POLYPLOIDY PLANT BREEDING IN ALLOPOLYPLOID

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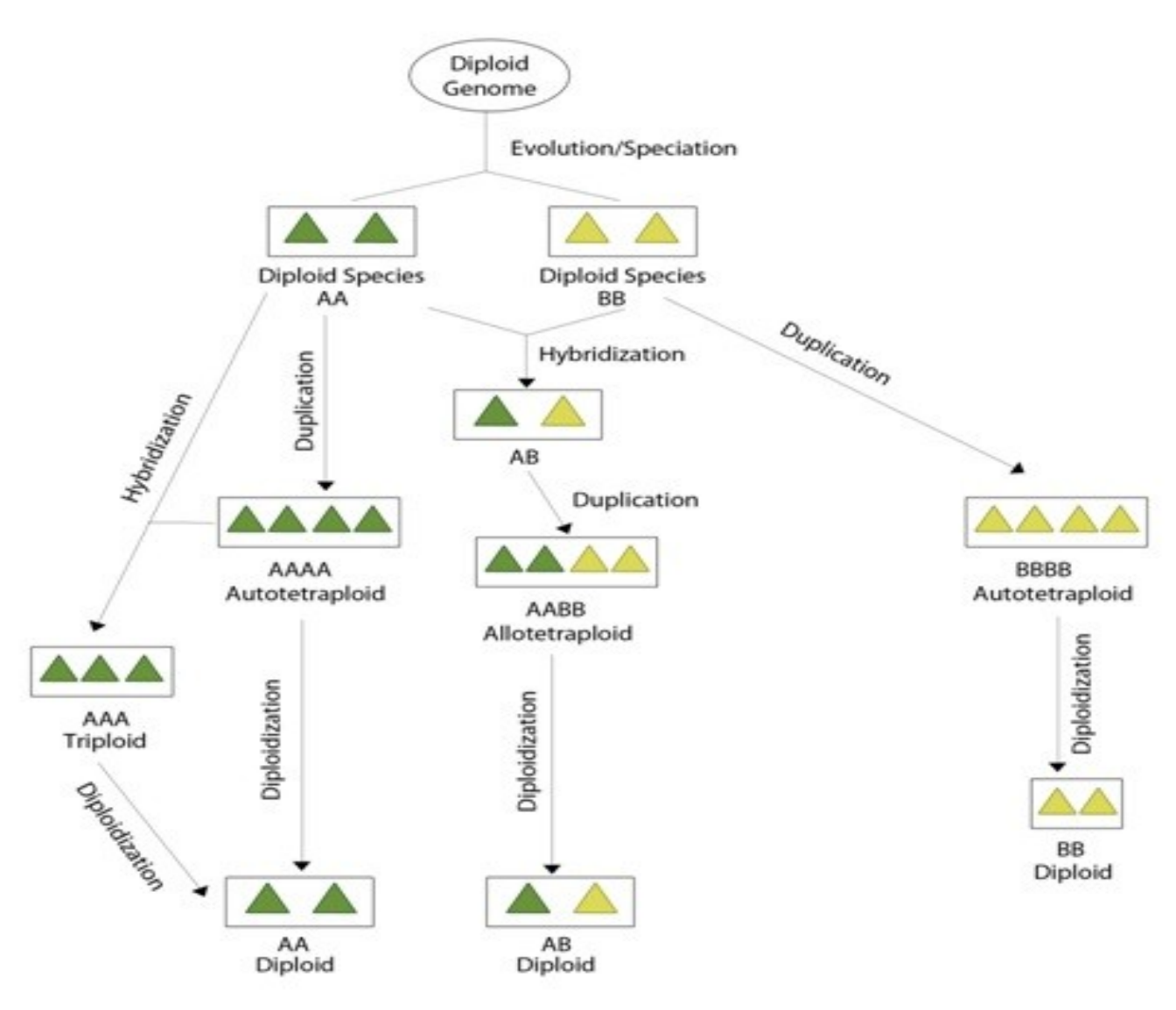
DEFINE

- Polyploids are organisms with multiple sets of chromosomes in **excess of the diploid number** (Acquaah, 2007; Chen, 2010; Comai, 2005; Ramsey and Schemske, 1998).
- Polyploidy is common in nature and provides a major mechanism for **adaptation and speciation**.
- Approximately **50-70% of angiosperms**, which include many crop plants, have undergone polyploidy during their evolutionary process (Chen et al., 2007)

