Biology 112 – Ch.11: Cell Cycle

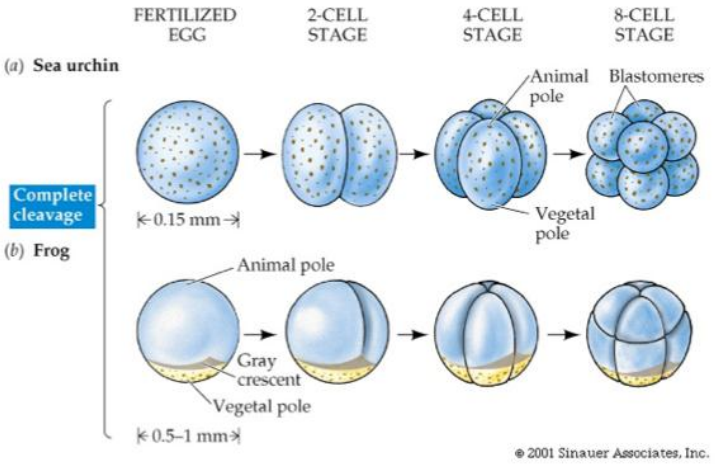
Heredity

The Mystery of Heredity:

- All organisms come from other organisms
- All organisms resemble their parents
- Siblings are not identical

Parents Share

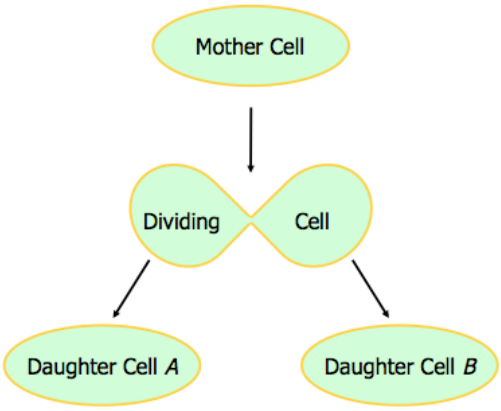
- Ancient Greeks figured that males and females must share some "essence" that mixes to produce the progeny → "essence" = cells (sperm & egg)
- Single fertilized egg undergoes cell division to divide and grow:



Cell Theory

i. All organisms consist of cells
ii. Cells divide to produce new cells
iii. Higher organisms fuse their cells (sperm & egg, pollen & egg) to produce a new organism)

→ Cells make more cells by dividing and growing



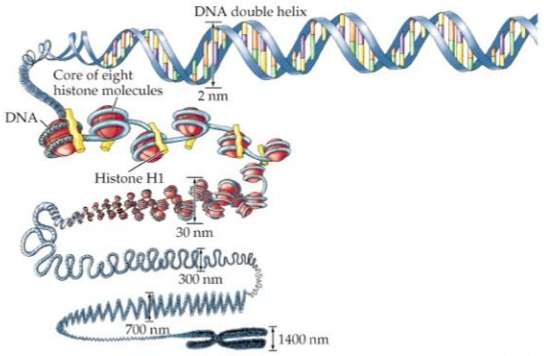
➔ Dividing cells devote a lot of resources to segregating their chromosomes

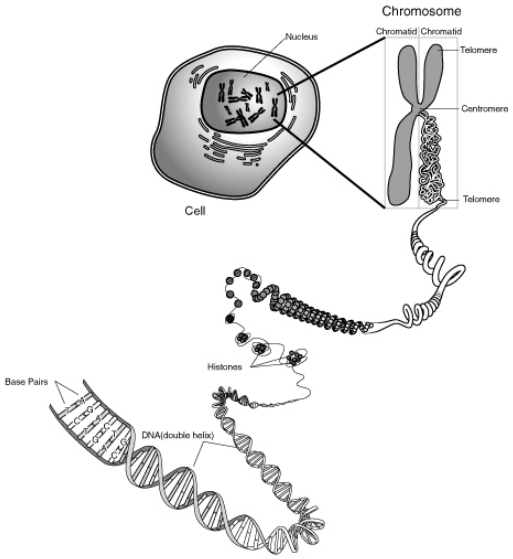
Chromosomes

- Chromosome – a single string of DNA
- Come in two forms:

- **Circular** (bacteria)
- **Linear** (most other organisms)

- When the cell is getting ready to divide, the chromosome condenses by associating with proteins (e.g. **histones**) → the combination of protein and DNA is called **chromatin** ➔ this is why we can see chromosomes





