Chromosomal Aberrations

Chromosomal contents (number and structure) of an individual, a crop variety or a species remain constant from generation to generation. The constancy of the chromosomal contents, ensures the constancy of the individual with all its characteristics. If a viable change occurs in the number or structure of the chromosomes of an individual, the properties of the individual change accordingly and the changed properties are also expressed in the offspring of the individual faithfully over the generations. Such a change can occur in the following three ways:

1. Recombination of the existing chromosomal material through crosses.
2. Change in the number of chromosomes.
3. Change in the chemical or physical composition of chromosomes.

1. Change by recombination —

Much has already been said in the previous sections about how individuals change genetically through recombination of chromosomes and, for that matter, of the genes carried on them. The genetic change caused by this process are expressed phenotypically in the next generation, the changed phenotypes can further change by going through further recombinations.

2. Change in chromosome number

There is a basic chromosome number within a genus or a species and additions to, or subtraction from, that basic number through evolution produce new individuals or species with modified character. This phenomenon of change in chromosome number is termed *polyploidy*. If the changed number is an exact multiple of the basic chromosome number, the polyploidy is called *Euploidy* and if it is not an exact multiple, the

polyploidy is called *aneuploidy*. Take, for instance, wheat. The basic chromosome number in wheat genus (*Triticum*) is 7, which may be designated as X. Its exact multiple numbers will be 14(2x), 21(3x), 28(4x), 35(5x), and 42(6x). The species with 14 chromosomes will be diploid; with 21 chromosomes triploid; with 28 chromosomes tetraploid; with 35 chromosomes, pentaploid; with 42 chromosomes hexaploid, while the basic number of 7 constitutes a monoploid. Our common bread wheat grown in this region is *Triticum aestivum* which is a hexaploid.

It will be noticed that in euploidy, the basic set of chromosomes is added or taken out, as a whole.

Euploid type of polyploidy is further divided into two classes:

(i) *Allopolyploidy.* "Different sets of chromosomes are derived from different sources through crossing followed by doubling." Species hybrids are usually sterile, and fertility may be restored if the chromosome number of such hybrids is doubled. Such chromosome doubling provides suitable mates (homologues) to synapse during cell division. Take the example of *Raphanobrassica*, a polyploid developed through the crossing of two different species, cabbage (AA) and radish (BB). The hybrid (AB) between these species was found to be sterile. On doubling its chromosome number, it produced viable gametes, because each duplicated genome provided proper homologues for due synapsis. It is illustrated as under:

Parents:	Cabbage	X	Radish
	AA (2n 18)		BB (2n 18)
Gametes	A, (n, 9),		B, (n, 9)
	AB (2n, 18),		

Chromosome doubling AA BB (2n, 36) *Raphanobrassica*

Our common bread wheat is an allopolyploid, because its three different chromosome sets (genomes) have been contributed by three different species.

(ii) *Autopolyploidy.* All the sets of the chromosomes (genomes) present in a polyploid belong to the same individual, and no prior crossing

is involved. In other words, one genome is repeated many times. Autopolyploids are usually sterile, because more than one homologue are present during meiosis and irregular pairing of chromosomes results in the production of unbalanced gametes which are usually sterile.

The autopolyploids may originate as a result of (1) doubling of the chromosome number in the somatic tissue, that takes part in gamete formation (2) failure of reductional division resulting in unreduced gametes.

Triploid. These have three sets of chromosomes and may be produced when an unreduced (2n) gamete is fertilized by a normal (n) gamete. They may also arise from a tetraploid crossed with a diploid. The triploids are usually unstable and sterile.

Tetraploid. These have four sets of chromosomes. Frequently, their origin is through doubling of diploid which may be allopolyploid or autopolyploid. Irregularity at the time of mitosis causes doubling of chromosomes. Any agency that does not allow the spindles to develop properly in cell division will obstruct the division of duplicated chromosomes which may then be enclosed in the same nuclear membrane producing a tetraploid.

In aneuploidy, the chromosome number is modified by adding or subtracting only one, two, three, etc. chromosomes and not the entire set. If from an amphidiploid (2n), one chromosome is missing, it is called *monosomic* (2n–1), and similarly with the addition of one extra chromosome resembling any other existing chromosomes, the individual is called *trisomic* (2n+1); (2n+2) will be *teterasomic* and (2n—2) *nullisomic*.

The aneuploids have a practical significance in identifying genes on different chromosome. The trisomic individuals (one chromosome is repeated three times), produce different phenotypes than the normal and so do the monosomes. The deficient or the additional chromosome can be identified cytologically and the changed phenotypic effect may be attributed to genes present on those chromosomes. It is rather difficult to establish monosomic lines in organisms which are not polyploids. Nullisomics are also usually inviable.

