or Intra allelic or allelic interactions.
- Intergenic gene interactions or inter allelic or non-allelic interactions.

15. Why extra chromosomal inheritance or extra nuclear Inheritance called cytoplasmic Inheritance?

- DNA is the universal genetic material.
- Genes located in nuclear chromosomes follow Mendelian inheritance.
- But certain traits cytoplasmic organelles such as chloroplast and mitochondrion that act as inheritance vectors, so extra nuclear inheritance are called cytoplasmic Inheritance.
- It is a kind of Non-Mendelian inheritance.

16. Describe factor hypothesis

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- The different types of interactions are possible between the genes.
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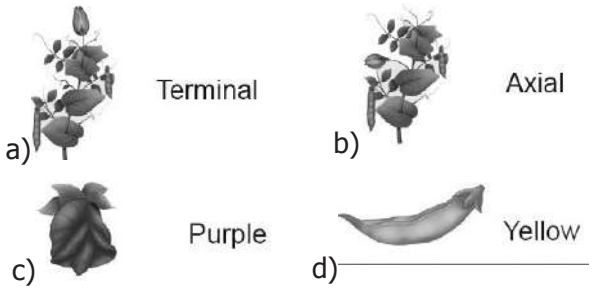
- This concept is known as Factor hypothesis or Bateson's factor hypothesis.

17. The phenotypic and genotypic ratio in F2 generation are same in certain kind of inheritance. Name an organism in which it occur and mention the kind of inheritance involved. Who explain this?

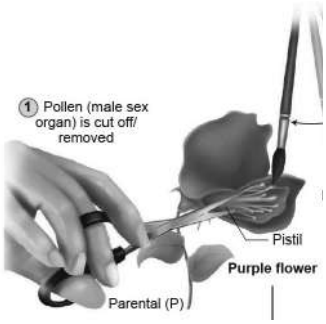
- The kind of inheritance involved is incomplete dominance. It occurs in 4 O' clock plant (*Mirabilis jalapa).*
- The German Botanist Carl Correns's (1905) explained this.

18. Observe carefully the given diagrams and characters. Identify a,b,c and d which is dominant and recessive



a) and d) - **Recessive** b) and c) - **Dominant**

19. Observe carefully the given diagram a) identify this process. b) define this process



a) **Emasculation**

b) **Removal of the anthers** from the bisexual flower and make it as a male flower before fertilization.

20. The F2 ratio of genotypic and phenotypic are given. a) Identify the cross. b) write the definition of the cross. c). write the genotype and phenotype of F1 hybrid.

Offspring (F_2) genotypes	TT	Tt	tt
Genotypic Ratio	1	: 2	: 1
Phenotypes	Tall		Dwarf
Phenotypic Ratio	3	:	1

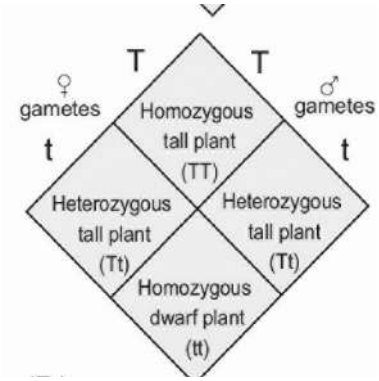
a) The cross is **Monohybrid cross**.

b) The cross made between two parents with single contrasting characters called monohybrid cross.

c) The genotype of F1 hybrid is **Tt**

The phenotype of F1 hybrid is **heterozygous tall plant**

21. Observe the Punnett's Square in given below. a) Identify the cross. b) write the definition of the cross. c) write the genotype and phenotype ratio of F2.



a) The cross is **Test cross**.

b) The cross made between F1hybrid with recessive parent is called Test cross.

c) The genotype ratio of F2 is **Tt : tt**

The phenotype ratio of F2 is **Heterozygous tall plant : Homozygous dwarf plant**

PART – D

ADDITIONAL QUESTIONS (5 MARKS)

1. Explain the biography of Mendel with his workin pea plant .

- The first Geneticist is Gregor Johann Mendel. He is called father of genetics.

- He was born on 22nd July 1822 in Heinzendorf Silesia (now Hyncice, Czechoslovakia), Austria.
- After school education, he studied botany, physics and mathematics at the University of Vienna.
- He then entered a monastery of St.Thomas at Brunn in Austria.
- He continued his interest in plant hybridization.
- In 1849 he got a temporary teacher and he performed experiments with pea plants in his garden.
- In 1856, he started his historic studies on pea plants (1856 to 1863).
- He studying the inheritance of seven pairs of contrasting traits of pea plant in his garden.
- Mendel crossed and catalogued 24,034
- His paper entitled **"Experiments on Plant Hybrids".**
- It was presented and published in the Brunn Society of Natural History in 1866.
- Mendel died in 1884.

2. Describe discontinuous variation:

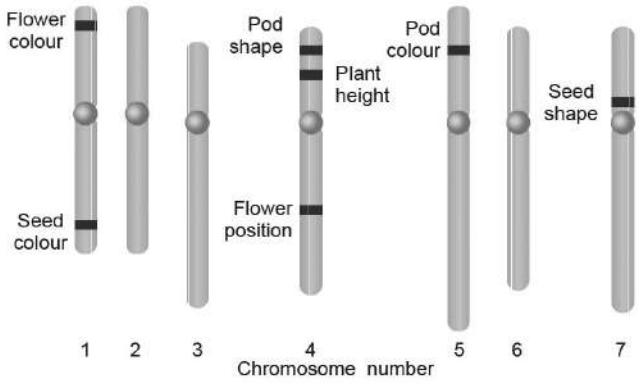
- Within a population there are some characteristics which show a limited form of variation.
- Example: Style length in *Primula*, Plant height of garden pea.
- The characteristics are controlled by one or two major genes.
- It may have two or more allelic forms.
- These variations are genetically determined by inheritance factors.
- Individuals produced by this variation show without any intermediate form
- There is no overlapping between the two phenotypes.
- The phenotypic expression is unaffected by environmental conditions.
- This is also called as qualitative inheritance.

3. Describe continuous variation:

- This variation may be due to the combining effects of environmental and genetic factors.
- In a population most of the characteristics exhibit a complete gradation, from one extreme to the other without any break.
- Inheritance of phenotype is determined by the combined effects of polygenes and environmental factors.
- This is also known as quantitative inheritance.
- Example: Human height and skin color.

4. Tabulate the seven characters of Pisum sativum with genes

S. No	Character	Gene	Dominant Trait	Recessive Trait
1.	Plant Height	Le	Tall	Dwarf
2.	Flower position	Fa	Axial	Terminal
3.	Flower colour	A	Purple	White
4.	Pod form	V	Inflated	Constricted
5.	Pod colour	GP	Green	Yellow
6.	Seed Shape	R	Round	Wrinkled
7.	Cotyledon colour	I	Yellow	Green



5. The Law of Dominance:

- The characters are controlled by discrete units called factors which occur in pairs.
- In a dissimilar pair of factors one member of the pair is dominant and the other is recessive.
- This law gives an explanation to the monohybrid cross the expression of only one of the parental characters in F1 generation and the expression of both in the F2 generation.
- It also explains the proportion of 3:1 obtained at the F2

6. With help of punnet square, find the percentage of homozygous tall in a F2 population involving a true breeding tall and true breeding dwarf pea plant.

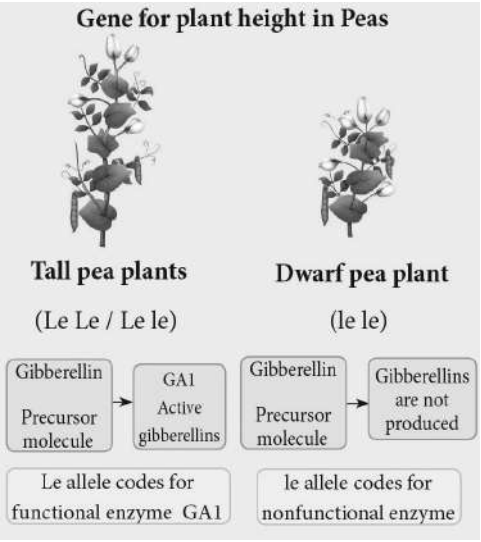
Refer : Cross in texual question

Percentage of homozygous tall =1/4X100 =25%

7. Describe mendel's analytical and empirical approach

- Mendel chose two contrasting traits for each character.
- In F1 the recessive trait are hidden and only to reappear in ¼ of the F2 generation.
- He concluded that tall and dwarf alleles of F1 heterozygote segregate randomly into gametes.
- Mendel got 3:1 ratio in F2 between the dominant and recessive trait.
- He was the first scientist to use this type of quantitative analysis.
- Units of heredity are transmitted from one generation to the other. They are called as genes.
- Mendel's experiments were well planned to determine the relationships which govern hereditary traits.
- This is called an empirical approach. Laws arrived from an empirical approach is known as empirical laws.

8. Why Mendel's pea plants are tall and dwarf ? Find out the molecular explanation.

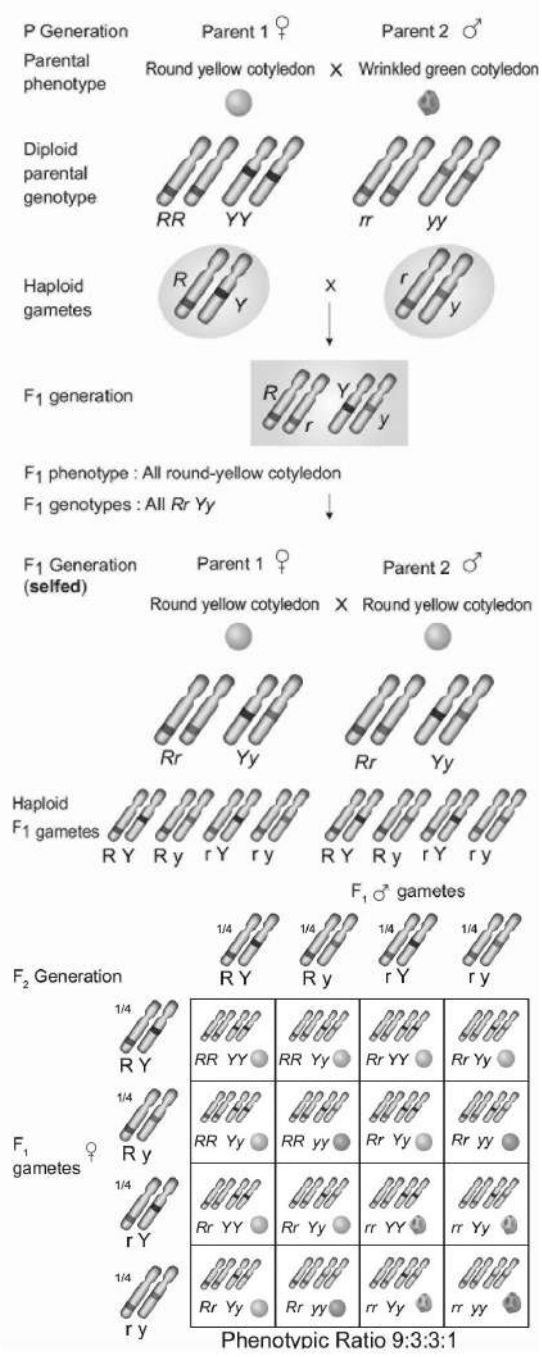


- The plant height is controlled by a single gene with two alleles.

The reason is follows:

- The cells of the pea plant have gibberellins into an active form (GA1)
- One allele (Le) that codes for a protein which catalyses the formation of gibberellins (GA1).
- Two (Le Le) or single (Le le), produces gibberellins and the pea plants are tall.
- Alleles (le le) which code for non-functional protein hence they are dwarf.

9. Explain dihybrid cross with your illustration.

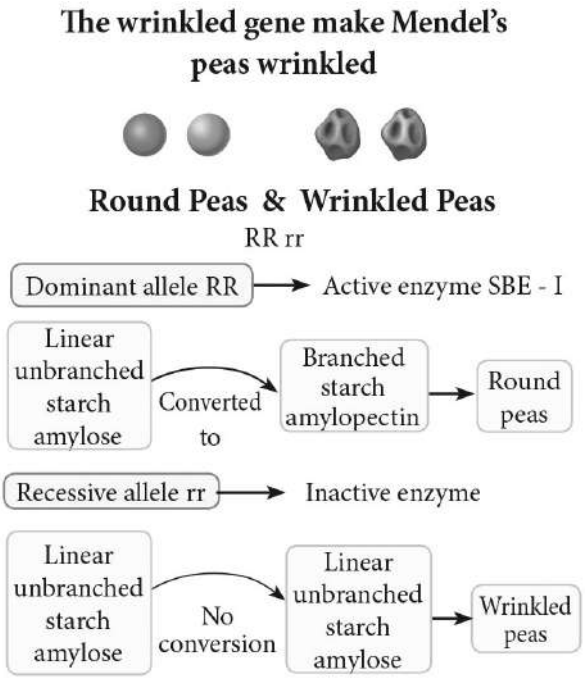


- In dihybrid cross, two characters are considered.
- 1.The seed shape (round and wrinkled)
- 2. Cotyledon colour (yellow & green).
- In seed shape round (R) is dominant over wrinkled (r)
- In cotyledon colour yellow (Y) is dominant over green (y).
- The pure breeding round yellow parent genotype is RRYY
- The pure breeding green wrinkled genotype is rryy.
- During gamete formation the paired genes of a character assorted independently of the other pair.
- During the F1 x F1 four types of gametes produced.

  1) Yellow round (YR) 2) Yellow wrinkled (Yr)

  3) Green round (yR) 4) Green wrinkled (yr)
- These four types of gametes fused.
- They produce sixteen types of individuals in F2 in the ratio of 9:3:3:1 .
- This ratio based on the segregation, independent assortment .

10. How does the wrinkled gene make Mendel's peas wrinkled? Find out the molecular explanation.

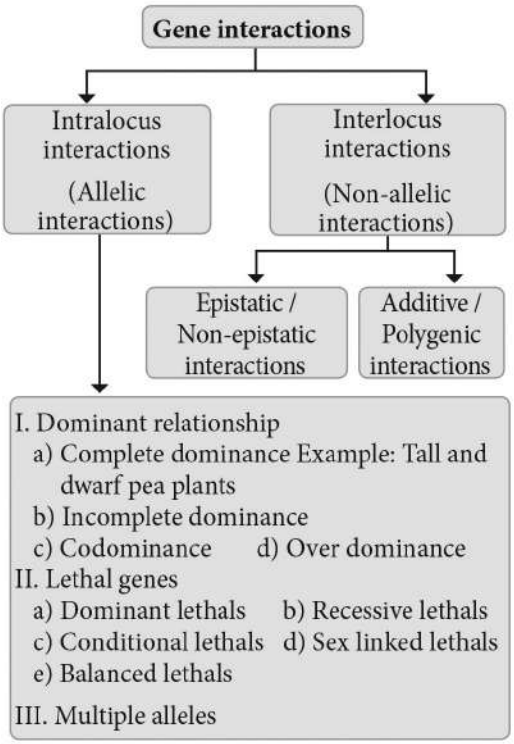


11. Trihybrid cross - explain briefly

Tall, Yellow, Round x Dwarf, Green, Wrinkled
TTYYRR ↓ ttyyrr
F_1 Tall, Yellow, Round (Selfed)
TtYyRr
F_2 Phenotypic ratio - 27 : 9 : 9 : 9 : 3 : 3 : 3 : 1

- A cross between homozygous parents that differ in three gene pairs is called trihybrid cross.
- Mendel Laws of segregation and independent assortment are applicable for this cross.
- A self-fertilizing tri hybrid plant forms 8 different gametes and 64 different zygotes.
- In this a combination of three single pair crosses operating together.
- The three contrasting characters of a trihybrid cross are

12. Draw the flow chart of gene interaction

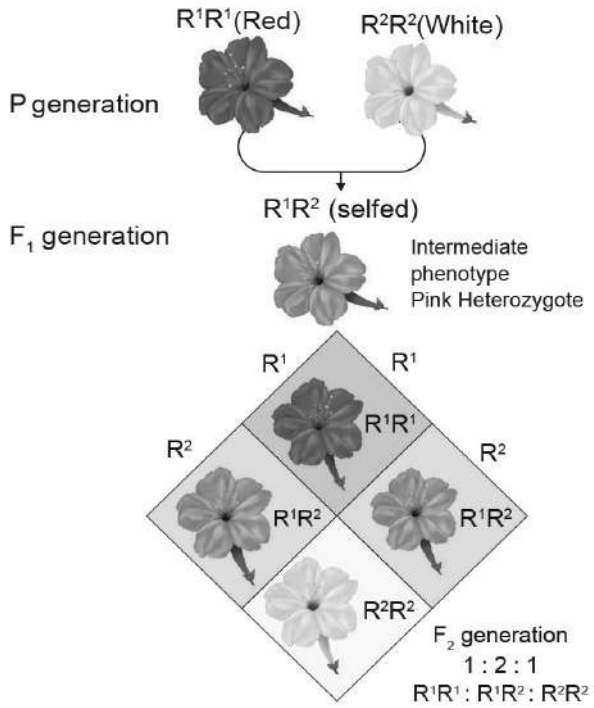


13. In 4 O' clock plant shows incomplete dominance for flower colour. Work out a cross and explain the phenomenon .

- The German Botanist Carl Correns's (1905) Explain in 4 O' clock plant (*Mirabilis jalapa)*
- The homozygous red (R1R1) parent is crossed with white (R2R2).

- The F1 produces an intermediate colour pink(R1R2).
- Here one allele is not completely dominant to another allele .
- Such allelic interaction is known as incomplete dominance.
- The pink coloured plants of F1 generation were interbred.
- In F2 both phenotypic and genotypic ratios are 1 : 2 : 1
- (1 red R1R1 : 2 pink R1R2 : 1 white R2R2).

The cross is explained as follows



14. How are we going to interpret the lack of dominance and give explanation to the intermediate heterozygote phenotype? How will you explain incomplete dominance at the molecular level?

- Gene expression is explained in a quantitative way.
- (R1 R1) produces an functional enzyme which synthesizes red pigments.
- (R2 R2) produces an enzyme which cannot synthesize necessary red pigments.
- The white flower is due to the mutation causing complete loss of function.
- The F1 intermediate phenotype heterozygote (R1R2) has one copy of the allele R1.
- R1 produces 50% of the functional protein resulting in half of the pigment of red flowered plant.
- so it is pink.

15. What is Codominance? Give examples. (1:2:1)

- The phenomenon in which two alleles are both expressed in the heterozygous individual is known as codominance. Phenotypic and genotypic ratios of co dominance is 1 : 2 : 1.
- Example: Red and white flowers of *Camellia*,
  - o Inheritance of sickle cell haemoglobin,
  - o ABO blood group system in humanbeings.
- In humanbeings, IA and IB alleles of I gene are codominant.
- It follows Mendels law of segregation.
- It was demonstrated in plants by electrophoresis or chromatography for protein or flavonoid substance.
- Example: *Gossypium hirsutum* and *Gossypium sturtianum*.

