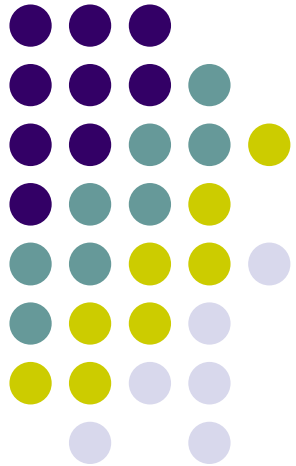
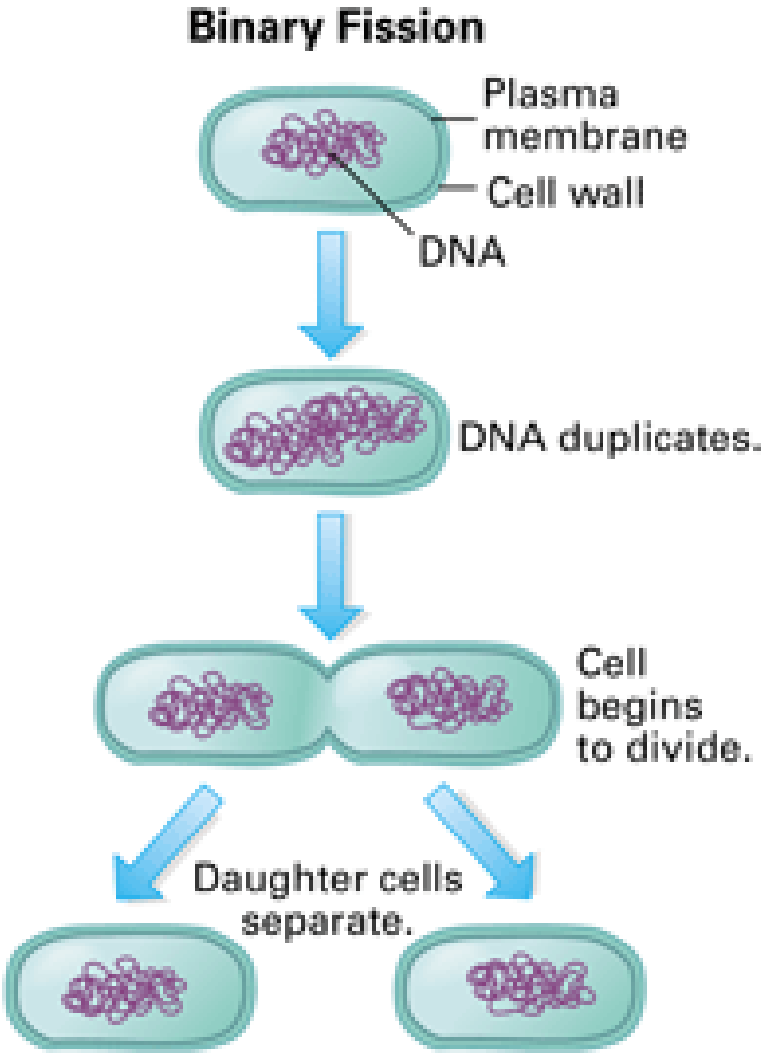
Cell division: mitosis and meiosis

Judit Varga

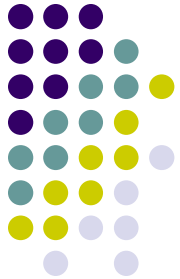


Cell division in prokaryotes - Fission



http://www.mtchs.org/BIO/text/chapter16/16images/16-11.gif

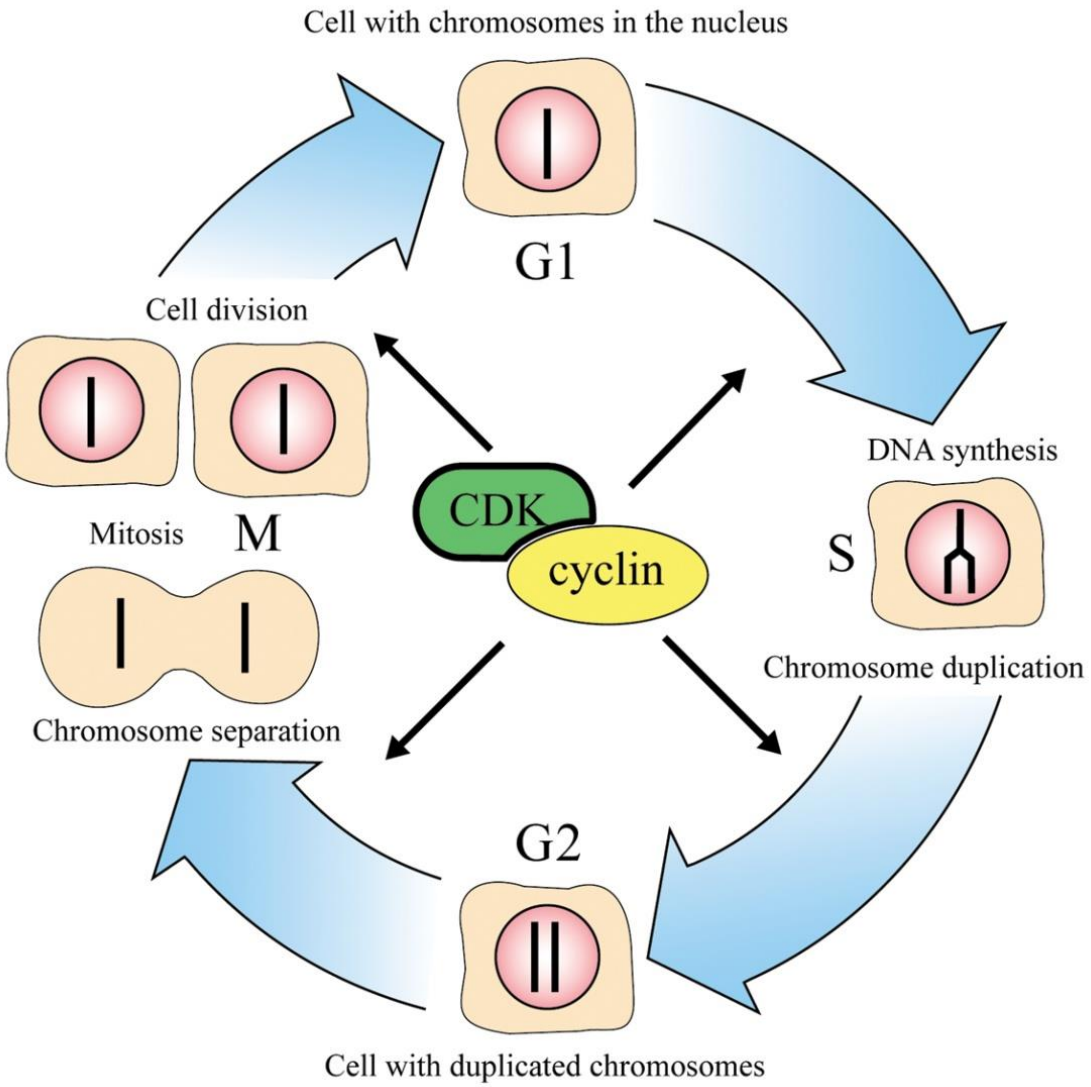
The cell cycle (of somatic cells)



