Chromosomal Theory of Inheritance :-

* This theory was proposed by Sutton and Boveri independently in 1903.
* In 1902, the chromosome movement during meiosis had been worked out.
* Walter Sutton and Theodore Boveri noted that the behaviour of chromosomes was parallel to the behaviour of genes and used chromosomal movement to explain Mendel's laws.
* Salient features :-
  1. Both chromosomes as well as gene occur in pairs in the somatic or diploid cells.
  2. A gametic carrier only one chromosome of a type and only one of a two alleles of a character.
  3. The paired condition of both chromosome as well as gene is restored during fertilization.
  4. Meiosis contain chromosomes. Therefore chromosomes must carry the hereditary traits.
  5. Homologous chromosomes segregate during meiosis and then segregate independently into different cells which establish the genetic basis for segregation and independent assortment of hereditary factors.
  6. The two alleles of a gene pair are located on homologous site of homologous chromosome.

Comparison b/w Behaviour of chromosomes & Genes

A	B
• occur in pairs	occur in pairs
• segregate at the time of gametic formation such that only one of each pair is transmitted to a gamete	•
• Independent pair segregate independent of each other.	• one pair segregate independency of another pair.
(gene)	(chromosomes)

Sutton & Boveri argued that the pairing and separation of a pair of chromosomes would lead to the segregation of a pair of factors they carried.

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

** Experimental verification of the chromosomal theory of inheritance by Thomas Hunt Morgan and his colleagues, led to discovering the basis for the variation that sexual reproduction produced.

Drosophila as Experimental Material for Genetic Studies :-

T.H. Morgan (Father of Experimental genetics) selected fruitfly Drosophila melanogaster as experimental material though it is small sized (2mm size) b/c of the following advantages in Drosophila over pea.

(1) They are easily available.
(2) They could be grown on simple synthetic medium in the laboratory (yeast culture over med containing cream of wheat, molasses, and agar)
(3) They complete their life cycle in 10 days.
(4) Single mating could produce a large number of fruitfly flies.
(5) male & female flies are easily distinguishable. → Dimorphism

(6) It has many hereditary variations that can be seen with low power microscope.

Linkage and Recombination :-

Linkage :- It is the tendency of genes to stay together during inheritance through generations without any shuffling or separation due to their being present on same chromosome.

Gene present on same chromosome - Linked Genes
Gene present on different chromosome - Unlinked Genes

Linked gene shows dihybrid ratio → 3:1
Test cross ratio → 1:1

Unlinked gene shows dihybrid ratio → 9:3:3:1
[Cis Parental, Trans Recombinant] Test cross ratio → 1:1:1:1

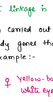
* Linkage was discovered by Bateson & Punnet in 1906 in sweet pea (Lathyrus odoratus). However, it was Morgan (1910) clearly proved and defined linkage. Term linkage was coined by Morgan.

* chromosome theory of linkage was proposed by Morgan and Castle (1911). It states that
  (1) Linked Gene occur in same chromosome.
  (2) Genes arranged linearly on chromosome.
  (3) Strength of linkage b/w two genes ∝ $\frac{1}{\text{distance b/w two genes}}$

* Linkage group :- Gene that are present on the same chromosome make one linkage grp. They inherit together except for crossing over.

** No. of linkage grp is equivalent to number of chromosome present in a genome.
  Human - 23
  Drosophila melanogaster - 4
  Pea plant - 7
  E. coli - 1

** Arrangement of linked gene



Cis arrangement
(genes are said to be in coupling state)

Trans arrangement
(genes are in repulsive state)

* complete linkage is observed in male drosophila

* Morgan carried out several dihybrid cross in drosophila to study genes that were sex-linked.

* For Example :-

♀ Yellow-bodied white eye × Brown-bodied Red-eyed ♂

↓

F_1 (test cross progeny)

↓

the observed the ratio is ≠ 9:3:3:1
• Genes did not segregate independently.

Morgan & his group knew that the genes were located on X-chromosomes and saw that when the two gene in a dihybrid cross were situated on the same chromosome, the proportion of parental gene combinations were much higher than non-parental recombination.

• Morgan attributed this to due to physical association or linkage of two genes. And coined the term linkage and the term recombination to describe the generation of non-parental gene combinations.

* Morgan proposed chiasmata type hypothesis showing that chiasmata cause crossing over.

* Morgan and Sturtevant (1911) used the frequency of recombination between gene pairs on the same chromosome as a measure of distance between genes. And mapped their position on the chromosome. Today genetic maps are extensively used as starting point in the sequencing of whole genomes as was done in the case of the human Genome sequencing Project.

1% recombination = 1 centi Morgan (1cM)
or 1 map unit

* Linkage Map :- A linkage or genetic or chromosome map is a linear graphic representation of the sequence and relative distances of the various genes present in a chromosome.

(Explain Q2 Acc) from chart

* Linkage →
  Strength lies with age.
  lies with temp lies
  lies with Radiation like X-ray/UV-ray
  lies with lies in distance b/w genes.

* Morgan is called Fly man of genetics or Father of experimental genetics

* Morgan (1916) discovered basis for variations due sexual reproduction

* Morgan gave gene theory of inheritance and suggested that specific gene is associated with a specific chromosome.

:- Sex-determination :-

* The cytological observation made in a number of insects led to the development of the concept of genetic chromosomal basis of sex-determination.

* Henking (1891) could trace a specific nuclear structure all through spermatogenesis in a few insects. (X0)
  Henking gave a name to this structure as the X-body but he could not explain its significance.

* Further investigations by the other scientists led to the conclusion that 'X-body' of Henking was in fact a chromosome, that is why it was given the name X-chromosome.

** Allosomic or chromosomal sex determination
  In majority of diploid and unisexual animals, the sex of individual is determined by specific chromosome. These chromosomes are called sex-chromosomes or allosomes or idiochromosomes.

  There are 5-type
  (1) XX-XY type :→ ♂XY & ♀XX — most insect including drosophila, gynaecer and mammals
  (2) XY-X0 type :→ In male insects, some female (some bugs, XY & X0♂ grasshoppers, cockroaches)
  (3) ZW-ZZ type :→ In birds & some reptiles ♀ZW & ♂ZZ
  (4) Z0-ZZ type :→ Some butterflies and moths ♀Z0 & ♂ZZ

** Sex determination in honey bee (haploid diploid sex determination system)