Class 13 9/22/17
Mitosis & Meiosis

- Announcements
- Class administration
- Check iLearn for suggested problems
- **Office hours HH668C:**
  - **NEXT WEEK 9/25 rescheduled to THU 9/28 3 – 5pm**

i>clicker

or

- ❑ Did you bring your clicker remote today? GREAT!!
- ❑ Please check iLearn for your clicker score in gradebook (Should now see only "**Sessions 1, 2, & 3**")
- ❑ If your clicker score is missing, please e-mail me your clicker remote ID.

Biol 572/872 Ecology, Evolution, & Conservation Biology Colloquium

Tuesday, 9/26/17
HH 543, 2:10pm

http://biology.sfsu.edu/content/EEC

Robin Elahi
Hopkins Marine Station
Benthic Ecology in a Changing Ocean

https://hopkinsmarinestation.stanford.edu/people/robin-elahi

Romberg Tiburon Center Seminar Series

http://rtc.sfsu.edu/seminar/index.htm

Wednesday, 9/27/17
Bay Conference Center, 3:30PM

Christopher Edwards
U.C. Santa Cruz
Coupled Biophysical Data Assimilation and its Application to the Recent Warm Blob and El Nino

http://oceanmodeling.ucsc.edu/

Biol 871 Colloquium in Microbiology, Cell & Molecular Biology

Thursday, 9/28/17
SCI 210, 2:10 pm

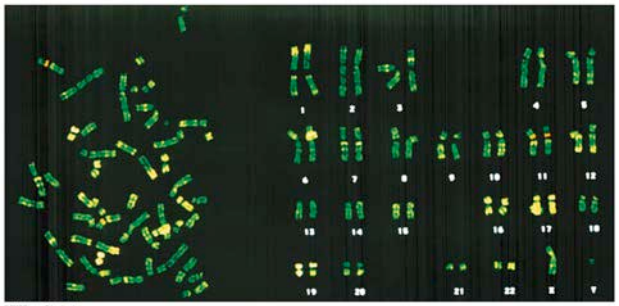
http://biology.sfsu.edu/content/MCMB

Hunter Fraser
Stanford University
Mapping human regulatory variation

https://web.stanford.edu/~hbfraser/

Even more chromosome terminology

- In diploid (2n) organisms, chromosomes occur in pairs, or homologs
- One homolog comes from each parent during fertilization



Human metaphase chromosomes and karyotype

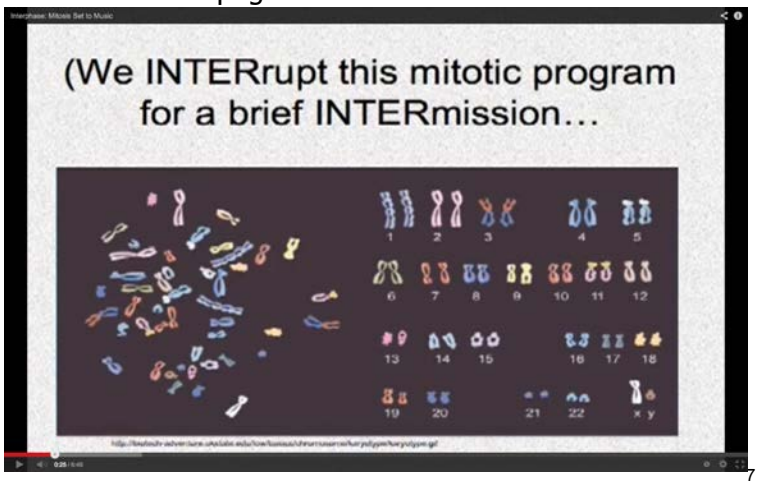
- After meiosis, gametes are haploid (n) and contain one member of each homologous pair, either a maternal or paternal chromosome

See Table 2.1 - Haploid number for different organisms

Figure 2.4

Interphase: Mitosis set to Music

- Link on iLearn page



https://www.youtube.com/watch?v=ODwt6OdN-8Y

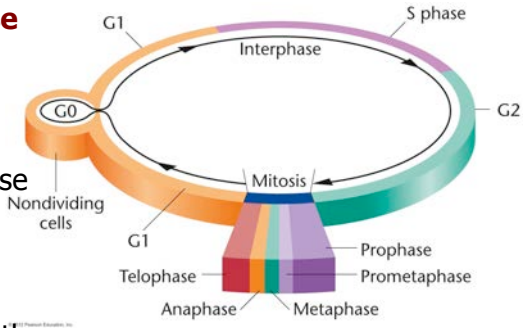
Clicker Question
please think about this question and answer on your own

Which of the following statements (describing human chromosomes) do you agree with most?