- interphase + M phase (cell division)
  - somatic cells → mitosis
  - germ cells → meiosis

- interphase:
  - G_1 phase:
    - diploid cells, 2n → 46 one-chromatid chromosomes
    - synthesis of proteins and organelles, energy production
    - G_0 phase: quiescent cells (e.g. neurons)
  - S phase:
    - DNA replication → production of two-chromatid chromosomes
    - duplication of centrosome
  - G_2 phase:
    - tetraploid cells, 4n → 46 two-chromatid chromosomes

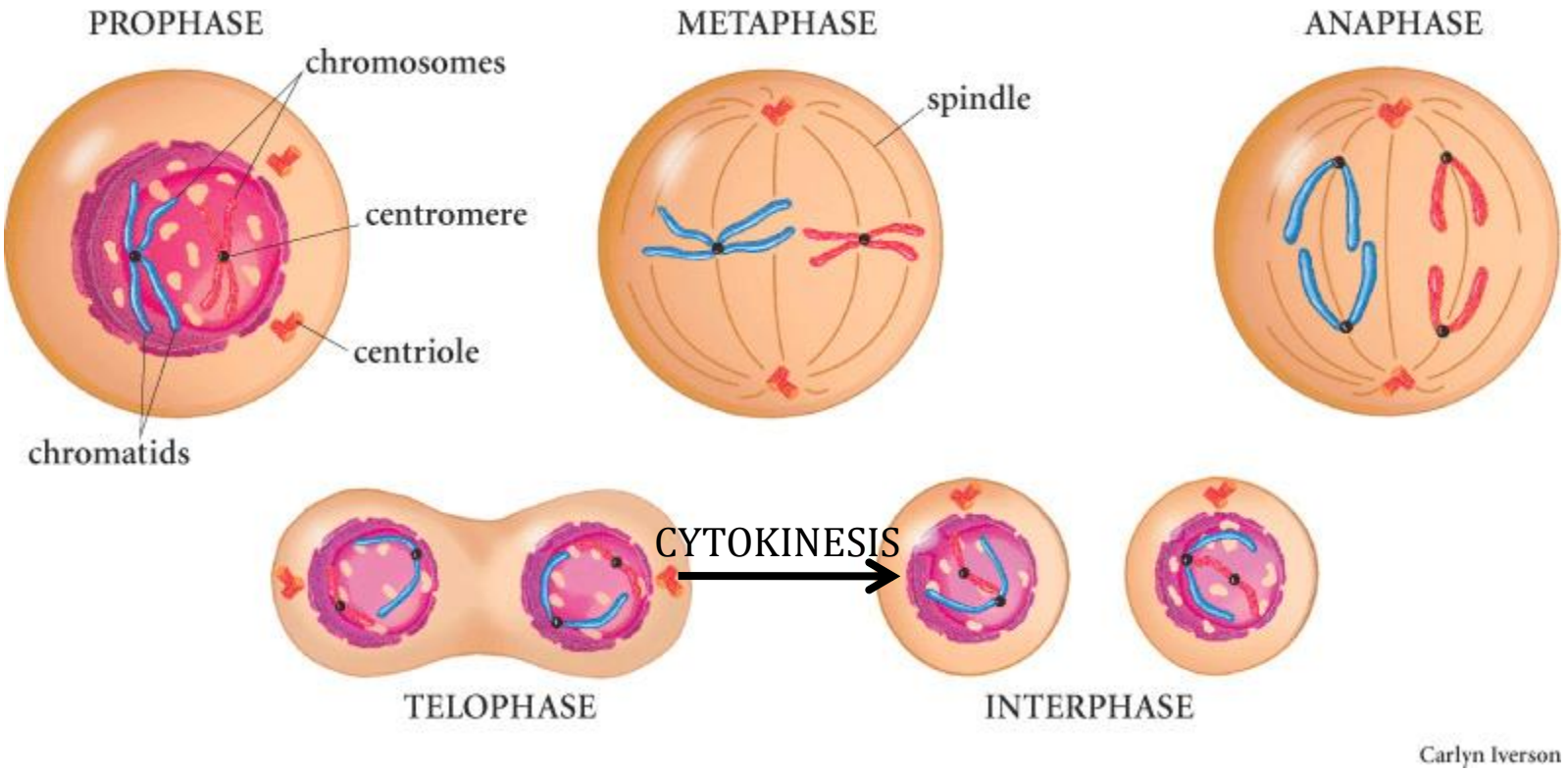
The Cell Cycle



http://www.nobelprize.org/nobel_prizes/medicine/laureates/2001/cellcycle_eng.jpg

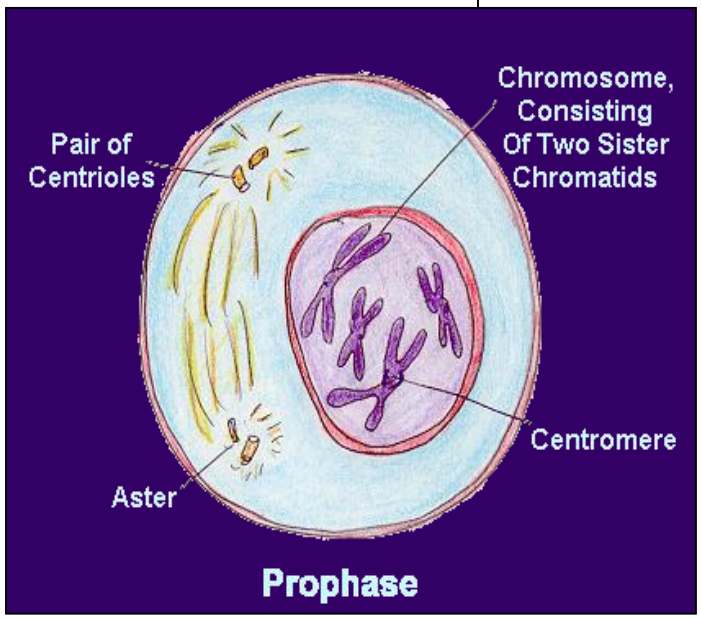
Mitosis

- eukaryotic somatic cells
