POLYGENIC TRAITS AND QUANTITATIVE INHERITANCE

- There are certain characters in human population, which show phenotypic variations (e.g., height, weight, skin colour, etc.).
- These characters are expected due to cumulative effect of genes.
- These genes are called polygenes and their inheritance is called polygenic inheritance, while the characters are called polygenic traits.

Characters

(i) The effect of polygenes is cumulative.
(ii) All the alleles of polygenes have equal effect.
(iii) The inheritance is free from dominance, epistasis and linkage.
(iv) The environment has little role in the expression of characters.
(v) It was first found in humans by F C Galton in 1883.
(vi) It was first found in wheat by H Nilsson Enile in 1909.

Example

(i) When homozygous red wheat of pure breeding line (AABB) is crossed with homozygous white of pure breeding line (aabb).
(ii) In the F_1 generation, all plants produce wheat grains of intermediate red colour.
(iii) The self-cross among the F_1 hybrids produces five types of wheat grains.

Result

Dark red = $^1/_{16}$
Medium red = $^4/_{16}$
Intermediate red = $^6/_{16}$
Light red = $^4/_{16}$
White = $^1/_{16}$

LINKAGE

- The tendency of two or more genes located on the same chromosome to remain together, inherited from generation to generation, is known as linkage.
- Linkage is an exception to the principle of independent assortment.
- The concept of linkage was first introduced by T H Morgan (1910).
- The event was first observed by Bateson and Punnet in 1906 in the sweet pea plant (*Lathyrus odoratus*).

Characters

- Arrangement of all genes including linked genes is linear in chromosomes.

- Linked genes are found in the same chromosomes.
- Linked genes have the least chance of separation by crossing over called strong linkage.
- The inheritance of linked genes is of pure and combined form.

Example

- In the sweet pea plant (*Lathyrus odoratus),* the two flower characters are expressed by linked genes.
- The purple-coloured flower (PP) is dominant over the red-coloured flower and the long pollen (LL) is dominant over the round pollen grains.
- When pure purple-flowered pea plants having long pollen grains are crossed with red-flowered short pollen grains pea plant:
- In the F_1 generation, all sweet pea plants have purple flowers and long pollen grains.
- The test cross of such an F_1 hybrid with double recessive parent fails to produce the expected 1:1:1:1 ratio.
- The new ratio found due to linkage of two genes is 7:1:1:7.
- If the two alleles (PPLL) come from the same parents (PPLL X ppll), they tend to enter the same gamete. This is known as coupling.
- When the same allele (P and L) come from different parents (PPll X ppll), they tend to enter different gametes. This is known as repulsion.
- T H Morgan (1910) pointed out that coupling and repulsion are two aspects of the same phenomenon called linkage.

Types of Linkage

Linkage is of the following two types:

1. **Complete Linkage –** When genes are closely associated, they are always transmitted together. They do not undergo crossing over showing complete linkage. No new forms are formed.
   - It is rare and is found in male *Drosophila,* female silkworms, and a few others.
2. **Incomplete Linkage –** Incomplete linkage is the tendency of linked genes to separate and form recombinant types due to crossing over.
   - Incomplete linkage has been studied in *Drosophila*, other animals and maize.

Significance – Linkage maintains a specific trait from generation to generation.

Linkage Groups

- All the genes present on a chromosome constitute a linkage group.
- The number of linkage groups is equal to the haploid number of chromosomes.
- In *Drosophila*, the number of linkage groups is four; in maize, it is 10; and in humans, it is 23.

CROSSING OVER

- It is the process of exchange of segment between homologous pairs of chromosomes.
- It leads to the production of a new combination of genes. It is also called genetic recombination.
- It was first described by T H Morgan in 1911.

Time and Stage of Crossing Over

- Crossing over takes place during gametogenesis.
- Gametogenesis involves meiosis cell division.
- The actual time of crossing over is pachytene stage of meiosis I.
- Crossing over results in the formation of chiasma or chiasmata.

Significance of Crossing Over

- It confirms the linear arrangement of genes in chromosomes.
- It produces a new combination of genes.
- It causes appearance of new characters.
- It causes variation among offsprings of the same parents and among the same species.
- The process is applied for improvement of economically important varieties of plants and animals.

SEX DETERMINATION

- Sex is a unique feature of sexually reproducing organisms.
- Majority of the organisms show sexual dimorphism in which egg-producing organisms are known as female, while sperm-producing organisms are called males.
- Sex is inherited according to Mendelian laws.

Time of Sex Determination

Sex is determined at the following three times:

1. **Progamic** – Sex is determined before fertilisation.
2. **Syngamic** – Sex is determined at the time of fertilisation.
3. **Epigamic** – Sex is determined after fertilisation.

Types of Sex Determination

Sex is determined by genetically controlled mechanisms of the following types:

I. Sex Chromosome Mechanism

Dioecious organisms have two sets of chromosomes, viz., autosomes and allosomes or sex chromosomes.

- Allosomes are of two types, viz., X and Y.
- In dioecious and diploid organisms, the sex is determined by the following two members:
  1. Heterogametic male
  2. Heterogametic female

1. Heterogametic Male

- Females are homogametic (XX), while males have only one X chromosome and are heterogametic.