Paper Code 402 :- Cytology & Molecular Biology in plants

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DATE

Variation in Chromosome Number (Unit-II)

Part-2 · Previous one is variation in structure

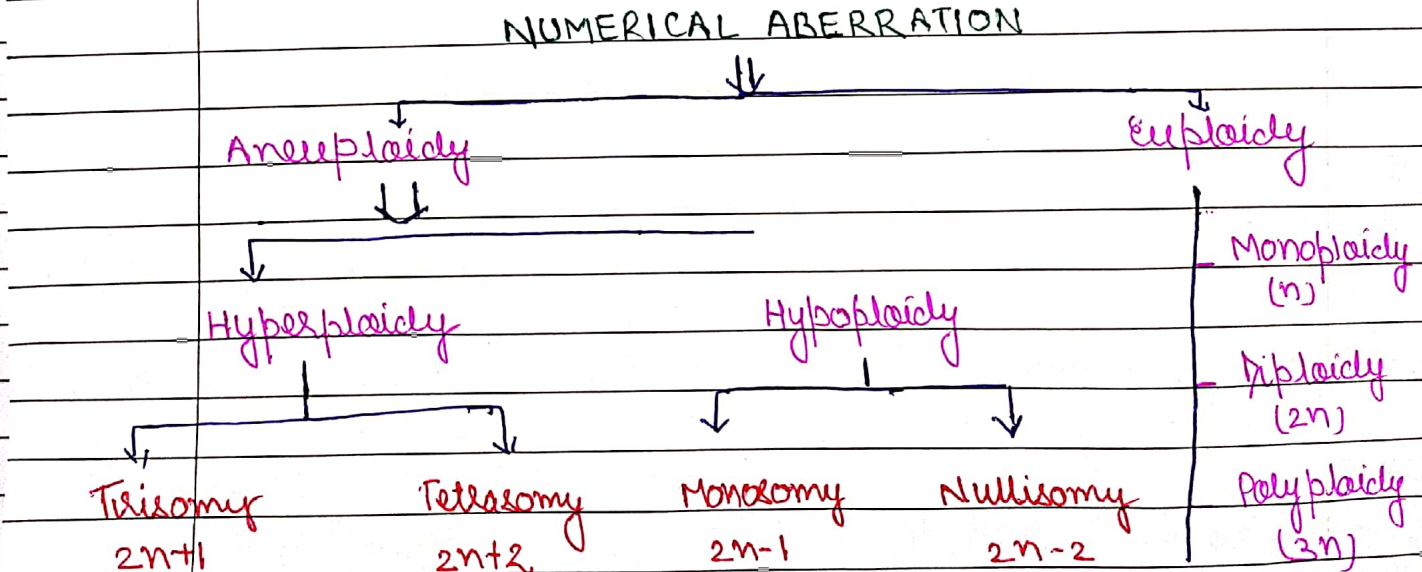
* Human Cells normally contain 23 pairs of chromosomes, for a total of 46 chromosome in each cell.

* A change in the number of chromosomes can cause problems with growth, development and function of the body's systems.

* Changes in number of whole chromosomes is called Heteroploidy.

* Heteroploidy may involves entire set of chromosomes (euploidy), or loss or addition of single whole chromosome (aneuploidy).

* Each may produce phenotypic changes, modifications of phenotypic ratio or alternation of linkage group.