Karyotype: a way of organizing and identifying chromosomes

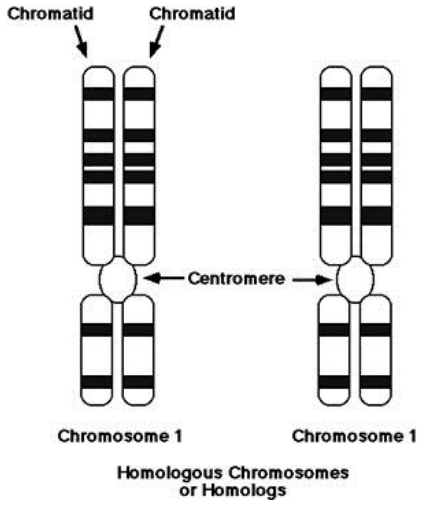
- Take a cell that is getting ready to divide
- Flatten it (mitotic squash)
- Stain the chromosomes with a dye
- Take a picture
- Cut out the chromosomes and line them up according to banding pattern

FACTS:

→ The number of chromosomes is a characteristic of the species of organism; bacteria typically have one; humans have 46

→ In eukaryotes, chromosomes typically come in (nearly) identical pairs called **homologs**

→ Just before cell division, each chromosome has been replicated once to produce two **chromatids**



Terminology:

- Normally a chromosome is a single piece of DNA → However, when we look at a Karyotype we are actually seeing **two** pieces of DNA, the two chromatids, bound by a centromere
  - ➔ Therefore we call these "mitotic chromosomes" to indicate that they represent a special case

Segregating chromosomes is exacting:

- Organisms need **at least** one of each chromosome because they each carry essential genetic material
- Organisms also typically need **exactly** one of each chromosome → excess can lead to various syndromes (Down Syndrome – extra chromosome 21)

→ Make sure the chromosomes are duplicated before the cell divides

Steps in Cell Division

- **Chromosome (DNA) replication** (S phase)
- **Mitosis (M)** the process by which somatic cells make identical copies (clones) of themselves by creating daughter cells that inherit one copy of each chromosome OR
- **Meiosis (M)** the processes by which germ cells make non-identical copies of themselves by creating daughter cells that have one of each homolog
- **Cytokinesis** dividing the cytoplasm in two (optional)

How do cells known when to divide?

- Most cells in your body are not dividing
- The cells that are not dividing are usually arrested in the G1 phase of the cell cycle
- Often they are waiting for signals from other cells to tell them to divide → example = immune cells

Cancer = unregulated division of cells

- If a cell's G1 – to – S checkpoint is defective, a cell can divide in an unregulated manner
- For instance, if cyclin E is always active and/pr overabundant, a cell will repeatedly divide – this can contribute to the cells becoming cancerous

→ If we understood how signals regulate the cell cycle, we might be able to design drugs that interfere with those signals; those drugs could be useful for treating cancer

<u>The Cell Cycle – Mitosis</u>

Interphase: During the S phase if Interphase, the nucleus replicates its DNA and centrosomes

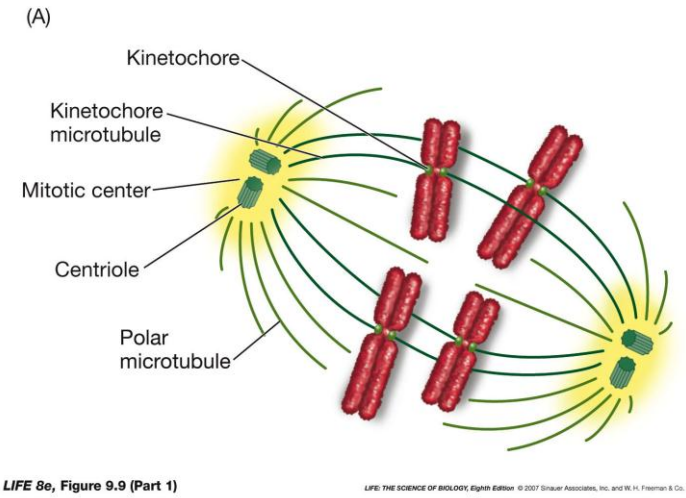
Prophase: The chomatin coils and supercoils become more and more compact, condensing into visible chromosomes; the chromosomes consist of identical, paired sister chromatids

Prometaphase: The nuclear envelope breaks down; Kinetochore microtubules appear and connect the kinetochores to the pores

Metaphase: The centromeres become aligned in a plane at the cell's equator

Anaphase: The paired sister chromatids separate and the new daughter chromosomes begin to move toward the poles