A. During G1 a chromosome contains 1 double helix of DNA.
B. During G2, a chromosome contains 1 double helix of DNA.
C. During M, a chromosome contains 1 double helix of DNA.
D. None of the above

Eukaryotic Cell Cycle - 1

- **Mitosis** and **Interphase** (G1 - S - G2)
- **G1 phase**
  - cell mass increases
  - Preparation for S phase
- DNA is replicated during the **S phase** (DNA Synthesis)
  - Each chromosome in the interphase nucleus is duplicated, generating two sister chromatids



- **G2 phase**
  - Growth
  - preparation for mitosis

Figure 2.5

Eukaryotic Cell Cycle - 2

- **Mitosis** and **Interphase** (G1 - S - G2)
- **M phase** (Mitosis)
  - sister chromatids separate from each other and enter the newly forming daughter cells
  - karyokinesis followed by cytokinesis
  - each cell receives a sister chromatid from each chromosome

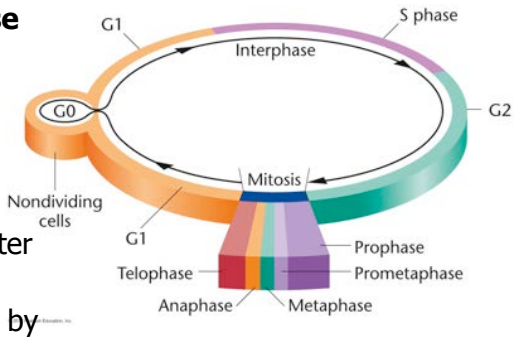
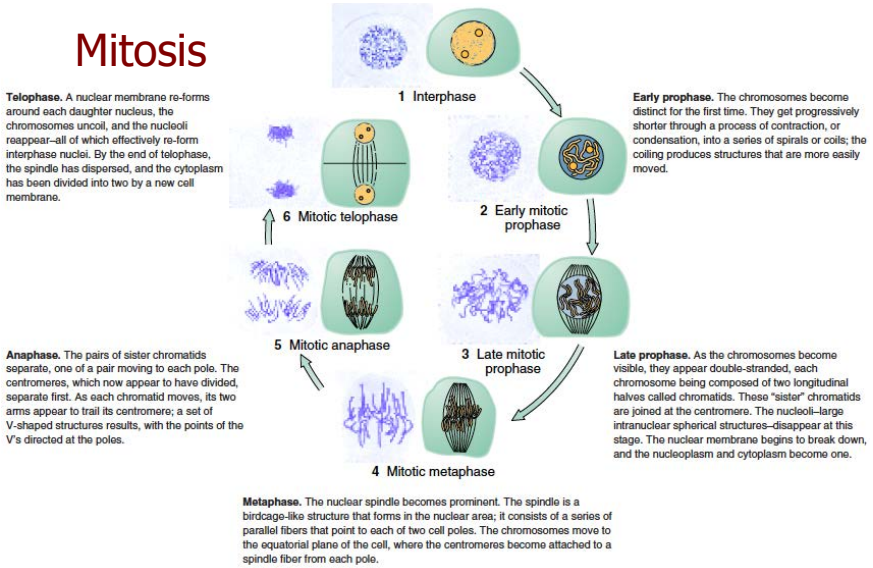


Figure 2.5

Mitosis



- Figure 3-3 from Griffiths textbook
- The photographs show nuclei of root-tip cells of *Lilium regale*.

