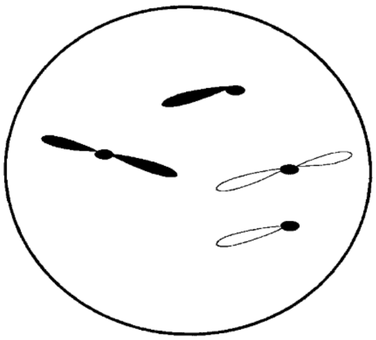
Stages of mitosis

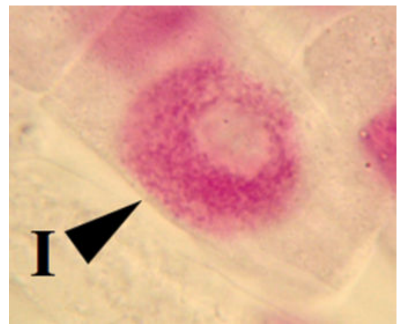
Photo credits: http://botit.botany.wisc.edu/images/130/Mitosis/Allium_Root_Prep._Slides

For a cell that is 2n = 2x = 4

Interphase

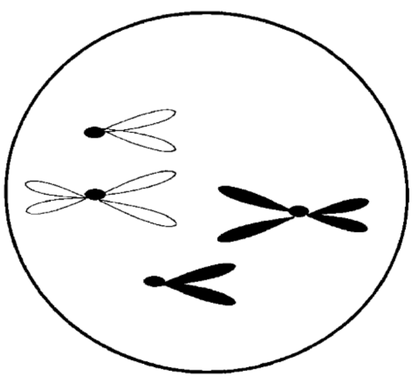


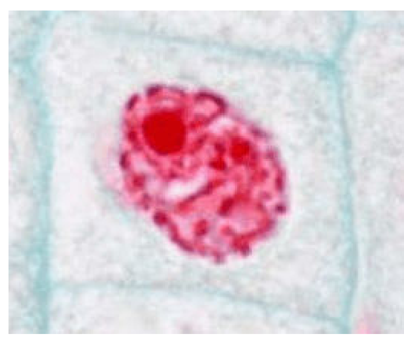
Would be decondensed, shown condensed in the diagram to show individual chromosomes



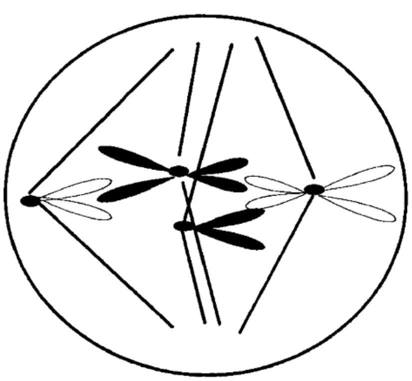
Paperwhite (Narcissus papyraceus) courtesy of course alumna Chandler Maddox

