Chapter 3
Chromosomal Basis of Inheritance

Question 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
Answer:
(b) Six copies of three different genomes

Question 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) 10AB, 10ab
(c) 45 AB, 45 ab
(d) 45 AB, 45 ab, 5 Ab, 5aB
Answer:
(b) 10AB, 10ab

Question 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

Answer:
(c) A-ii, B-iii, C-i, D-iv

Question 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. grossing over is absent in complete linkage
(a) 1 and 2
(b) 2 and 3
(c) 3 and 4
(d) 1 and 4
Answer:
(c) 3 and 4

Question 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 crosses over
(d) Possibility of recombination frequency
Answer:
(b) Possibility of double cross over

Question 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
Answer:
(b) 7 : 1 : 1 : 7

Question 7.
Genes G S L H are located on the same chromosome. The recombination percentage is between and G is 15%, S and L is 50% and H and S are 20%. The correct order of genes is _____
(a) GHSL
(b) SHGL
(c) SGHL
(d) HSLG

Answer:
(b) SHGL

Question 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
Answer:
(b) A to G, C to T, C to G and T to A

Question 9.
If the haploid number in a cell is 18. The double monosomic and trisomic number will be _____
(a) 35 and 37
(b) 34 and 37
(c) 37 and 35
(d) 17 and 19
Answer:
(b) 34 and 37

Question 10.
Changing the codon AGC to AGA represents _____
(a) mis-sense mutation
(b) non-sense mutation
(c) frameshift mutation
(d) deletion mutation
Answer:
(a) mis-sense mutation

Question 11.
Assertion (A): Gamma rays are generally used to induce mutation in wheat varieties.
Reason (R): Because they carry lower energy to non-ionize electrons from an 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
Answer:
(c) A is correct. R is wrong explanation of A

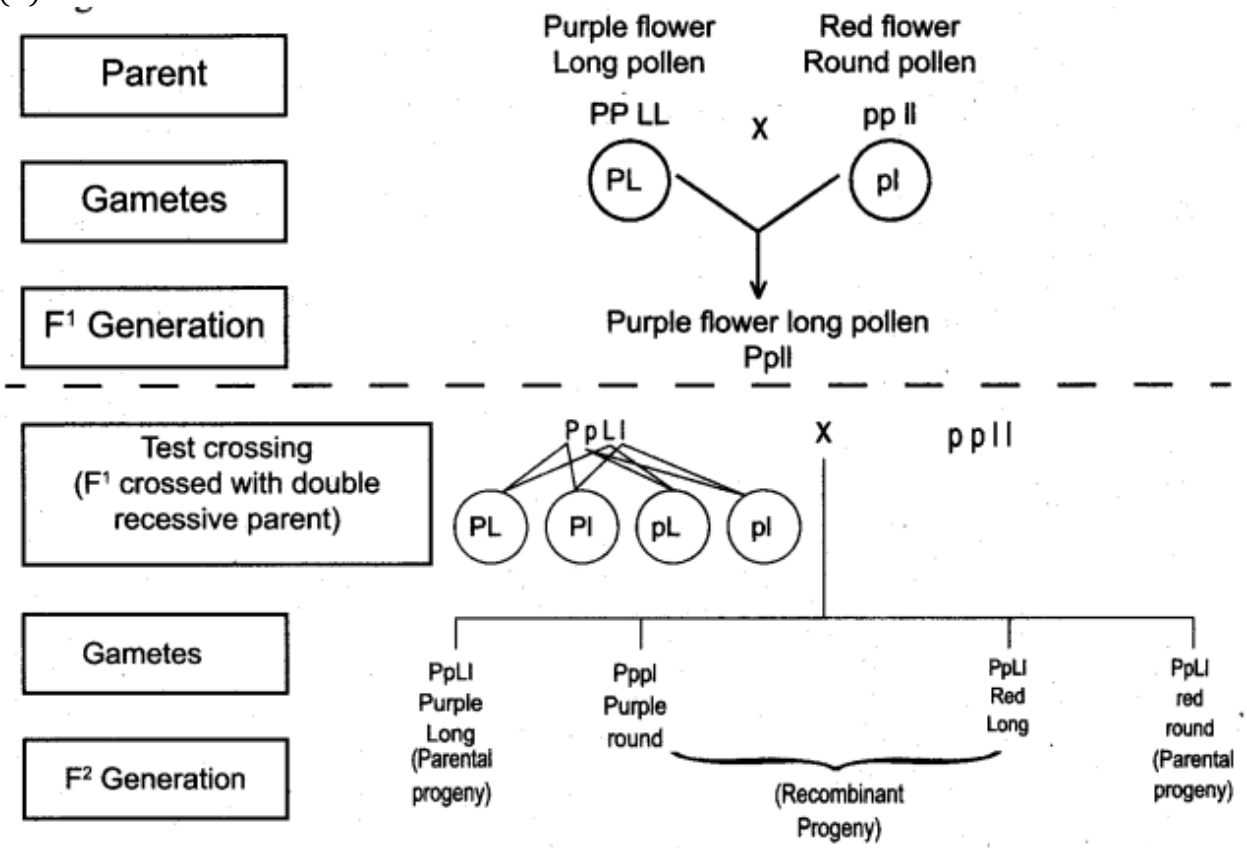
Question 12.
How many map units separate two alleles A and B, if the recombination frequency is 0.09?