Figure 3-3

Interphase

- Chromosomes are not distinct
- The centrosome which contains the centrioles in animal cells is duplicated during S phase
  - each centrosome copy acts as a ***microtubule organizing center*** and functions as the spindle pole during mitosis
  - pair of centrioles at the center replicate and eventually separate as microtubules radiate outwardly, forming an aster

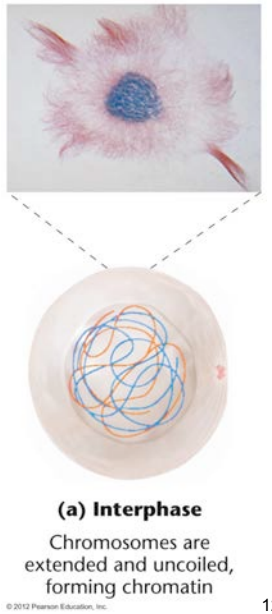


Figure 2.7a

Prophase

- the two centrosomes (centrioles) move to opposite poles of the cells
- replicated chromosomes begin condensing so that by late prophase they are highly condensed and sister chromatids become visible
- The nuclear membrane fragments and the nucleolus disperses

Figure 2.7b

Prometaphase & Metaphase

- During **prometaphase**, microtubules attach to the kinetochores at the centromeres to guide sister chromatid separation
- fully condensed chromosomes *move* to the metaphase plate
- During **metaphase**, chromosomes are lined up on the central equatorial plates between the centrosome poles

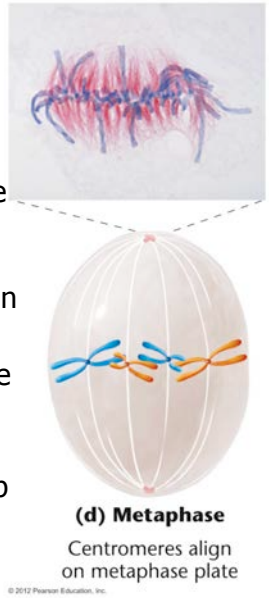
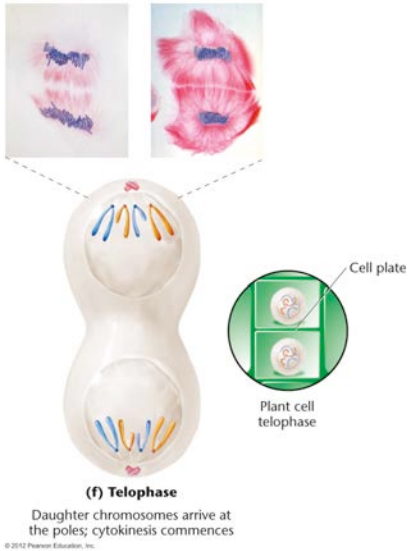


Figure 2.7c and 2.7d

Anaphase

- DISJUNCTION - centromeres "split" and each carries a sister chromatid to opposite poles of the cell via microtubule shortening
- each chromatid is also now a chromosome so…
  - At this point, the mitotic cell has "doubled" its chromosome number

Figure 2.7e



Do these daughter cells carry identical chromosomes?

Telophase

- Chromosome movement ceases at each pole
- Microtubules disassemble
- Nuclear membrane reforms and nucleolus reappears
- Chromosomes decondense
- cell completes division by separating into two daughter cells via cytokinesis
- gradual midline constriction in most cells, but in plant cells with rigid cell walls a cell plate forms between daughters
- The 2 cells have now entered G1 and interphase

Figure 2.7f

Mitosis & Meiosis questions - 1

1. A diploid cell has 6 chromosomes.

During mitosis, how many chromosomes are observed during anaphase?

A. 3
B. 6
C. 12
D. 24

Answer independently

Mitosis & Meiosis questions - 2

Answer independently

2. A diploid cell has 6 chromosomes.

During meiosis, how many chromosomes are observed during anaphase I?

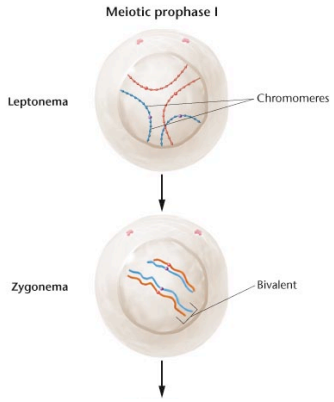
A. 3
B. 6
C. 12
D. 24

Prophase I

- Leptonema or leptotene stage
- Zygonema or zygotene stage
- Pachynema or pachytene stage
- Diplonema or diplotene stage
- Diakinesis or diakinetic stage
- "Lazy zebras ponder dire disasters"
- Lazy zebras ponder diplomatic disasters"
- **L**arge **Z**ippers **P**ut **D**igits in **D**anger

Meiosis I: Prophase I…(a)

- 1. Leptonema: Replicated chromosomes appear as a single threadlike structure
- 2. Zygonema: chromosomes continue condensing and homologs pair to form bivalents
  - ladder-like structure called the synaptonemal complex (SC) starts to form

