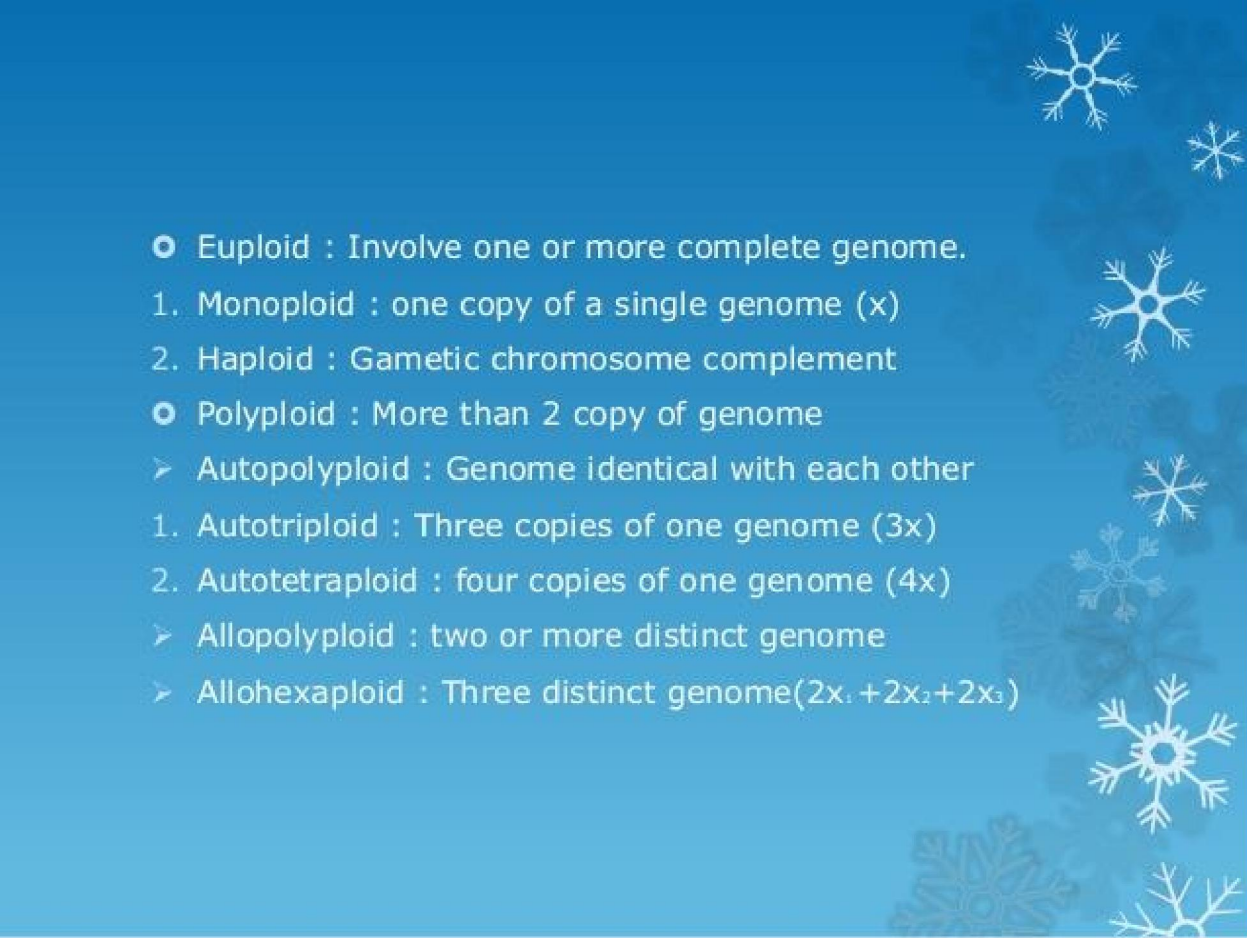


- 
- Euploid : Involve one or more complete genome.
    1. Monoploid : one copy of a single genome ( $x$ )
    2. Haploid : Gametic chromosome complement
  - Polyploid : More than 2 copy of genome
    - Autopolyploid : Genome identical with each other
      1. Autotriploid : Three copies of one genome ( $3x$ )
      2. Autotetraploid : four copies of one genome ( $4x$ )
    - Allopolyploid : two or more distinct genome
    - Allohexaploid : Three distinct genome( $2x_1 + 2x_2 + 2x_3$ )