PAGE

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DATE

Aneuploidy

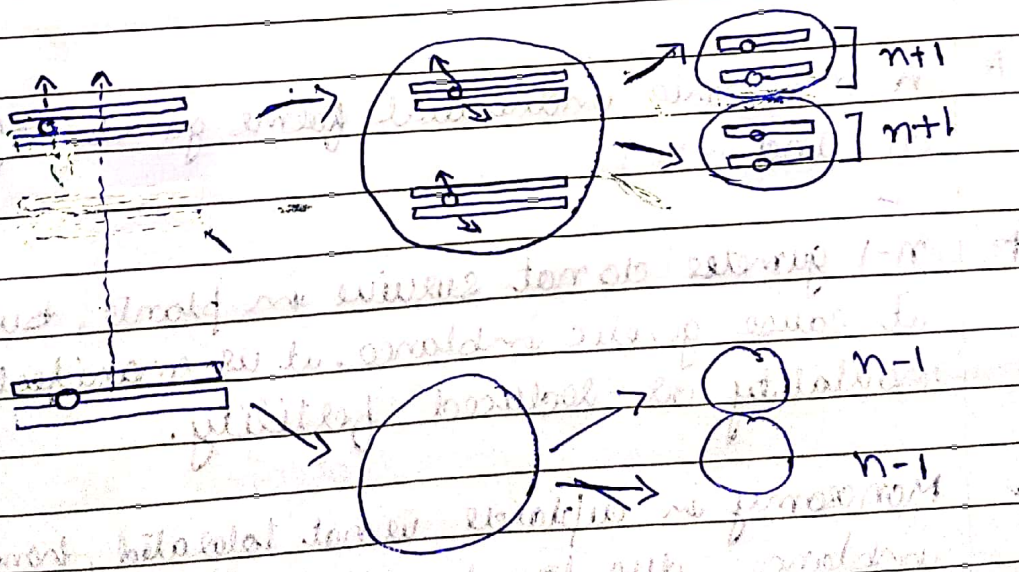
* Changes that involve parts of a chromosome set results in individual, called aneuploidy (Gr. aneu = uneven; ploid = unit)

* Aneuploidy can be either due to the loss of one or more chromosomes known as hypoploidy

* Addition of one or more chromosome to the complete chromosome set known as hyperploidy.

* Hypploidy is mainly due to the substraction of a single chromosome called monosomy (2n-1) or due to the loss of one pair of chromosome called nullisomy (2n-2)

* Hyperploidy may involve addition of either a single chromosome called trisomy (2n+1) or a pair of chromosome called tetrasomy (2n+2).



Non-disjunction at first division

PAGE

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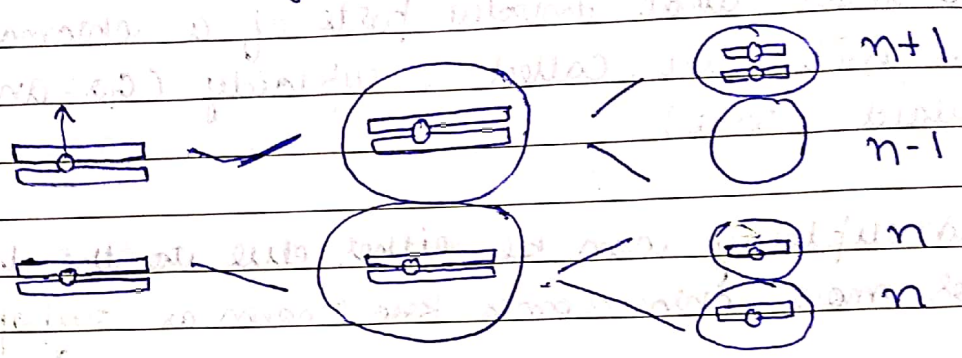
DATE

Non-disjunction at second division



- The mode of origin of aneuploid gametes by non-disjunction at either the first or second meiotic division

i. Monosomy

- Diploid organisms with are missing one chromosome of a single pair are monosomic with genomic formula 2n-1.

- A monosomic individual forms gametes of two types. (n) and (n-1)

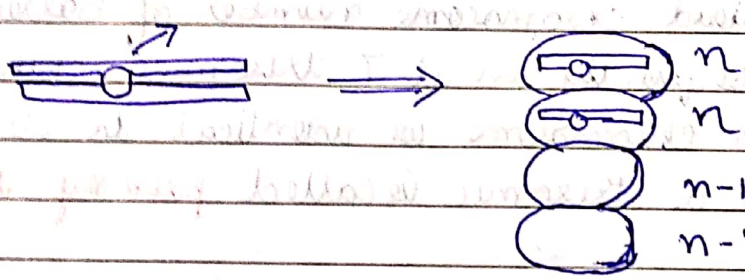
- n-1 gametes do not survive in plants, but in animals it cause genetic imbalance. it is manifested by high mortality or reduced fertility.