Prophase

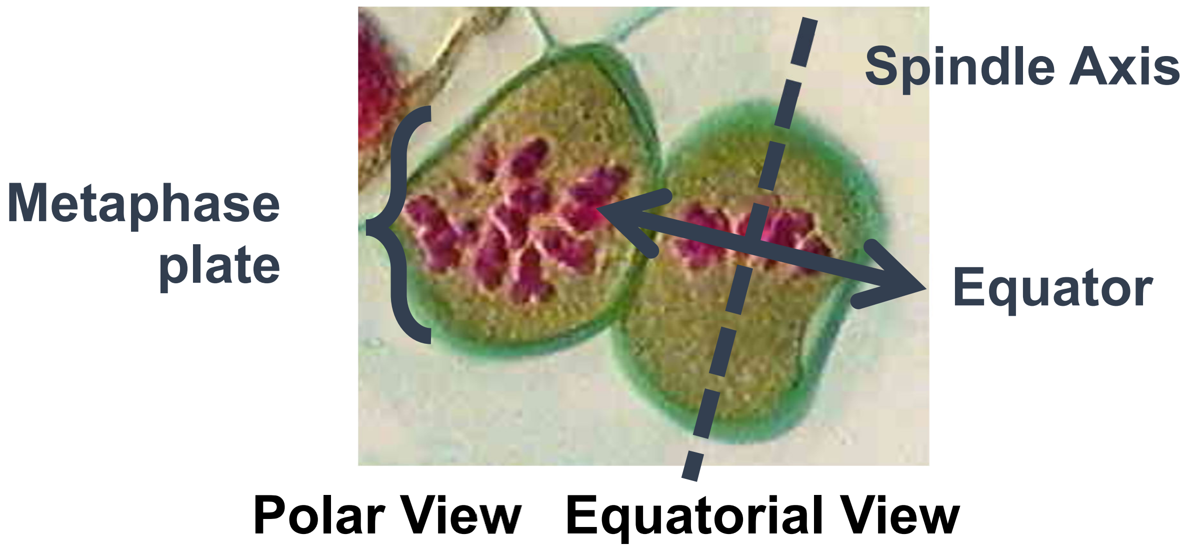




Metaphase

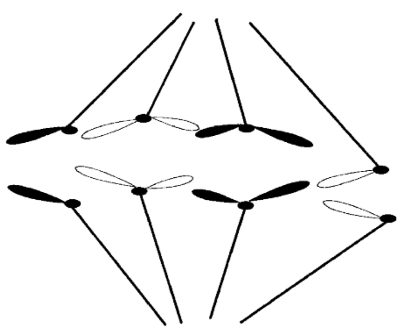


Orientation Terminology

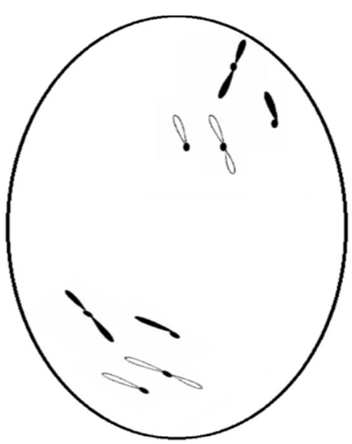


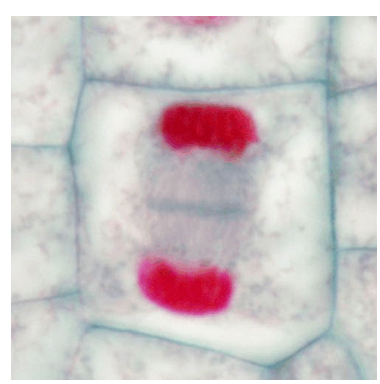
https://www.iasprr.org/old/iasprr-pix/lily/meta-i.jpg

Anaphase

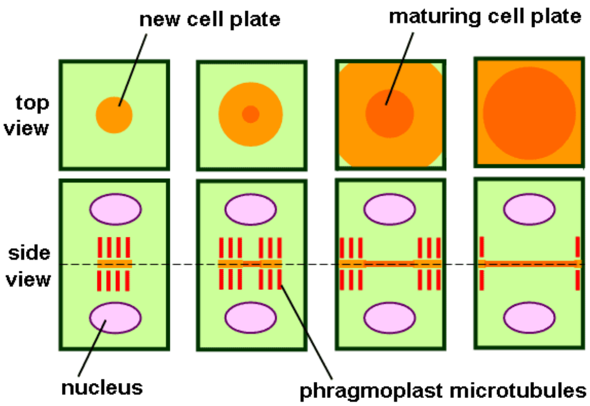


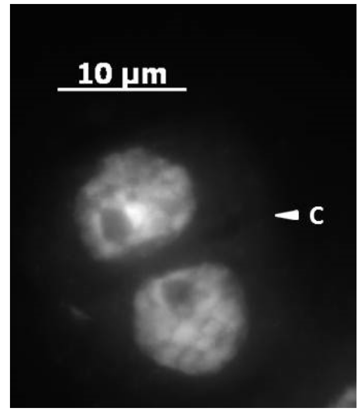
Telophase





Cytokinesis





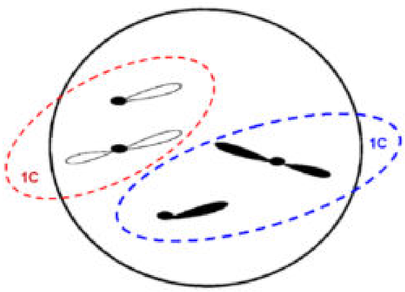
Cotton, courtesy of course alumnus Nino Brown

Chromosome Number Convention

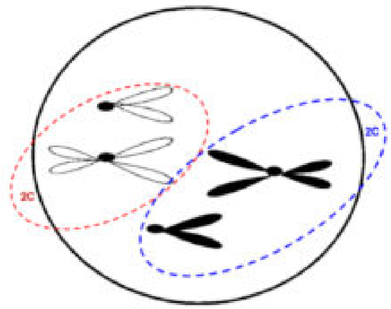
Swift, 1950. Physiol. Zool. 23:169-191

_n = _x = _c = ___

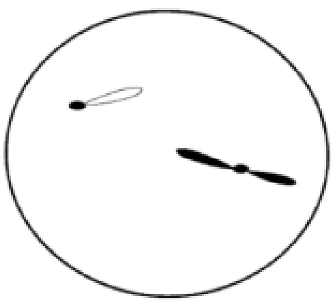
A cell with



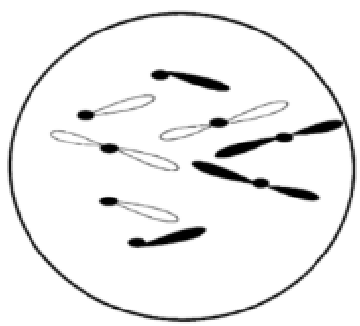
When the previous cell is ready for meiosis, it becomes