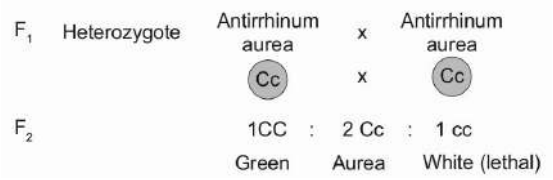
16. Explain lethal genes

- An allele which has the potential to cause the death of an organism is called a "Lethal Allele".
- E. Baur (1907) reported in snapdragon (*Antirrhinum sp.*).
- It is an example for recessive lethality.
- In snapdragon there are three kinds of plants.
- Green plants with chlorophyll. (CC)
- Pale green, golden or aurea plants (Cc)
- White plants without any chlorophyll. (cc)
- The genotype of the homozygous green plants is CC.
- The genotype of the homozygous white plant is cc.

Cross

- Crossing of green (CC) and white (cc) plants.
- They produced aurea plants (Cc) are heterozygous in F1 progeny.
- F1 progeny aurea plants(Cc) are self-pollinated
- In F2 identical phenotypic and genotypic ratio of 1 : 2 : 1 (1 Green (CC): 2 Aurea (Cc): 1 White (cc))

- The white plants lack chlorophyll pigment, they will not survive.
- So the F2 ratio is modified into 1 : 2.
- In this case the homozygous recessive genotype (cc) is lethal.



- The fully dominant or fully recessive lethal allele kills in its homozygous condition.
- So the F2 genotypic ratio will be 2 : 1 or 1 : 2 respectively.

17. Describe Pleiotropy with an example

- A single gene affects multiple traits and alter the phenotype of the organism is called Pleiotropy.
- The pleiotropic gene influences a number of characters simultaneously .
- Such genes are called pleiotropic gene.
- Mendel noticed in peas (*Pisum sativum*).
- purple flowers, brown seeds and dark spot on the axils of the leaves crossed with
- white flowers, light coloured seeds and no spot on the axils of the leaves,
- Flower colour, seed colour and a leaf axil spot all were inherited together as a single unit.
- This is due to the three traits were controlled by a single gene with dominant and recessive alleles.
- Example: sickle cell anemia.

18. Dominant Epistasis –explain

- It is a gene interaction in which two alleles of a gene at one locus interfere and suppress or mask the phenotypic expression of a different pair of alleles of another gene at another locus.
- The gene that suppresses or masks the phenotypic expression of a gene at another locus is known as **epistatic**.
- The gene whose expression is interfered by non-allelic genes and prevents from exhibiting its character is known as **hypostatic**.
- When both the genes are present together, the phenotype is determined by the epistatic gene and not by the hypostatic gene.

Intra genic or allelic interaction

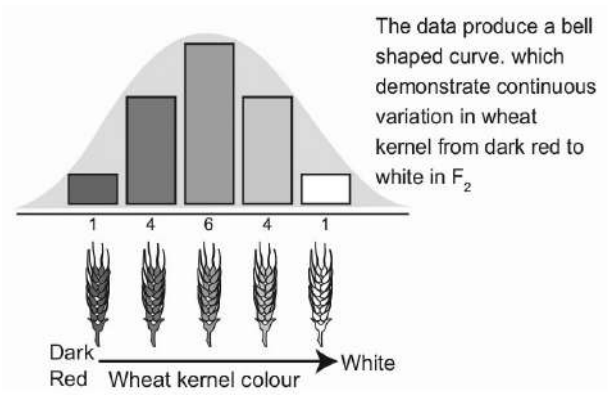
S. No.	Gene interaction	Example	F2 Pheno-typic ratio
1.	Incomplete Dominance	Flower colour in *Mirabilis jalapa.*	1 : 2 : 1
		Flower colour in snapdragon (*Antirrhinum spp.*)	1 : 2 : 1
2 .	Codominance	ABO Blood group system in humans	1 : 2 : 1

Inter genic on non-allelic interaction

S. No.	Epistatic interaction	Example	F2 Ratio Pheno-typic ratio
1	Dominant epistasis	Fruit colour in summer squash	12 : 3 : 1
2	Recessive epistasis	Flower colour of Antirrhinum spp.	9 : 3 : 4
3	Duplicate genes with cumulative effect	Fruit shape in summer squash	9 : 6 : 1
4.	Complementary genes	Flower colour in sweet peas	9 : 7
5.	Supplementary genes	Grain colour in Maize	9 : 3 : 4
6.	Inhibitor genes	Leaf colour in rice plants	13 : 3
7	Duplicate genes	Seed capsule shape (fruit shape) in shepherd's purse Bursa bursa-pastoris	15 : 1

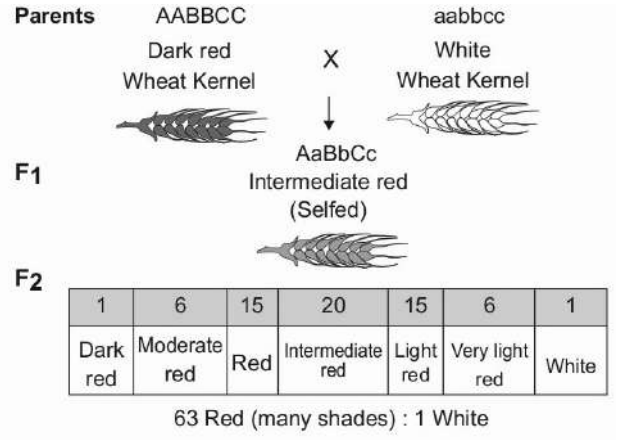
19. Explain bell shaped curve with kernel colour of wheat.

- In polygenic inheritance the R gene in an additive manner produces the red kernel colour. The number of each phenotype is plotted against the intensity of red kernel colour which produces a bell shaped curve. This represents the distribution of phenotype.
- Other example: Height and skin colour in humans are controlled by three pairs of genes.



20. Conclusion of Polygenic inheritance- Explain .

- Finally Nilsson – Ehle were the genes not linked and the genes assorted independently.
- Later, researchers discovered the third gene that also affect the kernel colour of wheat.
- The three independent pairs of alleles were involved in wheat kernel colour.
- Nilsson – Ehle found the phenotypic ratio is 63 red : 1 white.
- Genotypic ratio is 1 : 6 : 15 : 20 : 15 : 6 : 1 in F2 generation.
- From the above results Nilsson – Ehle showed that the blending inheritance was not taking place in the kernel of wheat.



- In F2 generation plants have kernels with wide range of colour variation.
- This is due to the segregating and recombination of genes.
- Another evidence for the absence of blending inheritance is that the parental phenotypes dark red and white appear again in F2.
- There is no blending of genes, only the phenotype.
- The cumulative effect of several pairs of gene interaction gives rise to many shades of kernel colour.
- He hypothesized that the two loci must contribute additively to the kernel colour of wheat.
- The contribution of each red allele to the kernel colour of wheat is additive.

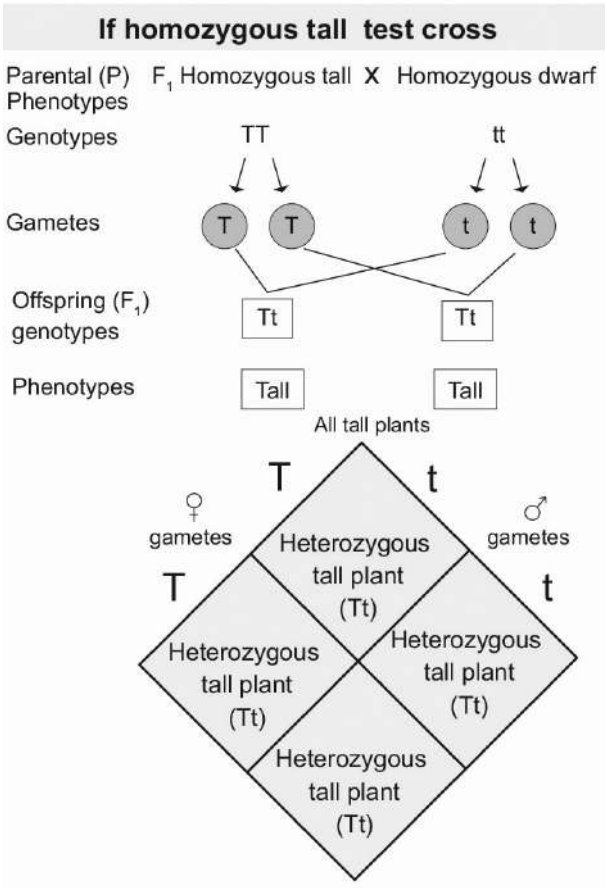
21. Mitochondrial Inheritance - Explain.

- Male sterility found in pearl maize (*Sorgum vulgare*) is the best example for mitochondrial cytoplasmic inheritance.
- Male sterility found in this pearl maize
- So it is called **cytoplasmic male sterility**.
- In this, male sterility is inherited maternally.
- The gene for cytoplasmic male sterility is found in the mitochondrial DNA.
- There are two types, one with normal cytoplasm (N) which is male fertile.
- The other one with aberrant cytoplasm (S) which is male sterile.
- These types also exhibit reciprocal differences as found in *Mirabilis jalapa*.
- Recently it has been discovered that cytoplasmic genetic male sterility is common in many plant species.
- This sterility is maintained by the influence of both nuclear and cytoplasmic genes.
- There are commonly two types of cytoplasm N (normal) and S (sterile).
- The genes for these are found in mitochondrion.
- There are also restores of fertility (Rf) genes.
- Even though these genes are nuclear genes, they are distinct from genetic male sterility genes of other plants. Because the Rf genes do not have any expression of their own, unless the sterile cytoplasm is present.
- Rf genes are required to restore fertility in S cytoplasm which is responsible for sterility.
- So the combination of N cytoplasm with rfrf and S cytoplasm with RfRf produces plants with fertile pollens, while S cytoplasm with rfrf produces only male sterile plants.

22. Describe Atavism

- **Atavism** is a modification of a biological structure
- An ancestral trait reappears after having been lost through evolutionary changes in the previous generations. Evolutionary traits that have disappeared phenotypically do not necessarily disappear from an organism's DNA.
- The gene sequence often remains, but is inactive.
- Such an unused gene may remain in the genome for many generations.
- As long as the gene remains intact, a fault in the genetic control suppressing the gene can lead to the reappearance of that character again.
- Re-emergence of sexual reproduction in the flowering plant *Hieracium pilosella* is the best example for Atavism in plants.

23. Draw the Schematic representation of test cross



UNIT VII: GENETICS

CHAPTER 3

CHROMOSOMAL BASIS OF INHERITANCE

POINTS TO REMEMBER

- The genes are hereditary units.
- Linkage is rare but has been reported in male *Drosophila* .
- The linked genes connected together on sex chromosome is called **sex linkage.**
- The linked genes are located very close together on the same chromosome and do not exhibit crossing over is called **complete linkage**.
- The linked genes exhibit some crossing over is called **incomplete linkage**.
- The groups of linearly arranged linked genes on a chromosome are called **Linkage groups**
- Crossing over takes place during pachytene stage of prophase I of meiosis.
- Crossing over includes stages like synapsis, tetrad formation, cross over and terminalization.
- Segments of DNA are broken and recombined to produce new combinations of alleles is called **Recombination.**
- **Genetic mapping** is also called as **linkage map**
- The unit of distance in a genetic map is called a **map unit** (m.u)
- One map unit is also called a centimorgan (cM). 100 centimorgan is equal to one Morgan (M).
- Three or more allelic forms of a gene occupy the same locus in a given pair of homologous chromosomes are called **multiple alleles**.
- Sex determination was first described in the bryophyte Sphaerocarpos donnellii Gibberellins play an important role in the suppression of stamens in florets on the ears.
- Mutation and recombination are the two major processes responsible for genetic variation.
- A sudden change in the genetic material of an organisms is called **mutation**.
- Agents which are responsible for mutation are called **mutagens,**
- Mutagens are of two types, physical mutagen and chemical mutagen.
- **Point mutation** refers to alterations of single base pairs of DNA
- Sharbati Sonora is a mutant variety of wheat, which is developed from Mexican variety (Sonora 64) by irradiating of gamma rays.
- Castor Aruna is mutant variety of castor by treatment of seeds with thermal neutrons
- The large-scale variations in chromosomes are termed as **chromosomal mutations** or **chromosomal aberrations**.
- Ploidy involving individual chromosomes within a diploid set (**Aneuploidy**)
- Ploidy involving entire sets of chromosomes (**Euploidy**)
- Double monosomics are observed in maize.
- An organism possesses more than two basic sets of chromosomesare called ploidy .
- **Simple trisomy** reported in Nicotiana, Pisum and Oenothera.
- All possible tetrasomics are available in Wheat
- Double monosomics are observed in maize.
- The common wheat plant is a example For polyploidy (hexaploidy)
- The cultivated banana are usually triploids and are seedless having larger fruits than diploids.

- Common doob grass (Cyanodon dactylon) is a natural autotriploid.
- Seedless watermelon, apple, sugar beet, tomato, banana are man made autotriploids.
- **Autotetraploids** rye, grapes, alfalfa, groundnut, potato and coffee.
- **Triticale**, the successful first man made cereal.
- **Colchicine** , an alkaloid is extracted from root and corms of Colchicum autumnale,
- Deletion is observed in Drosophila and Maize.
- **Reciprocal translocations** also called **illegitimate crossing over.**
- Translocations play a major role in the formation of species.

Scientists and their contributions

- **G. J. Mendel** (1865) studied the inheritance in pea plant.
- **De Vries, Correns and Tschermak** independently rediscovered Mendel's results.
- **Wilhelm Roux** (1883) postulated that the chromosomes of a cell are responsible for transferring heredity.
- **Montgomery** (1901) was first to suggest occurrence of distinct pairs of chromosomes
- **Sutton and Boveri** (1903) independently proposed the chromosome theory of inheritance
- Linkage reported in Sweet pea *(Lathyrus odoratus)* by **Willium Bateson and Reginald C. Punnet** in 1906
- **Thomas Hunt Morgan** (1933)received Nobel Prize in Physiology or Medicine for his chromosomes in heredity.
- **T.H. Morgan** found two types of linkage.
- **C.B Bridges** (1919) discovered that crossing over is completely absent in some species of male Drosophila
- Incomplete linkage was observed in maize by **Hutchinson.**
- The term 'crossing over' was coined by **Morgan (1912).**
- Holliday's hybrid DNA model was first proposed by **Robin Holliday** in 1964
- gene mapping was first developed by Morgan's student **Alfred H Sturtevant** in 1913.
- **East (1925)** observed multiple alleles in Nicotiana which are responsible for self-incompatibility
- **C.E. Allen (1917)** discovered sex determination in plants
- **Hawaii** discovered sex chromosomes in Papaya
- The unit centimorgan (cM) in honour of **T.H. Morgan**.
- The term mutation was introduced by **Hugo de Vries** (1901) in evening primrose (Oenothera lamarkiana) and proposed **'Mutation theory'**
- **Muller** (1927) was the first to find out physical mutagen in *Drosophila*.
- Dr. **M.S.Swaminathan** who is known as **'Father of Indian green revolution**
- **H J Muller** (1928) first time used X rays to induce mutations in fruit fly.
- **L J Stadler** reported induced mutations in plants by using X rays and gamma rays.
- Chemical mutagenesis was first reported by **C. Auerback** (1944).
- Trisomics were first reported by **Blackeslee** (1910) in Datura stramonium (Jimson weed).
- Raphanobrassica, **G.D. Karpechenko** (1927) a Russian geneticist, crossed the radish (Raphanus sativus, 2n=18) and cabbage (Brassica oleracea, 2n=18)
- **Duplication** was first reported in Drosophila by Bridges (1919) and other examples are Maize and Pea.
- Inversion was first reported in Drosophila by **Sturtevant** (1926).

Book Evaluation

PART – A

(1 MARK)

1. An allohexaploidy contains

a) Six different genomes

b) Six copies of three different genomes

c) Two copies of three different genomes

d) Six copies of one genome **Ans : c**

2. The A and B genes are 10 cM apart on a chromosome. If an AB/ab heterozygote is testcrossed to ab/ab, how many of each progeny class would you expect out of 100 total progeny?

a) 25 AB, 25 ab, 25 Ab, 25 aB

b) 10 AB, 10 ab

c) 45 AB, 45 ab

d) 45 AB, 45 ab, 5 Ab, 5aB **Ans : d**

3. Match list I with list II

List I	List II
A. A pair of chromosomes extra with diploid	i) monosomy
B. One chromosome extra to the diploid	ii) tetrasomy
C. One chromosome loses from diploid	iii) trisomy
D. Two individual chromosomes lose from diploid	iv) double monosomy

a) A-i, B-iii, C-ii, D-iv b) A-ii, B-iii, C-iv, D-i

c) A-ii, B-iii, C-i, D-iv d) A-iii, B-ii, C-i, D-iv

Ans : c

4. Which of the following sentences are correct?

1. The offspring exhibit only parental combinations due to incomplete linkage
2. The linked genes exhibit some crossing over in complete linkage
3. The separation of two linked genes are possible in incomplete linkage
4. Crossing over is absent in complete linkage

a) 1 and 2 b) 2 and 3

c) 3 and 4 d) 1 and 4 **Ans : c**

5. Accurate mapping of genes can be done by three point test cross because increases

a) Possibility of single cross over

b) Possibility of double cross over

c) Possibility of multiple cross over

d) Possibility of recombination frequency **Ans : b**

6. Due to incomplete linkage in maize, the ratio of parental and recombinants are

a) 50:50 b) 7:1:1:7

c) 96.4: 3.6 d) 1:7:7:1 **Ans : b**

7. Genes G S L H are located on same chromosome. The recombination percentage is between L and G is 15%, S and L is 50%, H and S are 20%. The correct order of genes is

a) GHSL b) SHGL c) SGHL d) HSLG

Ans : b

8. The point mutation sequence for transition, transition, transversion and transversion in DNA are

a) A to T, T to A, C to G and G to C

b) A to G, C to T, C to G and T to A

c) C to G, A to G, T to A and G to A

d) G to C, A to T, T to A and C to G **Ans : b**

9. If haploid number in a cell is 18. The double monosomic and trisomic number will be

a) 34 and 37 b) 34 and 35

c) 37 and 35 d) 17 and 19 **Ans : a**

10. Changing the codon AGC to AGA represents

a) missense mutation b) nonsense mutation

c) frameshift mutation d) deletion mutation

Ans : a

11. Assertion (A): Gamma rays are generally use to induce mutation in wheat varieties.

Reason (R): Because they carry lower energy to non-ionize electrons from atom

a) A is correct. R is correct explanation of A

b) A is correct. R is not correct explanation of A

c) A is correct. R is wrong explanation of A

d) A and R is wrong **Ans : c**

12. How many map units separate two alleles A and B if the recombination frequency is 0.09?

a) 900 cM b) 90 cM

c) 9 cM d) 0.9 cM **Ans : c**

PART – B,C AND D

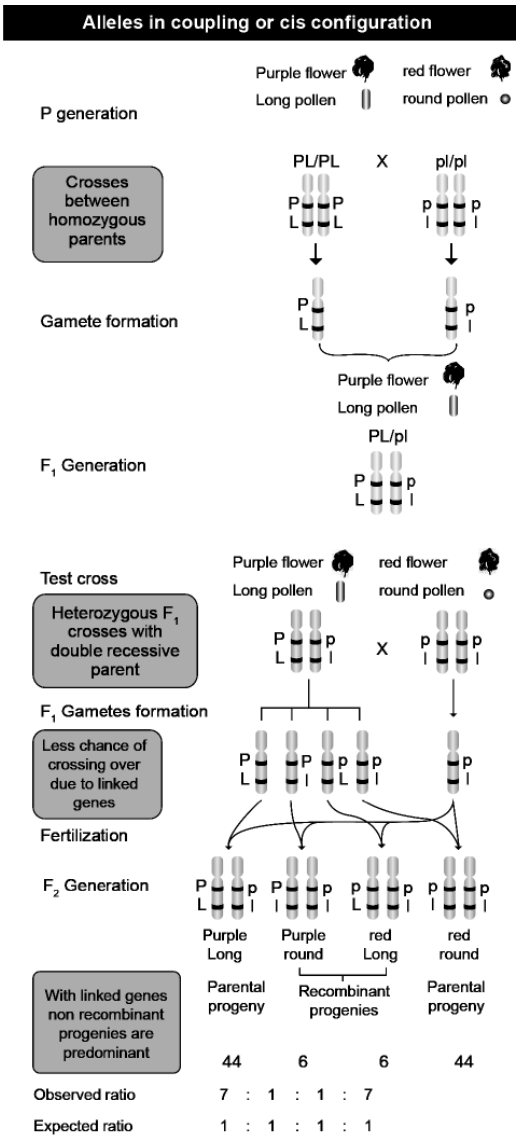
(2,3 AND 5 MARKS)

13. When two different genes came from same parent they tend to remain together.

i. What is the name of this phenomenon?

ii. Draw the cross with suitable example.

iii. Write the observed phenotypic ratio.