- Monosomy in diploids is not tolerated, hence it create imbalance due to loss of one complete chromosome

DATE

* The number of possible monosomics in an organism will be equal to the haploid chromosome number. for eg: in common wheat, since 21 pairs of chromosome are present, 21 possible monosomics are known. Those 21 monosomics were produced by E.R Sears in variety called Chines spring.

* Monosomics were also reported in cotton ($2n=52$) by J. Endrizzi.



Behaviour of a chromosome at meosis

2. Nullisomy

* An organism which has lost a chromosome pair is a nullosomic.

* The nullosomic organism has the genomic formula ($2n-2$).

* A nullosomic diploid often does not survive, a nullosomic polyploid (eg. hexaploid wheat, $6x-2$) may survive but reduced vigour & fertility.

DATE

3. Trisomy :- It was first observed in Datura stramonium by A.F. Blakeslee and J. Belling (1924).

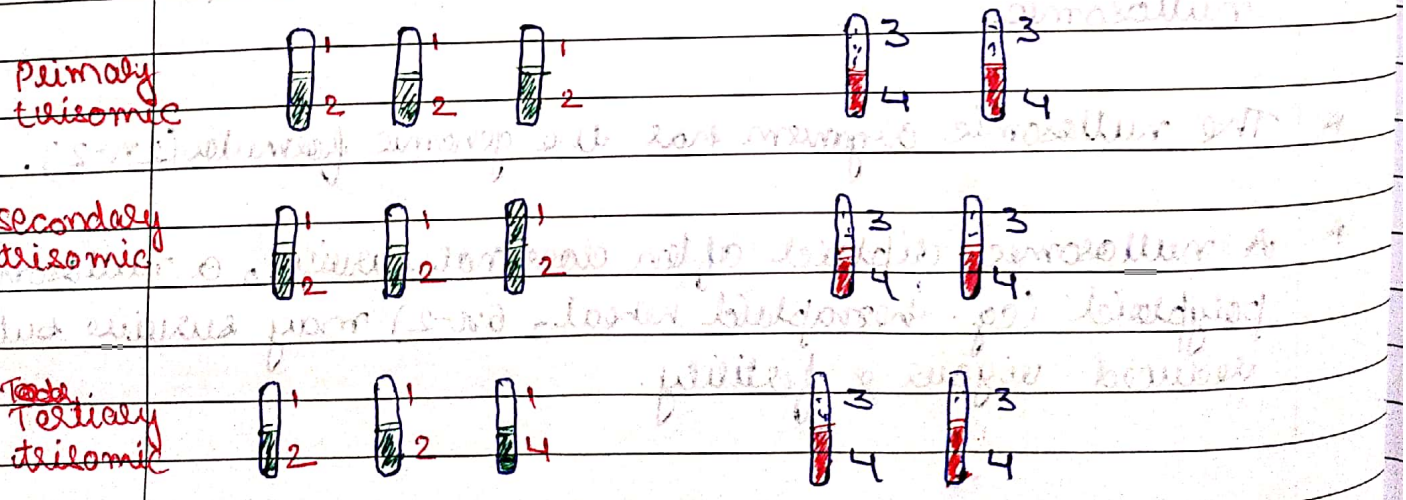
+ Trisomics are those diploid organisms which have an extra chromosome (2n+1).

+ The extra chromosome may belong to any one of different chromosome of a haploid complement, the number of possible trisomics will be equal to the haploid chromosome number.

For eg:- haploid chromosome number of barley is 7, consequently in it 7 trisomics. when the extra chromosome is identical to its homologs such a trisomic is called primary trisomics.