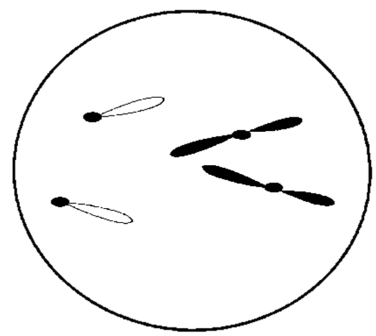


Following meiosis, each resulting gamete would be



When the tetraploid cell undergoes meiosis, the resulting cell would be

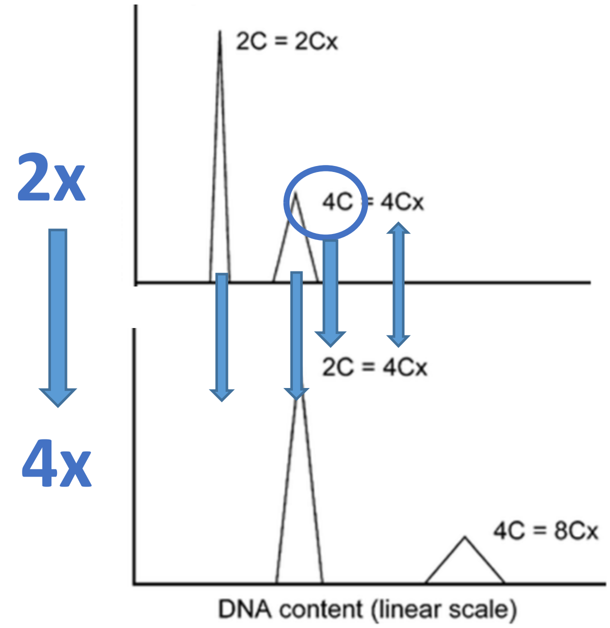




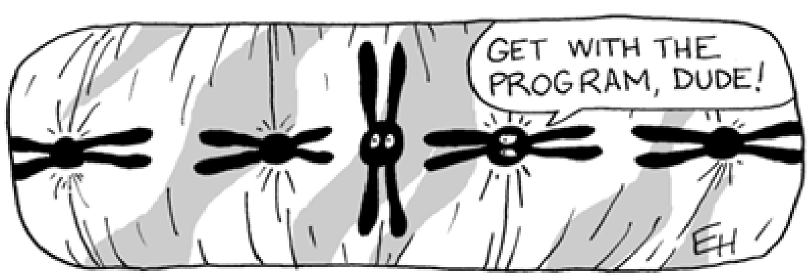
If the chromosome number of the original cell is doubled with colchicine, it becomes

C_x Terminology

Greilhuber et al., 2005



Modifications to Mitosis



Normal cell division entails:

A. DNA replication
B. Sister chromatid separation
C. Chromosome separation (nuclear division)
D. Cytokinesis

Interruptions to mitosis

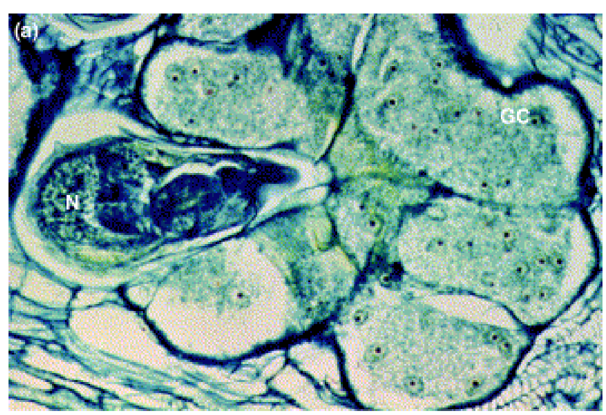
1. A → B → C $\cancel{\rightarrow}$ D multinucleate condition, syncytium
2. A → B $\cancel{\rightarrow}$ C $\cancel{\rightarrow}$ D **endomitosis,** which leads to **polysomaty**
3. A $\cancel{\rightarrow}$ B $\cancel{\rightarrow}$ C $\cancel{\rightarrow}$ D **endoreduplication,** which leads to **polyteny**
4. B → C → D **reduction**, as in Meiosis I; **somatic reduction**
5. A → B → C → D (abnormal) **aneusomaty**, e.g. sports in plants

Interruption before cytokinesis

A → B → C $\cancel{\rightarrow}$ D

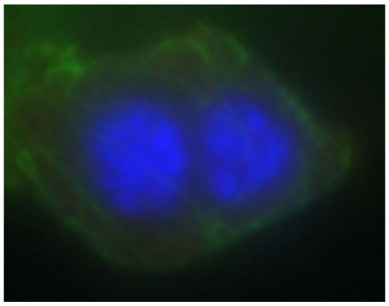
Multinucleate conditions

Drosophila multinucleate condition during embryogenesis

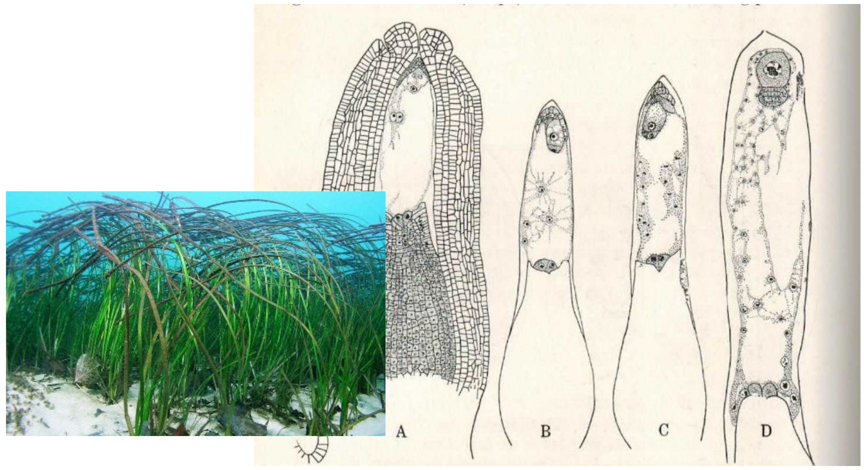


A (N) nematode at the 9 o'clock position and multinucleate (GC) giant cells upon which it feeds. Photo by RS Hussey.

Multinucleate cells



Maize tapetum cells
Course alumnus, Kyle Swentowsky



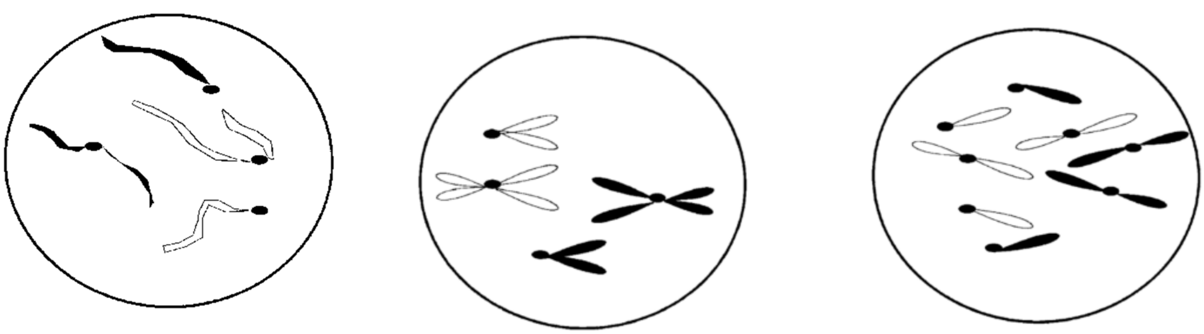
Endosperm formation in eelgrass, Zostera marina (Dahlgren, 1939)