- 1 cell → 2 genetically identical daughter cells

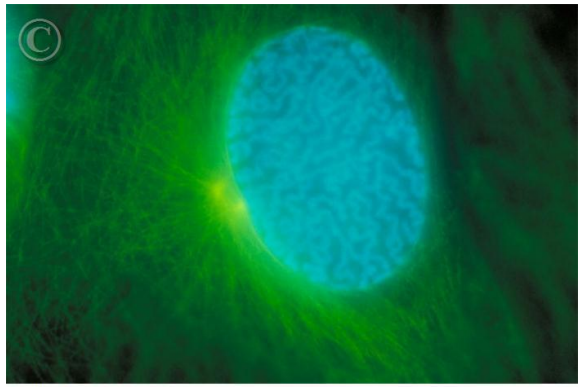


Prophase

- chromatin condensation → chromosomes
- formation of **mitotic spindle** starts
  - centrosomes/MTOCs (microtubule organizing centers) + microtubules
  - kinetochore + non-kinetochore MTs
- breakdown of nuclear membrane
- fragmentation of ER and Golgi complex

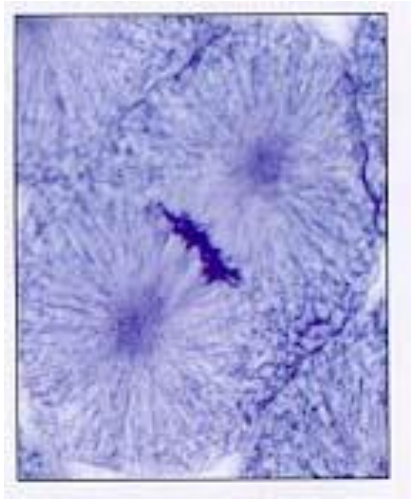


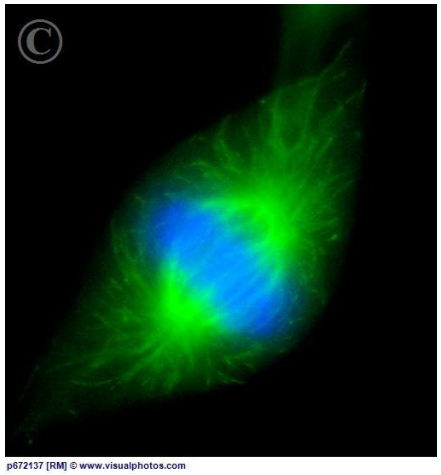
http://66.media.tumblr.com/tumblr_lfc8zpZWMc1qf5zt6o1_500.gif

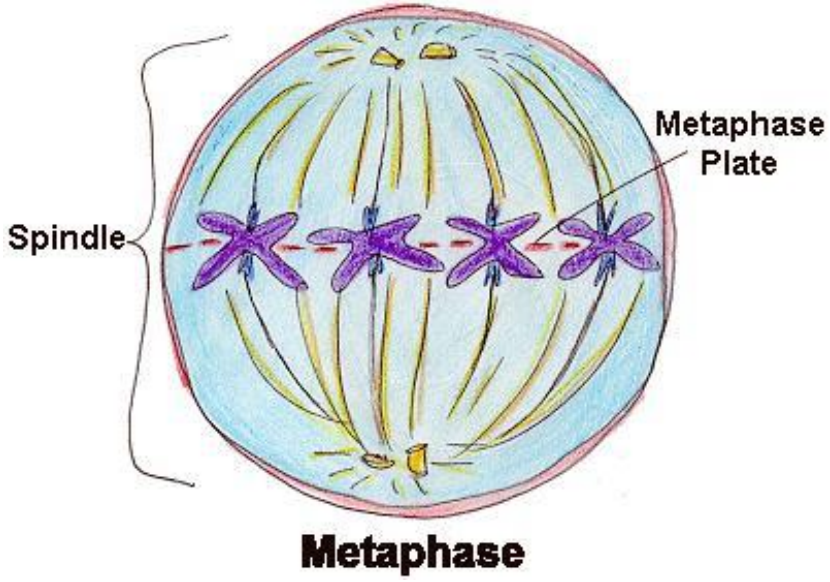


Metaphase

- **metaphase chromosomes**
- chromosomes are lined up in the equatorial plane → **metaphase plate**
- spindle formation is complete



