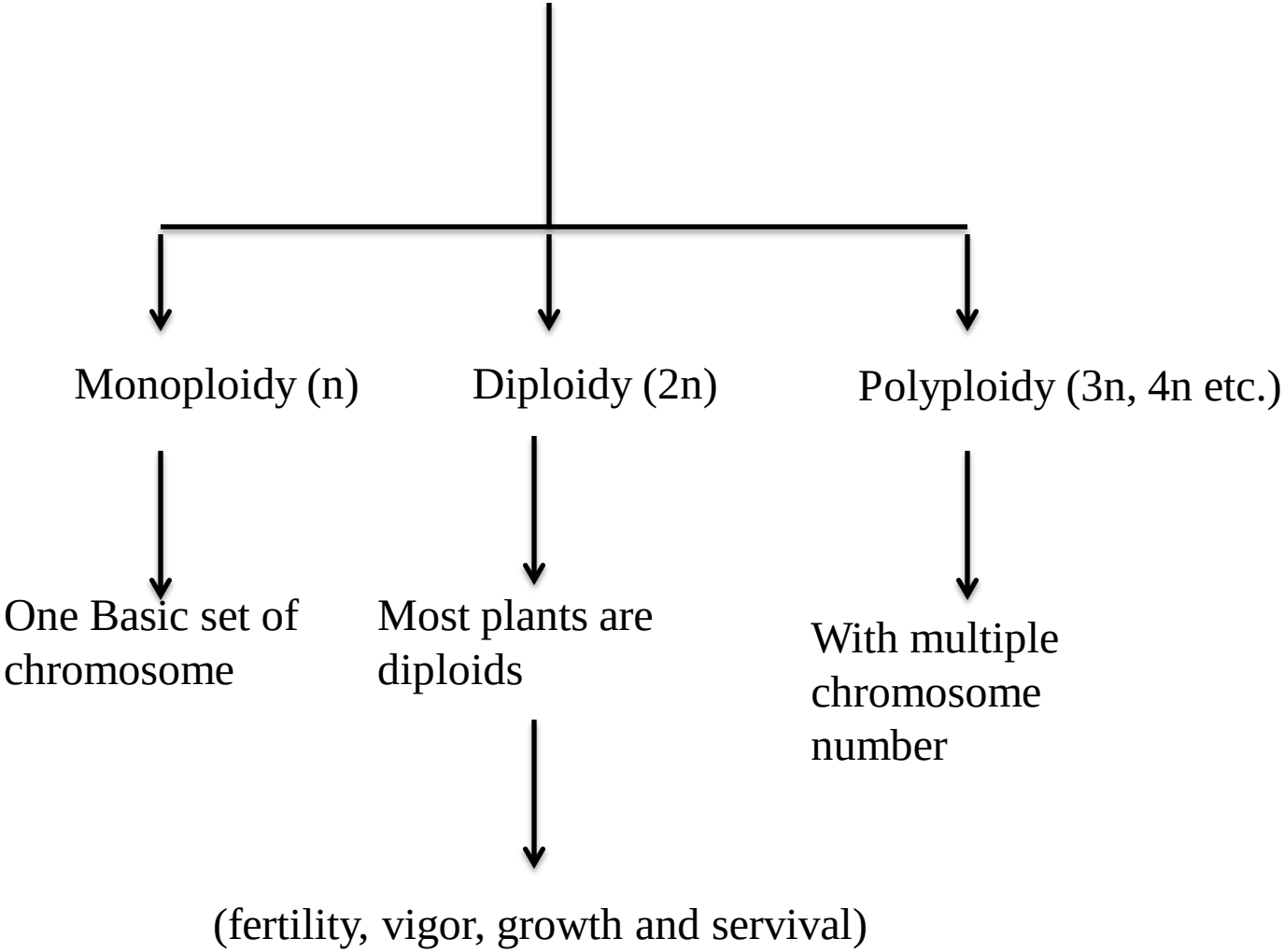
Polyploidy

- Polyploidy
  - Increase in the number of multiple of haploid chromosome
  - Variation in whole set of chromosome (genome): **Euploidy**
  - Variation in chromosome number: **Aneuploidy**