Eelgrass photo: https://aggietranscript.ucdavis.edu/the-relationship-between-genetic-diversity-and-disturbance-in-the-eelgrass-species-zostera-marina/

Endomitosis and Polysomaty

A → B ~~→~~ C ~~→~~ D

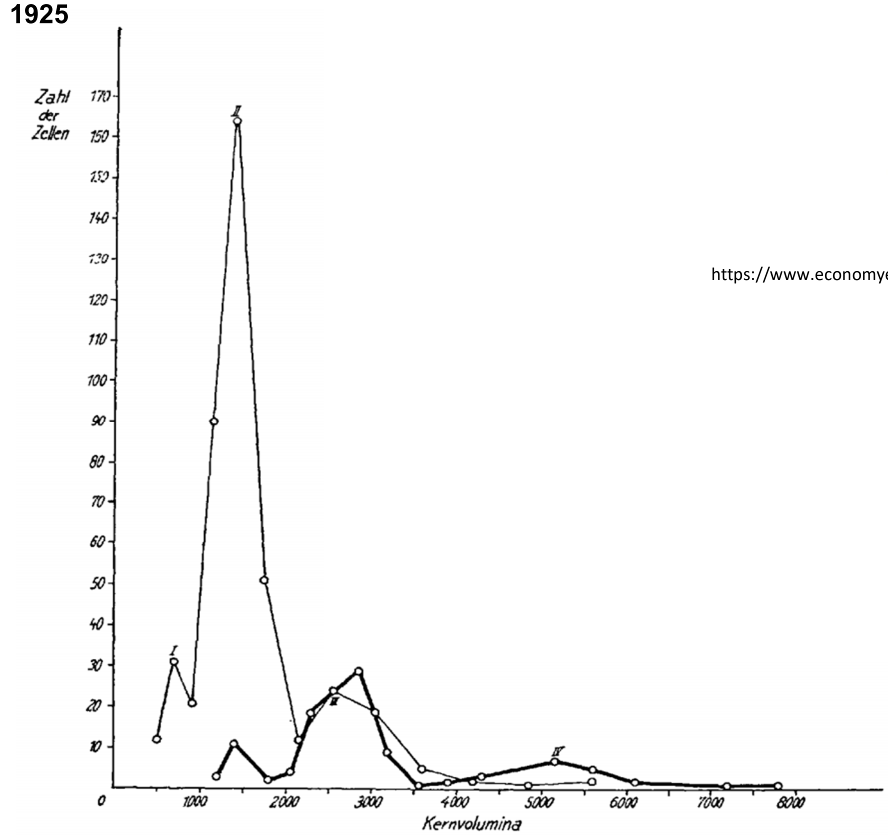
- Chromosomes are replicated but do not segregate
- One nucleus re-forms around a doubled chromosome set



Endoprophase Endometaphase Endoanaphase

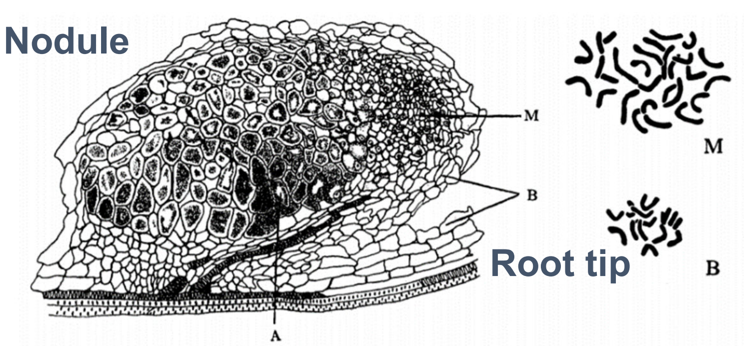
2n = 2x = 2C = 4

Jacobj, 1925

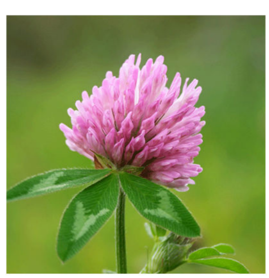


https://www.economyexterminators.com/pest/house-mice/

Wipf & Cooper, 1938; Wipf, 1939



Common vetch
Vicia angustifolia
2n = 12



Red clover
Trifolium pratense
2n = 14

Pea
Pisum sativum
2n = 14

https://pladias.cz/en/taxon/overview/Vicia%20angustifolia
https://www.seed-bank.ca/product/red-clover-seeds/
https://www.mediastorehouse.com/auscape/photographer-galleries/nature-production-collection/pea-pisum-sativum-18980773.html