- The name of this phenomenon is coupling or *cis* configuration of linkage.
- This was reported in Sweet pea (Lathyrus odoratus)
- Exprimented by **Willium Bateson** and **Reginald C. Punnet** in 1906.
- They crossed homozygous **purple flowers** and **long pollen grains** with **red flowers** and **round pollen grains.**
- All the F1 had purple flower and long pollen grains indicating purple flower long pollen **(PL/PL)** was dominant over red flower round pollen **(pl/pl)**
- When they crossed the F1 with double recessive parent (test cross) in results, F2 progenies did not exhibit in 1:1:1:1 ratio as expected with independent assortment.
- A greater number of F2 plants had purple flowers and long pollen or red flowers and round pollen.
- So they concluded that genes for purple colour and long pollen grain and the genes for red colour and round pollen grain were found close together in the same homologous pair of chromosomes.
- These genes do not allow themselves to be separated.
- So they do not assort independently.
- This type of tendency of genes to stay together during separation of chromosomes is called **Linkage.**
- The two different genes came from same parent they tend to remain together is called
- coupling or *cis* configuration
- The observed phenotypic ratio is 7:1:1:7

14. If you cross dominant genotype PV/PV male Drosophila with double recessive female and obtain F1 hybrid.

Now you cross F1 male with double recessive female.

i. What type of linkage is seen?

ii. Draw the cross with correct genotype.

iii. What is the possible genotype in F2 generation?

i) The type of linkage seen is complete linkage

ii) Draw the cross with correct genotype.(Refer complete linkage linkage. Change the alphabets RL into PV. (See additional five mark question no.7)

iii) The possible genotype in F2 generation is 1:1

15.

S. no	Gamete types	Number of progenies
1.	ABC	349
2.	Abc	114
3.	abC	124
4.	AbC	5
5.	aBc	4
6.	aBC	116
7.	ABc	128
8.	abc	360

i) What is the name of this test cross?

ii) How will you construct gene mapping from the above given data?

iii) Find out the correct order of genes.

a) The name of the cross is **Three-point test cross.**

These three recessive alleles (abc) are crossed with wild type dominant alleles (ABC)

Parents ABC / ABC x abc / abc

Gametes ABC x abc

F1 trihybrid ABC / abc

Test cross

- (Heterozygous F1 crosses with triple recessive alleles) ABC / abc x abc / abc
- This trihybrid test cross produces 8 different types (23=8) of gametes.
- It produces 1200 progenies. The results are tabulated.

S. no	Gamete types	Number of progenies
1.	ABC	349
2.	Abc	114
3.	abC	124
4.	AbC	5
5.	aBc	4
6.	aBC	116
7.	ABc	128
8.	abc	360
Total		**1200**

- From the above result, we observe parental (P) and recombinant (R) types.
- The parental genotypes for the triple homozygotes are A B C and a b c,
- Analyse two recombinant loci at a time orderly A B/ a b, A C/ a c and B C/ b c.
- In this any combination other than these two constitutes a recombinant (R)

S. no.	Gamete types	Number of progenies	Recombinant for loci		
			A and B	A and C	B and C
1.	ABC	349			
2.	Abc	114	R	R	
3.	abC	124		R	R
4.	AbC	5	R		R
5.	aBc	4	R		R
6.	aBC	116	R	R	
7.	ABc	128		R	R
8.	abc	360			
Total		**1200**	**239**	**482**	**261**

- Let's analyse the loci of two alleles A and B.
- The A B and a b parental genotypes the recombinants will be A b and a B.
- The Recombinant frequency (RF) for these two alleles calculated as follows

$$RF = \frac{\text{Total number of recombinants}}{\text{Total number of progenies}} \times 100$$

$$RF = \frac{114+5+4+116}{1200} \times 100$$

$$RF = \frac{239}{1200} \times 100$$

$$RF = 19.9\%$$

- For A and C loci, the recombinants are A c and a C. The Recombinant frequency (RF) will be as follows

$$RF = \frac{\text{Total number of recombinants}}{\text{Total number of progenies}} \times 100$$

$$RF = \frac{114+124+116+128}{1200} \times 100$$

$$RF = \frac{482}{1200} \times 100$$

$$RF = 40.1\%$$

- For B and C loci, the recombinants are B c and b C. The Recombinant frequency (RF) will be as follows

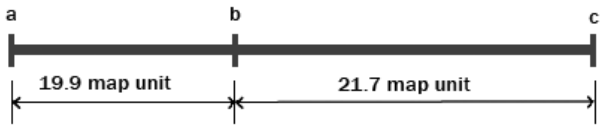
$$RF = \frac{\text{Total number of recombinants}}{\text{Total number of progenies}} \times 100$$

$$RF = \frac{124+5+4+128}{1200} \times 100$$

$$RF = \frac{261}{1200} \times 100$$

$$RF = 21.7\%$$

- All the loci are linked, because all the RF values are considerably less than 50%.
- In this A C loci show highest RF value, they must be farthest apart.
- Therefore, the B locus must lie between them. The order of genes should be abc.
- A genetic map can be drawn as follows



The correct order of genes are a b c

16. What is the difference between missense and nonsense mutation?

Missense mutation	Nonsense mutation.
The mutation where the codon for one amino acid is changed into a codon for another amino acid is called **Missense or non-synonymous mutations**	The mutations where codon for one amino acid is changed into a termination or stop codon is called **Nonsense mutation**.

17.  **From the above figure identify the type of mutation and explain it.**

- The given figure is identify as reverse tandem duplication type of Structural changes in chromosome (Structural chromosomal aberration)

Reverse tandem duplication

- The duplicated segment is located immediately after the normal segment but the gene sequence order will be reversed.

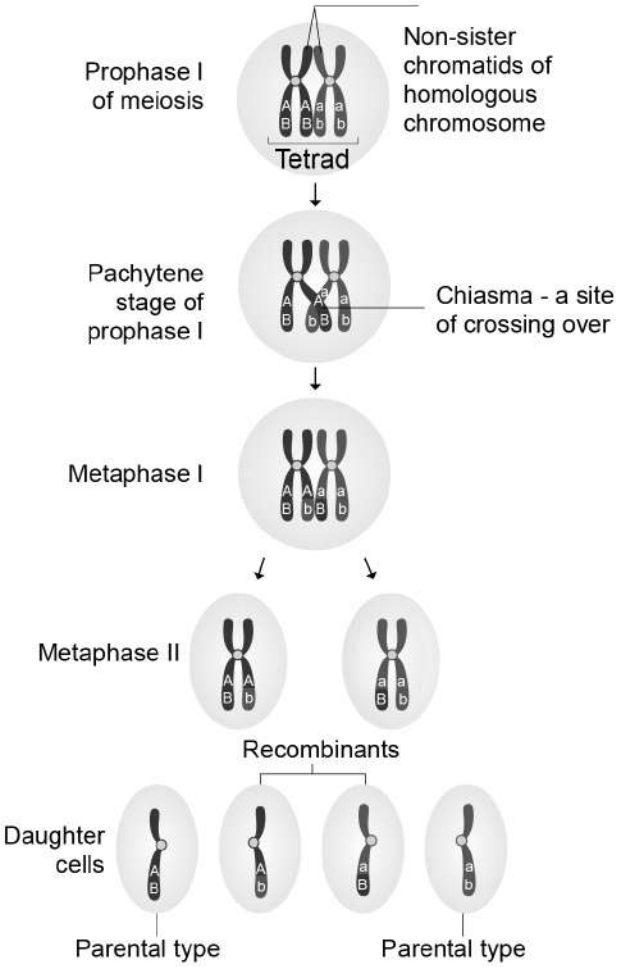
18. Write the salient features of Sutton and Boveri concept.

- Somatic cells are derived from the zygote by mitosis.
- These consist of two identical sets of chromosomes.
- One set is received from female parent and the other from male parent.
- These two constitute the homologous pair.
- Chromosomes retain their structural uniqueness and individuality throughout the life cycle.
- Each chromosome carries specific determiners or Mendelian factors which are now termed as genes.
- The behaviour of chromosomes during the gamete formation (meiosis) provides evidence to the fact that genes or factors are located on chromosomes.

19. Explain the mechanism of crossing over.

The stages of the mechanism of crossing over are

1.Synapsis, 2.Tetrad formation, 3.Cross over and 4.Terminalization.



i) Synapsis

- The pairing between two homologous chromosomes are called **synapsis or syndesis**.
- It is initiated during zygotene stage of prophase I of meiosis I.

- Homologous chromosomes pairs are aligned side by side called **bivalents**.

Synapsis is of three types,

- **Procentric synapsis:** Pairing starts from middle of the chromosome.
- **Proterminal synapsis:** Pairing starts from the telomeres.
- **Random synapsis:** Pairing may start from anywhere.

ii) Tetrad Formation

- Each homologous chromosome form two identical sister chromatids.
- It remain held together by a centromere.
- At this stage each bivalent has four chromatids.
- This stage is called **tetrad stage**.

iii) Cross Over

- Crossing over occurs in pachytene stage.
- The non-sister chromatids of homologous pair make a contact at one or more points are called **Chiasmata.**
- At chiasma, cross-shaped or X-shaped structures are formed.
- The breaking and re-joining of two chromatids occur in that point.
- This results in reciprocal exchange of equal and corresponding segments between them.

iv) Terminalisation

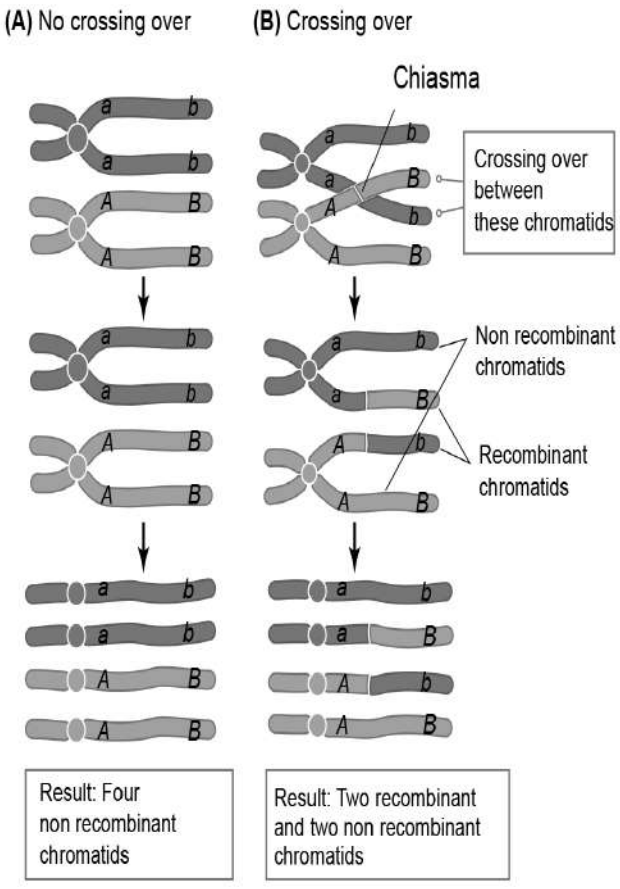
- After crossing over, chiasma starts to move towards the terminal end of chromatids.
- This is known as **terminalisation**.
- As a result, complete separation of homologous chromosomes occurs.
- A recent study reveals that synapsis and chiasma formation are facilitated by a highly organised structure of filaments called **Synaptonemal Complex (SC)**

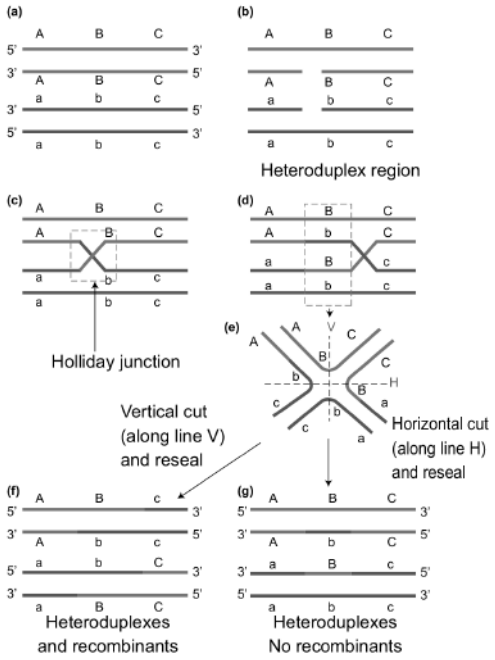
20. Write the steps involved in molecular mechanism of DNA recombination with diagram.

Crossing over results in the formation of new combination of characters in an organism called recombinants. In this, segments of DNA are broken and recombined to produce new combinations of alleles. This process is called **Recombination.**

The widely accepted model of DNA recombination during crossing over is **Holliday's hybrid DNA model**. It was first proposed by **Robin Holliday** in 1964. It involves several steps.

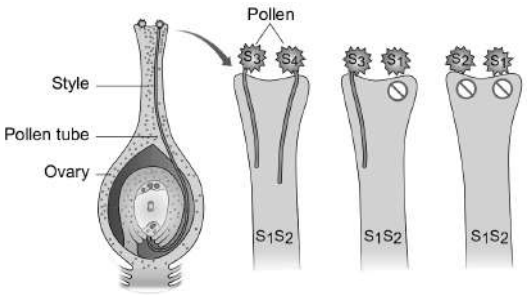
1. Homologous DNA molecules are paired side by side with their duplicated copies of DNAs
2. One strand of both DNAs cut in one place by the enzyme **endonuclease**.
3. The cut strands cross and join the homologous strands forming the **Holliday structure** or **Holliday junction**.
4. The Holliday junction migrates away from the original site, a process called **branch migration,** Its result heteroduplex region is formed.
5. DNA strands may cut along through the vertical (V) line or horizontal (H) line.
6. The vertical cut will result in heteroduplexes with recombinants.
7. The horizontal cut will result in heteroduplex with non recombinants.





21. How is Nicotiana exhibit self-incompatibility. Explain its mechanism.

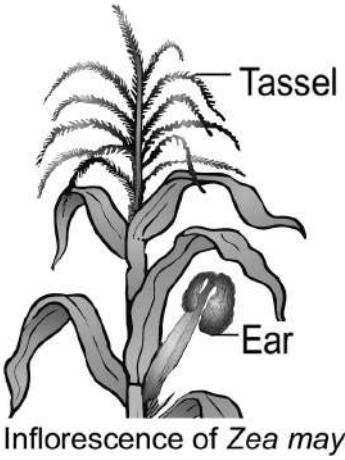
- In plants, multiple alleles have been reported in association with self-sterility or self-incompatibility.
- Self-sterility means that the pollen from a plant is unable to germinate on its own stigma.
- This will not be able to bring about fertilization in the ovules of the same plant.
- self-incompatibility or self-sterility observed by East (1925) in *Nicotiana*.
- The gene for self-incompatibility can be designated as S, which has allelic series S1, S2, S3, S4 and S5.
- The cross-fertilizing tobacco plants were not always homozygous as S1S1 or S2S2,
- but all plants were heterozygous as S1S2, S3S4, S5S6.
- When crosses were made between different S1S2 plants, the pollen tube did not develop normally.
- But effective pollen tube development was observed when crossing was made with other than S1S2 for example S3S4.
- When crosses were made between seed parents with S1S2 and pollen parents with S2S3, two kinds of pollen tubes were distinguished.
- Pollen grains carrying S2 were not effective, but the pollen grains carrying S3 were capable of fertilization.
- Thus, from the cross S1S2XS3S4, all the pollens were effective and four kinds of progeny resulted: S1S3, S1S4, S2S3 and S2S4.



Some combinations are showed in the table

Female parent (Stigma spot)	Male parent (Pollen source)		
	S1S2	**S2S3**	**S3S4**
S1S2	Self Sterile	S3S2 S3S1	S3S1 S3S2 S4S1 S4S2
S2S3	S1S2 S1S3	Self Sterile	S4S2 S4S3
S3S4	S1S3 S1S4 S2S3 S2S4	S2S3 S2S4	Self Sterile

22. How sex is determined in monoecious plants. write their genes involved in it.



Inflorescence of *Zea mays*

- Zea mays (maize) is an example for monoecious.
- There are two types of inflorescence.
- Terminal staminate florets develops from shoot apical meristem called tassel.
- The lateral pistillate florets from axillary bud is called ear or cob.
- the selective abortion of stamens in ear florets and pistils in tassel florets.

- A substitution of two single gene pairs 'ba' for barren plant and 'ts' for tassel seed makes the difference between monoecious and dioecious (rare) maize plants.
- The allele for barren plant (ba) when homozygous makes the stalk staminate by eliminating silk and ears.
- The allele for tassel seed (ts) transforms tassel into a pistillate structure that produce no pollen.
- The resultant sex expression based on the combination of these alleles given in the table.
- Most of these mutations are shown to be defects in gibberellin biosynthesis. Gibberellins play an important role in the suppression of stamens in florets on the ears.