- when the extra chromosome should be an isochromosome (i.e both chromosome arm genetically similar) is called Secondary trisomics

- when the extra chromosome should be the product of translocation.



Three kinds of trisomics

DATE

* Trisomy in human

1) Down's Syndrome (DS) or Trisomy-21

* Down's syndrome is named after the physican J. Langdon Down in 1866 it was formally called mongolism or mongolian idiocy.

* It is usualy associated with a trisomic condition for one of the smallest human autosome ie. chromosome 21.

* These include mild or moderate mental retardation, eyes that slant up & out; a tounge that is large, swollen & protruding; small and under developed ears; short stature; stubby fingers; an enlarged liver & spleen.

2 Edward Syndrome or Trisomy-18

* It was first describe in 1960 by John H. Edwards & his colleagues.

* It is characterized by multiple malformations, primally low-set ears; small receding lower jaw, flexed & clenched fingers; cardiac malformations & various deformaties of skull, face & feet.

DATE

3 Patau syndrome or Trisomy-13

* It is described in 1960 by ~~Ke~~ Klaus Patau

* Symptoms appear to be mentally retarded; have sloping forehead, hare lip & cleft palate

4. Double Trisomy

* When two different chromosomes are represented in triplicate & double trisomics is resulted its genomic formula 2n+1+1

5. Tetrasomy

* When the diploid organisms have two extra chromosome are known as tetrasomic. They have genomic formula 2n+2.

DATE

2. Euploidy

* The term euploidy (Gr. eu = even or true ; ploid = unit) designates genomes containing chromosomes that are multiples of some basic number (x).

* Euploids are those organisms which contain balance set or sets of chromosomes in any number.

* The number of chromosomes in a basic set is called monoploid number. When the number of set is greater than two called polyploid.

* Thus 1x is monoploid, 2x is diploid and polyploid types are 3x triploid, 4x tetraploid, 5x, pentaploid 6x, hexaploid.

1.) Monoploidy

* Monoploidy have a single set of chromosome.
eg:. 7 in barley and 10 in corn

* Monoploidy is common in plant but rare in animals.

1) Origin & production of monoploids

* Monoploids are found normally & are produced due to parthenogenesis, as in male (drone) hymenopteran insects such as bees, wasps & ants.

DATE

* In angiosperms monoploids may also originate spontaneously due to parthenogenetic development of egg.
* Such rare monoploids have been obtained in tomato & cotton under cultivation
* Monoploids can be produced by artifical means by following method

1) X-ray treatments
2) Delayed pollination
3) Temperature shock
4) Colchicine treatment
5) Distant hybridization
6) Anther or pollen culture

* Among these, distant hybridization & anther culture

2) Morphology of monoploids

* Monoploids plants have reduced size of all vegetative & floral parts.
* In monoploid Nicotiana reported that the leaves, flowers and over all plant size were smaller.
* The size of seeds & stomata as well as diameter of pollen were found smaller in monoploids than in the diploids.

DATE

3) Uses of monoploids

A In a monoploids, since there is only one copy of each chromosome & only one allele of each gene, so in it each gene is expressed, whether it is dominant or recessive

A Success has been achieved in developing monoploids strain Nicotiana, Datura and Triticum.

2) Polyploidy

A Any organism with more than two genomes (2n) is called a polyploidy.

A For eg:- the rose genus Rosa include species with the somatic number 14, 21, 28, 35, 42 & 56. These number are the multiples of 7. This is a euploid series of the basic monoploid number 7 which gives 2n. 2n, 3n, 4n, 5n, 6n and 8n species.

