Linkage

the hereditary units or genes which determine the char determination of various different characters. As there are more genes than the chromosomes, it can be expected that each chromosome contains more than one gene. The genes for different characters may be either situated in the same chromosome or in different chromosomes.

When the genes are situated in different chromosomes, the characters they control appear in the next generation either together or apart, depending on the chance alone. They assort independently according to Mendel's law of independent assortment. But if the genes are situated in the same chromosome and are fairly close to each other, they tend to be inherited together. This type of coexistence of two or more genes in the same chromosome is known as **linkage**.

HISTORICAL

The hypothesis that linked genes tend to remain in their original combinations because of their location in the same chromosome was advanced by **T.H. Morgan** in 1911. But prior to Morgan, **W. Sutton** and **T. Boveri** (1902), **Sutton** (1903) and **Bateson** and **Punnet** (1906) had given some hints about the phenomenon of linkage. It is strange that **Mendel** could not detect the phenomenon of linkage in pea plant, since extensive linkage studies of**Lamprecht** (1961) have demonstrated that seven genes used by Mendel belonged to only four linkage groups (chromosomes 1,4,5 and 7).

Morgan's Views on Linkage

Morgan stated that the pairs of genes of homozygous parent tend to enter in the same gametes and to remain together, whereas same genes from heterozygous parent tend to enter in the different gametes and remain apart from each other. He further stated that the tendency of linked genes remaining together in original combination is due to their location in the same chromosome.

According to him the degree or strength of linkage depends upon the distance between the linked genes in the chromosome. Morgan's concept about the linkage developed the theory of linear arrangement of genes in

the chromosomes which helped the cytogeneticists in the construction of genetic or linkage maps of chromosomes.

Chromosome Theory of Linkage

Morganalong with**Castle**formulated the chromosome theory of linkage which is as follows:

1. The genes which show the phenomenon of linkage are situated in the same chromosomes and these linked genes usually remain bounded by the chromosomal material so that they cannot be separated during the process of inheritance.
2. The distance between the linked genes determines the strength of linkage. The closely located genes show strong linkage than the widely located genes which show the weak linkage.

3. The genes are arranged in linear fashion in the chromosomes.

KINDS OF LINKAGE

T.H. Morgan and his co-workers by their investigation on the Drosophila and other organisms have found two types of linkage, viz., complete linkage and incomplete linkage.

1- Complete Linkage

The complete linkage is the phenomenon in which parental combinations of characters appear together for two or more generations in a continuous and regular fashion. In this type of linkage genes are closely associated and tend to transmit together.

Example. The genes for bent wings (bt) and shaven bristles (svn) of the fourth chromosome mutant of Drosophila melanogaster exhibit complete linkage.

2- Incomplete Linkage

The linked genes do not always stay together because homologous non-sister chromatids may exchange segments of varying length with one another during meiotic prophase. This sort of exchange of chromosomal segments in between homologous chromosomes is known as**crossing over** (Fig. 7.3).

The linked genes which are widely located in chromosomes and have chances of separation by crossing over are called **incompletely linked genes** and the phenomenon of their inheritance is called **incomplete linkage**.

Example. The incomplete linkage has been reported in female Drosophila and various other organisms such as tomato, maize, pea, mice, poultry and man, etc. Here, the examples of incomplete linkage have been considered only for Drosophila and maize.