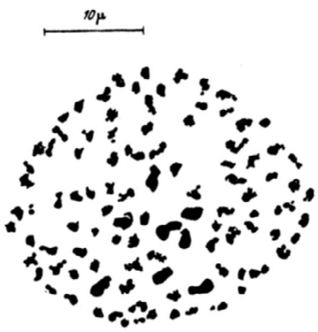
Wipf, 1939

Anaphase in a nodule of 8x alfalfa, with 128 chromosomes going to each pole

http://www.glbinvest.com/abouttheproject/alfalfa

Alfalfa
Medicago sativa
2n = 2x = 16
2n = 4x = 32
2n = 8x = 64 → 2n = 16x = 128

Geitler, 1939

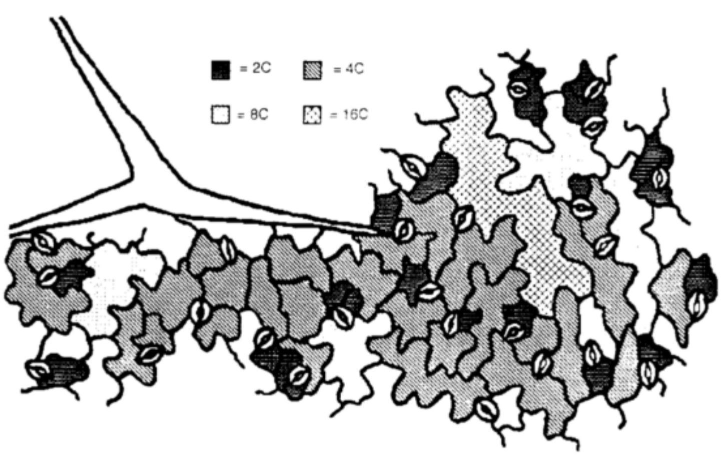


A cell with 8 heteropigmatic X chromosomes, indicating the cell is 16x.

Gerris lateralis

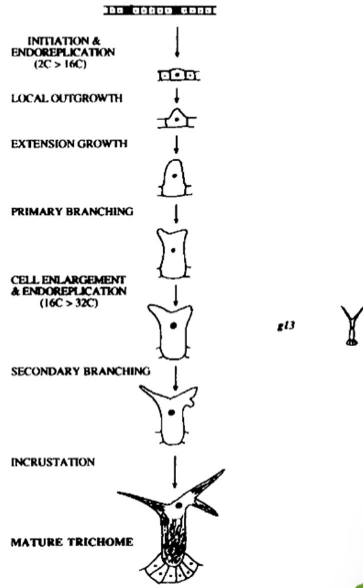
Wikimedia commons

- **Pattern can be highly variable**

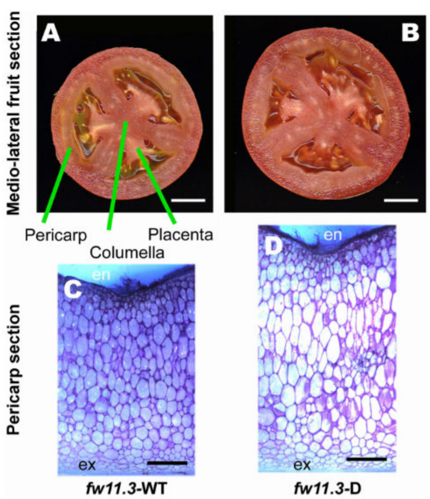


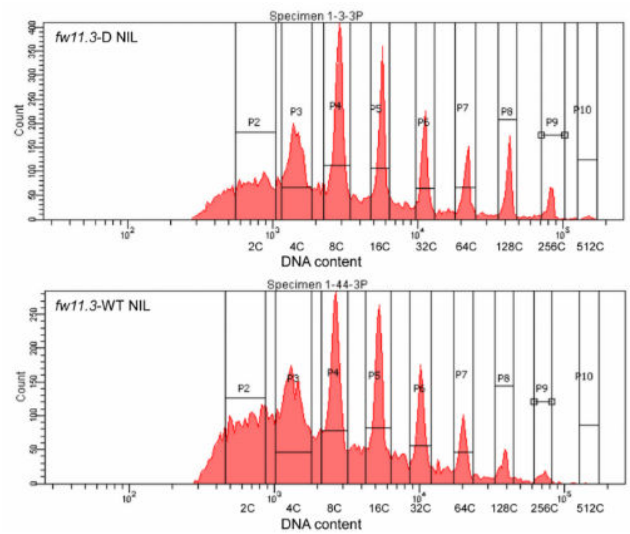
*From **Melaragno et al., 1993**. Endopolyploidy in the polysomatal epidermis of arabidopsis*