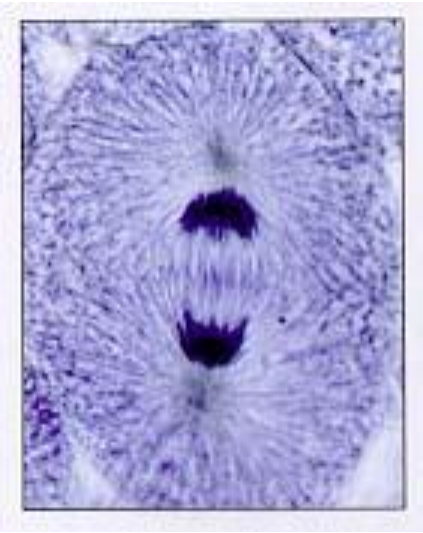


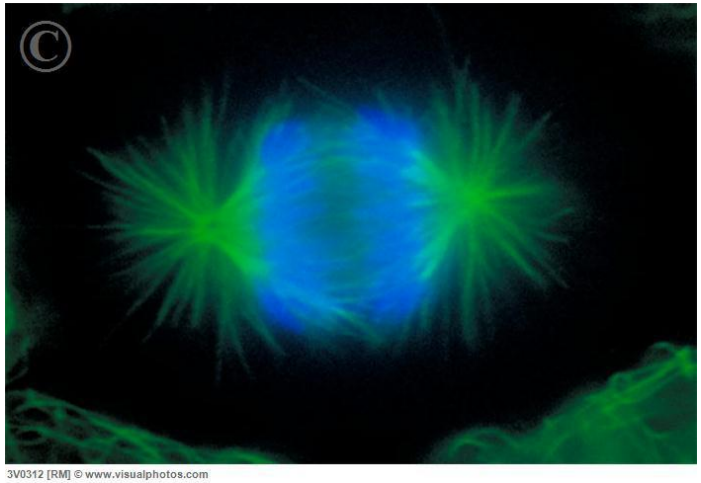


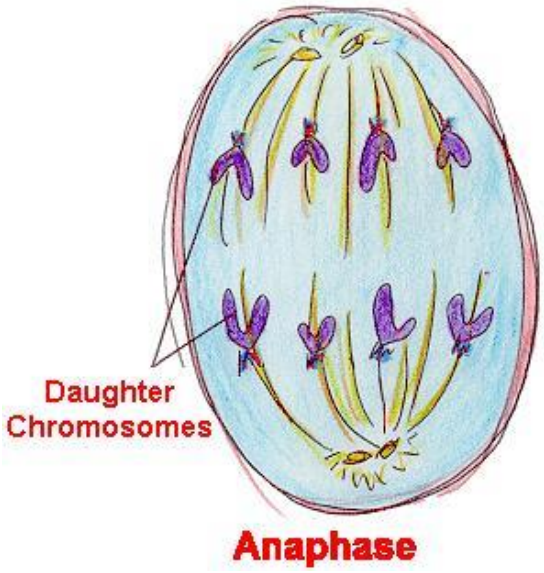
http://66.media.tumblr.com/tumblr_lfc9g2cm0l1qf5zt6o1_500.jpg

Anaphase

- separase → chromatid segregation
- shortening of kinetochore microtubules → migration of chromatids
- sliding of microtubules → elongation of the cell
- microtubules pull the centrosomes toward the cell membrane