Genotype	Dominant/ recessive	Modification	Sex
ba/bats/ts	Double recessive	Lacks silk on the stalk, but transformed tassel to pistil	Rudimentary female
ba/bats+/ts+	Recessive and dominant	Lacks silk and have tassel	Male
ba+/ba+ts+/ ts+	Double dominant	Have both tassel and cob	Monoecious
ba+/ba+ ts/ts	Dominant and recessive	Bears cob and lacks tassel	Normal female

Sex determination in Maize (Superscript (+) denotes dominant character)

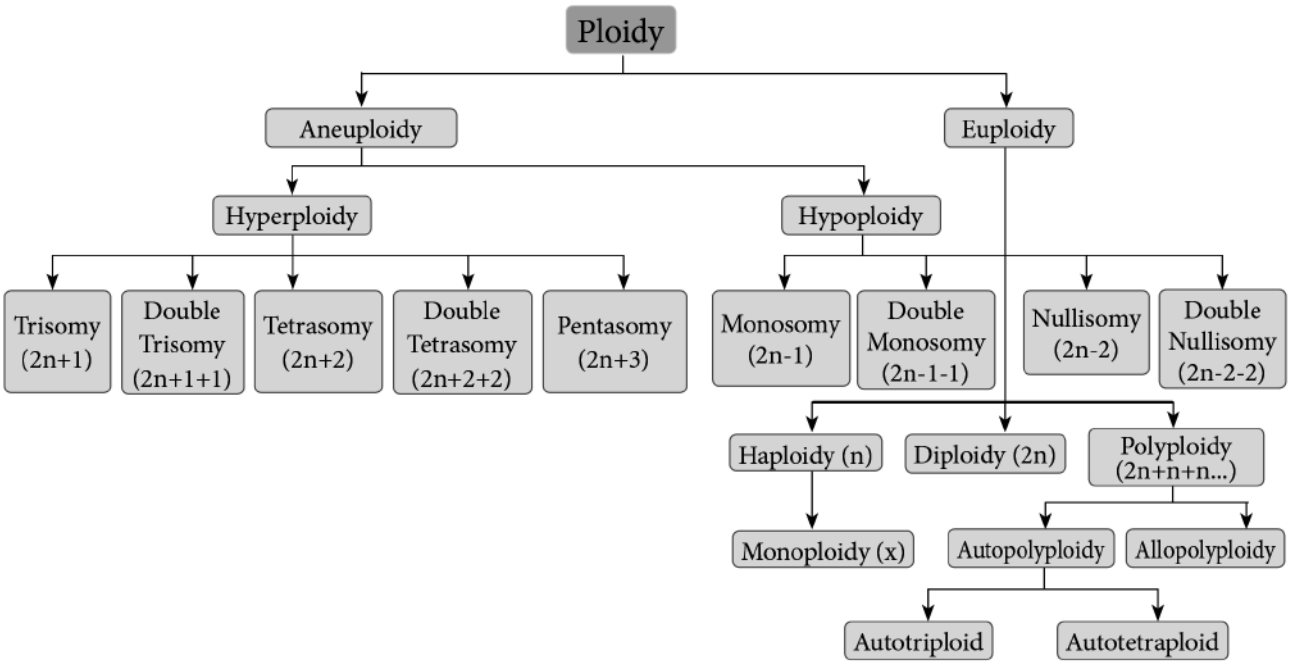
23. What is gene mapping? Write its uses.

- The diagrammatic representation of position of genes and related distances between the adjacent genes is called **genetic mapping**.
- It is directly proportional to the frequency of recombination between them.
- It is also called as **linkage map**.
- The gene mapping was first developed by Morgan's student **Alfred H Sturtevant** in 1913.
- It provides clues about where the genes lies on that chromosome.

Uses

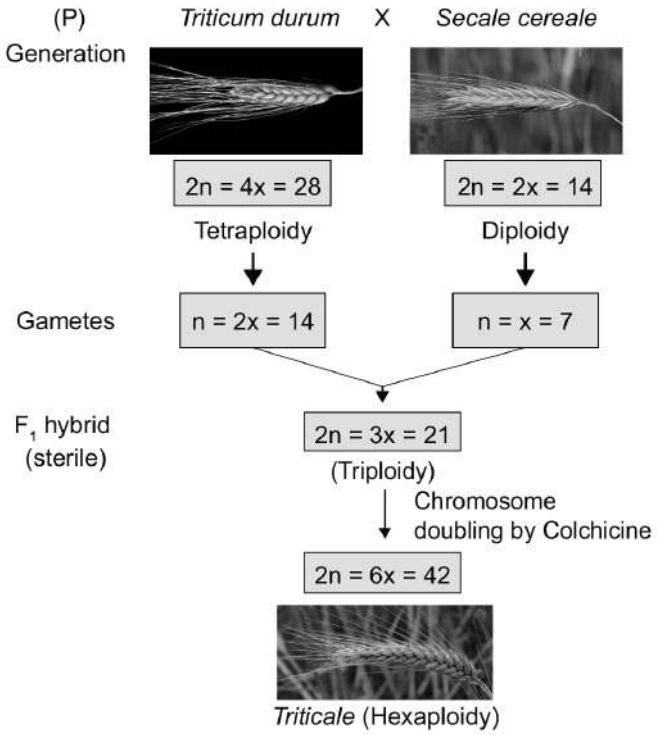
- Determine gene order,
- Identify the locus of a gene and
- Calculate the distances between genes.
- It is useful in predicting results of dihybrid and trihybrid crosses.
- To understand the overall genetic complexity of particular organism.

24. Draw the diagram of different types of aneuploidy.



25. Mention the name of man-made cereal. How it is formed?

- Triticale is the successful first man made cereal.
- Hexaploidy *Triticale* hybrid plants demonstrate characteristics of both macaroni wheat and rye
- For example, they combine the high-protein content of wheat with rye's high content of the amino acid lysine, which is low in wheat.
- It can be explained by chart below



PART – A

ADDITIONAL QUESTIONS (1 MARK)

1. Triticale has been evolved by intergeneric hybridization between

a) rice and maize
b) wheat and rye
c) wheat and Aegilops
d) wheat and rice

Ans : b

2. Diploid chromosome number in humans is

a) 48 b) 46 c) 42 d) 44

Ans : b

3. Mutations used in agriculture are commonly

a) lethal b) induced
c) recessive and lethal d) spontaneous **Ans : b**

4. Cross between AaBB and aaBB will form

a) 3 AaBB: 1 aaBB b) 1 AaBB: 1aaBB
c) 1 AaBB: 3 aaBB d) All AaBB **Ans : b**

5. Bateson used the terms coupling and repulsion for linkage and crossing over. Name the correct parent of coupling type alongwith its cross repulsion

a) Coupling aaBB, aabb; Repulsion AABB, aabb
b) Coupling AABB, aabb; Repulsion AABB, AAbb
c) Coupling AABB, aabb: Repulsion AAbb, aaBB
d) Coupling AAbb, aaBB; Repulsion AaBb, aabb

Ans : c

6. The allele which is unable to express its effect in the presence of another is called

a) complementary b) codominant
c) recessive d) supplementary

Ans : c

7. Multiple alleles control inheritance of

a) sickle cell anaemia b) phenylketonuria
c) blood groups d) colour blindness

Ans : c

8. Mendel's last law is

a) independent assortment
b) segregation
c) polygenic inheritance
d) dominance **Ans : a**

9. Segregation of Mendelian factors (no linkage, no crossing over) occurs during

a) diplotene b) anaphase I
c) metaphase I d) anaphase II

Ans : b

10. Two dominant nonallelic genes are 50 map units apart. Then linkage is

a) complete b) cis type
c) absent/ Incomplete d) trans type **Ans : c**

11. Which crop variety is not due to induced mutations?

a) Sharbati Sonora of Wheat
b) Reimei of Rice
c) Aruna of Castor
d) Prabhat of Arhar **Ans : c**

12. Which of the following is suitable for experiment on linkage

a) AaBb × AaBb b) aaBB × aaBB

c) AAbb × AaBB d) AABB × aabb

Ans : d

13. H.J.Muller was awarded Nobel Prize for his

a) work on gene mapping in Drosophila

b) discovery that chemicals can induce gene mutations

c) efforts to prevent the use of nuclear weapons.

d) discovery that ionizing radiations can induce gene mutations

Ans : d

14. The formation of multivalents at meiosis in a diploid organism is due to

a) monosomy

b) inversion

c) reciprocal translocation

d) deletion **Ans : c**

15. Crossing over in diploid organism is responsible for

a) linkage between genes

b) segregation of alleles

c) recombination of linked alleles

d) dominance of genes **Ans : c**

16. Which of the following is the main category of mutation?

a) Somatic mutation b) Genetic mutation

c) All of these d) Zygotic mutation

Ans : b

17.A and B genes are linked what shall be genotype of progeny in a cross between AB/ab and ab/ab?

a) AABB and aabb b) AAbb and aabb

c) None of these d) AaBb and aabb

Ans : d

18.There are three genes a, b, c. Percentage of crossing over between a and b is 20%, b and c is 28% an a and c is 8%. What is the sequence of genes on chromosome?

a) a, c, b b) b, a, c

c) none of these d) a, b, c **Ans : b**

19.Lack of independent assortment of two genes A and B in fruit fly Drosophila is due to

a) linkage b) repulsion

c) crossing over d) recombination

Ans : a

20.Point mutation involves:

a) deletion b) change in single base pair

c) insertion d) duplication

Ans : b

21. Select the correct statement from the ones given below with respect to dihybrid cross.

a) Genes loosely linked on the same chromosome show similar recombinations as the tightly linked ones

b) Tightly linked genes on the same chromosome show higher recombinations

c) Tightly linked genes on the same chromosome show very few recombinations

d) Genes far apart on the same chromosome show very few recombinations **Ans : c**

22. Mutations can be induced with:

a) ethylene b) infra red radiations

c) gamma radiations d) I AA **Ans : c**

23. Which one of the following is a wrong statement regarding mutations?

a) UV and Gamma rays are mutagens.

b) Deletion and insertion of base pairs cause frame-shift mutations.

c) Change in a single base pair of DNA does not cause mutation.

d) Cancer cells commonly show chromosomal aberrations.

Ans : c

24. Which of the following statements is not true of two genes that show 50% recombination frequency?

a) If the genes are present on the same chromosome, they undergo more than one crossovers in every meiosis

b) The genes are tightly linked

c) The genes may be on different chromosomes

d) The genes show independent assortment

Ans : b

25. Genetic variation in a population arises due to

a) Mutations as well as recombination
b) Mutations only
c) Reproductive isolation and selection
d) Recombination only **Ans : a**

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

a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
c) If Assertion is true but Reason is false.
d) If both Assertion and Reason are false.

26. Assertion: An organism with lethal mutation may not even develop beyond the zygote.

Reason: All types of gene mutations are lethal **Ans : c**

27. Assertion : The genetic complement of an organism is called genotype.

Reason : Genotype is the type of hereditary properties of an organism. **Ans : a**

28. Assertion : In case of incomplete linkage, linked gene show new combination along with parental combination.

Reason : In case of incomplete linkage, linked genes are separated by crossing over. **Ans : a**

29. Assertion: Aneuploidy may be of hypoploidy or hyperploidy type.

Reason: Monosomy lacks one pair of chromosomes. **Ans : c**

30. Who is known as father of radiation genetics?

a) Slatyer b) Charles Elton
c) Taylon d) H.J. Mullen **Ans: d**

31. Mutation can be induced with

a) IAA b) Ethylene
c) Gamma radiation d) Infrared radiation **Ans: c**

32. The loss of Chromosome segment in due to

a) Polyploidy b) Deletion
c) Duplication d) Inversion **Ans: b**

33. The Chromosome constitution 2n-2 of an organism represent

a) Monosomic b) Nullisomic
c) Haploid d) Trisomic **Ans: b**

34. Which of the following is not considered as Mutagens?

a) Low temperature b) X rays
c) Higher temperature d) UV rays **Ans: a**

35. Which of the following condition is called monosomic?

a) 2n+1 b) 2n+2
c) n+1 d) 2n-1 **Ans: d**

36. The genes of different traits located on different loci on the some chromosomes are

a) Alleles b) Linked
c) Mutated d) Pleomorphic **Ans: b**

37. Frame shift mutation occurs when

a) Base is added
b) Base is deleted
c) Base is added or deleted
d) None of the above **Ans: c**

38. 2n-1 Condition is called

a) Trisomy b) Monosomy
c) Nullisomy d) Telrasomy **Ans: b**

39. The Mutation, which is not transferred to the offspring?

a) Gene Mutation
b) Point Mutation
c) Chromosomal Mutation
d) Somatic Mutation **Ans: d**

40. Crossing over that results in genetic recombination in higher organism occurs between

a) Sister Chromatids of bivalent
b) Non-Sister Chromatids of a bivalent
c) Two daughter nuclear
d) Two different bivalents **Ans: b**

41. The exchange of chromosomal parts between non-homologous chromosomal is known as

a) Translocation b) Transcription
c) Transduction d) Translation **Ans: a**

42. Polyploidy means occurrence of

a) Haploid sets of Chromosomes
b) Diploid sets of Chromosomes
c) More than diploid sets of Chromosomes
d) All of the above

Ans: c

43. Genes when close together on a chromosome are known as

a) Linkage b) Mutation
c) Translation d) Transcription

Ans: a

44. *Triticum aestiuvm*, the common bread wheat is

a) Triploid with 21 Chromosomes
b) Hexaploid with 42 Chromosomes
c) Tratraploid with 30 Chromosomes
d) Diploid with 14 Chromosomes

Ans: a

45. Monosomy and trisomy cause represented as

a) 2n+1, 2n+3 b) 2n-1, 2n-2
c) 2n, 2n+1 d) 2n-1, 2n+1 **Ans: d**

46. Exchange of genetic material from non-sister Chromatid is called

a) Transformation b) Crossing Over
c) Translocation d) Deletion **Ans: b**

47. The distance between the genes ABC and D in moping units are A-D=35; B-C=1; A-B=6; C- D=15; A-C=5; Find out the Sequences of arrangement of these genes.

a) ACDB b) ABCD
c) ACBD d) ADBC **Ans: c**

48. Chromosome theory of inheritance was proposed by

a) Mendel b) Hugo de vries
c) Bateson & Punnett d) Sutton and Boveri

Ans: d

49. There are these genes a,b,c percentage of crossing over between a and b is 20%, b and is 28%, and a and c is 18%, what is the sequence of genes on Chromosomes?

a) a,b,c b) b,a,c
c) a,c,b d) None of these **Ans: b**

50. Man made allopolyploid Cereal Crop is

a) Rhonobrassica b) Triticale
c) Pomato d) None of these **Ans: b**

51. An Organism which processes two complete basic sets of chromosomes are called

a) Haploid b) Diploid
c) Triploid d) None of these **Ans: b**

52. The Chromosomes of a cells are responsible for transferring heredity said by

a) Wilhelm Roux b) Montogeny
c) T. Boveri d) W.S. Sutton **Ans: a**

53. Who got nobel prize for chromosomes in heredity?

a) T.Boveri b) W.S. Sutton
c) T.H. Morgan d) Mendel **Ans: c**

54. The two dominant alleles or recessive alleles occur in the same homologous chromosomes, tend to inherit together in the same gamete are called

a) Cis configuration b) Trans Configuration
c) Repulsion d) None of these **Ans: a**

55. In which organism the crossing over is completely absent

a) Maize b) Drosophila
c) both a and b d) None of these **Ans: b**

56. In which stage of meiosis, the crossing over is takes place

a) Leptons stage of prophase I of Meiosis
b) Pachytene stage of Prophase I of Meiosis
c) Diplotene stage of Prophase I of Meiosis
d) Zygotene stage of Prophase I of Meiosis

Ans: b

57. During Synapsis, pairing starts from the telomeres are called

a) Pro centric synapsis b) Random Synapsis
c) both a and b d) Proterminal Synapsis

Ans: d

58. The Pausing between two homologous chromosomes are called

a) Synapsis b) Syndesis
c) both a and b d) Crossing over **Ans: c**

59. The environment play a role on sex determination in
a) Equisetum b) Maize
c) Wheat d) Rice **Ans: a**

60. Who introduce the term Mutation?
a) Hugo devries b) T.H. Morgen
c) Bateson d) None of these **Ans: a**

61. Which one is not a chemical Mutagens
a) Enthrosine b) Magnous salt
c) Safrain d) Eosin **Ans: c**

62. The addition of two individual pairs of chromosomes to diploid set is called
a) 2n+2 b) 2n+2+2
c) 2n+1 d) 2n-2 **Ans: b**

63. Loss of one on more chromosomes from the diploid set in the cell is called
a) Herperploidy b) Hypo ploidy
c) Polyploidy d) None of these
Ans: b

64. Which of the following is called Triploid Monosomy
a) 2n-1 b) 2n-1-1
c) 2n-1-1-1 d) 2n-1+1 **Ans: c**

65. A inversion that includes the Centromere is
a) Paracentric b) Pericentric
c) Inversion d) Translocation **Ans: b**

66. The Mutations where codon for one amino acid is changed into a termination or stop codon is called
a) Indel Mutation b) Silent Mutation
c) Nonsense Mutation d) Missense Mutation
Ans: c

67. The number of Linkage groups in sweet pea
a) 4 b) 5 c) 6 d) 7 **Ans: d**

68. Sharbati Sonora is a mutant variety of
a) Rice b) Maize c) Wheat d) Pea Ans: c

69. The Compounds which are not having own mutagenic properties are called
a) Co mutagens b) Mutagens
c) both a and b d) None of these **Ans: a**

70. Chemical Mutagenesis was first reported by
a) H.J. Muller b) L.J. Stadler
c) C. Auer back d) Morgan **Ans: c**

71. Tri somic was first reported by
a) H.J. Muller b) L.J. Stadler
c) C. Auerback d) Blackes lee **Ans: d**

72. Selfing of Monosomic plants produce
a) Mullisomic b) Monosomic
c) Trisomic d) Tetrasomic **Ans: a**

73. Man made auto triploids are
a) Banana b) Apple
c) Tomato d) All of these Ans: d

74. Examples of autotetraploids
a) Grapes b) Groundnut
c) Coffee d) All of these **Ans: d**

75. Closely linked genes show
a) Weak linkage b) Strong linkage
c) Lethal linkage d) Incomplete linkage
Ans: b

76. Self In compatibility in *Nicotiana* observed by
a) East b) T.H. Morgan
c) Punnett d) Mendel **Ans: a**

77. Complete linkage in *Drosophila* was discovered by
a) Hutchinson b) T.H. Morgan
c) C.B. Bridges d) M.J. Muller **Ans: c**

78. Incomplete linkage in Maize was discovered by
a) Hutchinson b) T.H. Morgan
c) C.B. Bridges d) M.J. Muller **Ans: a**

79. Hawalli discovered Sex Chromosomes in
a) Potato b) Tomato
c) Papaya d) Watermelon **Ans: c**

80. Which Chemical induced artificial ploidy in plants
a) Colchicine b) Benzene
c) Aceto carmine d) None of these
Ans: a

81. The Map distance between genes A and B is 3 units between B and C is 10 units and between C and A is 7 units, the order of the genes in a linkage Map constructed on the above data would perhaps be

A ABC b) ACB c) BA d) BAC **Ans: d**

82. How many different types of genetes can be formed by F1 progeny resulting from the following cross AABBCC X aabbcc

a) 3 b) 8 c) 27 d) 64 **Ans: d**

83. The recombination frequency (RF) of Four strand double cross over is

a) 60 b) 80 c) 90 d) 100 **Ans: d**

84. The recombination frequency (RF) of two strand double crossing over is

a) 0 b) 10 c) 20 d) 30 **Ans: a**

85. Which of the ploidy is lethal

a) Monosomy b) Nullisomy

c) Tetrasomy d) Trisomy **Ans: b**

PART – B

ADDITIONAL QUESTIONS (2 MARK)

1. Define Chromosomes.

In eukaryotic cells, worm-shaped structures formed during cell division are called **chromosomes** colored bodies, visualized by staining)

2. Why the organism is called diploid ?

An organism which possesses two complete basic sets of chromosomes are known as diploid.

3. What are called genes ?

A chromosome consists of long, continuous coiled piece of DNA in which genes are arranged in linear order.

Each gene has a definite position (locus) on a chromosome.

4. Which are called hereditary units?

Genes are called hereditary units.