3. Change in chromosome structure

Physical and chemical changes in the chromosomes of an individual can occur in several ways. We may first discuss physical ones.

(i) *Deficiency.* When a chromosome somehow loses a portion of itself, deficiency occurs. A break may occur at the end of the chromosome, which will produce a terminal deficiency. Two breaks may delete a middle portion of the chromosome, which will be an intercalary deficiency. When a normal homologue pairs with its deficient mate, it shows a buckling effect as follows:

A B C D E F

Normal chromosome

A B C D

Terminal deficiency

A B E F

Intercalary deficiency

(ii) *Duplication.* A chromosome gains a portion of a homologous chromosome and is thus doubled for that chromosome material. The duplication provides a means to study the effect of some genes in single, double or more doses.

A B C D E F

A B C D E F

Break occurs in one chromosome

A B C D E F E F

Duplicated chromosome

(iii) *Translocation.* When two non-homologous chromosomes exchange their corresponding portions, they are said to have undergone translocation; the translocation will be reciprocal. In the non-reciprocal translocation corresponding portions are not exchanged. Translocations

usually do not involve any loss or addition of the chromosome material but only represent the engineering of new chromosomes and alter the linkage groups, besides inducing partial sterility in the gametes.

A B C D
W X Y Z

Non-homologous chromosomes

A B C D
W X Y Z

Break occurs in one chromosome

A B C D
W X Y Z

Break occurs in corresponding portion

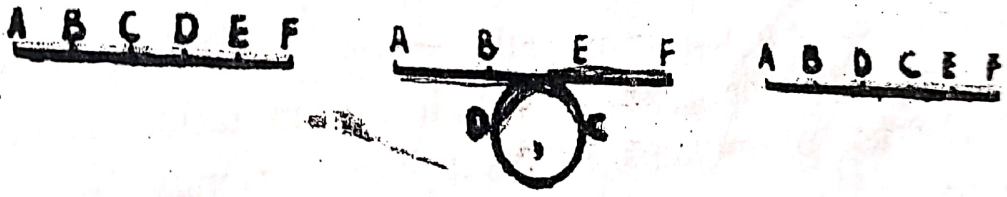
A B C D Z

Non-reciprocal translocation

A B Y Z
W X C D

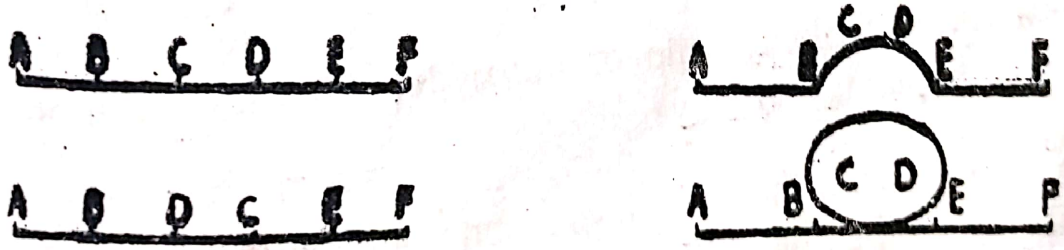
Reciprocal translocation

(iv) *Inversion.* Certain segment of a chromosome may break at two places and if the breaking points are close to each other due to the formation of a loop, the broken ends may reunite on the wrong ends and produce an altered gene order.



Normal chromosome — Formation of loop — Inverted chromosome

When the inverted chromosome pairs with a normal chromosome, forms a loop, as shown in the following diagram:



Inversion has occurred in one homologue

Pairing between inverted and normal homologous pairs of chromosome

Chemical change in the chromosome

Structural change does not obviously alter its physical shape and form, but definitely imparts new qualities to the genetic matter contained

therein. A gene which is located on the chromosome, is a chemical entity and its three important components are (i) Nitrogenous bases, which are of 4 kinds (ii) Pentose sugar and (iii) Phosphoric acid. These three chemicals combine to form 4 nucleotides according to the 4 nitrogenous bases. In the chromosome, these nucleotides are arranged in different orders giving rise to various genes. If this arrangement is disturbed by changing the order through some means, the gene is changed and a new phenotype results. Such changes occur very rarely in nature, but can be induced by artificial means and this process is called *mutation*.

Mutation is permanent in nature but a gene can back-mutate restoring the original genotype and the phenotype.

Mutation can be induced by the following agencies:

(i) *Ultraviolet light*

(ii) *Ionizing radiations* (X-ray, Gamma rays) etc.

(iii) *Chemical substance,* i.e. Colchicine, acenapthene, Sodium azide, mustard gas, E.M.S. etc. Ethyl methane sulphonate.

(iv) *Temperature*

Agents which cause mutation are called *mutagens* and the new forms produced are *mutants*. The process of inducing mutation is called *mutagenesis*. The use of mutants in plant breeding may be called *Mutation breeding*.

PROBLEMS