Types of Polyploids

1) Autopolyploids
2) Allopolyploids
3) Autoallopolyploids

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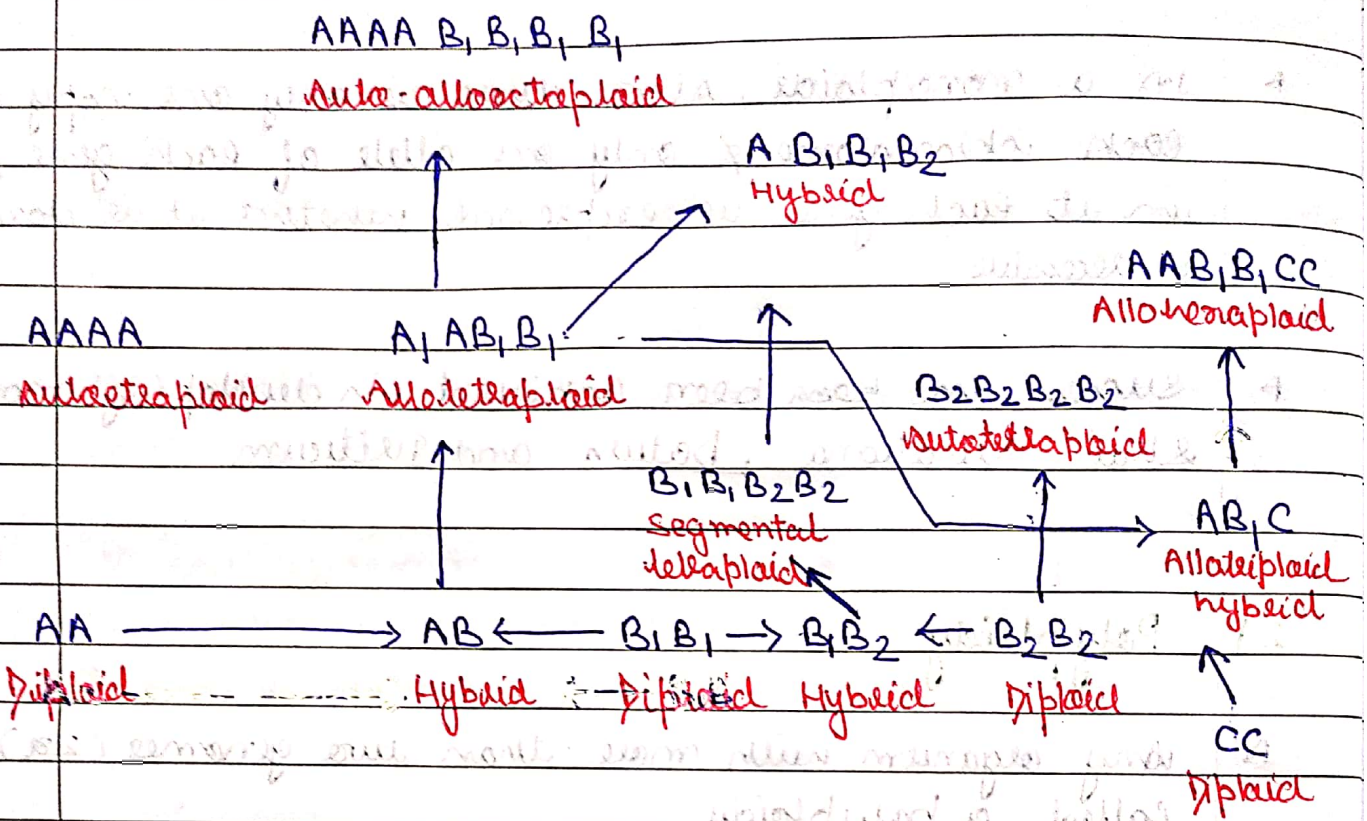

Mode of formation of different kinds of Polyploid

Types of Polyploid

i) Autopolyploids

* These consist of some basic set of chromosome multiplied. for eg. if a diploid species has two similar sets of chromosomes (AA), an autotriploid will have 3 similar genomes (AAA) & autotetraploid will have 4 (AAAA) genomes.

DATE

1) Origin & production of autopolyploids

A The autopolyploids may occur in nature or produced artificially.

A Nebaur is one of the common example of natural autoploidy is "doob grass" (cynodon dactylon). where its autoploidy nature is deduced by their meiotic behavior.

b Polyploidy may arise by:-

i) as a result of interference with cytokinesis, once chromosome replication has occured.

ii) It may occur in somatic tissues which give rise to tetraploid branches.