(a) 900 cM
(b) 90 cM
(c) 9 cM
(d) 0.9 cM
Answer:
(d) 0.9 cM

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

1. What is the name of this phenomenon?
2. Draw the cross with a suitable example.
3. Write the observed phenotypic ratio.

Answer:
(i) Linkage
(ii)



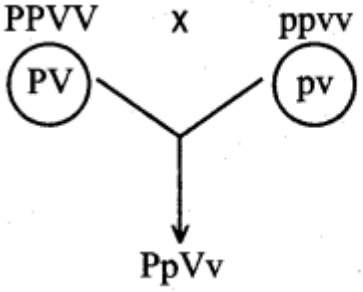
(iii) Observed Pherotypic ratio 7 : 1 : 1 : 7

Question 14.
If you cross dominant genotype PV/PV male Drosophila with double recessive female and obtain F_1 hybrid. Now you cross F_1 male with double recessive female.

1. What type of linkage is seen?

2. Draw the cross with correct genotype.
3. What is the possible genotype in F_2 generation?

Answer:
(i) Incomplete linkage
(ii) Parent Garnets



(selfing)

F_1 hybrid

(*iii*) F2 hybrids with their genotypes

	PV	Pv	pV	pv
PV	PPVV	PPVv	PpVV	PpVv
Pv	PPVV	PPvv	PpVv	PpVV
PV	PpVV	PpVv	ppVV	ppVv
pv	PpVv	Ppvv	ppVv	ppvv

Question 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

1. What is the name of this test cross?
2. How will you construct gene mapping from the above-given data?
3. Find out the correct order of genes.

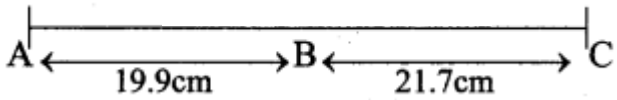
Answer:
(i) Three-point test cross.
(ii) Construction of gene map:
To construct the gene map, the recombinant frequency (RF) of the alleles has to be

calculated.
From the given data it is clear that ABC and abc are parental (P) types and the others (Abe, abC, AbC, aBc, ABc) are recombinant (R) type.

Gametes	No. of Progenies	Recombinant for the alleles		
		A and B	A and C	B and C
ABC	349	–	–	–
Abc	114	R	R	–
abC	124	–	R	R
AbC	5	R	–	R
aBc	4	R	–	R
aBC	116	R	R	–
ABc	128	–	R	R
abc	360	–	–	–

Lets analyse the loci of two alleles at a time starting with A and B. Since the genes AB and ab are parental type, the recombinants will be Ab and aB.
Therefore
Recombinant frequency of alleles Ab and aB $= \frac{No.of recombinant}{\text{Totalprogenies}} \times 100$
$\frac{114+5+4+116}{1200} \times 100 = 19.91\%$
Recombinant frequency for the loci B and C
The parental form are Be and bC and the recombinant are Be and bC.

Recombinant frequency of alleles Be and bC $= \frac{4+128+124+5}{1200} \times 100 + 21.75\%$
Since the recombinant frequency of the alleles A and C shown highest frequency, they must be the farthest apart and alleles B must lie in between A and C. So the gene map can be constructed as follows



(iii) The correct gene order is ABC/abc.

Question 16.
What is the difference between missense and nonsense mutation?
Answer:
Missense mutation (Non-synonymous)

1. The mutation where the codon for one amino acid is changed into a codon for another amino acid.

2. Change in amino acid encoded TTA→AAT (Transition)

Nonsense mutation (Termination) :

1. The mutation where codon for one amino acid is changed into a termination or stop
2. Creates translational termination codon (UAA, UAG, UGA)

Question 17.

A B C C B D E F G H I

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

Answer:

In reverse tandem duplication, the duplicated segment is located immediately after the normal segment but the gene sequence other will be reversed.