When all the genomes present in a polyploid species are identical, it is known as 'autopolyploid'.  
In case of allopolyploids, two or more distinct genomes.

Polyploidy is of two types, viz. 1) autopolyploidy, and 2) allopolyploidy.

### **Autopolyploidy**

Polyploids which originate by multiplication of the chromosome of a single species are known as autopolyploids or autopoloids and such situation is referred to as autopolyploidy. Autopoloids include triploids (3x), tetraploids (4x), pentaploids (5x), hexaploids (6x), septaploids (7x), octaploids (8x), and so on. Autopoloids are also known as simple polyploids or single species polyploids.

### **Allopolyploidy**

A polyploid organism which originates by combining complete chromosome sets from two or more species is known as allopolyploid or allopoloid and such condition is referred to as allopolyploidy. Allopoloids are also known as **hybrid polyploids** or **bispecies** or **multispecies polyploids**. Allopolyploidy can be developed by interspecific crosses and fertility is restored by chromosome doubling with colchicine treatment. Allopoloidy has played greater role in crop evolution than autopolyploidy, because allopolyploidy is found in about 50% of crop plants.

**AUTOPOLYPLOIDY:** In autopolyploidy are included triploidy, tetraploidy and higher levels of ploidy. Autopolyploids are produced directly or indirectly through chromosome doubling, which is briefly considered as follows.

Origin and production of Doubled Chromosome Numbers Cells/ individuals having doubled chromosome numbers may originate in one of the following several ways:

- (1) Spontaneous,
  - (2) Due to treatment with physical agents,
  - (3) Regeneration in vitro,
  - (4) Colchicine treatment,
- and (5) Other chemical agents.

(1) Spontaneous – Chromosome doubling occurs occasionally in somatic tissues and unreduced gametes are also produce in low frequencies.

(2) Physical Agents – Heat or cold treatments, and X-ray or gamma-ray irradiation may produce polyploids in low frequencies. Tetraploid branches were produced in *Datura* in response to cold treatment. Exposure of maize (*Z.mays*) plants or ears to a temperature of 38-45OC at the time of the first division of zygote produces 2-5 per cent tetraploid progeny. Heat treatment has been successfully used in barley (*H.vulgare*), wheat (*T.aestivum*), rye (*S.cereale*) and some other crop species.

(3) Regeneration in vitro – Polyploidy is a common feature of the cells cultured in vitro. Some of the plants regenerated from callus and suspension cultures may be polyploids. Plants of various ploidy have been regenerated from callus cultures of *Nicotiana*, *Datura*, rice (*O. sativa*) and several other species.

(4) Colchicine treatment – Colchicine treatment is the most effective and the most widely used treatment for chromosome doubling. It has been used with great success in a large number of crop species belonging to both dicot and monocot groups. Pure colchicine is  $C_{22}H_{25}O_6N$ . It blocks spindle formation and thus inhibits the movement of sister chromatids to the opposite poles. The resulting restitution nucleus includes all the chromatids; as a result, the chromosome number of the cell is doubled.

(5) Other chemical agents – several other chemical have polyploidizing effect. Notable among them are, 8-hydroxyquinoline and nitrous oxide. These chemicals are much less effective than colchicine and are not commonly used.