Euploidy

Variation in whole set of chromosome



Monoploidy

- 1-basic set of chromosome
- Cells do not contain homologous pair
- **Effect:**
  - Plants are smaller
  - Less vigorous
  - Sterile (no homologous chrm)
- **Origin:**
  - In nature: Spontaneously
  - Artificial:
    - Anther culture
    - Pollen culture
    - Distance Hybridization
    - X-ray treatment
    - Delayed pollination
    - Temperature shock
- **Importance:** Genetical studies, diploid homozygous, pure line, breeding
- **Example:** rice, wheat, barley, maize, tomato

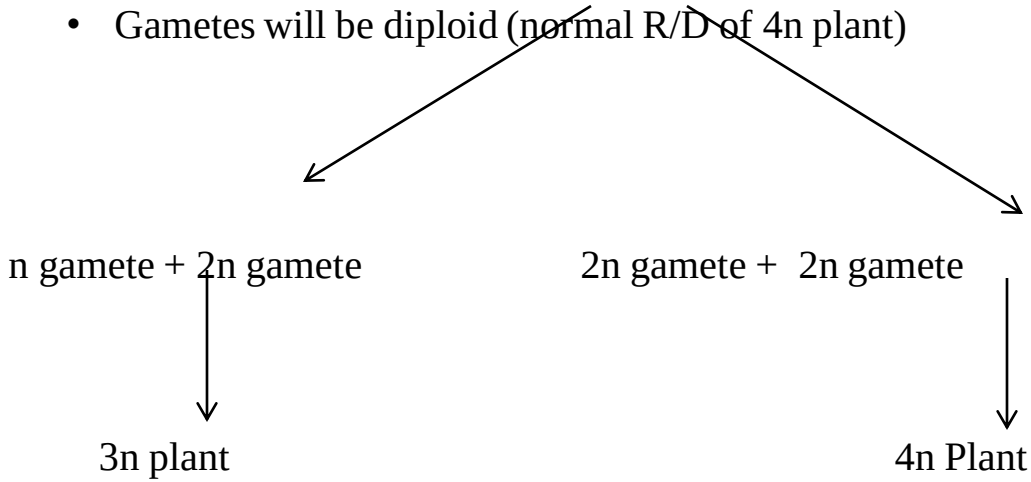
Polyploidy

- Individual with multiple chromosome number
- 3 or more genomes
- May be 3n, 4n, 5n, 6n and 8n.
- Higher than 4n- rare
- **Types**
  - **Autopolyploidy**
    - chromosome set of same sp. is multiplied
  - **Allopolyploidy**
    - multiplication after hybridization of genetically isolated species
    - Different set of chromosomes are involved

Autopolyploidy

- Effect
  - Phonotypic:
    - gigantism (leaf size, fruit size, pollen grain size)
    - 3n: more vigorous, stronger
    - Sometimes
      - Rate of growth is slower (slower rate of cell division)
      - Decreased auxin supply
      - Decreased respiration
      - Flowering time is delayed
  - Gametes: unbalanced genetically (meiotic irregularities), sterility,
  - New plants- apomixing (aseual repd)
  - Seedless fruit
  - Higher polyploidy death may occur

- Origin of polyploidy
  - **Natural**
  - Somatic doubling (mitosis)
    - Arrestation of spindle mechanism
    - Failure of cell plate formation
    - Chromosome no will be douboled- bud initial – branch (4n)
  - Irregularities in spindle mechanism (meiosis)
    - Gametes will be diploid (normal R/D of 4n plant)



Artificial Induction

- Physical Method
  - Temp. shock
  - Centrifugation
  - X-ray
  - Gamma ray
  - UV radiation
- Chemical agent
  - Mustard gas
  - Acenapthene chloral hydrate
  - Hexachlorocyclohexane
  - Colchicine (Colchicum autumnale, seeds and corm)- 0.01-0.5% aq. solution- spindle arrestation, cell plate formation
  - Seeds, apical bud, axillary bud, seedling-treatment