Hülskamp et al., 1994



Mu et al., 2017 (van der Knaap lab) - Endopolyploidy & fruit size

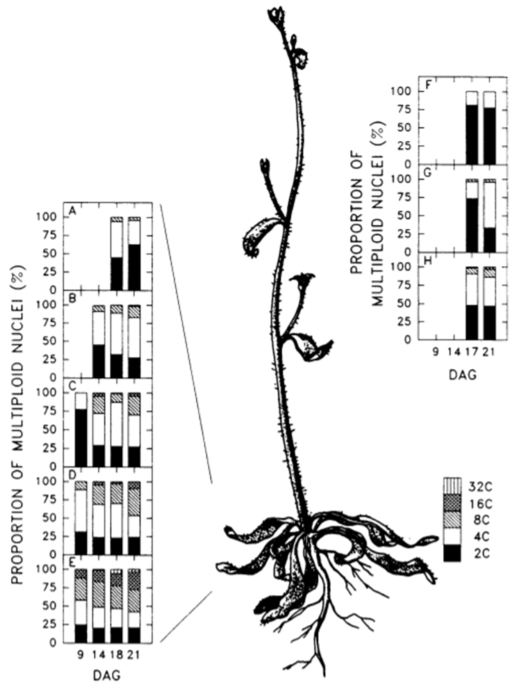


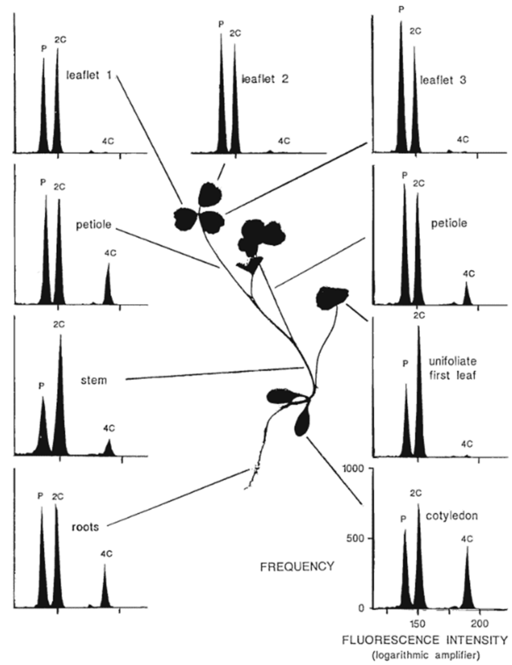


• Endopolyploidy in different tissues

Galbraith et al., 1991

Blondon et al., 1994





• Levels of endopolyploidy

Nagl, 1976; 1978

Family	Species	Cells/tissues	Endopoly-ploidy x=genome
Araceae	Arum maculatum	endosperm austoria	24,576x
Cucurbitaceae	Cucumis sativus	nucellus	16x
Fabaceae	Lupinus regalis	tapetum	8x
	Phaseolus coccineus	suspensor	4,096x
	P. vulgaris	endosperm	96x
	Vicia faba	stem epidermis	61x
Geraniaceae	Geranium phaeum	integument	512x
Rosaceae	Prunus sp.	fruit	32x
Crassulaceae	Crassula arborescens	mesophyll	16x

- **DNA content vs ploidy level**

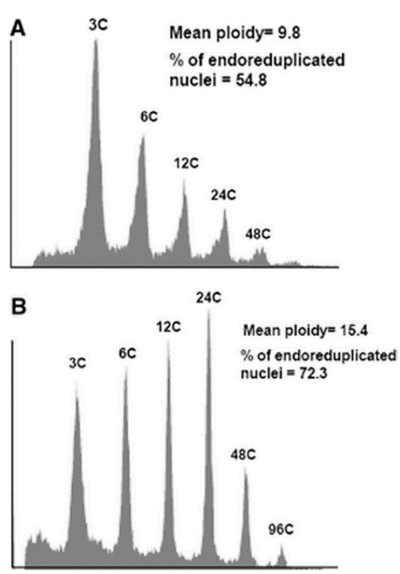
Nagl, 1976

Nuclear DNA contents and maximum endopolyploidy levels in various plants and animals

Species	DNA (pg/2C)	Max. C level
Capsella bursa-pastoris	1.7	1,024
Cucurbita pepo	2.6	384
Phaseolus coccineus	2.7	8,192
Tropaeolum majus	2.7	2,048
Helianthus annuus	6.1-9.9	16
Hordeum vulgare	13.4	256
Lathyrus spp.	9-20	64
Vicia faba	23.9 - 28.7	16
Allium cepa	35.5	8
Drosophila melanogaster	0.36	2,048
Chironomus tentans	0.5	32,768
Bombyx mori	1.0	524,288
Aplysia californica	2.0	200,000
Rattus rattus	6.1	4,096

- **Genetic control**

Coelho et al., 2007



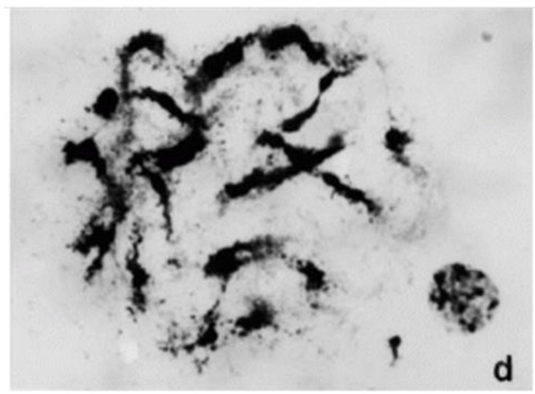
Endoreduplication in maize inbreds Mo17 (top) and Sg18 (bottom)

Polyteny

$A \cancel{\rightarrow} B \cancel{\rightarrow} C \cancel{\rightarrow} D$

Mosquito polytene chromosomes

Cowpea polytene chromosomes

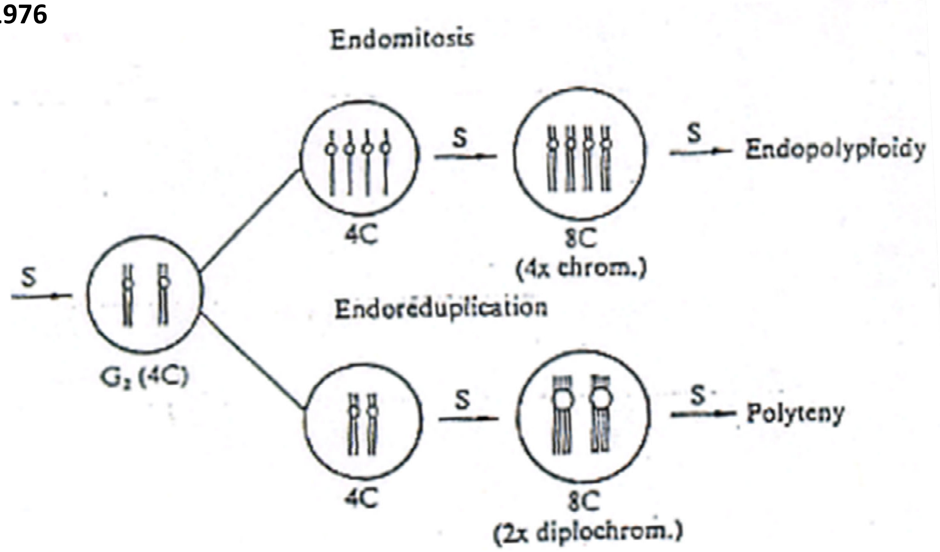


Cowpea tapetal cell. Note a nucleus containing non-polytene chromosomes right over the "d"