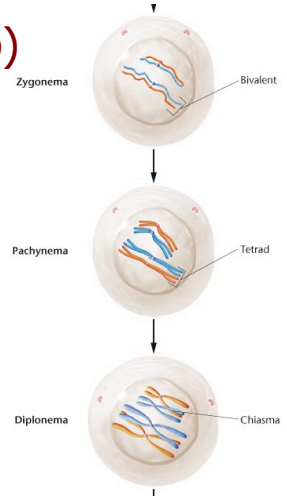


Note: mechanism for homolog pairing is unclear, initial pairing is not dependent on microtubules

Klug 10th edition, Figure 2.10

Meiosis I: Prophase I…(b)

- 3. Pachynema: pairing at various sites is called synapsis
  - SC further develops and paired homologs (tetrads) resolve into a pair of recognizable replicated chromosomes, each containing a pair of sister chromatids
  - crossing over occurs between chromatids
- 4. Diplonema: Homologs desynapse and repel from each other but remain attached at the chiasmata (evidence of crossing over)

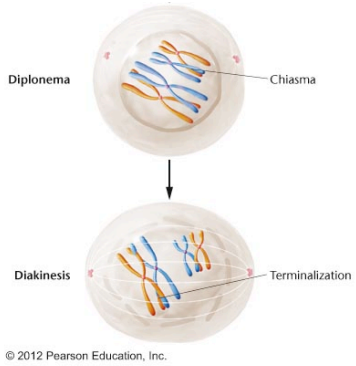


In human female fetuses, about 400,000 immature eggs or oocytes arrest at this stage until puberty when one egg continues through meiosis during each menstrual cycle

Klug 10th edition, Figure 2.10

Meiosis I: Prophase I…(c)

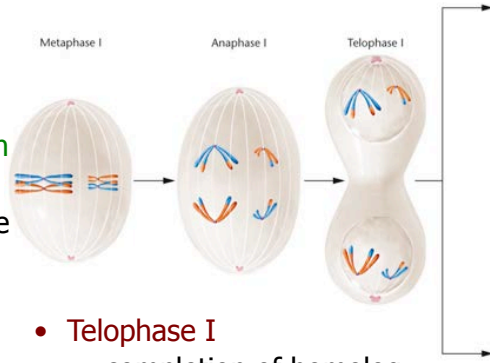
- 5. Diakinesis: Homologs pull further apart but retain chiasmata
  - Chiasmata move toward ends of tetrads (terminalization initiated in diplonema completes in diakinesis)
  - the nuclear membrane and nucleolus disperse
  - microtubules from the centrosomes attach to the kinetochore



Klug 10th edition, Figure 2.10

Meiosis I: M-A-T

- Metaphase I
  - condensed homolog pairs lined up on opposite sides of the equatorial plate
- Anaphase I
  - Chromosome disjunction
    - homologs separate and move to opposite poles
  - centromeres do not divide so each homolog still contains a pair of sister chromatids

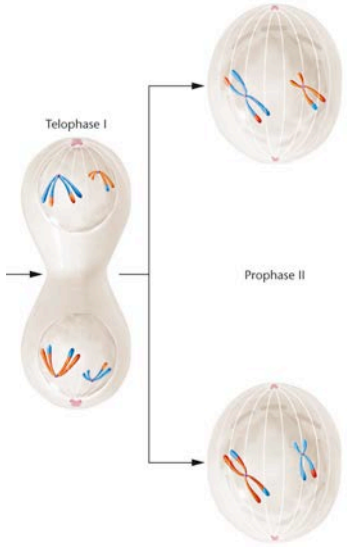


- Telophase I
  - completion of homolog movement to opposite poles
  - reformation of nucleolus and the nuclear membrane

Note: If one pole sends microtubules and attaches to the centromeres of both sisters in one homolog, AND the microtubules are pulling that homolog to one pole…why do the two homologs stay at the metaphase plate? The chiasmata remaining after crossing over may help keep the homologs at the metaphase plate, until anaphase I.

Klug, 10th ed. Figure 2.11

Meiosis I --> Meiosis II



- Cytokinesis
  - cells have entered G1 of interphase II
  - there is no replication of DNA
  - each chromosome already contains a pair of sister chromatids
- Are these sister chromatids identical?

Klug, 10th ed. Figure 2.11