Meiotic behaviour

- More than 2 sets of chromosome-
  - Multi-valents
  - 3n: separate as 2:1 pattern
  - 4n: disjunction as 2;2 or 3:1
  - Bothe cases 1 chromosome- laggerred
- Unbalanced gametes
- Sterility

Example- autopolyploid

- *Oenothera lamarkiana* (evening primrose, by Hugo de Vries)
- Plums, tomatoes, maize, rye
- Commercially: banana, apples and pears- 3n
- Potato, coffee, pea nuts- 4n

Importance- autopolyploid

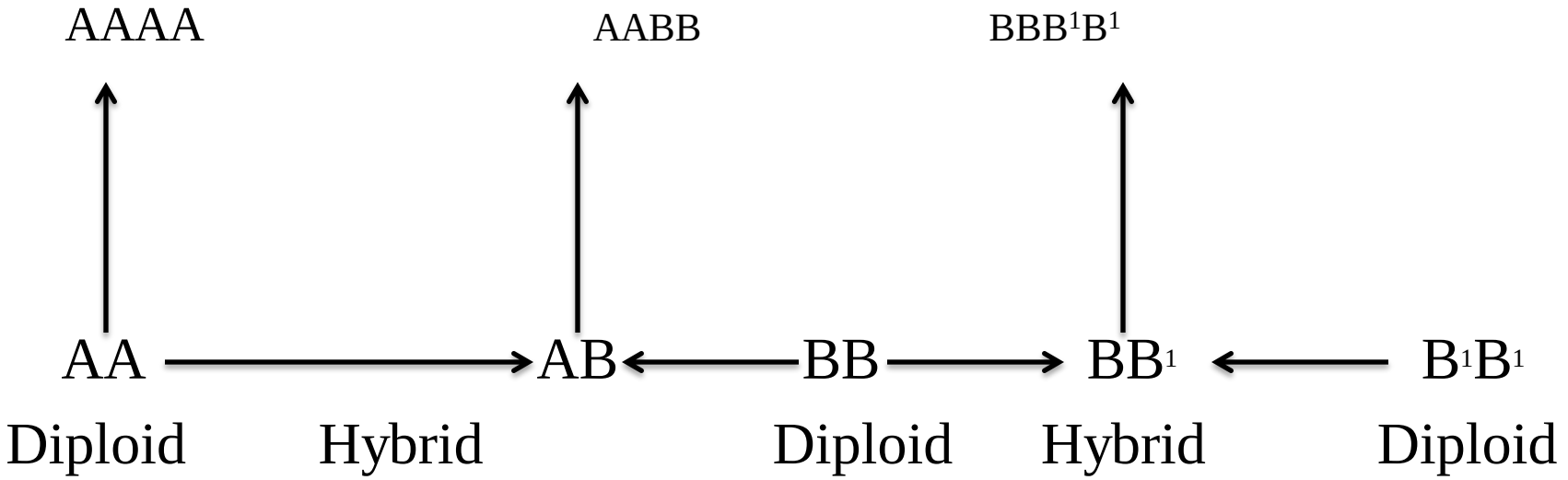
- Seedless fruit
- Propagation without fertilization
- Artificial triploid: sugar beat, tomato, grapes.
- Tetraploid: Rye, barley, maize, apples and grapes
- Horticultural Tetraploid:merigold, snapdragon, lily etc
  –

Allopolyploidy

- Multiplication of chromosomes after hybridization of genetically isolated species