Mosquito: http://www.impact-malaria.com/FR/EPS/Formations_et_cours_internationaux/Formation_de_la_Liverpool_School_LSTMH/cours_liverpool/Unit_2/2_8.html
Cowpea: Carvalheira GMG. 2000. Plant polytene chromosomes. Genet. Mol. Biol. 23:1043-1050.

- **Endomitosis vs Endoreduplication**

  Nagl, 1976



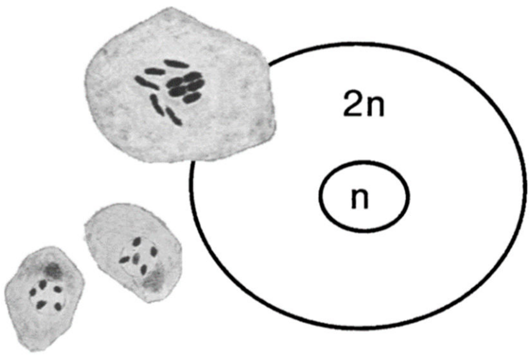
Somatic reduction

→ B → C → D

Schrader, 1921; Schrader and Hughes-Schrader, 1931

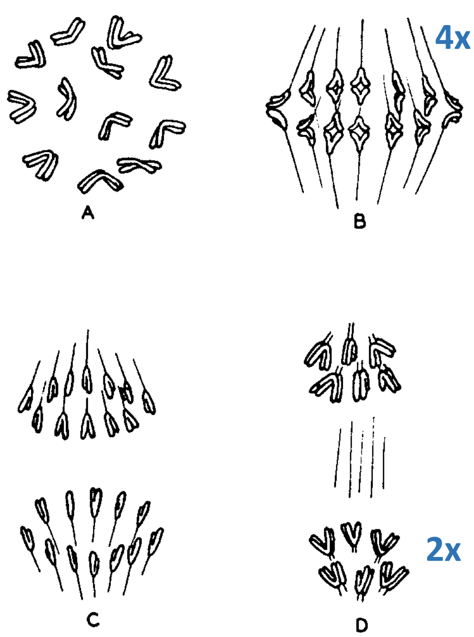
Coconut mealybug, Nipaecoccus nipae. Photograph by Lyle J. Buss, University of Florida