5. States chromosomal theory of inheritance.

Chromosomal theory of inheritance states that Mendelian factors (genes) have specific locus (position) on chromosomes

6. What is the function of Genes?

Genes carry information from one generation to the next generation.

7. States chromosomal theory of Wilhelm Roux(1883)

The chromosomes of a cell are responsible for transferring heredity.

8. States chromosomal theory of Montgomery (1901)

First to suggest occurrence of distinct pairs of chromosomes.

He concluded that maternal chromosomes pair with paternal chromosomes only during meiosis.

9. States chromosomal theory of T. Boveri (1902)

The chromosomes contain genetic determiners.

He was largely responsible for developing the chromosomal theory of inheritance.

10. States chromosomal theory of W.S. Sutton (1902)

He independently recognized a parallelism (similarity) between the behaviour of chromosomes and Mendelian factors during gamete formation.

11. States Sutton chromosomal theory of inheritance.

Sutton united the knowledge of chromosomal segregation with Mendelian principles and called it chromosomal theory of inheritance.

12. Who is a young American student who propose the chromosome theory of inheritance ?

W.S. Sutton (1902) is a young American student, propose the chromosome theory of inheritance.

13. Who got Nobel prize for chromosomes in heredity?

Thomas Hunt Morgan (1933) received Nobel Prize in Physiology or Medicine for his discoveries concerning the role played by chromosomes in heredity.

14. What is meant by linked genes?

Genes located close together on the same chromosome and inherited together are called **linked genes.**

15. What is meant by unlinked genes or syntenic genes?

The two genes that are sufficiently far apart on the same chromosome are called **unlinked genes or syntenic genes**.

Such condition is known as **synteny**

16. What is coupling ?

The two dominant alleles or recessive alleles occur in the same homologous chromosomes, tend to inherit together into same gamete are called **coupling or** cis **configuration.**

17.What is repulsion ?

The dominant or recessive alleles are present on two different, but homologous chromosomes they inherit apart into different gamete are called **repulsion or** trans **configuration.**

18. Who classify the Linkage and write their types.?

T.H. Morgan classify two types of linkage.

They are 1. complete linkage and 2. incomplete linkage

19. In which organism the crossing over is completely absent. Who discover this ?

Crossing over is completely absent in some species of male Drosophila.

It was discovered by **C.B Bridges** (1919)

20. What is crossing over ?

Inter-changing the corresponding segments between non-sister chromatids of homologous pair of chromosomes is called Crossing over.

21. What is the use of crossing over ?

It produces new combination of genes.

22. Who term crossing over ?

The term 'crossing over' was coined by **Morgan (1912)**

23. In which stage of meiosis ,crossing over takes place ?

Crossing over takes place during pachytene stage of prophase I of meiosis.

24. Describe germinal crossing over. write their other name

Crossing over occurs in germinal cells during gametogenesis is called germinal crossing over.

It is also called meiotic crossing over.

25. What is somatic crossing over ? write their other name.

Crossing over rarely occurs in somatic cells during mitosis is called somatic.

It is also called mitotic crossing over.

26. In which stage of meiosis I, synapsis is initiated ?

Synapsis is initiated during **zygotene** stage of **prophase I**.

27. Name the three types of synapsis,

1. Procentric synapsis
2. Proterminal synapsis
3. Random synapsis

28. Define Chiasmata

During crossing over, the non-sister chromatids of homologous pair make a contact at one or more points are called **Chiasmata.**

29. Define bivalents

The homologous chromosomes pairs are aligned side by side called **bivalents**.

30. What is known as terminalisation ?

After crossing over, chiasma starts to move towards the terminal end of chromatids. This is known as **terminalisation**.

31. What is synaptonemal complex?

A recent study reveals that synapsis and chiasma formation are facilitated by a highly organised structure of filaments called Synaptonemal Complex (SC)

32. In which organism synaptonemal complex formation is absent. Why?

The synaptonemal complex formation is absent in some species of male Drosophila.

Because crossing over does not takes place

33. Name the stages of crossing Over

The stages of crossing over are

1.Synapsis, 2.Tetrad formation, 3.Cross over and 4.Terminalization

34. What is synapsis ? give the other name of this.

The pairing between two homologous chromosomes are called **synapsis.** The other name is **syndesis**.

35. Define recombinants

Crossing over results in the formation of new combination of characters in an organism called recombinants.

36. What is recombination ?

During crossing over segments of DNA are broken and recombined to produce new combinations of alleles.

This process is called **Recombination.**

37. What is locus ?

Genes are present in a linear order along the chromosome.

They are present in a specific location called **locus**.

38. Define genetic mapping.

The diagrammatic representation of position of genes and related distances between the adjacent genes is called **genetic mapping**. It is also called as **linkage map**.

39. Write the formula of calculation of recombination frequency (RF)

The recombination frequency (RF) is calculated by.

$$RF = \frac{\text{Number of recombinants}}{\text{Number of off springs}} \times 100$$

40. Who propose the concept of gene mapping. Write its use.

The concept of gene mapping was first developed by Morgan's student **Alfred H Sturtevant** in 1913.

It provides clues about where the genes lies on that chromosome.

41. Define chromosomal mutations

By altering the chromosome structure in a larger scale or by changing the number of chromosomes in a cell are called **chromosomal mutations** or **chromosomal aberrations**.

42. What is meant by numerical chromosomal aberration or ploidy ?

The chromosome number of somatic cells are changed due to addition or elimination of individual chromosome or basic set of chromosomes are known as **numerical chromosomal aberration** or **ploidy**.

43. Rearrange the order of stages of crossing Over and describe Tetrad Formation.

Tetrad formation, Cross over ,Synapsis and Terminalization

The stages of crossing over are

1.Synapsis, 2.Tetrad formation, 3.Cross over and 4.Terminalization

44. What is meant by procentric synapsis ?

During synapsis the pairing starts from middle of the chromosome is called procentric synapsis.

45. What is meant by proterminal synapsis ?

During synapsis the pairing starts from the telomeres is called proterminal synapsis

46. What is meant by random synapsis ?

During synapsis the pairing may start from anywhere is called random synapsis

47. What is Chiasmata ?

During crossing over the non-sister chromatids of homologous pair make a contact at one or more points are called Chiasmata.

48. What is terminalisation ?

After crossing over, chiasma starts to move towards the terminal end of chromatids is known as **terminalisation**.

49. Define synaptonemal complex (SC)

synapsis and chiasma formation are facilitated by a highly organised structure of filaments called **synaptonemal complex (SC)**

50. What is the widely accepted model of DNA recombination during crossing over?

The widely accepted model of DNA recombination during crossing over is **Holliday's hybrid DNA model**.

51. Who propose holliday's hybrid DNA model ?

Holliday's hybrid DNA model was first proposed by Robin Holliday in 1964.

52. What is branch migration ?

The holliday junction migrates away from the original site, a process called **branch migration,**

Its result heteroduplex region is formed.

53. Define two point crosses

Genetic maps can be constructed from a series of test crosses for pairs of genes called **two point crosses**.

But this is not efficient because double cross over is missed.

54. Define three point test cross

To analyzing the inheritance patterns of three alleles by test crossing a triple recessive heterozygote with a triple recessive homozygote is called three point test cross.

55. Define multiple alleles.

Three or more allelic forms of a gene occupy the same locus in a given pair of homologous chromosomes, are called **multiple alleles**.

56. Define monomorphic

Most of the flowering plants have both male organs (the stamens) and female organs (the carpels) are called **monomorphic**.

57. Define dimorphic

Some of the flowering plants which have two separate sexes are called **dimorphic**

58. Does environment play a role on sex determination in plants?

Yes. Horsetail plant (Equisetum) grown under good conditions develop as female and those grown under stress condition develop into males.

59. Define mutation

A sudden change in the genetic material of an organisms is called mutation.

60. Who interduce the term mutation ? In which plant the mutation is reported ?

The term was introduced by **Hugo de Vries** (1901)

Mutation is reported in evening primrose (*Oenothera lamarkiana*)

61. Define mutagens

The agents which are responsible for mutation are called **mutagens.**

62. Define point mutation

The mutation that affecting single base or base pair of DNA are called point mutation

63. What is called base substitutions ?

one base pair is replaced by another base pair in the DNA is called base substitutions.

64. Define addition or deletion

The additions or deletions of nucleotide pairs is called addition or deletions

65. State indel mutations

Insertion and deletion collectively termed as indel mutations.

66. What is nonsense mutation ?

The mutations where codon for one amino acid is changed into a termination or stop codon is called nonsense mutation

67. What are called physical mutagens ?

Temperature and radiations such as X rays, gamma rays, alfa rays, beta rays, neutron, cosmic rays, radioactive isotopes, ultraviolet rays as physical mutagen.

68. Define chemical mutagens

Chemicals which induce mutation are called chemical mutagens.

69. What are called chemical mutagens ?

Mustard gas, nitrous acid, ethyl and methyl methane sulphonate (EMS and MMS), ethyl urethane, magnous salt, formaldehyde, eosin and enthrosine.

70. Define aneuploidy.

Diploid number is altered either by addition or deletion of one or more chromosomes are called Aneuploidy**.**

71. What is known as aneuploids or heteroploids ?

Organisms showing aneuploidy are known as aneuploids or heteroploids.

72. What is hyperploidy ?

Addition of one or more chromosomes to diploid sets are called hyperploidy.

73. Define disomy

The diploid set of chromosomes called disomy.

74. Define trisomy

The addition of single chromosome to diploid set is called Simple trisomy (2n+1)

75. Define double trisomy

The addition of two individual chromosome from different chromosomal pairs to normal diploid sets are called double trisomy (2n+1+1)

76. Define tetrasomy

The addition of a pair of chromosomes to diploid set is called **tetrasomy** (2n+2).

77. What are called double tetrasomy ?

The addition of two individual pairs of chromosomes to diploid set is called **Double tetrasomy** (2n+2+2)

78. What is pentasomy ?

The addition of three individual chromosome from different chromosomal pairs to normal diploid set are called pentasomy (2n+3)

79. Define hypoploidy

Loss of one or more chromosome from the diploid set in the cell is called hypoploidy.

80. Define monosomy

The loss of a single chromosome from the diploid set are called monosomy (2n-1)

81. Define double monosomy

The loss of two individual chromosomes are called double monosomy (2n-1-1)

82. What is triple monosomy ?

The loss of three individual chromosomes are called and triple monosomy (2n-1-1-1)

83. Define nullisomy

The loss of a pair of homologous chromosomes from the diploid set are called **Nullisomy** (2n-2)

84. What is double nullisomy ?

The loss of two pairs of homologous chromosomes from the diploid set are called **double Nullisomy** (2n-2-2).

85. Define euploidy

An organisms possess one or more basic sets of chromosomes are called Euploidy.

86. What is polyploidy ?

An organism possesses more than two basic sets of chromosomes are called Polyploidy.

87. Define diploid

An organism or somatic cell has two sets of chromosomes are called diploid (2n)

88. Define triploidy

An organism possesses three basic sets of chromosomes are called triploidy (3x)

89. Define tetraploidy

An organism possesses four basic sets of chromosomes are called tetraploidy (4x)

89. What is pentaploidy ?

An organism possesses five basic sets of chromosomes are called pentaploidy (5x)

90. Whatbis hexaploidy ?

An organism possesses six basic sets of chromosomes are called hexaploidy (6x)

91. Define autopolyploidy

More than two haploid sets of chromosomes derived from within the same species is called autopolyploid.

92. Define allopolyploidy

Two or more basic sets of chromosomes derived from two different species is called allopolyploidy.

93. What is Raphano brassica ?

Cross made between the radish (*Raphanus sativus*) and cabbage (*Brassica oleracea*) produces in F1 hybridare called *Raphano brassica*.

94. What is the example for tetraploidy ?

Cross made between diploid wheat and rye is called tetraploidy.

95. What is the example for hexaploidy ?

Cross made between tetraploid wheat Triticum durum (macaroni wheat) and rye is called hexaploidy

96. What is the example for octoploidy ?

Cross made between hexaploid wheat T. aestivum (bread wheat) and rye is called octoploidy

97. What is structural chromosomal aberration ?

Addition or deletion of a part of chromosome leading to rearrangement of genes is called structural chromosomal aberration.

98. What is deletion or deficiency ?

Loss of a portion of chromosome is called deletion.

99. What is terminal deletion ?

A single break in any one end of the chromosome is called terminal deletion.

100. What is intercalary deletion or interstitial deletion ?

It is caused by two breaks and reunion of terminal parts leaving the middle is called intercalary deletion or interstitial deletion.

101. What is duplication or repeat ?

Arrangement of the same order of genes repeated more than once in the same chromosome is known as **duplication.**

102. What is tandem duplication ?

The duplicated segment is located immediately after the normal segment of the chromosome in the same order is called tandem duplication.

103. What is reverse tandem duplication?

The duplicated segment is located immediately after the normal segment but the gene sequence order will be reversed is called reverse tandem duplication.

104. Define displaced duplication ?

The duplicated segment is located in the same chromosome, but away from the normal segment is called displaced duplication.

105. What is inversion ?

A rearrangement of order of genes in a chromosome by reversed by an angle 180^0 is called inversion.

106. Define paracentric inversion.

An inversion which takes place apart from the centromere is called paracentric inversion.

107. Define pericentric inversion

An inversion that includes the centromere.

108. What is translocation ?

The transfer of a segment of chromosome to a non-homologous chromosome is called translocation..

109. What is simple translocation ?

A single break is made in only one chromosome.

The broken segment gets attached to one end of a non-homologous chromosome.

110. What is shift translocation ?

Broken segment of one chromosome gets inserted interstitially in a non-homologous chromosome is called translocation.

111. What is reciprocal translocations ?

The mutual exchange of chromosomal segments between two non-homologous chromosomes are called reciprocal translocations.

It is also called **illegitimate crossing over.**

112. What is the other name of illegitimate crossing over ?

Reciprocal translocations also called illegitimate crossing over.

113. Define homozygous translocation

Both the chromosomes of two pairs are involved in translocation. Two homologous of each translocated chromosomes are identical. These are called homozygous translocation.

114. Define heterozygous translocation

Only one of the chromosome from each pair of two homologous are involved in translocation, while the remaining chromosome is normal. This is called heterozygous translocation.

115. Define single cross over

The formation of single chiasma and involves only two chromatids out of four is called single cross over.

116. Define double cross over

The formation of two chiasmata and involves two or three or all four strands is called double cross over.

117. Define multiple cross over

The formation of more than two chiasmata and crossing over frequency is extremely low is called multiple cross over.

118. Define the term mutagenesis and mutagenized

The production of mutants through exposure of mutagens is called mutagenesis, and the organism is said to be mutagenized.

119. Describe synonymous or silent mutations

The mutation that changes one codon for an amino acid into another codon for that same amino acid are called Synonymous or silent mutations.

120. Describe missense or non-synonymous mutations

The mutation where the codon for one amino acid is changed into a codon for another amino acid is called Missense or non-synonymous mutations.

PART – C

ADDITIONAL QUESTIONS (3 MARK)

1. Write parallelism between mendelian factors and chromosomal behaviour.

	Mendelian factors	Chromosomes behaviour
1	Alleles of a factor occur in pair	Chromosomes occur in pairs
2	Similar or dissimilar alleles of a factor separate during the gamete formation	The homologous chromosomes separate during meiosis
3	Mendelian factors can assort independently	The paired chromosomes can separate independently during meiosis but the linked genes in the same chromosome normally do not assort independently

2. Describe Fossil Genes:

- Some of the junk DNA is made up of pseudogenes.
- The sequences presence in that was once working genes.
- They lost their ability to make proteins.
- They tell the story of evolution through fossilized parts.

3. Define Linkage. Who reported this ?

- Mendel's Independent Assortment will not takes place in some organisms because of genes to stay together during separation of chromosomes is called **Linkage.**
- It was reported in Sweet pea (Lathyrus odoratus) by **Willium Bateson** and **Reginald C. Punnet** in 1906.

4. Define linkage groups. Give examples.

- The groups of linearly arranged linked genes on a chromosome are called **Linkage groups**.
- The number of linkage groups corresponds to the number haploid set of chromosomes.
- Example:

Name of organism	Linkage groups
Mucor	2
Drosophila	4
Sweet pea	7
Neurospora	7
Maize	10

5. Describe tetrad formation

- Each homologous chromosome form two identical sister chromatids.
- It remain held together by a centromere.
- At this stage each bivalent has four chromatids.
- This stage is called **tetrad stage**

6. Describe three types of synapsis

- **Procentric synapsis:** Pairing starts from middle of the chromosome.
- **Proterminal synapsis:** Pairing starts from the telomeres.
- **Random synapsis:** Pairing may start from anywhere.

7.Describe synapsis or syndesis

- The pairing between two homologous chromosomes are called **synapsis or syndesis**.
- It is initiated during zygotene stage of prophase I of meiosis I.
- Homologous chromosomes pairs are aligned side by side called **bivalents**

8. Explain cross over

- Crossing over occurs in pachytene stage.
- The non-sister chromatids of homologous pair make a contact at one or more points are called **Chiasmata.**
- At chiasma, cross-shaped or X-shaped structures are formed.
- The breaking and re-joining of two chromatids occur in that point.
- This results in reciprocal exchange of equal and corresponding segments between them.

9. Describe terminalisation

- After crossing over, chiasma starts to move towards the terminal end of chromatids.
- This is known as **terminalisation**.
- As a result, complete separation of homologous chromosomes occurs.
- A recent study reveals that synapsis and chiasma formation are facilitated by a highly organised structure of filaments called **Synaptonemal Complex (SC)**

10. Explain types of crossing over depending upon the number of chiasmata formation

- **Single cross over**: Formation of single chiasma and involves only two chromatids out of four.
- **Double cross over:** Formation of two chiasmata and involves two or three or all four strands
- **Multiple cross over**: Formation of more than two chiasmata and crossing over frequency is extremely low.

11. Describe genetic map distance

- The unit of distance in a genetic map is called a **map unit** (m.u)
- One map unit is equivalent to one percent of crossing over.
- One map unit is also called a centimorgan (cM) in honour of **T.H. Morgan**.
- 100 centimorgan is equal to one Morgan (M)

12. Describe genetic mapping

- The diagrammatic representation of position of genes and related distances between the adjacent genes is called **genetic mapping**.
- It is directly proportional to the frequency of recombination between them.
- It is also called as **linkage map**.

13. Describe mutation

- A sudden change in the genetic material of an organisms is called mutation.
- The term was introduced by **Hugo de Vries** (1901) in evening primrose (*Oenothera lamarkiana*)
- He proposed **'Mutation theory'**

14. Describe the sex determination in *Silene latifolia*

- Sex determination in *Silene latifolia* (*Melandrium album*)
- is of controlled by three distinct regions in a sex chromosome.
- Y chromosome determines maleness
- X specifies femaleness
- X and Y show different segments (I II III IV and V)

15.Describe the two types of mutation based on their origin

- Based on the origin, mutations are two types
- **Spontaneous mutation** : It occurs in the absence of known mutagen
- **Induced mutation:** It occurs in the presence of known mutagen

16. Describe the two types of mutation based on their cell types

- Based on the cell types, mutations are two types
- **Somatic mutation :** It occurs in non-reproductive cells
- **Germ-line mutation :** It occurs in reproductive cells

17. Describe the four types of mutation based on their effect on function

- Based on the effect on function , mutations are four types
- **1.Loss-of-function (knockout, null) mutation :**It eliminates normal function.
- **2.Hypomorphic (leaky) mutation :** It reduces normal function.
- **3.Hypermorphic mutation :** It increases normal function.
- **4.Gain-of-function (ectopic expression) mutation :** It expressed at incorrect time or inappropriate cells.