- Flowering plants form polyploids at a significantly high frequency of 1 in every 100,000 plants (Comai, 2005)

EVOLULATION OF POLYPLOID



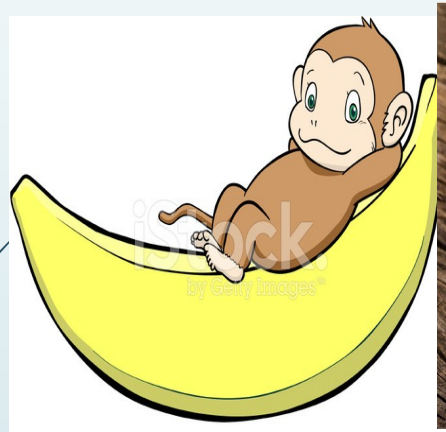
Classification of ploidy

- Based on their chromosomal composite
- **Euploids**
- **Aneuploids**.
- Euploids constitute the majority of polyploids

Euploidy

- Are polyploids with multiples of the complete set of chromosomes specific to a species.
- Depending on the composition of the genome,
- Tetraploidy is the most common class of euploids (Comai, 2005)
- **Euploids can be further classified into**
- **Autopolyploids**
- **Allopolyploids**

- Natural autoploids include tetraploid crops such as alfafa, peanut, potato and coffee and triploid banana




ANEUPLOID

- Are polyploids that contain either an addition or subtraction of one or more specific chromosome(s) to the total number of chromosomes that usually make up the ploidy of a species.

Table 5.2: Classification of aneuploids

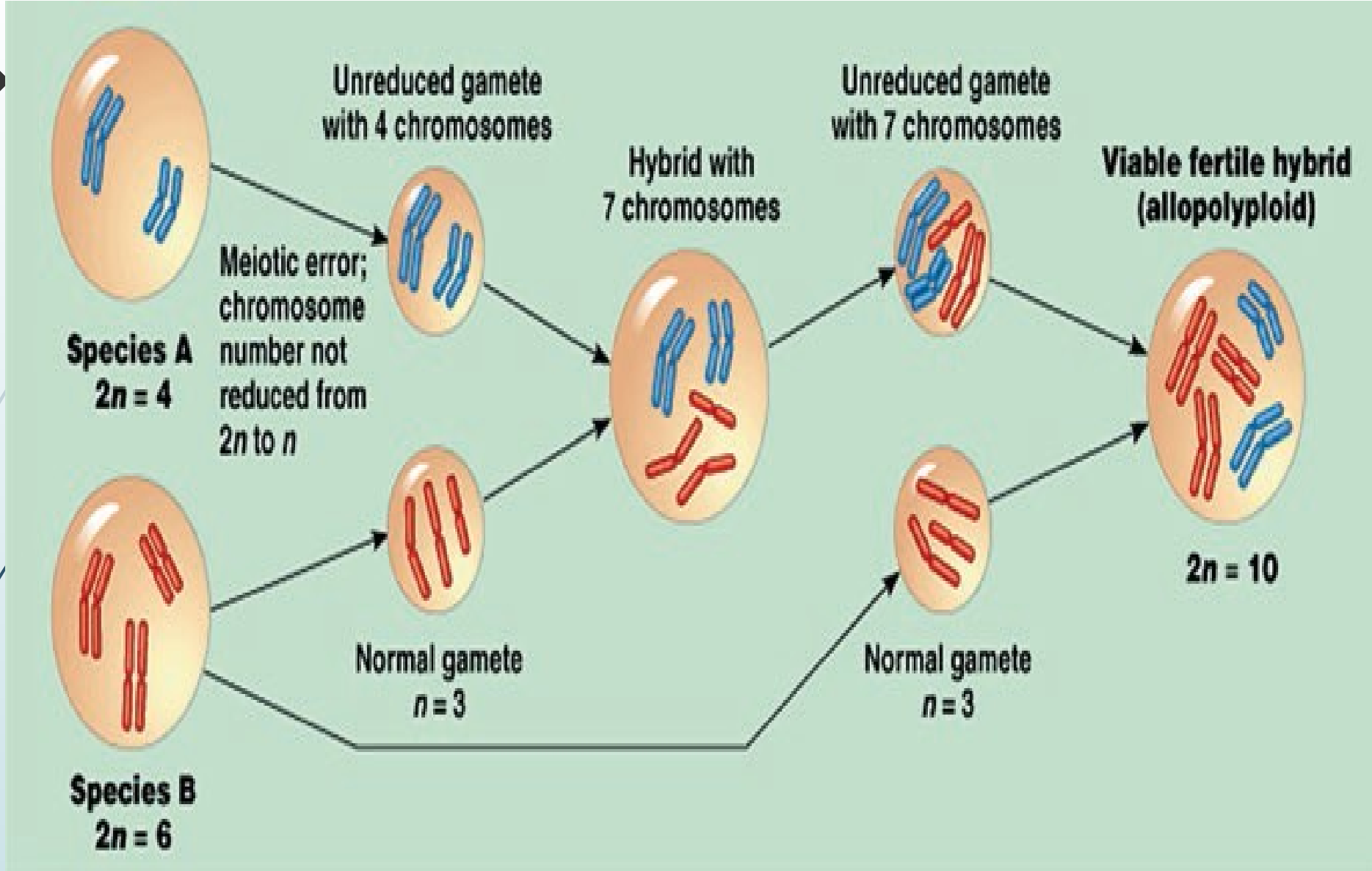
Term	Chromosome number
Monosomy	2n-1
Nullisomy	2n-2
Trisomy	2n+2
Tetrasomy	2n+2
Pentasomy	2n+3

