

CHROMOSOME MAPS

Chromosome maps can be prepared by genetical or cytological methods

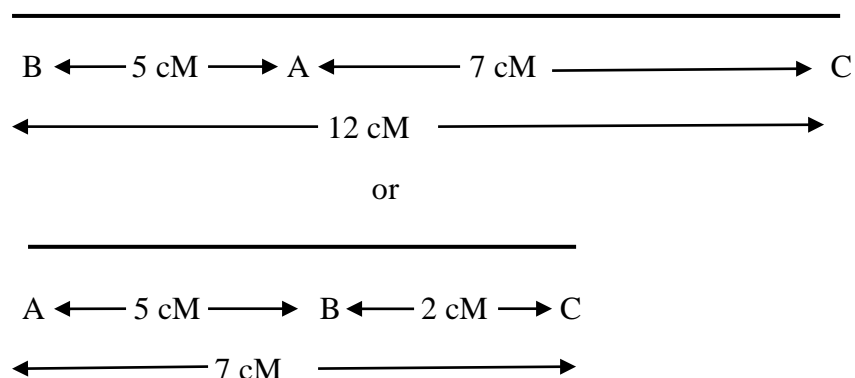
1. Genetical method: This is the general method and is based upon cross over data. The resulting map is the linkage map. Linkage map (cross over map or genetical map) map be defined as a line on which the relative positions of genes proportional to the amount of crossing over between them is represented.

A rule widely followed in plotting genes is that if genes A and B are known to be linked and if a particular gene is found by experiment to be linked with gene A it must also be linked with gene B. This principle follows from the fact that two linked genes are on the same chromosome. The genes, which are linked together on the same chromosomes are called syntenic genes.

Genetic mapping of chromosomes is based on the following assumptions:

- The genes are arranged in a linear order.
- Crossing over is due to breaks in the chromatids
- Crossing over occurs by chance and is at random
- The percentage of crossing over between the genes is an index of their distance apart.

Map distance: Recombination frequencies between the linked genes are determined from appropriate testcrosses. These percent frequencies are used as map units for preparing linkage maps. A map unit is that distance in a chromosome, which permits one percent recombination (crossing over) between two linked genes. A map unit is also called a centi-Morgan, after the name of the scientist Morgan, who first constructed the linkage map in *Drosophila*. Thus 5 % crossing over between genes A and B is taken to mean that they are situated 5 map units of distance apart on the same chromosome. If a third gene C with 7 % crossing over between A and C is included the relationship of linkage between the three genes A, B and C is indicated as below:



To choose the correct one between these two alternatives, one more information i.e. either the order of arrangement of the three genes or the cross over value between B and C is required. Eg: If the crossover value between B and C is found to be 2 % by actual experiments, the second arrangement is the correct one. Therefore, for preparing a chromosome map of three genes either the map distances (cross over frequencies) between all three gene pairs must be known or the cross over frequencies between any two gene pairs plus the order or sequence of these three genes in the chromosome must be known. In obtaining cross over value care should be taken about the occurrence of double crossing over between the concerned genes. If two genes A and B are rather far apart in a chromosome and if two crossing overs (i.e. double cross over) occur between A and B, the chromatids involved do not show recombination of marker genes. If double crossing over occurs frequently, the recombination value will be less and gives a false impression that the distance between the concerned two genes is less. To overcome this difficulty, data for chromosome mapping should be taken from linked gene pairs that are quite close together. Usually double crossing over does not occur within distances less than 5 map units or for certain chromosome segments within distances upto 15 or 20 map units.

2. Cytological maps: By cytological studies of chromosomal aberrations and by their behaviour in genetical experiments, it is possible to construct map of chromosome showing the actual physical location of gene in a chromosome. Such maps are called cytological maps of chromosomes. The work on cytological maps also confirm the theory of linear arrangement of genes in chromosomes.

Comparison between linkage maps and cytological maps: The relative distances between the genes on linkage map and cytological map do not always correspond. The discrepancies are greatest in the vicinity of the centromere where one cross over unit corresponds to a relatively much greater physical distance on the chromosome than in other regions of the same chromosome.

These discrepancies may be explained on the basis that different chromosomes and various regions in the same chromosome may also show variations in frequency of crossing over. Eg: In *Drosophila*, frequency of crossing over seems to be affected by temperature of the mother flies and by environmental factors.

Importance of linkage and chromosome maps in plant breeding:

1. They give an idea whether particular genes are linked or segregate independently.
2. Linkage intensities can be known and the probability of obtaining a given combination of genes can be assessed. If linkage between two genes is close, it is difficult to obtain recombination. In such cases, linkage can be broken artificially by irradiating with x-rays etc. and the desired combinations may be obtained. However, close linkage is useful to preserve desirable gene combinations.
3. Help the geneticist to plan how large the experimental population should be to obtain plants with the desired gene combination.
4. If an easily identifiable qualitative character is found to be linked with the quantitative character, the qualitative character can be used to easily identify the recombinants. This means that when a particular qualitative character is observed in a recombinant plant, it can be understood that the associated linked quantitative character is also present. Eg: Anthocyanin pigment and yield in rice
5. Linkage limits the variability among the individuals