18. Describe the four types of mutation based on their molecular change

- Based on the molecular change, mutations are four types
- **Transition mutation:** A base pair in DNA duplex is replaced with a different base pair

i.e) purine to purine (AG) or pyrimidine to pyrimidine (TC)

- **Transversion mutation:** Replaced with purine to pyrimidine (AT) or pyrimidine to purine(CG)
- **Insertion mutation :** One or more extra nucleotides are present
- **Deletion mutation :** One or more nucleotides are missing

19. Describe the four types of mutation based on their effect on translation

- Based on the effect on translation, mutations are four types
- **Silent (synonymous) mutation:** No change in amino acid encoded
- **Missense (non-synonymous) mutation:** Change in amino acid encoded
- **Nonsense (termination) mutation:** Creates translational termination codon (UAA, UAG, or UGA)
- **Frame shift mutation:** Shifts triplet reading of codons out of correct phase

20. Describe addition or deletion

- additions or deletions of nucleotide pairs.
- It also called base pair addition or deletions.
- Collectively, they are termed **indel mutations** (for insertion-deletion)
- Substitution mutations or indel mutations affect translation.

21. Describe frame shift mutations

- Mutations that result in the addition or deletion of a single base pair of DNA.
- It changes the reading frame for the translation process.
- Its result there is complete loss of normal protein structure and function are called **Frame shift mutations**

22. What are mutagenic agents ?

- The factors which cause genetic mutation are called **mutagenic agents or mutagens**.
- Mutagens are of two types, physical mutagen and chemical mutagen.
- **Muller** (1927) was the first to find out physical mutagen in *Drosophila*.

23. Explain physical mutagens

- Temperature and radiations such as X rays, gamma rays, alfa rays, beta rays, neutron, cosmic rays, radioactive isotopes, ultraviolet rays as physical mutagen.

24. How temperature induce mutation artificially?

- Increase in temperature increases the rate of mutation.
- While rise in temperature, breaks the hydrogen bonds between two DNA nucleotides which affects the process of replication and transcription.

25. Describe ionizing radiation

- It is short wave length and carry enough higher energy to ionize electrons from atom.
- Example : X rays, gamma rays, alfa rays, beta rays and cosmic rays.
- It breaks the chromosomes (chromosomal mutation) and chromatids in irradiated cells.

26. Describe non-ionizing radiation

- It is a longer wavelengths and carry lower energy.
- **Example :** UV rays
- They have lower penetrating power than the ionizing radiations.
- It is used to treat unicellular microorganisms, spores, pollen grains which possess nuclei located near surface membrane.

27. Describe sharbati sonora

- Sharbati Sonora is a mutant variety of wheat.
- It is developed from Mexican variety (Sonora 64) by irradiating of gamma rays.
- It is the work of Dr. **M. S. Swaminathan.**

28. Describe Castor Aruna

- Castor Aruna is mutant variety of castor.
- It is developed by treatment of seeds with thermal neutrons.
- It induces very early maturity (120 days instead of 270 days as original variety)

29. List out the chemicals that used for mutation

- Chemicals which induce mutation are called chemical mutagens.
- Example : Mustard gas, nitrous acid, ethyl and methyl methane sulphonate (EMS and MMS), ethyl urethane, magnous salt, formaldehyde, eosin and enthrosine.

30. How nitrous oxide react DNA?

- Nitrous oxide alters the nitrogen bases of DNA.
- It disturbs the replication and transcription that leads to the formation of incomplete and defective polypeptide during translation.

31. Explain briefly about Comutagens

- The compounds which are not having own mutagenic properties.
- But can enhance the effects of known mutagens are called comutagens.
- Example: Ascorbic acid increase the damage caused by hydrogen peroxide.
- Caffeine increase the toxicity of methotrexate

32. How the chemicals that are used for mutation by different people ?

- Mustard gas (Dichloro ethyl sulphide) used as chemical weapon in world war I.
- H J Muller (1928) first time used X rays to induce mutations in fruit fly.
- L J Stadler reported induced mutations in plants by using X rays and gamma rays.
- Chemical mutagenesis was first reported by C. Auerback (1944)

33. Describe neuploidy

- Diploid number is altered either by addition or deletion of one or more chromosomes are called Aneuploidy.
- Organisms showing aneuploidy are known as aneuploids or heteroploids.
- They are of two types, Hyperploidy and Hypoploidy

34. Explain briefly about hyperploidy

- Addition of one or more chromosomes to diploid sets are called hyperploidy.
- Diploid set of chromosomes represented as Disomy.
- Hyperploidy can be divided into three types.,

35. What is trisomy and double trisomy ? Give examples.

- Addition of single chromosome to diploid set is called Simple trisomy(2n+1)
- Trisomics were first reported by Blackeslee (1910) in *Datura stramonium* (Jimson weed)
- But later it was reported in *Nicotiana, Pisum* and *Oenothera.*
- Addition of two individual chromosome from different chromosomal pairs to normal diploid sets are called double trisomy (2n+1+1)

36. What is tetrasomy and double tetrasomy? Give examples

- Addition of a pair of chromosomes to diploid set is called tetrasomy (2n+2).
- Addition of two individual pairs of chromosomes to diploid set is called Double tetrasomy (2n+2+2)
- All possible tetrasomics are available in Wheat.

37. What is monosomy and add note on double and triple monosomy ?

- Loss of a single chromosome from the diploid set are called monosomy (2n-1)
- loss of two individual chromosomes are called double monosomy (2n-1-1)
- loss of three individual chromosomes are called and triple monosomy (2n-1-1-1)
- Double monosomics are observed in maize.

38. What is nullisomy and add note on double Nullisomy ?

- Loss of a pair of homologous chromosomes from the diploid set are called Nullisomy (2n-2)
- Loss of two pairs of homologous chromosomes from the diploid set are called double Nullisomy (2n-2-2).
- Selfing of monosomic plants produce nullisomics. They are usually lethal.

39. Describe euploidy

- The organisms possess one or more basic sets of chromosomes are called Euploidy.
- It is classified as monoploidy, diploidy and polyploidy.
- An organism or somatic cell has two sets of chromosomes are called diploid (2n)
- Half the number of somatic chromosomes is referred as gametic chromosome number called haploid(n)
- It should be noted that haploidy (n) is different from a monoploidy (x)

40. Explain the example of monoploidy

- The common wheat plant is a polyploidy (hexaploidy) 2n=6x=72 chromosomes.
- Its haploid number (n) is 36, but its monoploidy (x) is 12.
- The haploid and diploid condition came regularly one after another.
- The same number of chromosomes is maintained from generation to generation,
- but monoploidy condition occurs when an organism is under polyploidy condition.
- In a true diploid both the monoploid and haploid chromosome number are same.
- Thus a monoploid can be a haploid but all haploids cannot be a monoploid.

41. What is polyploidy ? Add different types of polypoidy.

- An organism possesses more than two basic sets of chromosomes are called Polyploidy.
- An organism possesses three basic sets of chromosomes are called triploidy (3x)
- An organism possesses four basic sets of chromosomes are called tetraploidy (4x)
- An organism possesses five basic sets of chromosomes are called pentaploidy (5x)
- An organism possesses six basic sets of chromosomes are called hexaploidy (6x)

42. Describe two types of ploidy.

- **Aneuploidy** Ploidy involving individual chromosomes within a diploid set.
- **Euploidy** Ploidy involving entire sets of chromosomes.

43. What is autotriploids?Describe with examples.

- Autotriploids have three set of its own genomes.
- They can be produced artificially by crossing between auto tetraploid and diploid species.
- They are highly sterile due to defective gamete formation.
- **Example:**
- The cultivated banana are usually triploids and are seedless having larger fruits than diploids.
- Triploid sugar beets have higher sugar content than diploids and are resistant to moulds.
- Common doob grass (Cyanodon dactylon) is a natural auto triploid.
- Seedless watermelon, apple, sugar beet, tomato, banana are manmade auto triploids.

44. What is autotetraploids ?

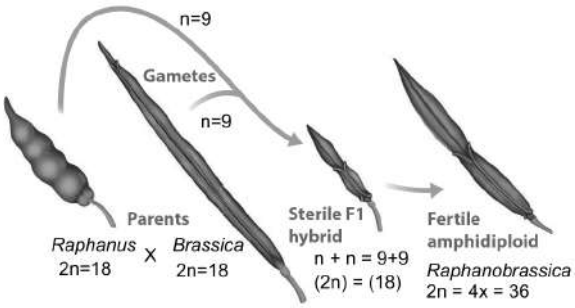
- It have four copies of its own genome.
- Autotetraploids have four copies of its own genome.
- They may be induced by doubling the chromosomes of a diploid species.
- **Example:** rye, grapes, alfalfa, groundnut, potato and coffee.

45. Describe allopolyploidy

- An organism which possesses two or more basic sets of chromosomes derived from two different species is called allopolyploidy.
- It can be developed by interspecific crosses.
- Fertility is restored by chromosome doubling with colchicine treatment.
- Allopolyploids are formed between closely related species only.

46. Explain Raphanobrassica with allopolyploidy

- G.D. Karpechenko (1927) (Russian) did this cross.
- He crossed the radish (*Raphanus sativus*, 2n=18) and cabbage (*Brassica oleracea*, 2n=18)
- F1 hybrid was sterile.
- When he doubled the chromosome of F1 hybrid he got it fertile.
- He expected the root of radish and the leaves like cabbage.
- but the case was vice versa, so he was greatly disappointed.



Rhaphanobrassica

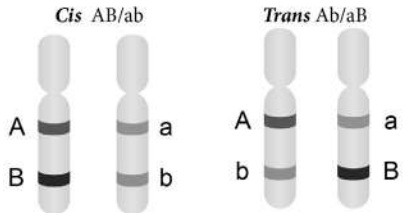
47. Explain Triticale first man made cereal, depending on the ploidy level

- Triticale, the successful first man made cereal. Depending on the ploidy level Triticale can be divided into three main groups.
- Tetraploidy: Crosses between diploid wheat and rye.
- Hexaploidy: Crosses between tetraploid wheat *Triticum durum* (macaroni wheat) and rye
- Octoploidy: Crosses between hexaploid wheat *T. aestivum* (bread wheat) and rye

48. Add notes on colchicine

- **Colchicine** an alkaloid is extracted from root and corms of Colchicum autumnale,
- It applied in low concentration to the growing tips of the plants it will induce polyploidy.
- Surprisingly it does not affect the source plant *Colchicum*, due to presence of anticolchicine.

49. Draw the diagram of cis-trans arrangement of genes.



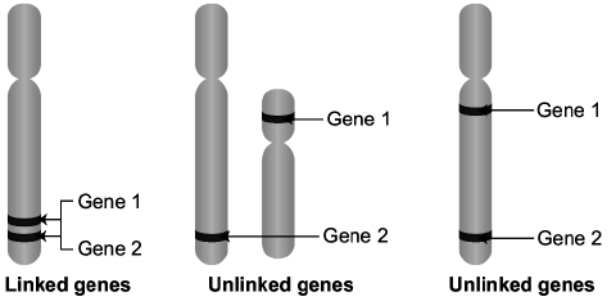
50. State the terms linked unlinked strong linkage and weak linkages.

The recombination frequency value is more than 50 % the two genes show unlinked.

The recombination frequency value is less than 50 %, they show linked.

Closely located genes show strong linkage,

The genes widely located show weak linkages.

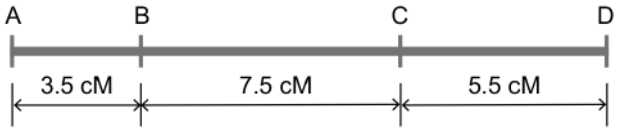


51. Describe genetic mapping and recombination frequency

Genetic mapping is directly proportional to the frequency of recombination between them.

For example: A distance between A and B genes is estimated to be 3.5 map units.

It is equal to 3.5 centimorgans or 3.5 % or 0.035 recombination frequency between the genes.



52. Describe Self-sterility

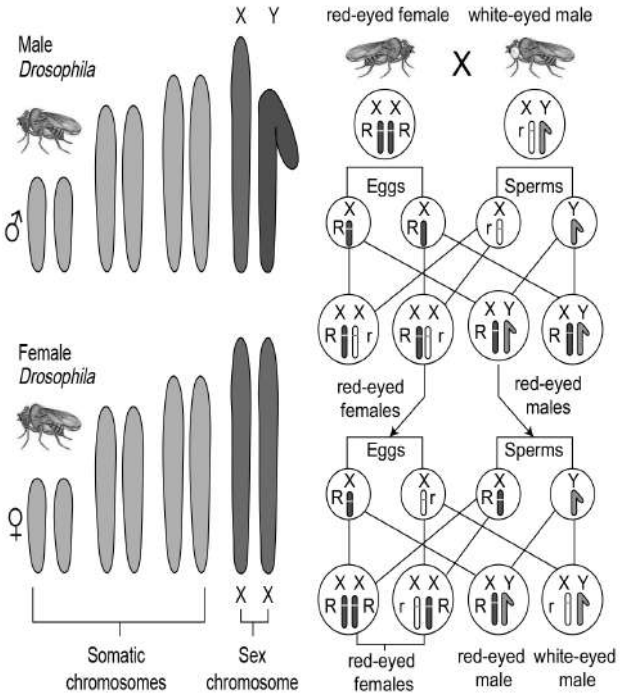
- Self-sterility means that the pollen from a plant is unable to germinate on its own stigma.
- This will not be able to bring about fertilization in the ovules of the same plant.
- self-incompatibility or self-sterility observed by **East (1925)** in Nicotiana.

PART – D

ADDITIONAL QUESTIONS (5 MARK)

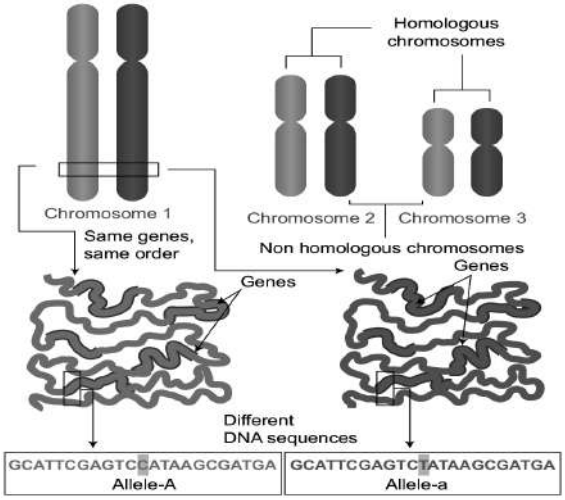
1. Explain the support for chromosomal theory of heredity

- It cleared by **Thomas Hunt Morgan** (1910) on the fruit fly *Drosophila melanogaster* (2n=8)
- This fruit fly completed their life cycle within two weeks.
- The alleles for red or white eye colour are present on the X chromosome
- But there is no counterpart for this gene on the Y chromosome.
- Thus, females have two alleles for this gene, whereas males have only one.
- The genetic results were completely based on meiotic behaviour of the X and Y chromosomes.
- Similarly, the genes for yellow body colour and miniature wings are also carried on the X chromosome. This study strongly supports the idea that genes are located on chromosomes.
- The linked genes connected together on sex chromosome is called **sex linkage.**



2. Describe the comparison between gene and chromosome behaviour

- The total number of chromosomes is constant in all cells of a species.
- A diploid eukaryotic cell has two haploid sets of chromosomes, one set from each parent.
- All somatic cells of an organism carry the same genetic complement.
- The behaviour of chromosomes during meiosis not only explains Mendel's principles,but it leads to new and different approaches to study about heredity.



3. Enumerate the important aspects to be remembered about the chromosome behaviour during cell division (meiosis)

- The alleles of a genotype are found in the same locus of a homologous chromosome (A/a)
- In the S phase of meiotic interphase each chromosome replicates forming two copies of each allele (AA/aa), one on each chromatid.
- The homologous chromosomes segregate in anaphase I,thereby separating two different alleles (AA) and (aa)
- In anaphase II of meiosis, separation of sister chromatids of homologous chromosomes takes place.
- Therefore, each daughter cell (gamete) carries only a single allele (gene) of a character (A), (A), (a) and (a).

4. Explain Linkage with suitable example. Linkage

- The genes are carried by the chromosomes.
- The genes for different characters are present in the same chromosome or in different chromosomes.
- The genes assort independently according to Mendel's Law of Independent Assortment.
- They crossed sweet peas having **purple flowers** and **long pollen grains (PL/PL)** with having **red flowers** and **round pollen grains (pl/pl)**
- All the F_1 progenies had purple flower and long pollen grains. **(PL/pl)**
- This indicating purple flower long pollen **(PL/PL)** was dominant over red flower round pollen **(pl/pl)**
- The F_1 crossed with double recessive parent (test cross) **(PL/pl) X (pl/pl)**
- In the F2 progenies did not exhibit in 1:1:1:1 ratio as expected with independent assortment.
- A greater number of F_2 plants had purple flowers and long pollen or red flowers and round pollen.
- So they concluded that genes were found close together in the same homologous pair of chromosomes.
- These genes do not allow themselves to be separated. So they do not assort independently.
- This type of tendency of genes to stay together during separation of chromosomes is called **Linkage.**

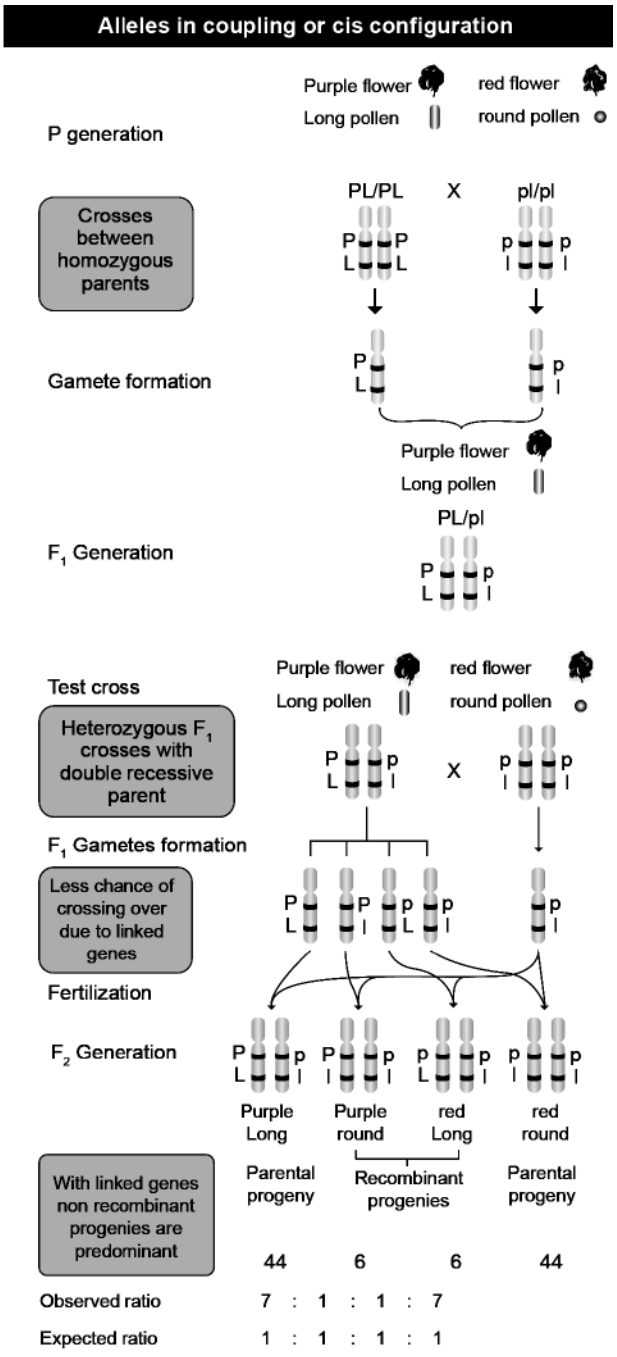
5. Differences between linkage and crossing over

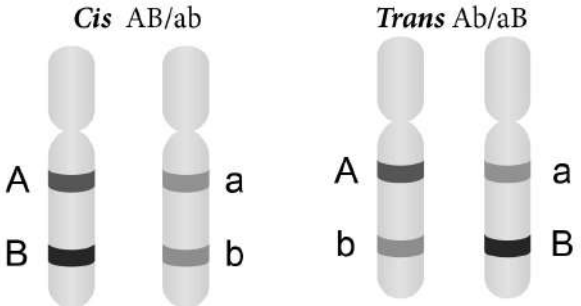
Linkage	Crossing over
1. Linkage keeps particular genes together	Crossing over mixes them
2. The genes present on chromosome stay close together	It leads to separation of linked genes
3. It involves same chromosome of homologous chromosome	It involves exchange of segments between non-sister chromatids of homologous chromosome.
4. It reduces new gene combinations	It increases variability by forming new gene combinations. lead to formation of new organism

6. Explain Coupling and Repulsion theory

The two dominant alleles or recessive alleles occur in the same homologous chromosomes, tend to inherit together into same gamete are called **coupling or** cis **configuration**.