Table 5.1: A list of major crops and their ploidy

Common name	Ploidy	Name	Propagation
Maize	2x=20	Diploid	Outcrossing
Wheat	6x=42	Hexaploid	Outcrossing
Rice	2x=24	Diploid	Selfing
Potatoes	4x=48	Tetraploid	Outcrossing; Vegetative
Soybeans	2x=40	Diploid	Selfing
Barley	2x=14	Diploid	Selfing
Tomatoes	2x=24	Diploid	Selfing
Bananas	3x=33	Triploid	Vegetative
Watermelon	2x=22	Diploid	Outcrossing
Sugarcane	8x=80	Octoploid	Outcrossing; vegetative
Sugar beet	2x=18	Diploid	Outcrossing
Cassava	2x=36	Diploid	Outcrossing; Vegetative

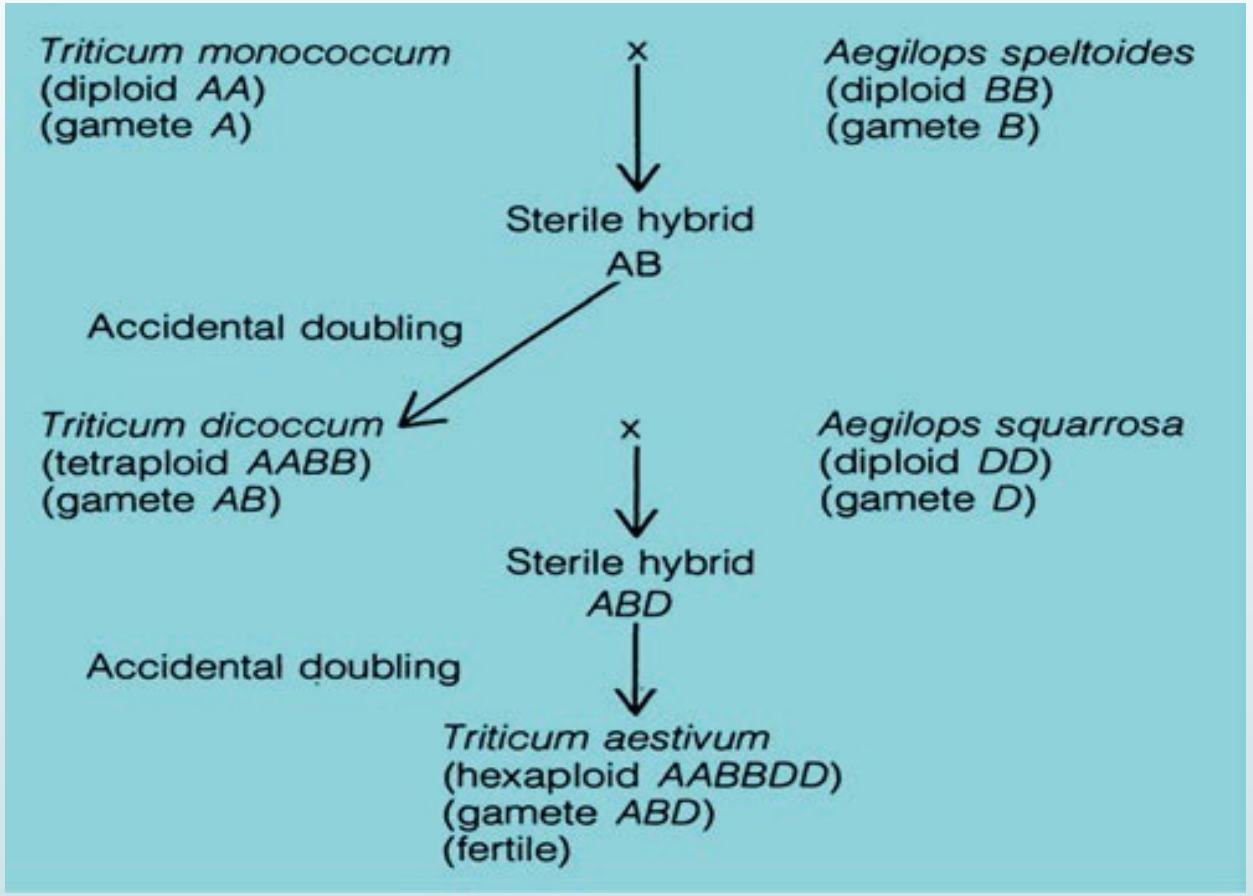
Origin of Allopolyploidy