Telophase: Daughter chromosomes reach the poles; as telophase concludes, the nuclear envelopes and nucleoli re-form, chomatin becomes diffuse, and the cell again enters Interphase



Making a metaphase mitotic spindle:

- Keep the chromatids paired until it is time to segregate
- Have unstable kinetochore microtubules that can probe the cytoplasm and only become stable upon being captured by a kinetochore
- Give each chromatid a kinetochore with a geometry such that two kinetochore microtubules from the same spindle can't capture both chromatids of a chromosome
- Have a checkpoint that senses when all the chromatids have been captured and only then allow the chromatids to separate

Cytokinesis:

- In animals, actin and myosin form a "purse string" that constricts and divides the cell
- In plants, vesicles fur to make membrane and cell plate, which becomes a new cell wall dividing the mother cell
- Some cells don't both to divide their cytoplasm → e.g. muscle cells have many nuclei (the are **syncytial**) because the go through mitosis without Cytokinesis

→ Mitosis makes identical genetic copies of the cell

<u>Meiosis</u>

Sex: mixing the genetic material of two organisms

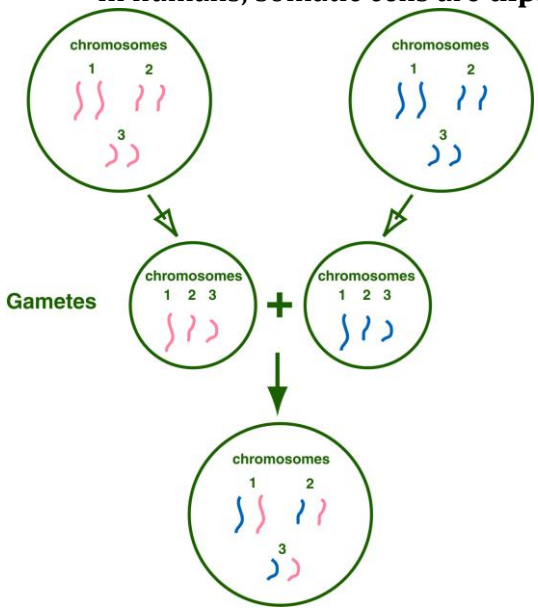
→ Before sexual reproduction, you must reduce the number of homologs by half

The terminology of ploidy:

- n = a set of chromosomes that includes exactly one of each homolog
- We give names to multiples of n:
  - 1n = haploid
  - 2n = diploid
  - 3n = triploid

- 4n = tetraploid

- In humans, somatic cells are **diploid** and gametes are **haploid**



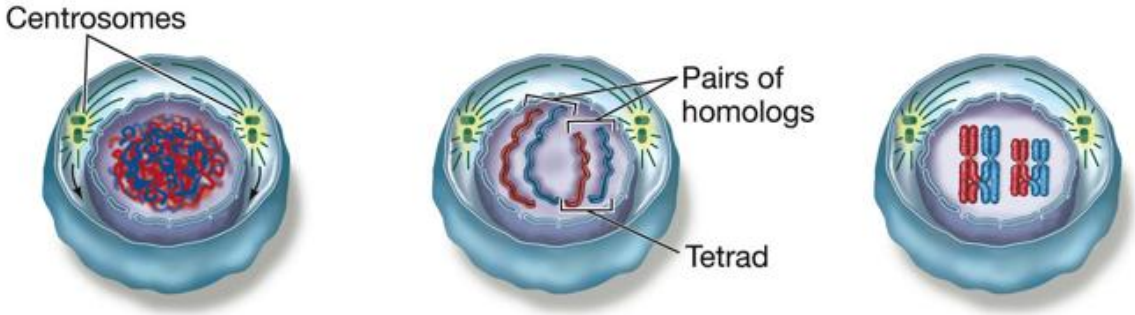
Meiosis → the process by which haploid cells are made