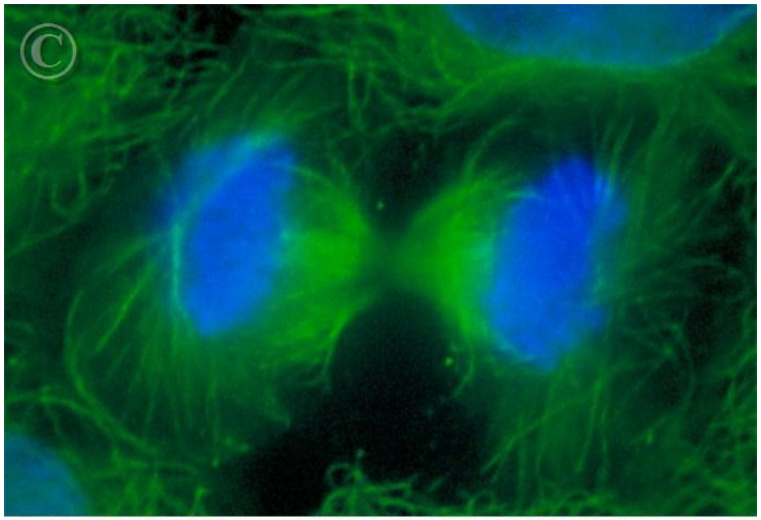


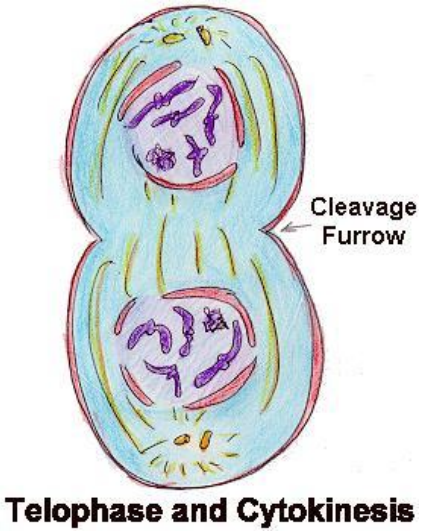


http://66.media.tumblr.com/tumblr_lfc9r48xCc1qf5zt6o1_400.jpg

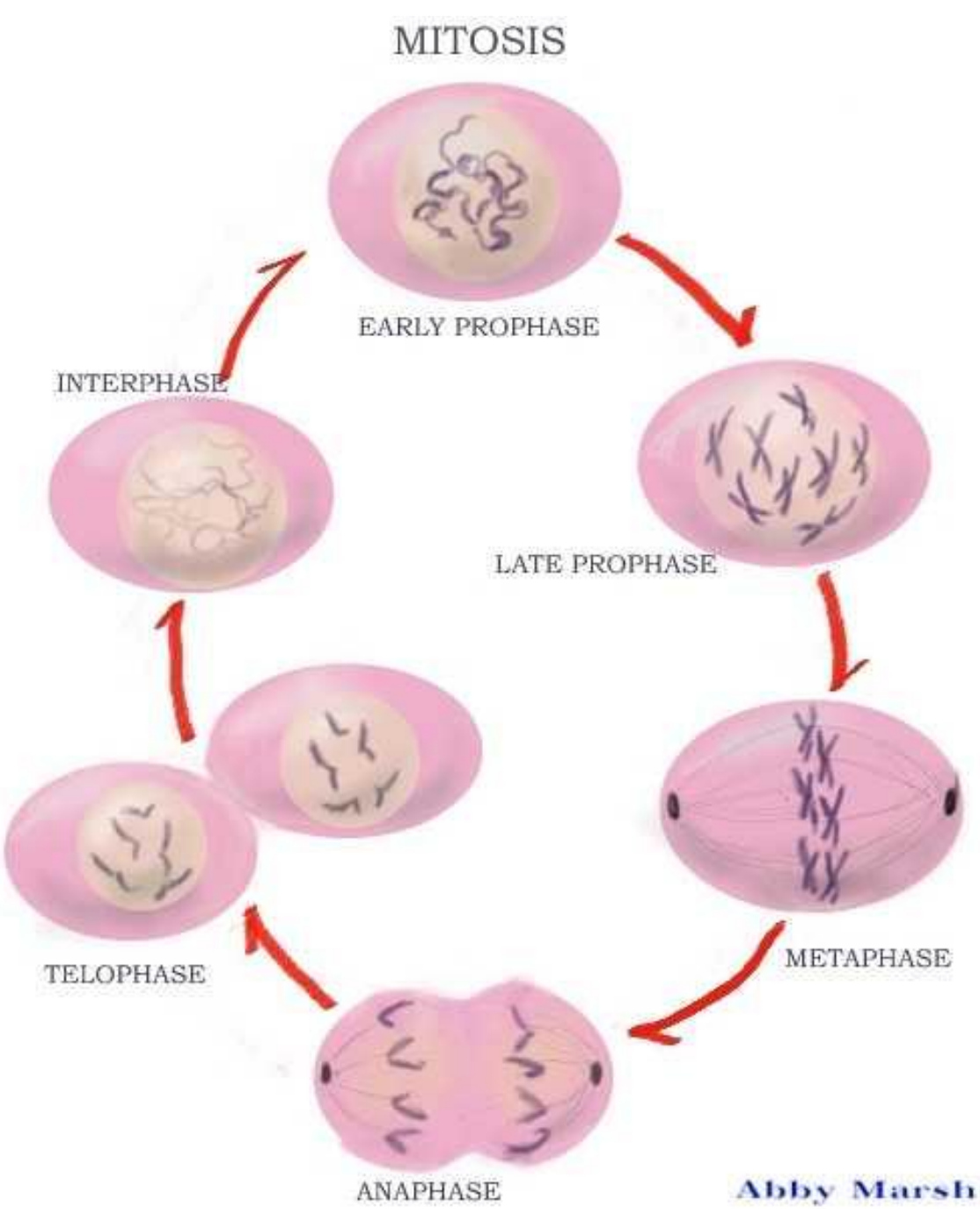
Telophase and cytokinesis

- decondensation of chromosomes → reformation of chromatin
- nuclear membrane, ER and Golgi complex are reformed
- **karyokinesis** → 2 nuclei
- **contractile ring** (actin + myosin) → division of cytoplasm (cytokinesis) → 2 identical daughter cells

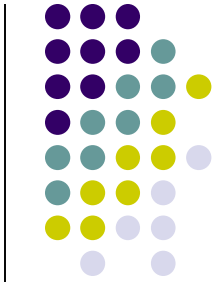




http://66.media.tumblr.com/tumblr_lfc9vcWybL1qf5zt6o1_400.jpg


MITOSIS
EARLY PROPHASE
LATE PROPHASE
METAPHASE
ANAPHASE
TELOPHASE
INTERPHASE
Abby Marsh

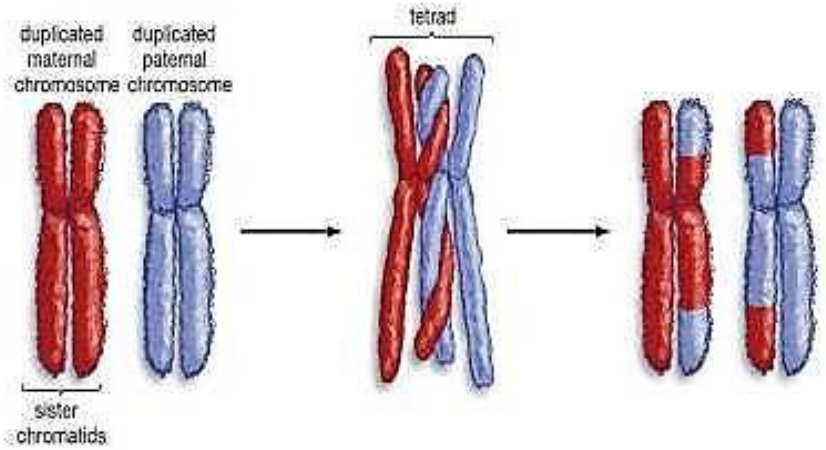
Meiosis



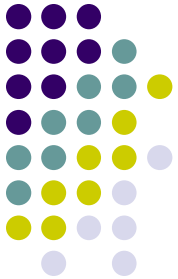
- production of germ cells (n)
  - oogenesis: formation of oocytes/egg cells
  - spermatogenesis: production of sperm cells
- 1 diploid cell → 4 haploid gametes (genetically different)
- humans: 46 one-chromatid chromosomes → 23 one-chromatid chromosomes
- fertilization → diploid zygote
- meiosis I and II