- The polyploids with chromosomes derived from different species are called allopolyploids
- The fusion of reduced 1*n* gamete with unreduced 2*n* gamete gives rise to 3*n* zygote followed by the subsequent fusion of 1*n* reduced gamete with 3*n* gamete in the next generation giving rise to a tetraploid individual.
- This two-step process of allopolyploid production is sometimes referred to as a **triploid bridge.**
- Environment and genotype have the influence on the formation of nonreduced gametes



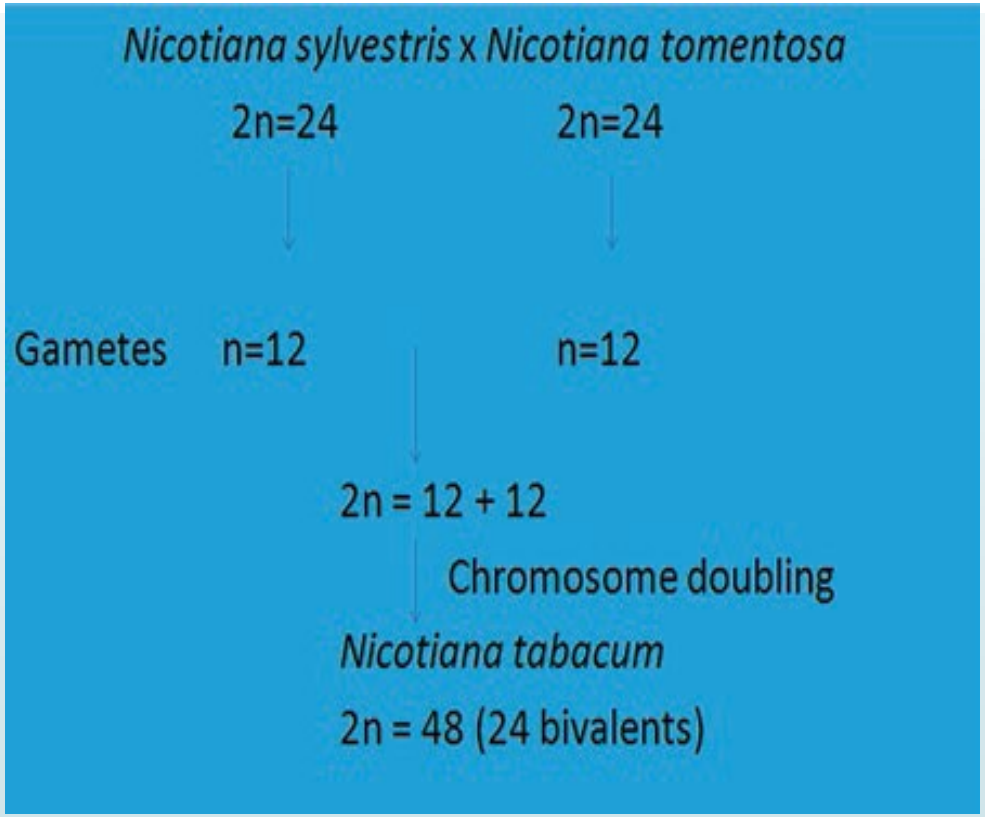
The origin of allopolyploid from unreduced and reduced gametes (Source: Campbell's Biology, page 454, 5th Edition)