Question 18.

Write the salient features of Sutton and Boveri concept.

Answer:

Sutton and Boveri (1903) independently proposed the chromosome theory of inheritance. Sutton united the knowledge of chromosomal segregation with mendelian principles and called it the chromosomal theory of inheritance.

Salient features of the chromosomal theory of inheritance

- Sometic cells of organisms are derived from the zygote by repeated cell division (mitosis).
- These consist of two identical sets of chromosomes. One set is received from female parent (maternal) and the other from male parent (Parental)
- These two chromosomes constitute the homologous pair.
- Chromosomes retain their structural uniqueness and individuality throughout the life cycle of an organism.
- Each chromosome carries specific determiners of mendalian 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.

Question 19.

“Explain the mechanism of crossing over.

Answer:

Crossing over is a precise process that includes stages like synapsis, tetrad formation, cross over and terminalization.

(i) Synapsis: Intimate pairing between two homologous chromosomes is initiated during zygotene stage of prophase I of meiosis I. Homologous chromosomes are aligned side by side resulting in a pair of homologous chromosomes called bivalents. This pairing phenomenon is called synapsis or syndesis. It is of three types:

1. Procentric synapsis: Pairing starts from middle of the chromosome.
2. Proterminal synapsis: Pairing starts from the telomeres.
3. Random synapsis: Pairing may start from anywhere.

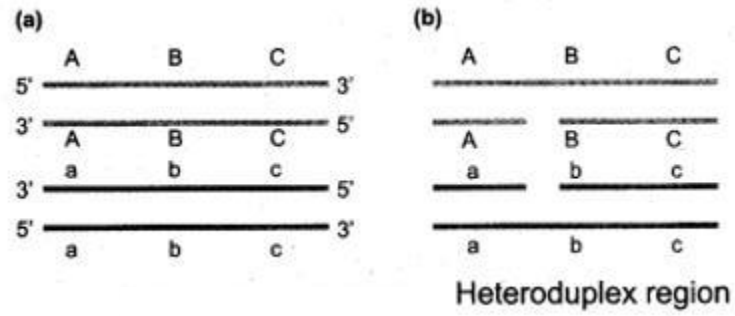
(ii) Tetrad Formation: Each homologous chromosome of a bivalent begin to form two identical sister chromatids, which remain held together by a centromere. At this stage each bivalent has four chromatids. This stage is called tetrad stage.

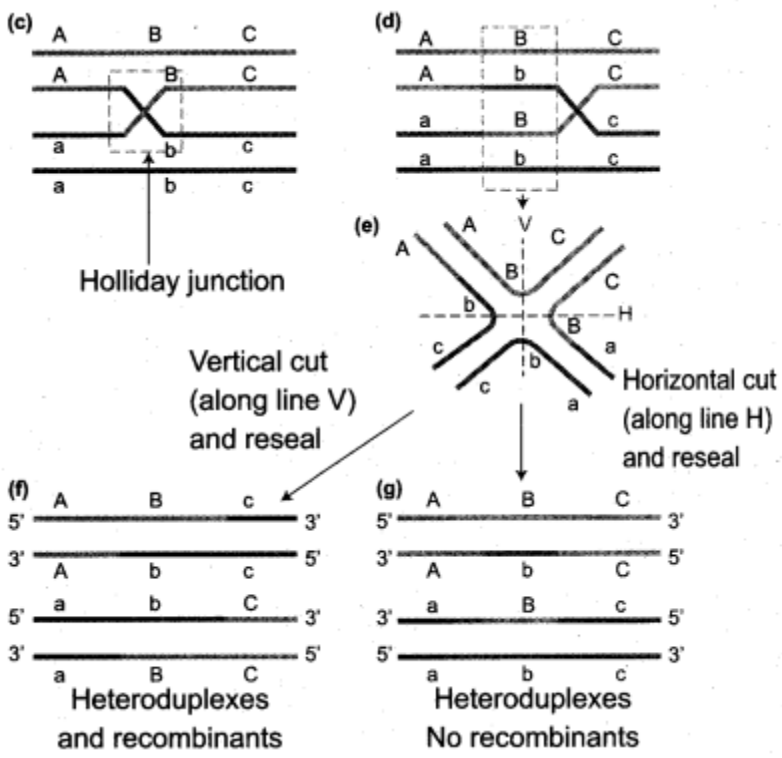
(iii) Cross Over: After tetrad formation, crossing over occurs in pachytene stage. The non-sister chromatids of homologous pair make a contact at one or more points. These points of contact between non¬sister chromatids of homologous chromosomes are called Chiasmata (singular-Chiasma).