Meiosis I

- **Interphase I**: DNA replication → tetraploid cell (4n) → 46 two-chromatid chromosomes/cell
- **Prophase I**:
  - chromatin condensation → chromosomes
  - pairing of homologous chromosomes
  - **crossing over**/homologous recombination → increased genetic variability → 2^{23} possibilities at the end of meiosis I
  - breakdown of nuclear membrane, ER and Golgi
  - formation of mitotic spindle starts

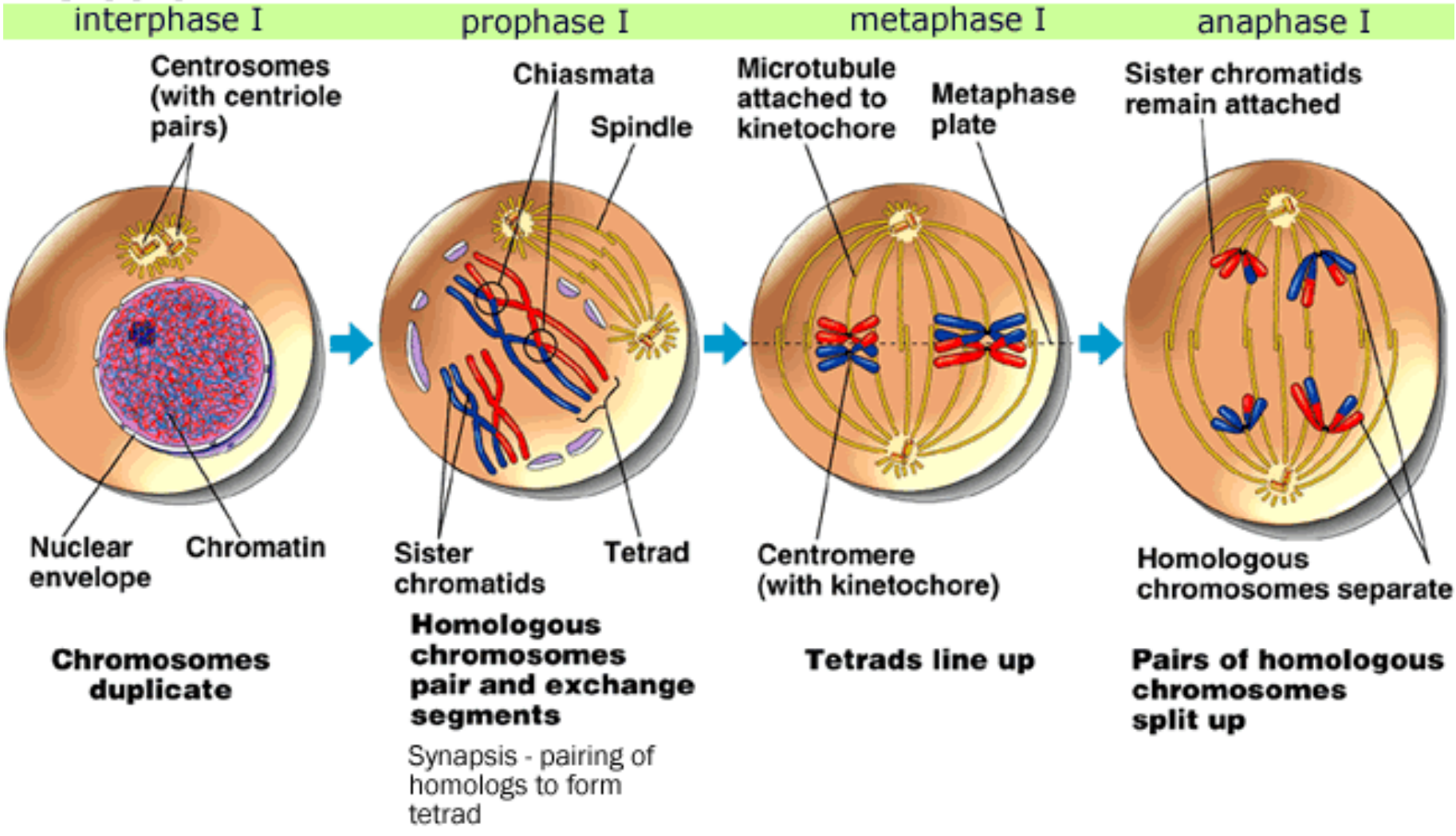


Meiosis I

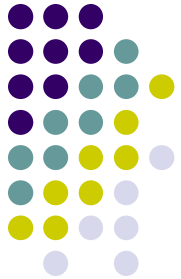


- **Metaphase I**:
  - completion of spindle formation
  - maternal and paternal chromosomes line up randomly within metaphase plate
- **Anaphase I**:
  - separation of homologous chromosomes
- **Telophase I**:
  - degradation of mitotic spindle
  - nuclear membrane forms
- **Cytokinesis I**:
  - 2 genetically different diploid cells → 23 two-chromatid chromosomes/cell