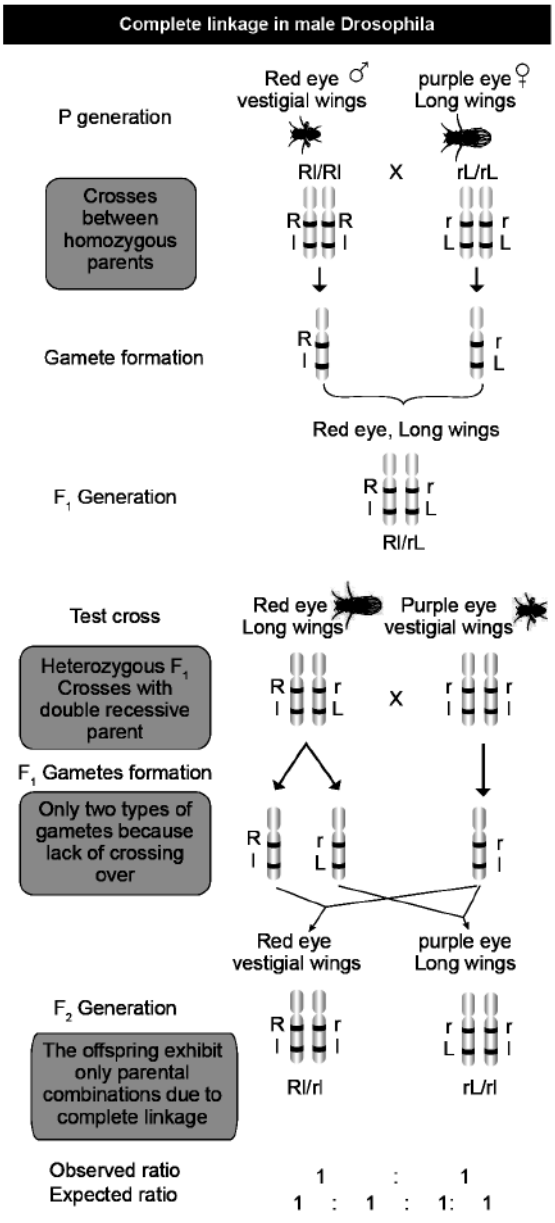
If dominant or recessive alleles are present on two different, but homologous chromosomes they inherit apart into different gamete are called **repulsion or** trans **configuration** (Figure: 3. 6)





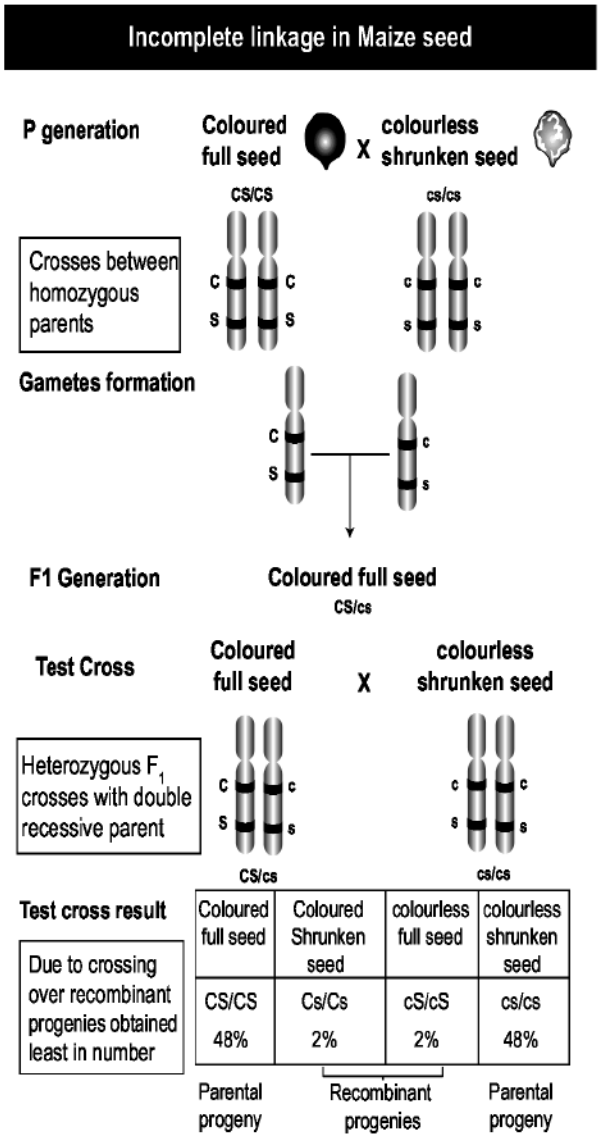
7. Explain Complete Linkage using the cross.

- The chances of separation of two linked genes are not possible.
- So those genes always remain together.
- As a result, only parental combinations are observed.
- The linked genes are located very close together on the same chromosome.
- Such genes do not exhibit crossing over. This phenomenon is called **complete linkage**.
- It is rare but has been reported in male Drosophila.
- It was discovered by **C.B Bridges**

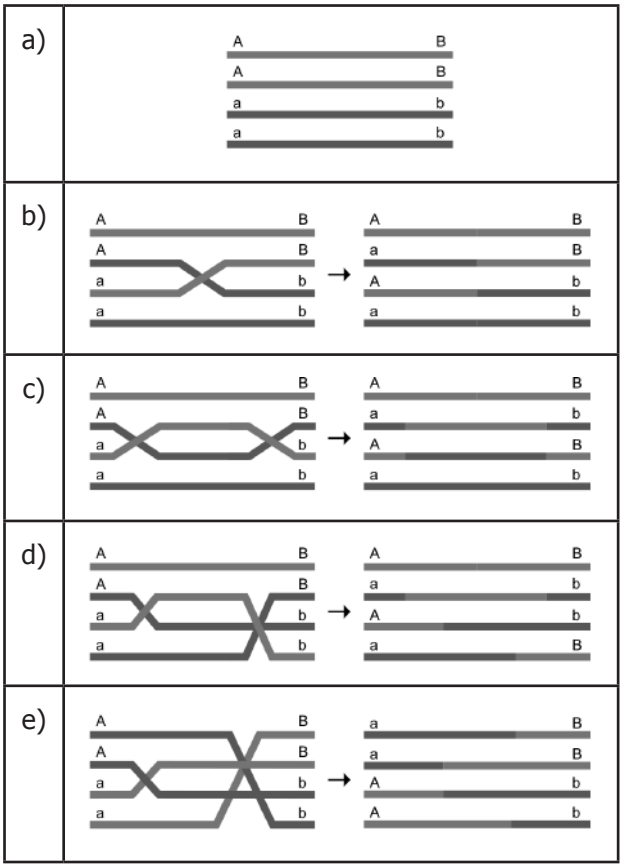


8. Describe about incomplete Linkage with example.

- The two linked genes are sufficiently apart, the chances of their separation are possible.
- As a result, parental and non-parental combinations are observed.
- The linked genes exhibit some crossing over.
- This phenomenon is called **incomplete linkage**.
- This was observed in maize. It was reported by Hutchinson.



9. Observe and name the following diagrams a, b, c, d and e.



a) No crossing over

b) Single crossing over

c) Two strand double crossing over

d) Three strand double crossing over

e) Four strand double crossing over

10. Write the importance of Crossing over?

- Crossing over leads to new gene combinations.
- It plays an important role in evolution.
- Studies of crossing over reveal that genes are arranged linearly on the chromosomes.
- Genetic maps are made based on the frequency of crossing over.
- It helps to understand the nature and mechanism of gene action.
- A useful new combination is formed it can be used in plant breeding.

11. Explain three point test cross with example

- A more efficient mapping technique is to construct based on the results of **three-point test cross**.
- Three-point test cross can be best understood by considering following an example.
- In maize (corn), the three recessive alleles are
- l for lazy or prostrate growth habit
- g for glossy leaf
- s for sugary endosperm
- These three recessive alleles (l g s) are crossed with wild type dominant alleles (L G S)

  Parents LGS / LGS x lgs / lgs

  Gametes LGS x lgs

  F1 trihybrid LGS / lgs
- **Test cross**
- (Heterozygous F1 crosses with triple recessive alleles) LGS / lgs x lgs / lgs
- This trihybrid test cross produces 8 different types (23=8) of gametes.
- It produces 740 progenies. The results are tabulated.

S. no.	Phenotype of test cross progeny	Gamete types	Number of progenies
1.	Normal (wild type)	L G S	286
2.	Lazy	l G S	33
3.	Glossy	L g S	59
4.	Sugary	L G s	4
5.	Lazy, glossy	l g S	2
6.	Lazy, sugary	l G s	44
7.	Glossy, sugary	L g s	40
8.	Lazy, glossy, sugary	l g s	272
Total			**740**

- From the above result, we observe parental (P) and recombinant (R) types.
- The parental genotypes for the triple homozygotes are L G S and l g s,
- Analyse two recombinant loci at a time orderly L G/ l g, L S/ l s and G S/ g s.
- In this any combination other than these two constitutes a recombinant (R)

S. No.	Phenotype of test cross progeny	Gamete types	Number of progenies	Recombinant for loci		
				L and G	L and S	G and S
1.	Normal (wild type)	L G S	286			
2.	Lazy	l G S	33	R	R	
3.	Glossy	L g S	59	R		R
4.	Sugary	L G s	4		R	R
5.	Lazy, glossy	l g S	2		R	R
6.	Lazy, sugary	l G s	44	R		R
7.	Glossy, sugary	L g s	40	R	R	
8.	Lazy, glossy, sugary	l g s	272			
	Total		**740**	**176**	**79**	**109**

- Let's analyse the loci of two alleles L and G.
- The L G and l g parental genotypes the recombinants will be L g and l G.
- The Recombinant frequency (RF) for these two alleles calculated as follows
- For L and S loci, the recombinants are L s and l S. The Recombinant frequency (RF) will be as follows

$$RF = \frac{\text{Total number of recombinants}}{\text{Total number of progenies}} \times 100$$

$$RF = \frac{33 + 59 + 44 + 40}{740} \times 100$$

$$RF = \frac{176}{740} \times 100$$

$$RF = 23.7\%$$

$$RF = \frac{33 + 4 + 2 + 40}{740} \times 100$$

$$RF = \frac{79}{740} \times 100$$

$$RF = 10.7\%$$

For G and S loci, the recombinants are G s and g S. The Recombinant frequency (RF) will be as follows

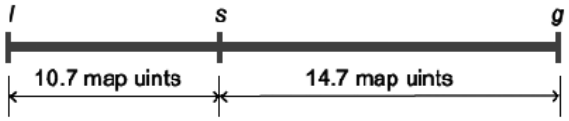
$$RF = \frac{59 + 4 + 2 + 44}{740} \times 100$$

$$RF = \frac{109}{740} \times 100$$

$$RF = 14.7\%$$

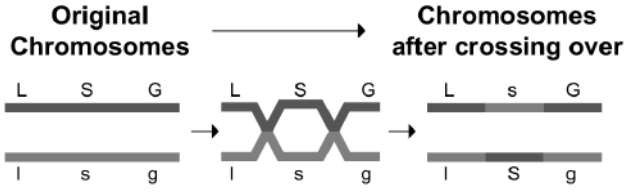
- All the loci are linked, because all the RF values are considerably less than 50%.

- In this L G loci show highest RF value, they must be farthest apart.
- Therefore, the S locus must lie between them. The order of genes should be l s g.
- A genetic map can be drawn as follows



- A final point note that two smaller map distances, 10.7 m.u and 14.7., is add up to 25.4 m.u.,
- which is greater than 23.7 m.u., the distance calculated for l and g.
- we must identify the two least number of progenies (totaling 8) in relation to recombination of L and G.
- These two least progenies are double recombinants arising from double cross over.
- The two least progenies not only counted once should have counted each of them twice because each represents a double recombinant progeny.
- Hence, we can correct the value adding the numbers 33+59+44+40+4+4+2+2=188.
- Of the total of 740, this number exactly 25.4 %, which is identical with the sum of two component values.
- The test cross parental combination can be re written as follows:

LSG / lsg x lsg / lsg



12. Write the characteristics of multiple alleles

- Multiple alleles of a series always occupy the same locus in the homologous chromosome.
- Therefore, no crossing over occurs within the alleles of a series.
- Multiple alleles are always responsible for the same character.
- The wild type alleles of a series exhibit dominant character.
- The mutant type will influence dominance or an intermediate phenotypic effect.
- Any two of the mutant multiple alleles are crossed the phenotype is always mutant type and not the wild type.

13. Sex determination in papaya - Discuss.

Hawaii discovered sex chromosomes in Papaya (*Carica papaya*, 2n=36)

Papaya has 17 pairs of autosomes and one pair of sex chromosomes.

Male papaya plants have XY and female plants have XX.

Papaya sex chromosomes look like autosomes and it is evolved from autosome.

The sex chromosomes are functionally distinct.

The Y chromosome carries the genes for male organ development.

The X bears the female organ developmental genes.

In papaya sex determination is controlled by three alleles.

They are m, M1 and M2 of a single gene.

Genotype	Dominant/ recessive	Modification	Sex
mm	Homozygous recessive	Restrict maleness	Female
M1m	Heterozygous	Induces maleness	Male
M2m	Heterozygous	Induces both the sex	Bisexual (rare)
M1M1 or M2M2 or M1M2	Homozygous/ Heterozygous dominant	Inviable plants	Sterile

14. Sex Determination in Sphaerocarpos

First described in the bryophyte *Sphaerocarpos donnellii*.

It has heteromorphic chromosomes.

The gametophyte is haploid and heteromorphic.

The male gametophyte and the female

gametophyte is an haploid organism with 8 chromosome (n=8).

The diploid sporophyte is always heterogametic.

Seven autosomes are similar in both male and female gametophyte.

But the eighth chromosome of female is X which is larger than the seven autosomes.

The eighth chromosome of male is Y which is comparatively smaller than autosomes.

The sporophyte containing XY combination produces two types of meiospores,

that is some with X and others with Y chromosomes.

The meiospores with X chromosomes produce female gametophyte.

Y chromosome produces male gametophyte.

15. Describe mutation

A sudden change in the genetic material of an organisms is called mutation.

The term was introduced by Hugo de Vries (1901) in evening primrose (*Oenothera lamarkiana*)

He proposed 'Mutation theory'.

There are two types 1.point mutation and 2.chromosomal mutations.

Mutational events that take place within individual genes are called gene mutations or point mutation,

The changes occur in structure and number of chromosomes is called chromosomal mutation.

Agents which are responsible for mutation are called mutagens.

It increases the rate of mutation.

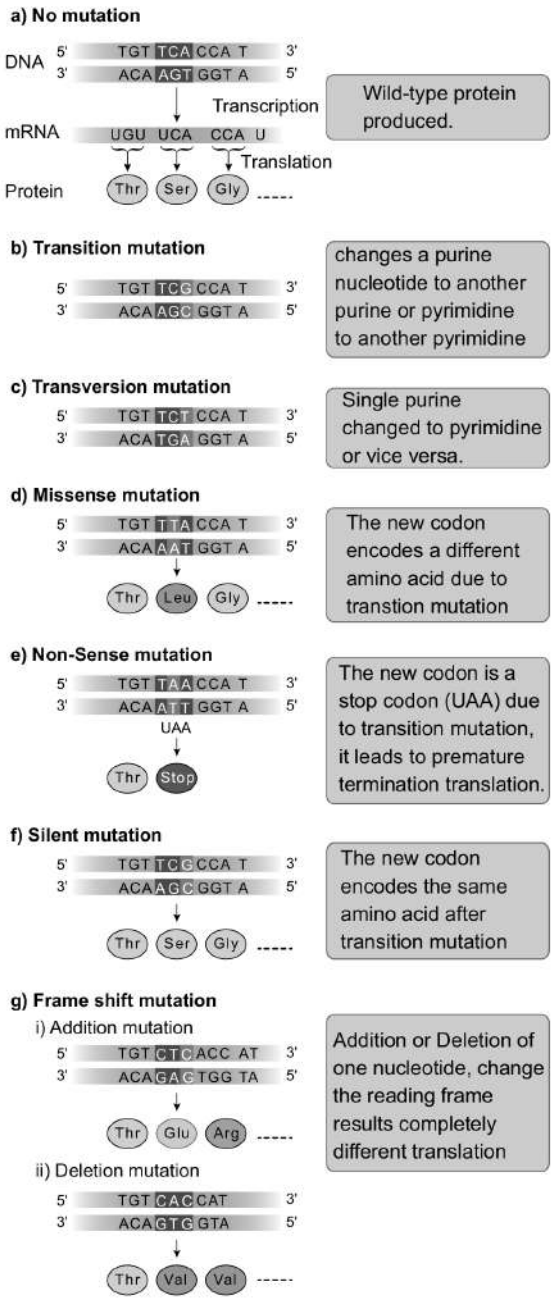
Mutations can occur either spontaneously or induced.