At chiasma, cross-shaped or X-shaped structures are formed, where breaking and rejoining of two chromatids occur. This results in reciprocal exchange of equal and corresponding segments between them. A recent study reveals that synapsis and chiasma formation are facilitated by a highly organised structure of filaments called Synaptonemal Complex (SC). This synaptonemal complex formation is absent in some species of male Drosophila, hence crossing over does not takes place.

(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.

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

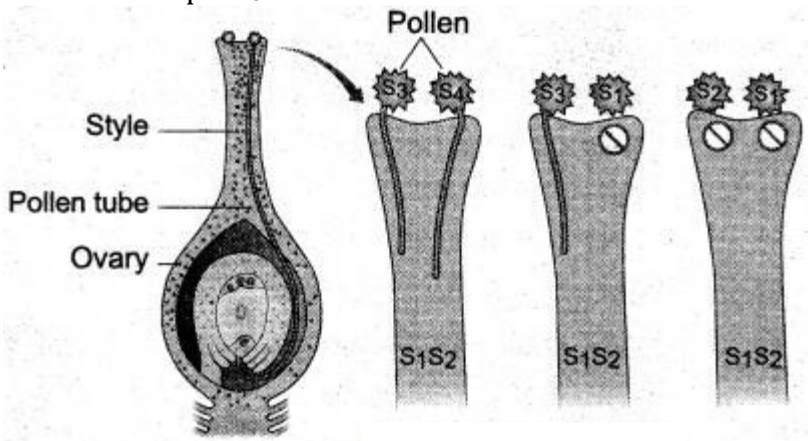




1. Homologous DNA molecules are paired side by side with their duplicated copies of DNAs
2. one stand place by the enzyme endonuclease.
3. The cut strands cross and join the homologous strands forming the Holliday structure or Holliday junction.
4. The Holliday junction migrates away from the original site, a process called branch migration, as a 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 a heteroduplex with nonrecombinants.

Question 21.
How is Nicotiana exhibit self-incompatibility? Explain its mechanism.
Answer:
Self-sterility means that the pollen from a plant is unable to germinate on its own stigma and will not be able to bring about fertilization in the ovules of the same plant. East (1925) observed multiple alleles in Nicotiana which are responsible for self-incompatibility or self-sterility. The gene for self-incompatibility can be designated as S, which has allelic series S_1 S_2, S_3, S_4 and S_5. The cross-fertilizing tobacco plants were not always homozygous as S_1 S_1 or S_2 S_2, but all plants were heterozygous as S_1 S_2, S_3 S_4 and S_5 S_6. When crosses were made between different S_1 S_2 plants, the pollen tube did not develop normally. But effective pollen tube development was observed when the crossing was made with other than

S_1S_2 for example S_3S4.



The self-incompatibility in relation to its genotype in tobacco

Female parent (Stigma spot)	Male parent (Pollen source)		
	S_1S_2	S_2S_3	S_3S_4
S_1S_2	Self Sterile	S_3S_2 S_3S_1	S_3S_1 S_3S_2 S_4S_1 S_4S_2
S_2S_3	S_1S_2 S_1S_3	Self Sterile	S_4S_2 S_4S_3
S_3S_4	S_1S_3 S_1S_4 S_2S_3 S_2S_4	S_2S_3 S_2S_4	Self Sterile

Different combinations of progeny in self-incompatibility

When crosses were made between seed parents with S_1S_2 and pollen parents with S_2S_3, two kinds of pollen tubes were distinguished. Pollen grains carrying S_2 were not effective, but the pollen grains carrying S_3 were capable of fertilization. Thus, from the cross $S_1 S_2$ X $S_3 S_4$, all the pollens were effective and four kinds of progeny resulted: S_1S_3, $S_1 S_4$, $S_2 S_3$ and $S_2 S_4$.

Question 22.
How sex is determined in monoecious plants? Write their genes involved in it.
Answer:
Zea mays (maize) is an example for monoecious, which means male and female flowers are present on the same plant. There are two types of inflorescence. The terminal inflorescence bears staminate florets that develop from shoot apical meristem called tassel. The lateral inflorescence which develop pistillate florets from axillary bud is called ear or cob. Unisexuality in maize occurs through the selective abortion of stamens in-ear florets and pistils in tassel florets. Substitution of two single gene pairs 'ba' for barren plant and 'ts' for tassel seed makes the difference between monoecious and dioecious (rare)

Genotype	Dominant/ recessive	Modification	Sex
ba/ba ts/ts	Double recessive	Lacks silk on the stalk, but transformed tassel to pistil	Rudimentary female
ba/ba ts^+/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)

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 table is the resultant sex expression ' based on the combination of these
alleles. 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.