(i) Bread wheat (*Triticum aestivum)*



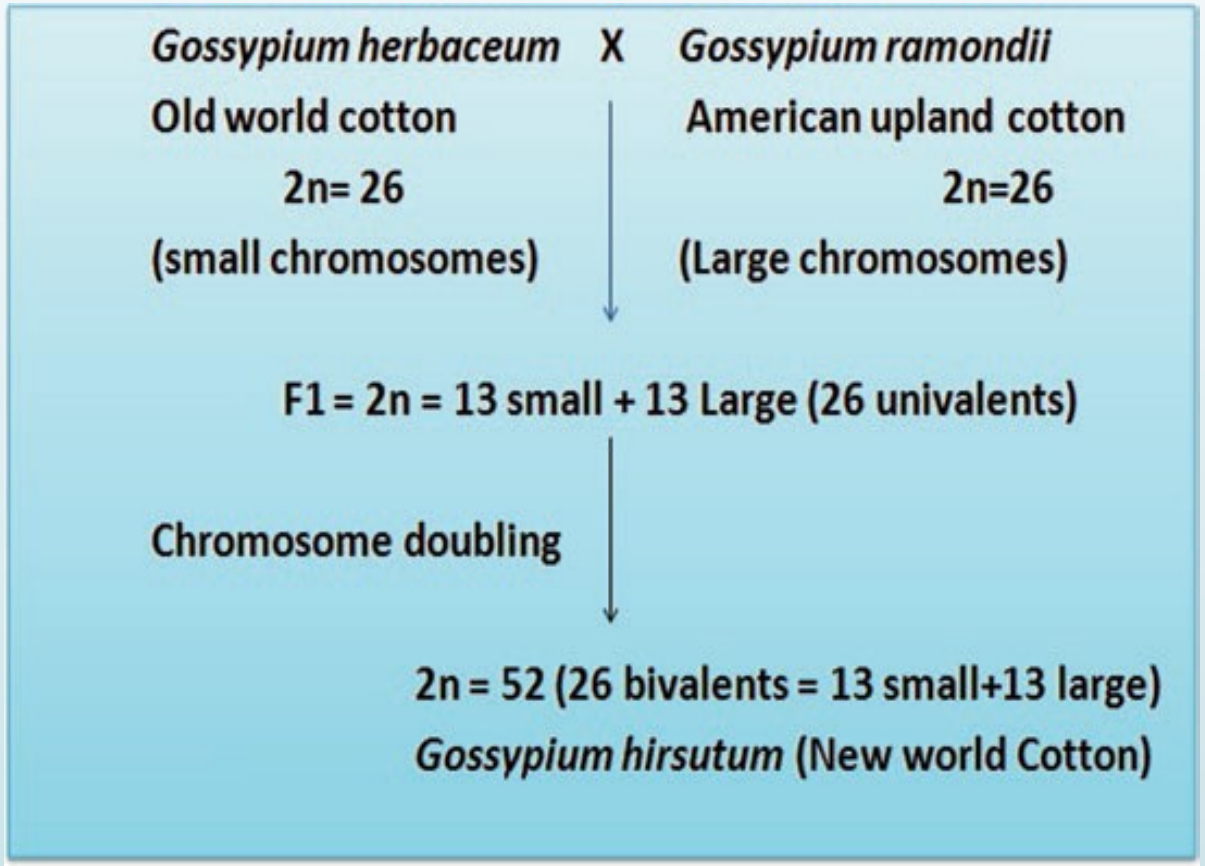
Evolution of bread wheat (*Triticum aestivum) (Source: http://www.ibri.org/Books/* Pun_Evolution/Figures/Fig03-12.gif