The production of mutants through exposure of mutagens is called mutagenesis, and the organism is said to be *mutagenized.*

16. Tabulate the classification and write major features.

S. No.	Basis of classification	Major types of mutations	Major features
1.	**Origin**	Spontaneous Induced	Occurs in the absence of known mutagen Occurs in the presence of known mutagen
2.	**Cell type**	Somatic Germ-line	Occurs in non-reproductive cells Occurs in reproductive cells
3.	**Effect on function**	Loss-of-function (knock-out, null) Hypomorphic (leaky) Hypermorphic Gain-of-function (ectopic expression)	Eliminates normal function Reduces normal function Increases normal function Expressed at incorrect time or inappropriate cells
4.	**Molecular change**	**Nucleotide substitution** • Transition	A base pair in DNA duplex is replaced with a different base pair Purine to purine(AG) or pyrimidine to pyrimidine(TC)
		• Transversion • Insertion • Deletion	Purine to pyrimidine(AT) or pyrimidine to purine(CG) One or more extra nucleotides are present One or more nucleotides are missing
5.	**Effect on translation**	Silent (synonymous) Missense (non-synonymous) Nonsense (termination) Frameshift	No change in amino acid encoded Change in amino acid encoded Creates translational termination codon (UAA, UAG, or UGA) Shifts triplet reading of codons out of correct phase

17. Explain the types of mutation with illustration.

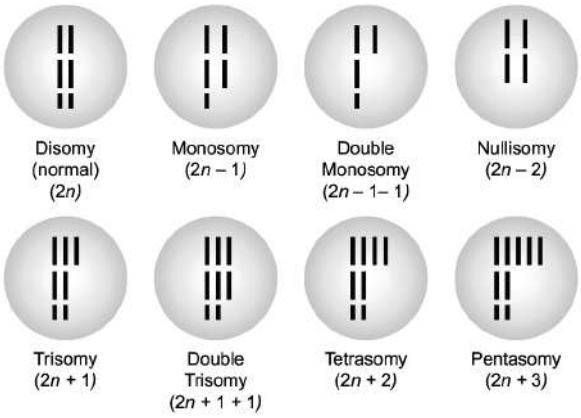


18. Explain aneuploidy with their types

- Diploid number is altered either by addition or deletion of one or more chromosomes are called **Aneuploidy.**
- Organisms showing aneuploidy are known as **aneuploids** or **heteroploids**.
- They are of two types, Hyperploidy and Hypoploidy

Hyperploidy

- Addition of one or more chromosomes to diploid sets are called **hyperploidy**.
- Diploid set of chromosomes represented as Disomy.
- Hyperploidy can be divided into three types. They are as follows,



Trisomy

- Addition of single chromosome to diploid set is called **Simple trisomy**(2n+1)
- Trisomics were first reported by Blackeslee (1910) in Datura stramonium (Jimson weed)
- But later it was reported in Nicotiana, Pisum and Oenothera.
- Sometimes addition of two individual chromosome from different chromosomal pairs to normal diploid sets are called **Double trisomy** (2n+1+1)

Tetrasomy

- Addition of a pair of chromosomes to diploid set is called **tetrasomy** (2n+2).
- Addition of two individual pairs of chromosomes to diploid set is called **Double tetrasomy** (2n+2+2)
- All possible tetrasomics are available in Wheat.

Pentasomy

- Addition of three individual chromosome from different chromosomal pairs to normal diploid set are called pentasomy (2n+3)

Hypoploidy

- Loss of one or more chromosome from the diploid set in the cell is called **hypoploidy**.
- It is two types.

Monosomy

- Loss of a single chromosome from the diploid

set are called **monosomy** (2n-1)

- loss of two individual chromosomes are called **double monosomy** (2n-1-1)
- loss of three individual chromosomes are called and **triple monosomy** (2n-1-1-1)
- Double monosomics are observed in maize.

Nullisomy

- Loss of a pair of homologous chromosomes from the diploid set are called **Nullisomy** (2n-2)
- Loss of two pairs of homologous chromosomes from the diploid set are called **double Nullisomy** (2n-2-2).
- Selfing of monosomic plants produce nullisomics. They are usually lethal.

19. What is euploidy. Explain only monoploidy

- The organisms possess one or more basic sets of chromosomes are called Euploidy.
- It is classified as monoploidy, diploidy and polyploidy.
- An organism or somatic cell has two sets of chromosomes are called diploid (2n)
- Half the number of somatic chromosomes is referred as gametic chromosome number called haploid(n)
- It should be noted that haploidy (n) is different from a monoploidy (x)

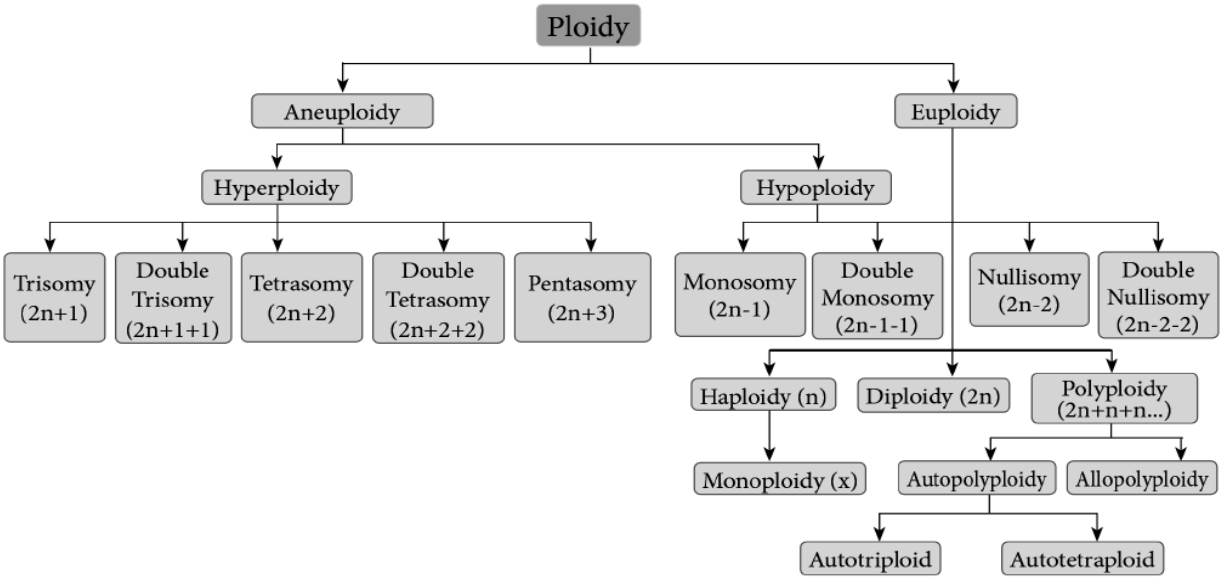
Monoploidy

- The common wheat plant is a polyploidy (hexaploidy) 2n=6x=72 chromosomes.
- Its haploid number (n) is 36, but its monoploidy (x) is 12.
- The haploid and diploid condition came regularly one after another.
- The same number of chromosomes is maintained from generation to generation,
- but monoploidy condition occurs when an organism is under polyploidy condition.
- In a true diploid both the monoploid and haploid chromosome number are same.
- Thus a monoploid can be a haploid but all haploids cannot be a monoploid.

20. Describe polyploidy

- An organism possesses more than two basic sets of chromosomes are called Polyploidy.
- An organism possesses three basic sets of chromosomes are called triploidy (3x)
- An organism possesses four basic sets of chromosomes are called tetraploidy (4x)
- An organism possesses five basic sets of chromosomes are called pentaploidy (5x)
- An organism possesses six basic sets of chromosomes are called hexaploidy (6x)
- Generally, polyploidy is very common in plants but rarer in animals.
- An increase basic sets has been an important factor in the origin of new plant species.
- But higher ploidy level leads to death.

21. Draw the flow chart of ploidy



22. Explain two types of Polyploidy.

- They are autopolyploidy and allopolyploidy

Autopolyploidy

- More than two haploid sets of chromosomes derived from within the same species is called autopolyploid.
- They are two types. Autotriploids and autotetraploids.

Autotriploids have three set of its own genomes.

- They can be produced artificially by crossing between autotetraploid and diploid species.
- They are highly sterile due to defective gamete formation.
- Example: The cultivated banana are usually triploids and are seedless having larger fruits than diploids.
- Triploid sugar beets have higher sugar content than diploids and are resistant to moulds.
- Common doob grass (*Cyanodon dactylon*) is a natural autotriploid.
- Seedless watermelon, apple, sugar beet, tomato, banana are man made autotriploids.

Autotetraploids

- They have four copies of its own genome.
- They may be induced by doubling the chromosomes of a diploid species.
- Example: rye, grapes, alfalfa, groundnut, potato and coffee.

Allopolyploidy

- An organism which possesses two or more basic sets of chromosomes derived from two different species is called allopolyploidy.
- It can be developed by interspecific crosses.
- Fertility is restored by chromosome doubling with colchicine treatment.
- Allopolyploids are formed between closely related species only.

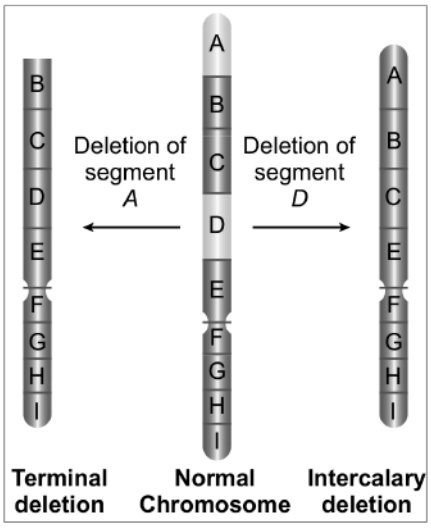
23. Enumerate the significance of ploidy

- Many polyploids are more vigorous and more adaptable than diploids.
- Many ornamental plants are autotetraploids and have larger flower and longer flowering duration than diploids.
- Autopolyploids usually have increase in fresh weight due to more water content.
- Aneuploids are useful to determine the phenotypic effects of loss or gain of different chromosomes.
- Many angiosperms are allopolyploids and they play a role in an evolution of plants.

24. What is meant by structural changes in chromosome (Structural chromosomal aberration) Classify them.

- Addition or deletion of a part of chromosome leading to rearrangement of genes is called **structural chromosomal aberration**.
- It occurs due to ionizing radiation or chemical compounds.
- They are classified under two groups.
- Changes in the number of the gene loci
- 1.Deletion or Deficiency
- 2.Duplication or Repeat
- Changes in the arrangement of gene loci
- 3. Inversion
- 4. Translocation

25. Explain structural chromosomal aberration deletion or deficiency with diagrams. Add Examples.

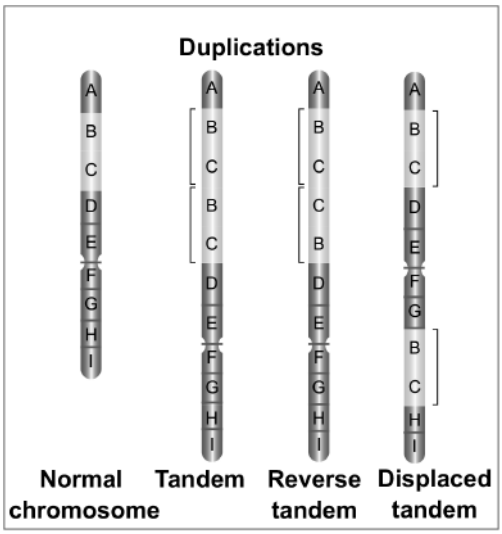


- Loss of a portion of chromosome is called deletion.
- It is divided into terminal deletion and intercalary deletion.

- It occurs due to chemicals, drugs and radiations.
- It is observed in *Drosophila* and Maize. There are two types of deletion:
- Terminal deletion: Single break in any one end of the chromosome.
- Intercalary deletion or interstitial deletion: It is caused by two breaks and reunion of terminal parts leaving the middle.
- Both deletions are observable during meiotic pachytene stage and polytene chromosome.
- The unpaired loop formed in the normal chromosomal part at the time of chromosomal pairing.
- Such loops are called as deficiency loops
- It can be seen in meiotic prophase.
- Larger deletions may lead to lethal effect.

Duplication or Repeat

- Arrangement of the same order of genes repeated more than once in the same chromosome is known as **duplication.**
- Due to duplication some genes are present in more than two copies.
- It was first reported in *Drosophila* by Bridges (1919)
- Other examples are Maize and Pea. It is three types.



i. Tandem duplication

- The duplicated segment is located immediately after the normal segment of the chromosome in the same order.

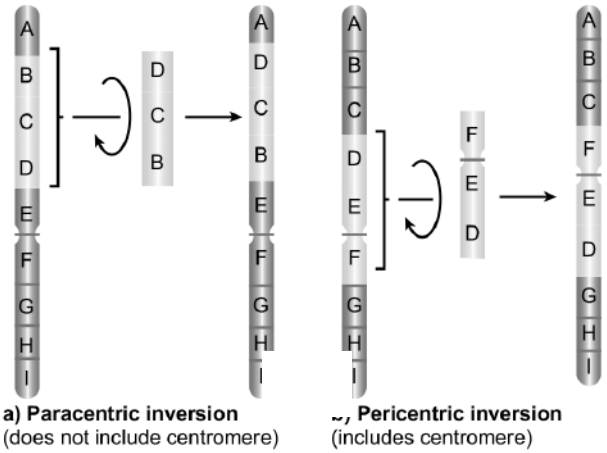
ii. Reverse tandem duplication

- The duplicated segment is located immediately after the normal segment but the gene sequence order will be reversed.

iii. Displaced duplication

- The duplicated segment is located in the same chromosome, but away from the normal segment.
- Duplications play a major role in evolution.

26. Explain inversion with their types.



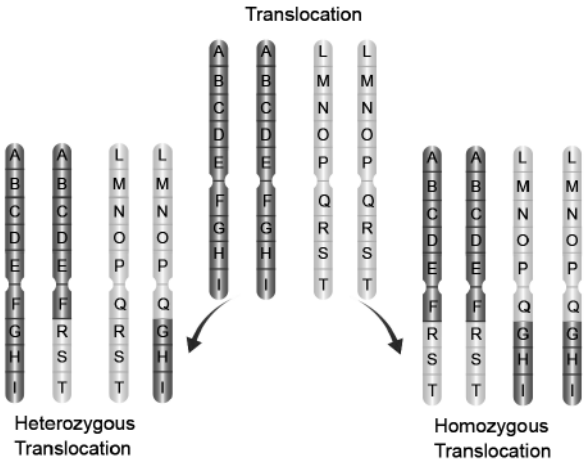
- A rearrangement of order of genes in a chromosome by reversed by an angle 1800.
- This involve two chromosomal breaks and reunion.
- During this process there is neither gain nor loss but the gene sequences is rearranged.
- It was first reported in *Drosophila* by Sturtevant (1926)
- There are two types of inversion, paracentric and pericentric.
- **Paracentric inversion:** An inversion which takes place apart from the centromere
- **Pericentric inversion:** An inversion that includes the centromere.
- Inversions lead to evolution of a new species.

27. Explain translocation with their types. Add diagrams

- The transfer of a segment of chromosome to a non-homologous chromosome is called translocation.. Translocation occurs as a result

of interchange of chromosome segments in non-homologous chromosomes. There are three types

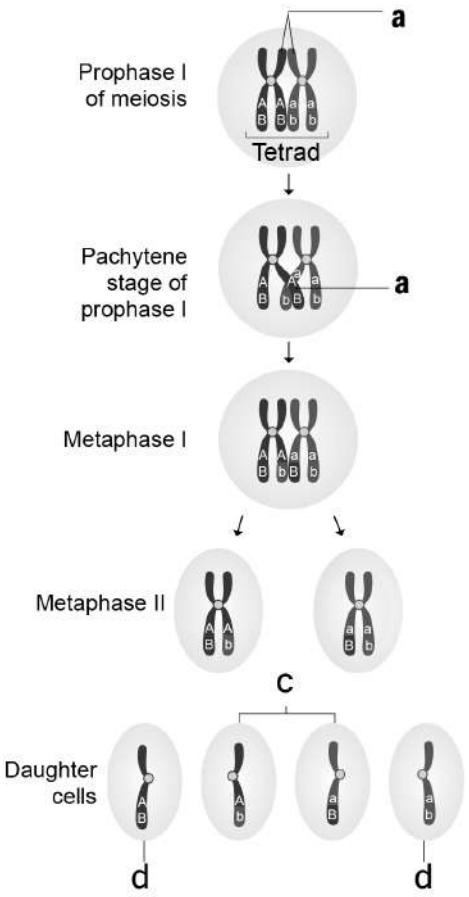
- Simple translocation
- Shift translocation
- Reciprocal translocation
- **Simple translocation**
- A single break is made in only one chromosome.
- The broken segment gets attached to one end of a non-homologous chromosome.
- It occurs very rarly in nature.



- **Shift translocation**
- Broken segment of one chromosome gets inserted interstitially in a non-homologous chromosome.
- **Reciprocal translocations**
- It involves mutual exchange of chromosomal segments between two non-homologous chromosomes.
- It is also called **illegitimate crossing over.**
- It is further divided into two types
- **Homozygous translocation**: Both the chromosomes of two pairs are involved in translocation. Two homologous of each translocated chromosomes are identical.
- **Heterozygous translocation**: Only one of the chromosome from each pair of two homologous are involved in translocation, while the remaining chromosome is normal.
- Translocations play a major role in the formation of species.

Diagram based questions

1. i) Observe and name of the process in the given diagram. ii) Identify the given a,b,c and d



i) Name of the process in the given diagram is stages of crossing over

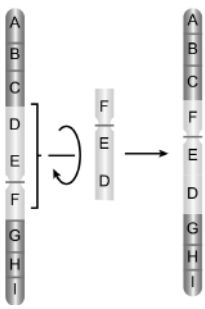
ii) a. Non-sister chromatids of homologous chromosome

b. Chiasma at a site of crossing over

c. Recombination

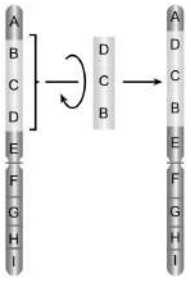
d. Parental type

2. From the given figure identify the type of mutation and explain it.



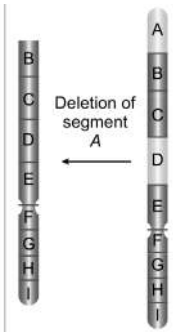
- The type of mutation is pericentric inversion:
- A rearrangement of order of genes in a chromosome by reversed by an angle 180º.
- This involve two chromosomal breaks and reunion.
- During this process there is neither gain nor loss but the gene sequences is rearranged.
- An inversion that includes the centromere.is called paracentric inversion

3. From the given figure identify the type of mutation and explain it.



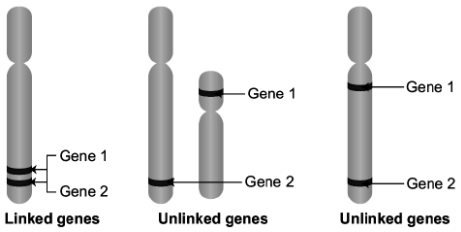
- The type of mutation is paracentric inversion:
- A rearrangement of order of genes in a chromosome by reversed by an angle 180º.
- This involve two chromosomal breaks and reunion.
- During this process there is neither gain nor loss but the gene sequences is rearranged.
- An inversion which takes place apart from the centromere is called paracentric inversion

4. From the given figure identify the type of mutation and explain it.



- The type of mutation is terminal deletion
- Loss of a portion of chromosome is called deletion.
- Terminal deletion: Single break in any one end of the chromosome.

5. Name the following a, b and c



(a) (b) (c)

a. Linked genes
b. Unlinked genes
c. Unlinked genes