Types

Autopolyploid Amphidiploid Segmental Polyploidy



Amphidiploid

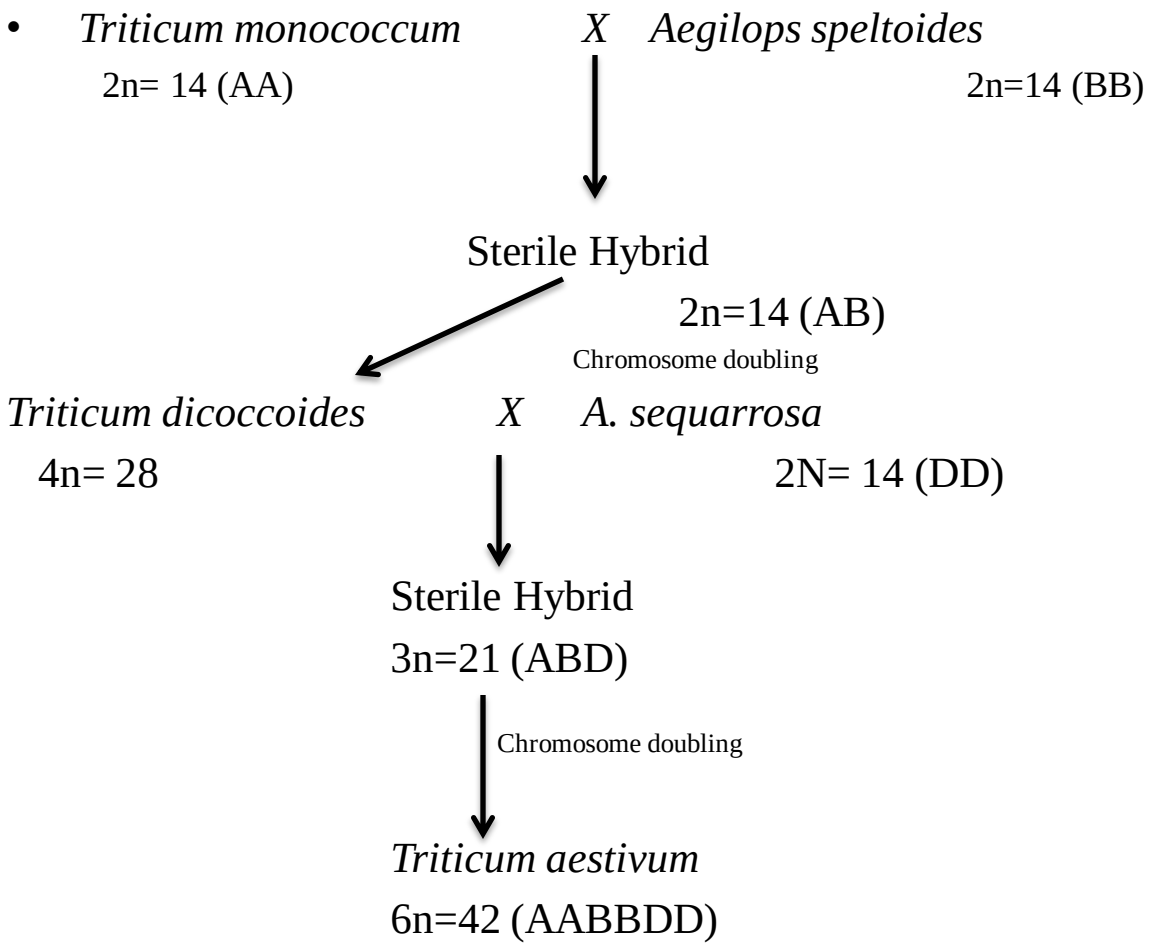
- Allo-tetraploids- behave as diploids
- Produce bivalents (meiosis)
- Origin:
  - Distantly related species (Intra-specicfic or inter-genic cross)- produce sterile hybrid (no homologous chr)
  - Sterile Hydrid- chromosome doubling
  - n X n= 2n (Sterile) → Chr. Doubling → 4n
  - It becomes fertile
  - In meiosis- bivalents are formed (not tetravalent)- ‘Amplidiploid’

Role of Amphidiploid

- In the origin of new species in nature
- Meiosis is regular-bivalents
- No chance of sterility
- Bread wheat, rice, tobacco (*N. tabacum*), long staple cotton (*G. hirsutum*)- originate naturally

a. Cultivated wheat (2n=42)