Meiosis I

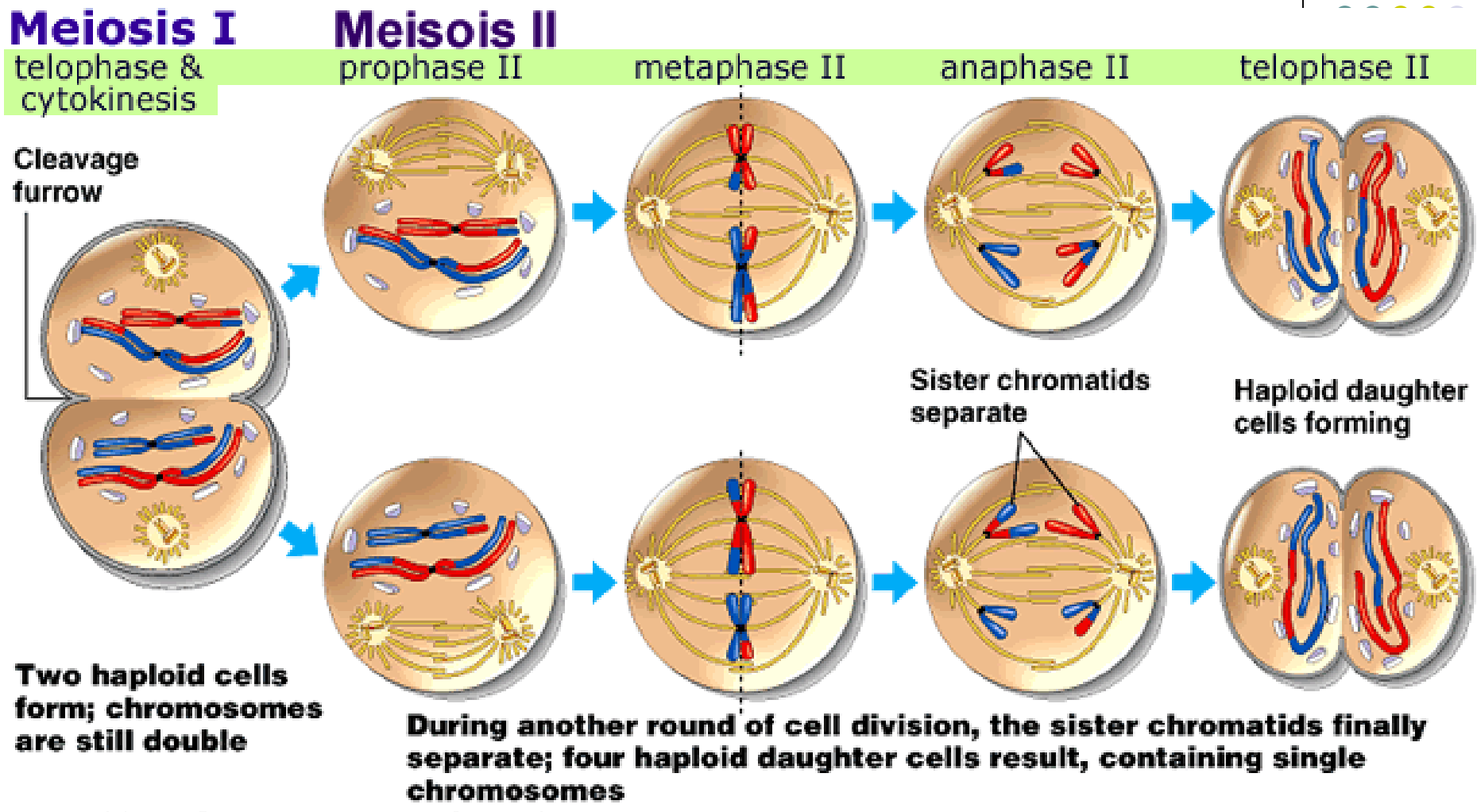

interphase I
prophase I
metaphase I
anaphase I
Centrosomes (with centriole pairs)
Nuclear envelope
Chromatin
Chromosomes duplicate
Chiasmata
Spindle
Sister chromatids
Tetrad
Homologous chromosomes pair and exchange segments
Synapsis - pairing of homologs to form tetrad
Microtubule attached to kinetochore
Metaphase plate
Centromere (with kinetochore)
Tetrads line up
Sister chromatids remain attached
Homologous chromosomes separate
Pairs of homologous chromosomes split up

Meiosis II



- **Interphase II**: no DNA replication

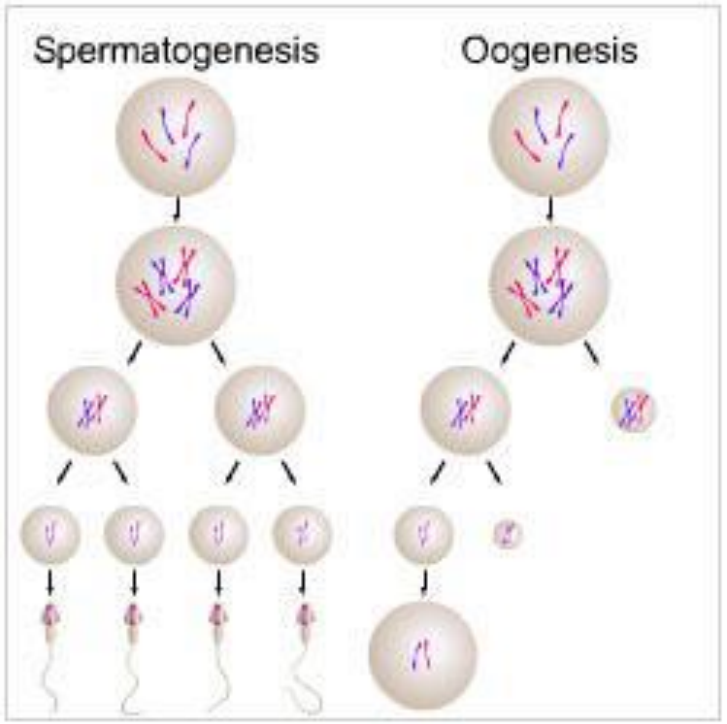
- **Prophase II**
  - no crossing over
- **Metaphase II**
- **Anaphase II**:
  - Separation of sister chromatids
- **Telophase II**
- **Cytokinesis II**:
  - 4 haploid cells (genetically different) → 23 one-chromatid chromosomes/cell