(ii) Tobacco (*Nicotiana tabacum)*



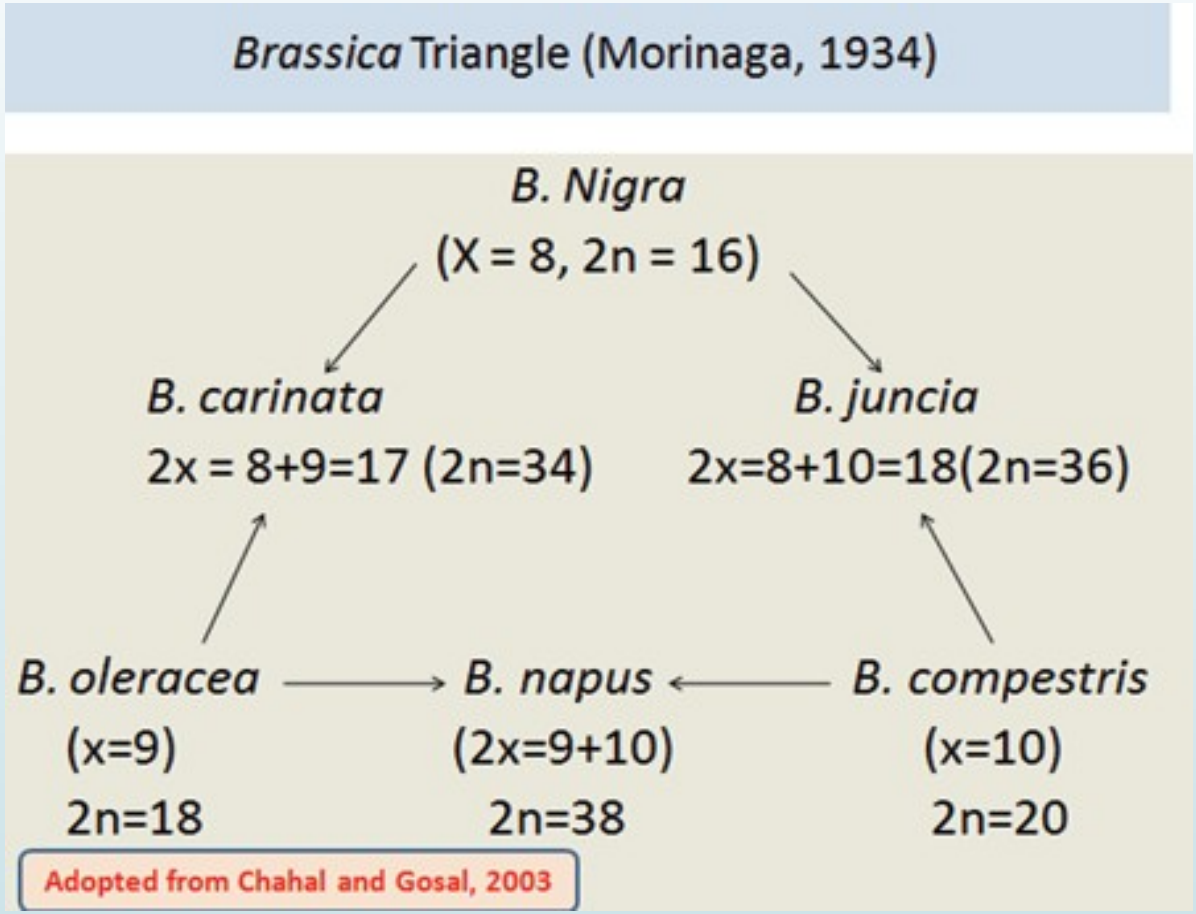
Evolution of *Nicotiana tabacum*

(iii) Cotton (*Gossypium hirsutum)*



Evolution of cotton (*Gossypium hirsutum)*

(iv) Amphidiploid *Brassica species*



Economically important natural alloploid crops include strawberry, wheat, oat, upland cotton, oilseed rape, blueberry and mustard

Characteristics of Allopolyploids

- Larger cells
- Vigorous plant
- Less complex than autopolyploids
- Recessive characters may appear less frequent

(A) diploid (B) induced tetraploid

Applications of Allopolyploidy

- Bridge crossing
- Creation of new crop specie
- Widening the genetic base of existing allopolyploids

Advantages of polyploids

- Identify genetic origin of plant species
- Produce new plant genotypes and plant species
- Facilitate transfer of genes from related species
- Facilitate transfer of individual chromosomes or pairs of chromosomes

DISADVANTAGE

- The effects of allopolyploidy cannot be predicted
- Newly synthesized allopolyploids have many defects
- The synthetic allopolyploids have to be improved through extensive breeding at the polyploid level
- Only a small proportion of allopolyploids are promising