### **Meiotic behaviour in autopolyploids-Autotriploids and autotetraloids:**

#### ***Cytology of autopolyploids.***

In an autopolyploid, there will be more than two sets of homologous chromosomes. This leads to formation of multivalents instead of bivalents as found in diploids. An important difference exists even between autotriploids and autotetraploids, because while in the latter normal disjunction is possible giving rise to diploid gametes, in triploids it is not possible. In an autotriploid, there are three sets of homologous chromosomes. If these three sets are normally paired, trivalents can not disjoin normally and will either disjoin 2 : 1 chromosomes to two poles or will disjoin 1 : 1 leaving one chromosome as a laggard. The number of chromosomes in gametes of triploid organism, therefore, will vary from  $n$  to  $2n$ . Most of these gametes are unbalanced leading to high degree of sterility.

In autotetraploids, since there are four sets of chromosomes, quadrivalents are formed, which disjoin in a normal 2 : 2 manner giving diploid gametes. Rarely however, a quadrivalent may disjoin 3 : 1 or may leave a chromosome as a laggard at anaphase I. Therefore autotetraploids also have a certain degree of sterility, although it will not be as high as in autotriploids.

#### ***Genetics of autopolyploids (trisomic and tetrasomic inheritance).***

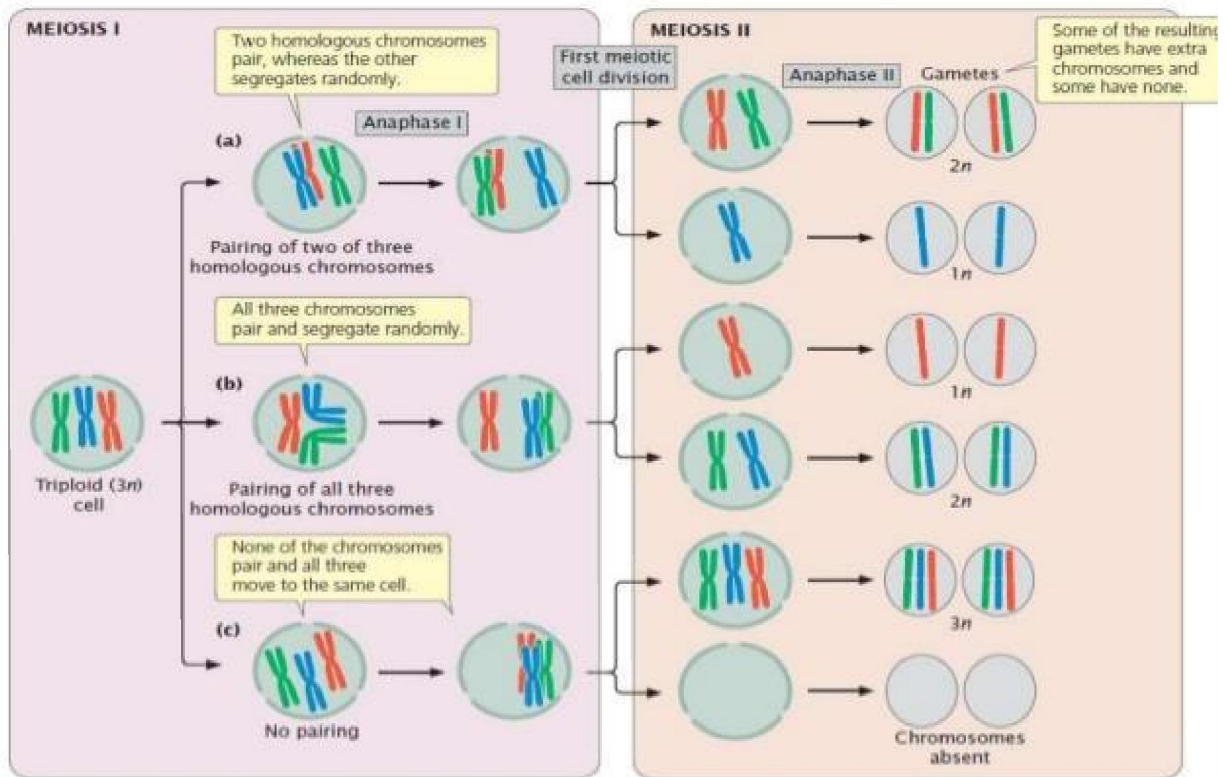
The segregation pattern in polyploids is quite different than what we find in diploids. In a polyploid there are more than one kind of heterozygotes, because there are more than two homologous chromosomes. The different possible genotypes and expected ratios in autotetraploids are given in Table 20.4. Similar ratios for triploids are given in Table 20.1. The ratios are based on the assumption that either the gene is close to centromere leading to what we call chromosome segregation or the gene is away from centromere so that crossing over between gene and centromere will take place and ratios will be modified. In the latter case it will be called **chromatid segregation**, because segregation is taking place not at chromosome level, but at chromatid level due to crossing over.