A Some examples of artifical methods are seedless varities of watermelon, sugar beet, tomato, grapes & banana.

A Autopolyploidy have been induced by artifical means such as chemical (colchicine, mercury chloride, chloral hydrate), radioactive substance (radium & X-rays) and temperature shock.

A #These inducers usually disturb the mitotic or meiotic spindle formation and cause non-segregation of already duplicate chromosomes, during cell division.#

PAGE

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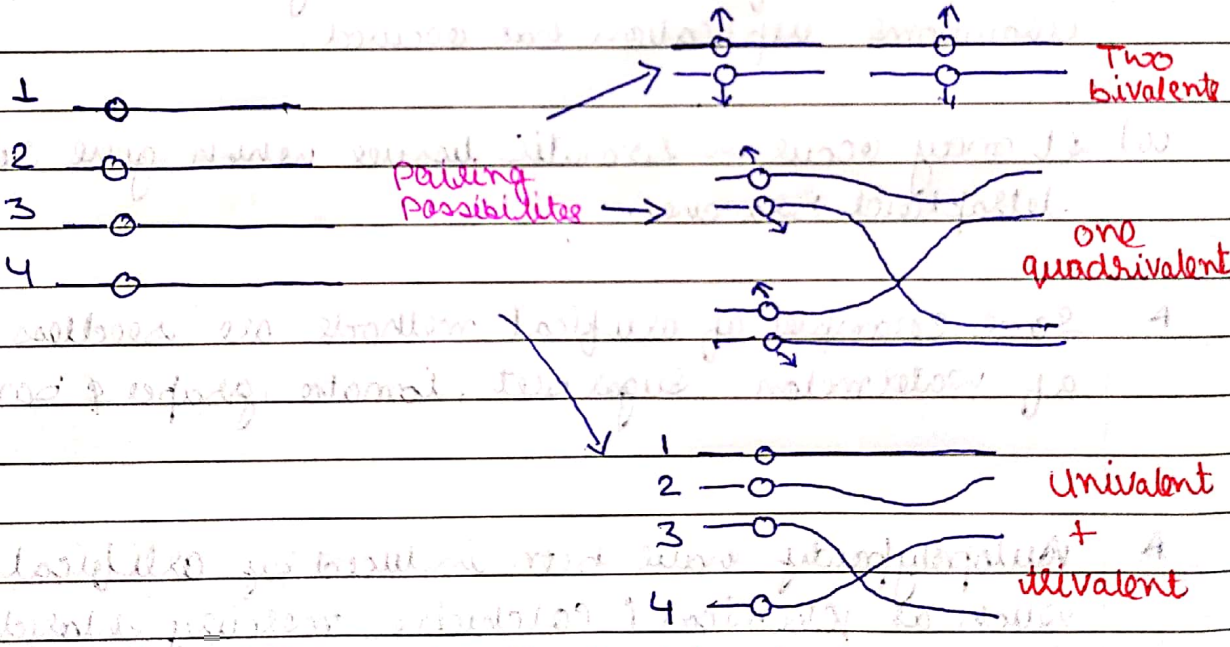
DATE

ii) Effects of autopolyploids.

- It results in gigantism of plant cells i.e. leaves, flower & fruits of an autoploidy are larger in size than a diploid plant.
- For eg :- the size of lower epidermis of leaf of a tetraploid Saxifraga pensylvanica was found greater than diploids
- Polyploid varieties with an even number of genomes (eg tetraploids) are often fully fertiles, whose



Meiotic pairing possibilities in tetraploids

- whose variety have an odd number (eg triploids) are highly sterile.