- **Haplodiploid**
  - Paternal genome loss



Sally Hughes-Schrader (1895–1984)
Franz Schrader (1891–1962)
From Richmond, 2020

Berger, 1938



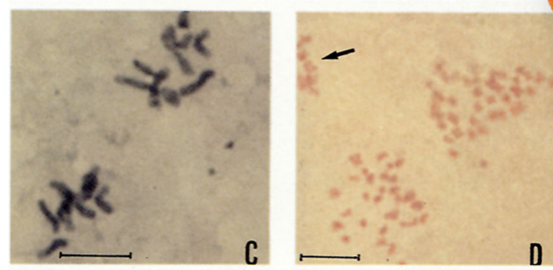
Culex pipiens, 2n = 6

https://www.eurekalert.org/multimedia/pub/132452.php

- **Reductional groupings**

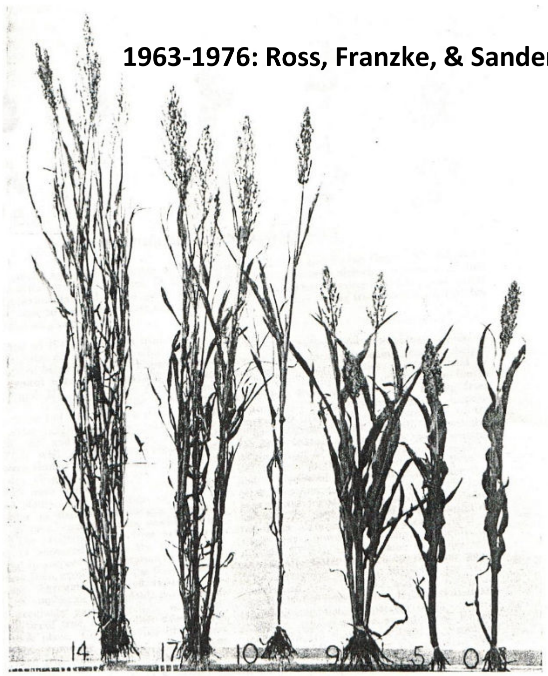
Huskins, 1948

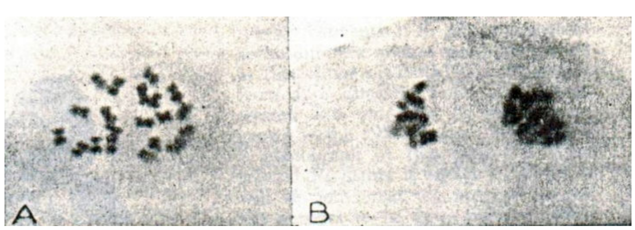
Nuti Ronchi et al., 1992



- **True-breeding mutants of sorghum**

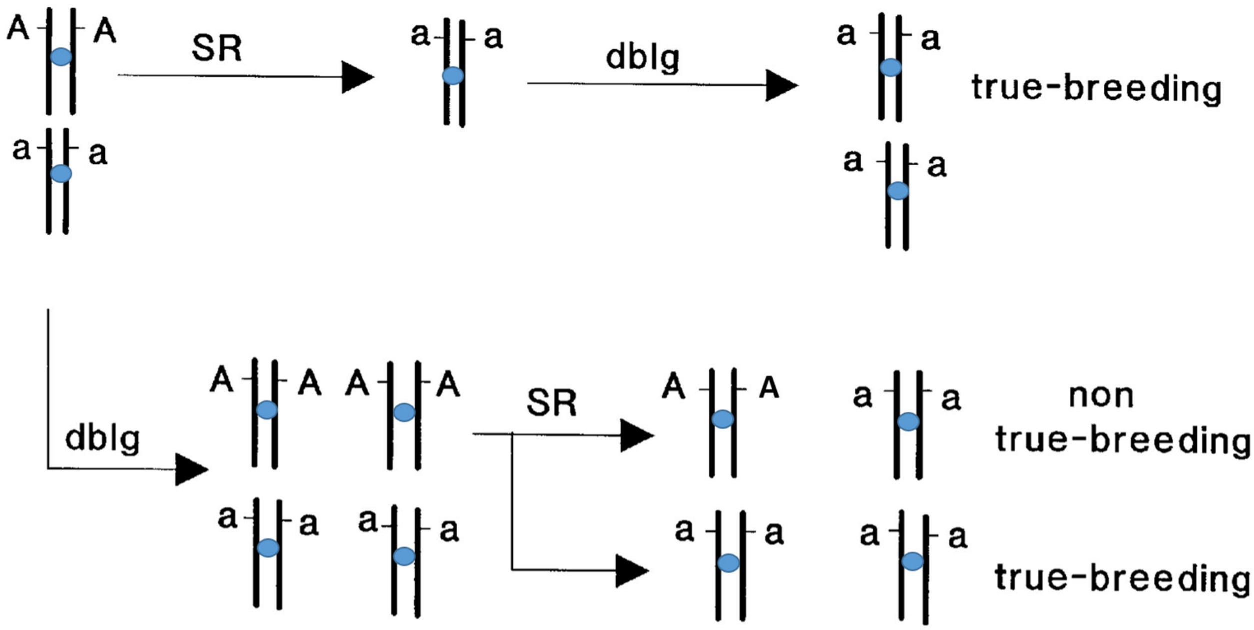
1963-1976: Ross, Franzke, & Sanders



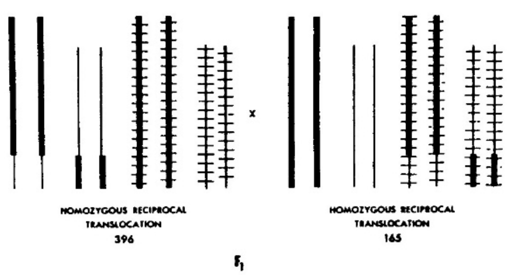


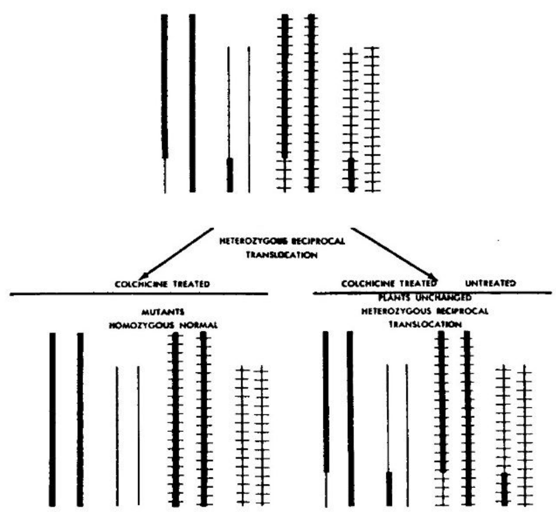
Franzke & Ross, 1952

Hypothesis



Simantel & Ross, 1963





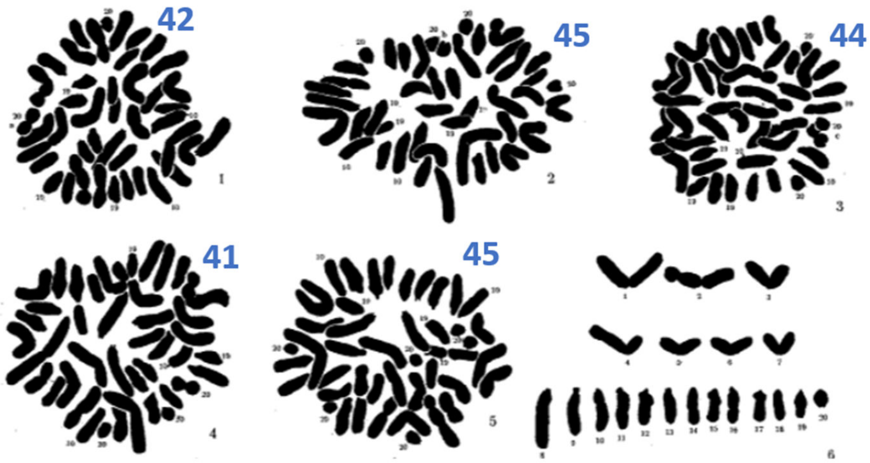
COLCHICINE-INDUCED HOMOZYGOSITY

Aneusomaty

A → B → C → D

Termed by Duncan 1945

Paphiopedilum wardii, Wikimedia commons



Britton & Hull, 1957

- Root tips from the same blackberry plant
- Both parents were 2n = 49