Meiosis I

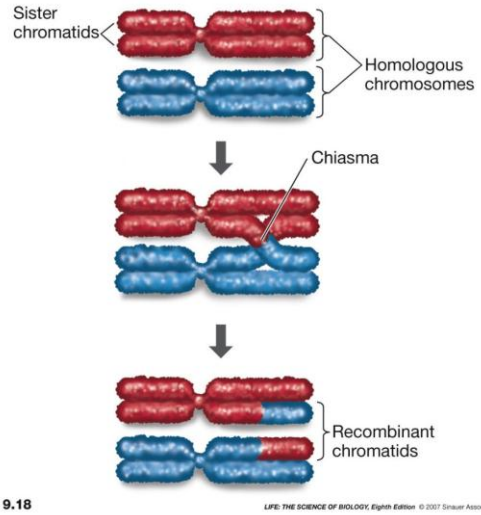
Early prophase I –

Mid-prophase I

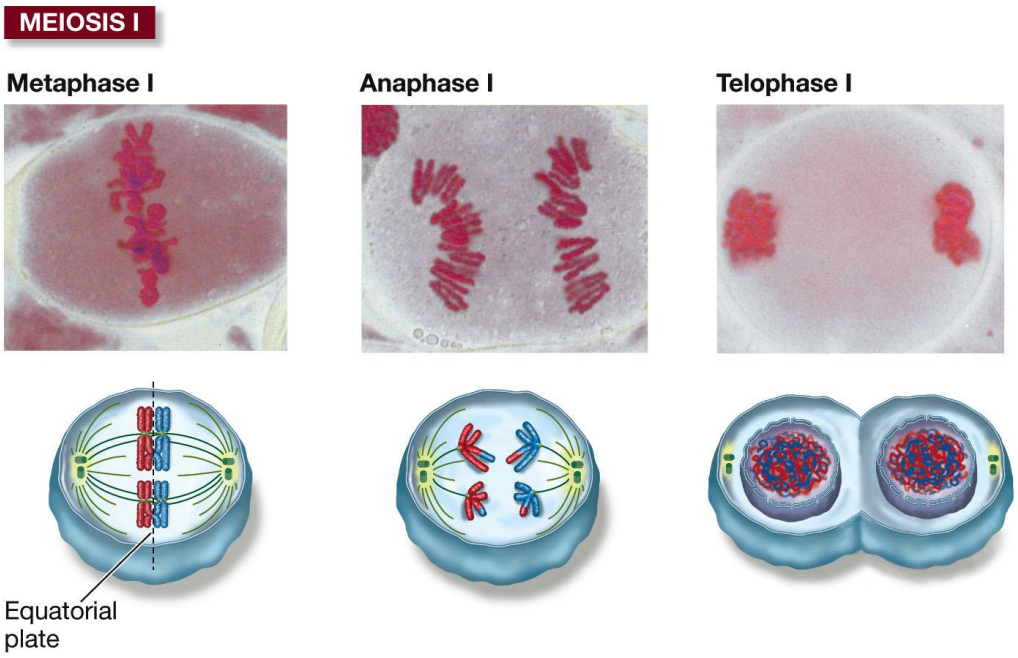
Late prophase I – prometaphase



Crossing Over:

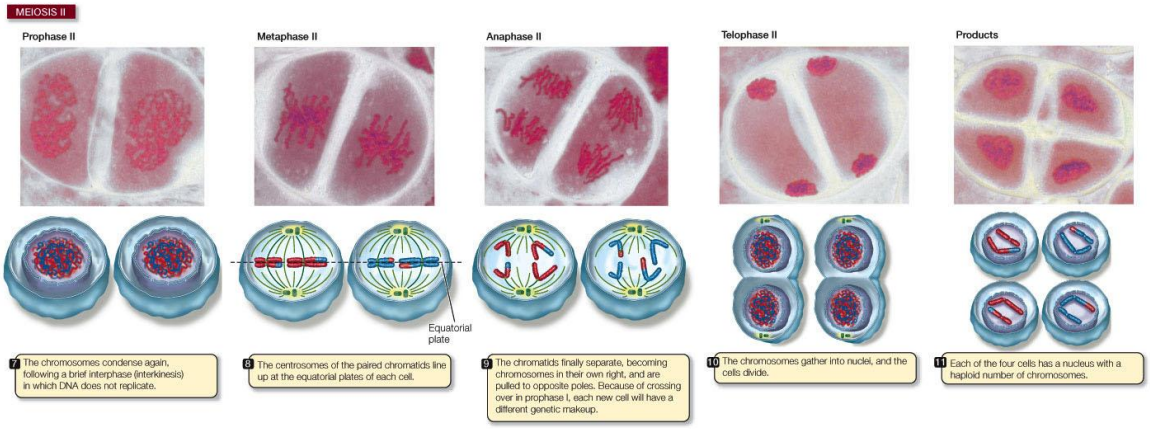


LIFE 8e, Figure 9.18



***LIFE 8e*, Figure 9.16 (Part 2)**

Meiosis II



***LIFE 8e*, Figure 9.16 (Part 2)**

➔ Cells can arrest in meiosis for a very long time; 40 years in prophase for human females