- Hexaploid, auto-alloploidy



Auto-alloploidy

- Common tobacco-allotetraploid

Nicotiana sylvestris *X* *N. tomentosa*

2n=24 2n=24

Sterile Hybrid
2n=24

N. tabacum
4n=48

Gossipium hirsutum (2n=52)

- Long staple type cotton- allopolyploid
- A cross= short Indian cotton and American cotton

Gossypium herbaceum *X* *G rarimondii*

2n=26 (AA) 2n=26 (DD)

↓

Sterile Hybrid

2n=26 (AD)

↓ Chromosome doubling

G. hirshutum

4n=52

(AADD)

Synthetic Allotetraploid

- Karpenchenko (1927) : *Raphanorassica*
- *Raphanus sativas X Brassica oleraceae*

Radish (2n=18) × cabbage (2n=18)

↓

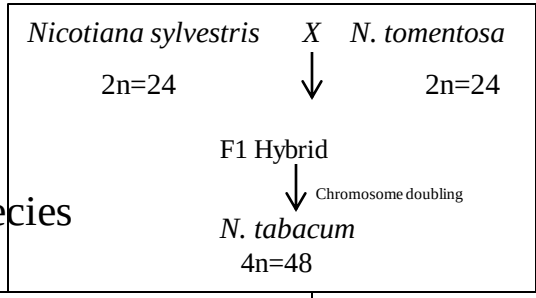
Sterile Hybrid
2n= 18

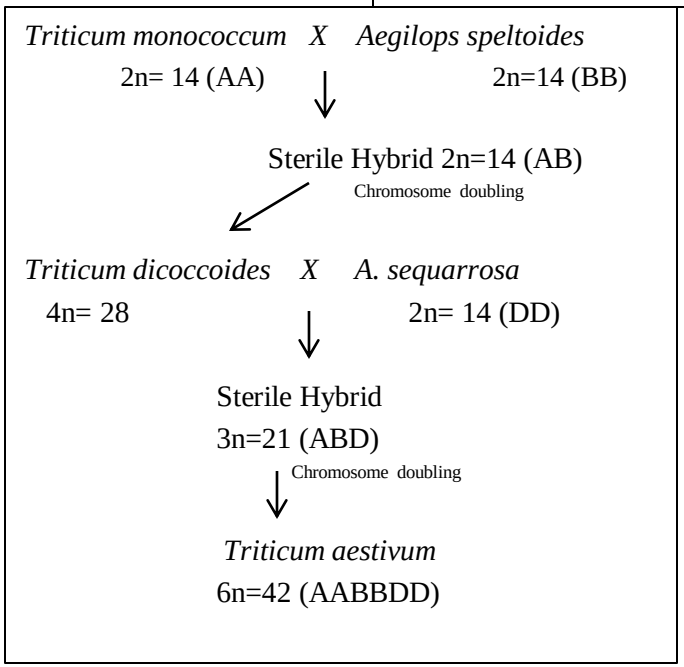
↓ Chromosome doubling (colchiploidy)

Raphanobrassica
4n=36
Root: cabbage
Foliage: raddish

Types of Allopolyploids

- Amphidiploids:
  - Chromosome doubling of F_1 sterile hybrid of 2-genetically isolated species
  - Behave like diploid (bivalents)
  - *Raphanobrassica*, *N. tabacum*, *G. hirsutum*
- Auto-allopolyploids:
  - Hexaploids or higher ploidy level
  - Single genome repeated 4 times
  - *Helianthus tuberosus*, *T. aestivum*
- Segmental allopolyploids
  - Two pairs of genome with some similarities
  - Some sort of synapsis may take place
  - Between auto and allopolyploid
  - *Solanum tuberossum*





Meiotic behaviour

- F_1: Univalent (haploid compliments-genetically different
- Irregular anaphasic separation
- Non functional gamete: Sterile hybrid
- Allotetraploid: chromosome doubling- allow the pairing
- Bivalents are formed- autosyndesis
- Segmentsl allopolyploids: genome having some similarities, pairing between chromosomes take place- Allosyndesis.