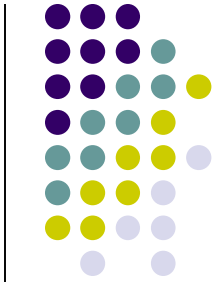
Gametogenesis

- Spermatogenesis:
  - starts at puberty, then it is continuous
  - 1 precursor cell → 4 haploid sperm cells

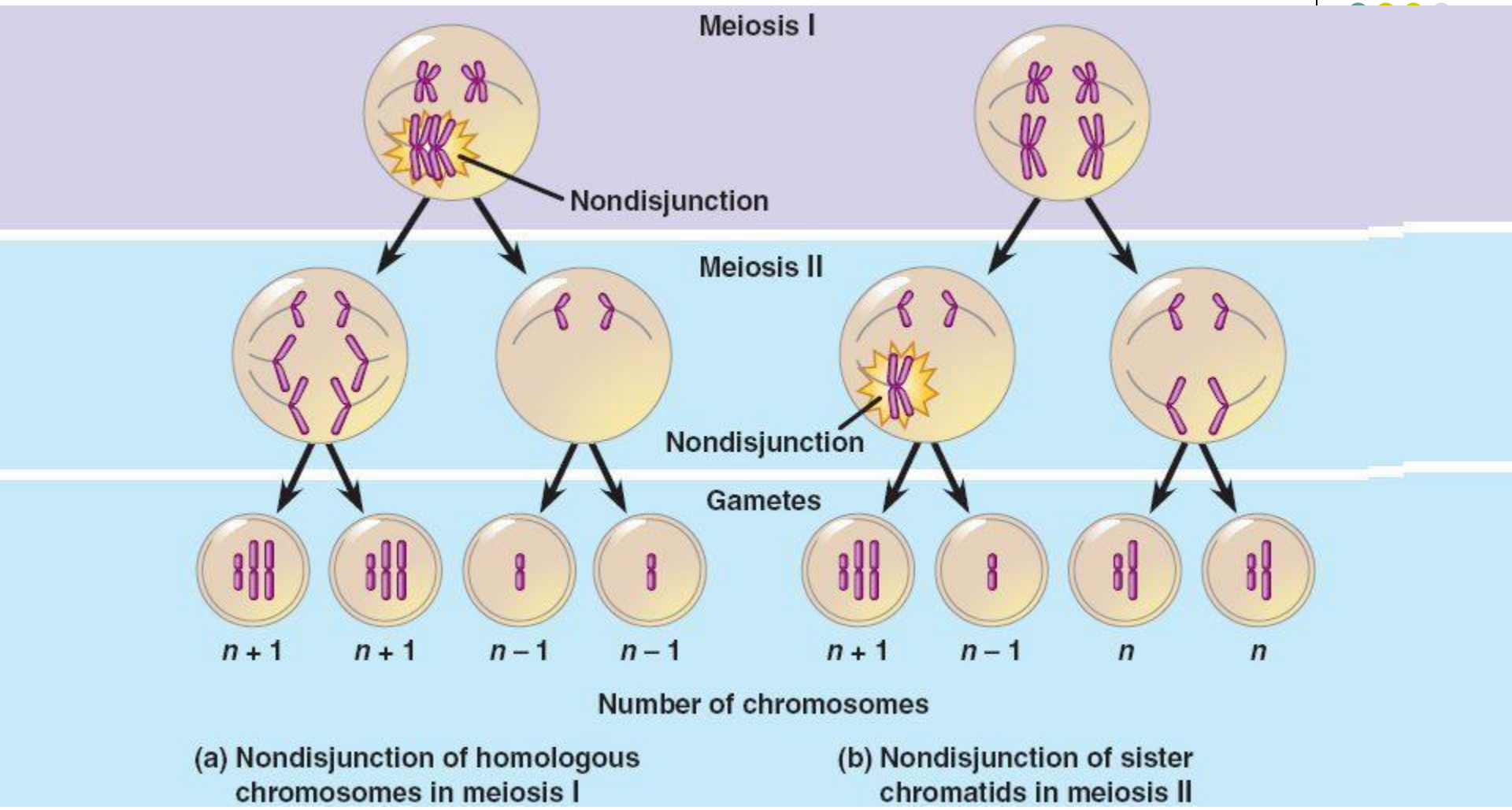
- Oogenesis:
  - starts during the embryonic development but stops in prophase I
  - ovulation: meiosis continues, then stops in metaphase II
  - fertilization: completion of meiosis II
  - 1 precursor cell → 1 egg cell + 3 polar bodies

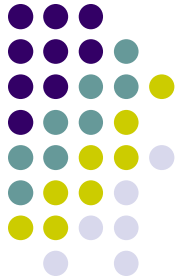


Abnormalities of meiosis



- non-disjunction:
  - abnormal segregation of chromosomes/sister chromatids
  - monosomy
    - Turner syndrome: 45, X0
  - trisomy
    - trisomy 21: Down syndrome
    - Klinefelter syndrome: 47, XXY
    - Triple X syndrome: 47, XXX
    - Double Y syndrome: 47, XYY


Meiosis I
Nondisjunction
Meiosis II
Nondisjunction
Gametes
n + 1
n + 1
n – 1
n – 1
n + 1
n – 1
n
n
Number of chromosomes
(a) Nondisjunction of homologous chromosomes in meiosis I
(b) Nondisjunction of sister chromatids in meiosis II



Thank you for your attention! ☺