Table 10.2 Some allopolyploid crop species and their gametic chromosome numbers

Scientific name	Common name	Gametic ch. no.	Cultivated/wild
Avena strigosa	Sand oats	7	Wild
A. barbata	Slender wild oats	14	Wild
A. sativa	Cultivated oats	21	Cultivated
A. byzantine	Cultivated red oats	21	Cultivated
Brassica nigra	Black sarson	8 (B)[a]	Cultivated
B. oleracea	Cabbage, cauliflower, etc.	9 (C)	Cultivated
B. campestris	Turnip rape	10 (A)	Cultivated
B. carinata	Abyssinian cabbage	17	Wild
B. juncea	Rai, Indian mustard	18	Cultivated
B. napus	Rape	19	Cultivated
Gossypium arboreum	Asiatic (desi) cotton	13 (A_2)	Cultivated
G. herbaceum	Asiatic cotton	13 (A_1)	Cultivated
G. thurberi	Wild American cotton	13 (D_1)	Wild
G. barbadense	Sea island (Egyptian) cotton	26 (A_2D_2)	Cultivated
G. hirsutum	American upland cotton	26 (A_1D_1)	Cultivated
Hordeum vulgare	Cultivated barley	7	Cultivated
H. jubatum	Squirrel tail barley	14	Wild
H. nodosum	Foxtail barley	21	Wild
Medicago hispida	California burclover	7	Cultivated
M. lupulina	Black medic	8, 16	Cultivated
M. falcate	Yellow alfalfa	8, 16	Cultivated
Nicotiana sylvestris	Wild tobacco	12	Wild
N. tomentosa	Wild tobacco	12	Wild
N. tabacum	Cultivated tobacco	24	Cultivated
N. rustica	Cultivated tobacco	24	Cultivated
N. bigelovii	Wild tobacco	24	Wild
N. debneyi	Wild tobacco	24	Wild
Prunus americana	American plum	8	Cultivated
P. avium	Sweet cherry	8	Cultivated
P. persica	Peach	8	Cultivated
P. cerasus	Sour cherry	16	Cultivated
P. domestica	European plum	16	Cultivated
Saccharum officinarum	Noble canes	40	Cultivated
S. barberi	Indian canes	41, 45, 46, 58, 62	Cultivated
S. sinensis	Indian canes	58, 59	Cultivated
S. spontaneum	Wild canes	20–64	Wild

(continued)

Table 10.2 (continued)

Scientific name	Common name	Gametic ch. no.	Cultivated/wild
S. robustum	Wild canes	30–74	Wild
Sorghum versicolor	Wild sorghum	5	Wild
S. bicolor	Jowar	10	Cultivated
S. halepense	Johnson grass	20	Cultivated
Trifolium pratense	Red clover	7	Cultivated
T. alexandrinum	Berseem clover	8	Cultivated
T. repens	White clover	16	Cultivated
T. medium	Zigzag clover	40, 48, 42, 49	Cultivated
Triticcum monococcum	Wild einkorn	7 (A)	Wild
T. turgidum var. dicoccoides	Wild emmer	14 (AB)	Wild
T. turgidum var. dicoccum	Emmer wheat	14 (AB)	Cultivated
T. turgidum var. turgidum	Solid stem wheat	14 (AB)	Cultivated
T. turgidum var. carthlicum	Persian wheat	14 (AB)	Cultivated
T. turgidum var. polonicum	Polish wheat	14 (AB)	Cultivated
T. turgidum var. durum	Durum wheat	14 (AB)	Cultivated
T. timopheevii	–	14 (AG)	Cultivated
T. timopheevii var. americanum	–	14 (AG)	Wild
T. aestivum var. spelta	Spelt wheat	21 (ABD)	Cultivated
T. aestivum var. aestivum	Common bread wheat	21 (ABD)	Cultivated
T. aestivum var. macha	–	21 (ABD)	Wild
T. aestivum var. compactum	Club wheat	21 (ABD)	Cultivated
T. aestivum var. sphaerococcum	Indian dwarf wheat	21 (ABD)	Wild
T. zhukovskyi	–	21 (AAG)	Cultivated

[a]Letters within parentheses denote the genomes present in the species
Source: Singh BD (2012), Plant Breeding, Principles and Methods

References

- Ranney, Thomas G. Polyploidy: From Evolution to New Plant Development. Combined Proceedings International Plant Propagators' Society, Volume 56, 2006, pp.137- 142. http://www.ces.ncsu.edu/fletcher/mcilab /publications/ranney-2006.p
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