Chapter on Genetics   Lecture-2   Bsc Part III

LINKAGE

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Genes that are located on the same chromosome are called linked genes. Alleles for of these genes tend to segregate together during meiosis, unless they are seperated by the process of crossing over. Crossing over occurs when two homologous chromosomes exchange genetic material during meiosis I. the two genes located located together or closer on a chromosome do not separated by crossing over.

The idea of genetic linkage was first discovered by the British geneticists by William Bateson, Edith Rebecca Saunders and Reginal Punnet. These three scientists noted that traits for flower colour and pollen shape in sweet Pea plants appeared to be linked together.

There are several thousand genes are present in an organism, but the number of chromosomes is limited, thus a single chromosome carry a large number of genes, of these the genes located on different chromosomes assort independently they do not have any connection with each other. It is observed in case of gene located on the same chromosome two possibilities arises —

(1) crossing over occurs between the genes present on the same chromosome

or

(2) Crossing over does not occur even though genes are present on the same chromosome.

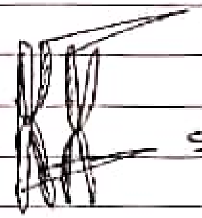
Types of linkage → There are two types of linkage

(1) Complete linkage
(2) incomplete or partial linkage

COMPLETE LINKAGE -

At the time of crossing over each chromosome which is made up of two chromatids and during homologous pairing of chromosomes in meiosis it becomes four, however only non sister chromatids participate in exchange of chromosomal segments, These two non sister chromatids are called cross overs and the remaining two are called non cross overs, Thus there would be no change in 50% gametes (having been formed without crossing over) while those formed by cross over chromatids will show new combination.

In non cross over or parental type of gametes there is no change in original arrangement of genes. This is known as complete linkage.



Incomplete linkage - However there are cases where genes are closely placed and their separation due to crossing over does not occur. Thus, only Parental or non cross over gametes would be produced. In nature, such a situation rarely exists. Crossing over takes place even if the genes are located very close to one another. This is known as incomplete linkage.

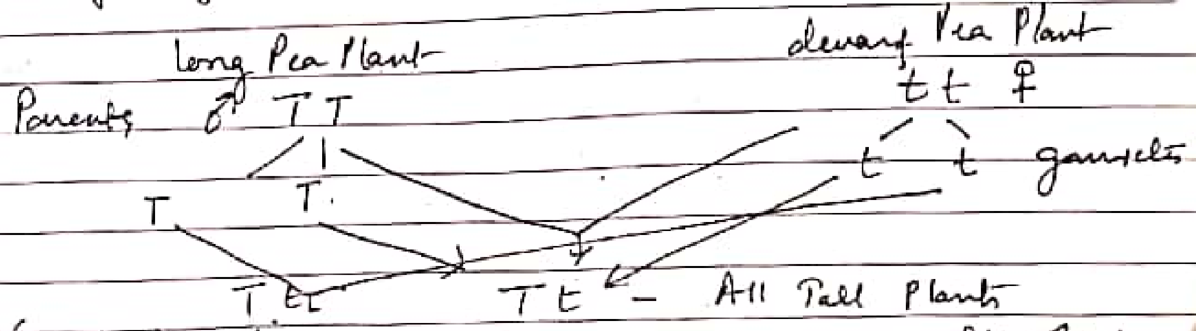
Strength of linkage - The ~~[illegible]~~ bonding between two genes is called strength of linkage. This strength depends upon following factors -

(1) Crossing over – If the number of ~~chromosomes~~ crossing-over is more the linkage strength will be less.

2) Distance between genes → If the genes are located at a distance there is more possibilities of crossing over, thus the linkage strength will be less.

③ Independent assortment – In Mendels dihybrid cross we see that in F_2 generation new combinations of characters in progeny arise due to independent assortment.

Genotype and Phenotype – In 1911 Johanssen proposed the term genotype for the genetic constitution and phenotype for the visible characters shown by the individual. For example Peas with green or yellow seeds there are two phenotypes or long pea plant and dwarf pea plants are phenotypic characters and their ratio in Mendels Monohybrid cross in F_2 generation is 3:1 but if we see the genetic combination it is about 1:2:1 this ratio is called genotype.



Genotypic ratio

1 : 2 : 1

♂/♀	T	t
T	TT	Tt
t	Tt	tt

Mendels Monohybrid cross

Tall plants – 3
dwarf plant – 1

Phenotypic ratio 3 : 1

Mendels dihybrid cross result in which we observed the phenomenon of independent assortment can be understood by following explainations -
A cross between a short haired Guinea Guinae Pig (BBSS) and a Brown, long haired guinae Pig (bbss). The BBSS individual produces only BS gametes and the bbss individual produces only bs gametes. At F_1 the offsprings are heterozygous for hair color and hair length. Phenotypically they would were all Black and short haired. However, when two of the F_1 dihybrids are mated, each produce four types of gametes (BS, Bs, bS, bs) which by fertilization result in 16 zygotic combinations. In F_2, there are nine black short haired, 3 black long haired, 3 brown short haired, and only one brown long haired individual. This phenotypic proportion (9:3:3:1) is characteristics of the second generation of a cross between two allelic pairs of genes.

All the above mentioned examples of genetic crosses illustrated the fact that during meiosis there is a random distribution of the chromosomes which leads to the segregation of the genes in the gametes. However when this type of of study was carried out in the fruit fly Drosophila melanogaster by Morgan and collaborators (1910 - 1915) it became evident that the law of Independent assortment is not universally ~~accepted~~ applicable and that in certain crosses of two or more allelic pairs of genes there was a certain limitation of free segregation. In each case there is marked tendency ~~to~~ for parental combination to remain linked and for a lesser proportion of new combinations to be produced. In Drosophila there are only four pairs of chromosomes which increases the chances of for genes to occupy loci in the same chromosome.

if two genes A and B with the corresponding alleles a and b are in the same gene chromosome only two classes of gametes will be obtained either AB or ab and there generations will be like following

Incomplete linkage

♂ $\frac{A \quad B}{A \quad B}$ × $\frac{a - b}{a - b}$ ♀ Parent

A — B A—B a—b a-b gamete

AaBb — F_1 Progeny

AaBb × aabb test cross

AB Ab aB ab × ab (only one type of gamete)

Four types of gametes

AaBb Aabb aaBb aabb — F_2 Progeny

Eg. of — Recombination of genes or Independent assortment an example of incomplete linkage.

Complete linkage

♂ $\frac{A — B}{a — b}$ × ♀ $\frac{a - b}{a - b}$ Parent

AB ab × ab ab Gamete

AaBb AaBb aabb aabb F_2

In this case we see that the progeny is similar to their parent showing complete linkage of genes.

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