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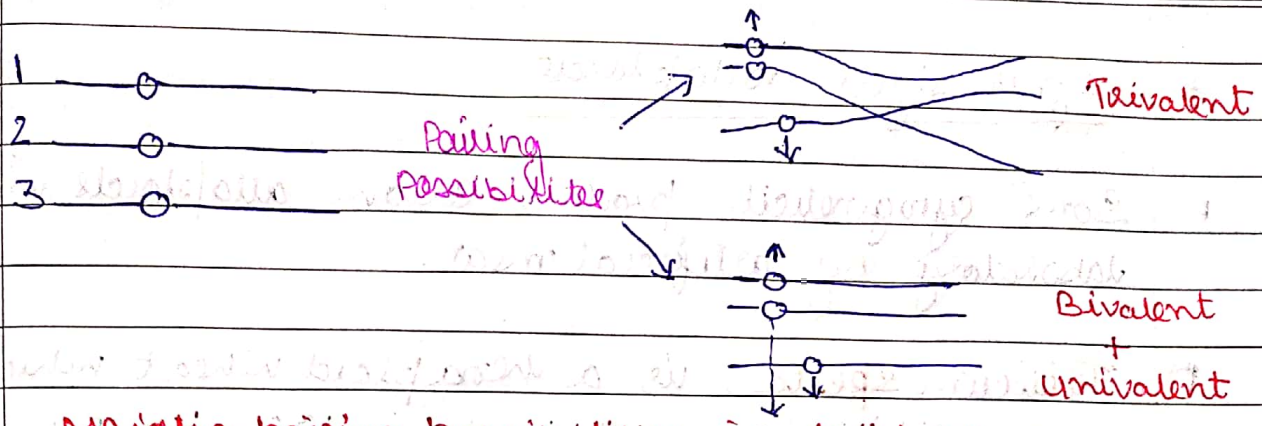

Meiotic pairing possibilities in triploids

(ii) Allopolyploids

- When the polyploidy results due the doubling of chromosome number in a F_1 hybrid which is derived from two distinctly different species, then, it is called allopolyploidy.
- Let, A represent a set of chromosome in species X and B represent another genome of species Y. The F_1 hybrid of these species will have one A & another B genome.

Species X (AA diploid) × Species Y (BB diploid)

↓

F_1 — AB diploid sterile hybrid

↓ Colchicine

Doubling of chromosome in F_1 hybrids will rise allotetraploids with 2A & 2B genome — AABB Amphidiploid tetraploid Fertile.

- Formation of an amphidiploid tetraploid

DATE

* Synthesized Alloploids

- Some cytogeneticits produce certain alloploids in laboratory by artificial mean.

1) Triticum spelta, is a hexaploid wheat which was artificially synthesized in 1964 by F.S. McFadden & E.R Sears.

+ They ~~synthesized~~ Crossed ~~of~~ Triticum dicoccoides (tetraploid 2n = 28) with goat grass Aegilos squarrosa (diploid 2n = 14) & doubled the chromosome number in F_1 hybrid.

Triticum dicoccoides X Aegilos squarrosa

AABB (2n = 28; 14 bivalent) × DD (2n = 14; 7 bivalent)

↓

ABD - Triploid hybrid (2n = 21; 21 univalent)

↓ Colchicine

↓

AABBDD

Synthesized hexaploid wheat

Triticum spelta

(2n = 42, 21 bivalent)

DATE

ii) Gossypium hirsutum, the new world cotton plant is the another example of it.
J.O Beasley crossed the old world & American cotton and doubled the chromosome number in the F_1 hybrids

Gossypium herbaceum × Gossypium raimondii
old world cotton — American cotton
2n = 26; 13 bivalent. — 2n = 26; 13 bivalent)

↓

F_1 hybrid
(2n = 26; 26 univalent)

↓ colchicine

New world cotton
Gossypium hirsutum
2n = 52; 26 bivalent

3) Autoalloploidy

* In this one genome is in more than diploid state. Commonly autoalloploidy are hexaploids. (AAAABB) eg:- Helianthus dis tuberosus.

* This term was used by Kostoff in 1939.

+ Polyploidy was found rare in animals but occur in flatworms, leeches and brine shrimp