**Table 20.4. Phenotypic ratios obtained from different genotypes of autotetraploid (4x) or tetrasomic (2x + 2) individuals due to selfing or testcrosses.**

Genotype	Phenotypic ratio			
	Chromosome segregation		Chromatid segregation	
	selfing	testcross	selfing	testcross
(1) AAAA (quadriplex)	all : 0	all : 0	all : 0	all : 0
(2) AAAa (triplex)	all : 0	all : 0	783:1	27 : 1
(3) AAaa (duplex)	35 : 1	5 : 1	187:9	11 : 3
(4) Aaaa (simplex)	3 : 1	1 : 1	559:225	13 : 15
(5) aaaa (nulliplex)	0 : all	0 : all	0 : all	0 : all

It can be seen from Table 20.4 that main effect of autopolyploidy on segregation, when compared with that of diploids is the reduction in frequency of genotype homozygous at a particular locus. The result is that recessive phenotype is much less frequent as shown by a ratio 35 : 1 as against a disomic ratio of 3 : 1 and so on (Table 20.4). Tetrasomic inheritance and trisomic inheritance are useful criteria to differentiate between autopolyploids and allopolyploids and for locating genes on specific chromosomes.

## In meiosis of an autotriploid, homologous chromosomes can pair or not pair in three ways



- A gamete produced by meiosis in such an autotriploid might receive, say, two copies of chromosome 1, one copy of chromosome 2, three copies of chromosome 3, and no copies of chromosome 4.
- When the unbalanced gamete fuses with a normal gamete (or with another unbalanced gamete), the resulting zygote has different numbers of the four types of chromosomes. This difference in number creates unbalanced gene dosage in the zygote, which is often lethal.

For this reason, triploids do not usually produce viable offspring.

- Because all the chromosome sets in autopolyploids are from the same species, they are homologous and attempt to align in prophase I of meiosis, which usually results in sterility.

- ❖ Consider meiosis in an autotriploid. **In** meiosis in a diploid cell, two chromosome homologs pair and align, but, in autotriploids, three homologs are present. One of the three homologs may fail to align with the other two, and this unaligned chromosome will segregate randomly.

- Which gamete gets the extra chromosome will be determined by chance and will differ for each homologous group of chromosomes. The resulting gametes will have two copies of some chromosomes and one copy of others. Even if all three chromosomes do align, two chromosomes must segregate to one gamete and one chromosome to the other.

- Occasionally, the presence of a third chromosome interferes with normal alignment, and all three chromosomes move to the same gamete.



## Chromosome segregation in autopolyploids

### Possible genotypes in an autotetraploid

- AAAA Quadruplex
- AAAa Triplex
- AAaa Duplex
- Aaaa Simplex
- aaaa Nulliplex

A simplex individual has one dominant and 3 recessive alleles(Aaaa), a duplex has 2 dominant and 2 recessive alleles (AAaa), while a nulliplex has none(aaaa)



## Examples of Autopolyploids

Plant	Type of polyploidy	Ploidy	Chromosome number
Potato	Autopolyploid	4n	48
Banana	Autopolyploid	3n	33
Peanut	Autopolyploid	4n	40
Sweet potato	Autopolyploid	6n	90