Question 23.
What is gene mapping? Write its uses.
Answer:
Definition:

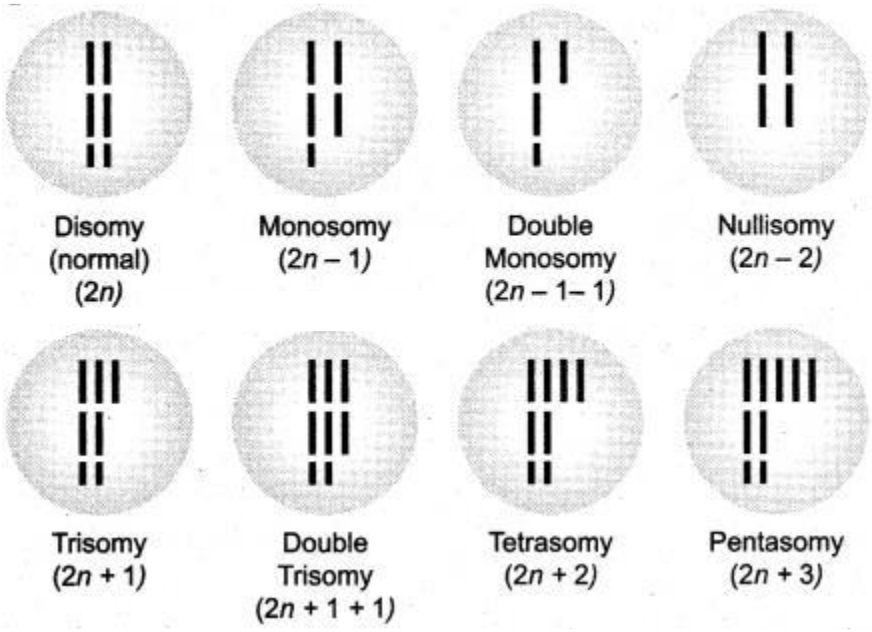
Genes on present on the locus in a chromosome. They – are arranged in a linear order. The diagrammatic representation of position of genes and related distance between adjacent genes is called Genetic mapping (linkage map).

- It is directly proportional to the frequency of recombination between them
- Concept of genetic mapping was 1st developed by Morgan's student – Alfred H.Sturtevant (1913)

Uses:

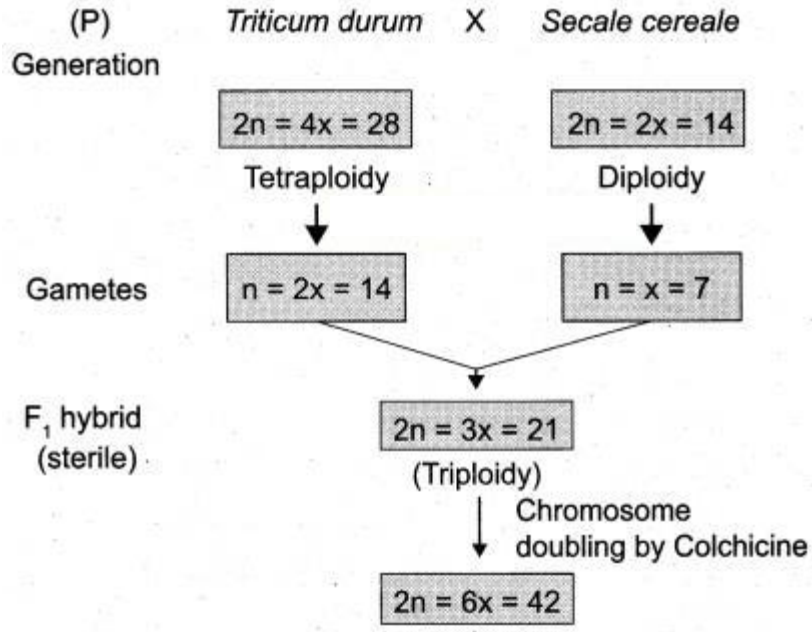
- It is used to determine gene order, identify the locus of a gene and calculate the distance between the genes.
- They are useful in predicting results of dihybrid and trihybrid crosses.
- It helps to understand the overall genetic complexity of particular organism.

Question 24.
Draw the diagram of different types of aneuploidy.
Answer:



Question 25.
Mention the name of man-made cereal. How it is formed?
Answer:
Triticale, the successful first man-made cereal. Depending on the ploidy level Triticale can

be divided into three main groups:



Triticale

- Triticale, the successful first man-made cereal – It has 3 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 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.