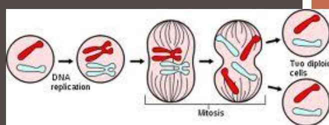
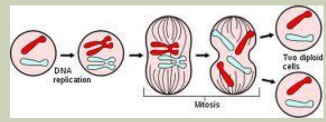
MITOSIS AND THE CELL CYCLE



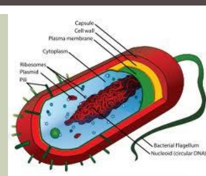
PURPOSE OF MITOSIS

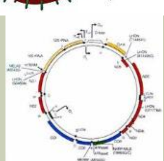
- Growth (of body, tissues)
  - Increase number of cells (cells grow in interphase)
- Repair damaged tissue or replace damaged or dead cells (not repair cells)
- Cell division between prokaryotes and eukaryotes is very different due to cell structures



PROKARYOTIC CELL DIVISION

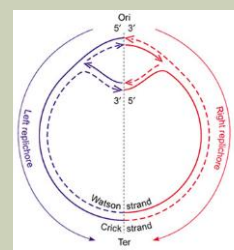
- Far more simple than in Eukaryotes
- Most prokaryotes have a genome made up of a single, circular DNA molecule
- Replicate via binary fission.





BINARY FISSION

- Begins with DNA replication
  - Starts at the origin site
  - Proceeds bidirectionally around the circular DNA to a specific site of termination.
- The evolution of eukaryotic cells = much more complex genomes
  - New and different ways to replicate and segregate the genome during cell division

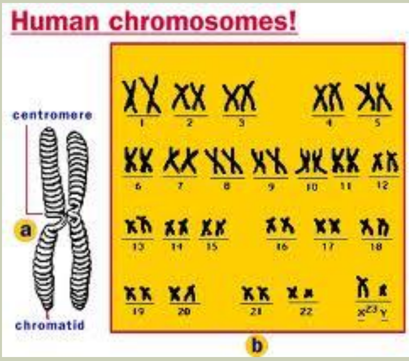


CHROMOSOMES

- Chromosomes were first discovered in 1882 by Walther Fleming.
- The number of chromosomes varies from one species to another.
  - Humans have 23 nearly identical pairs for a total of 46 chromosomes.

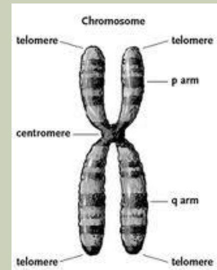
CHROMOSOME STRUCTURE

- DNA extends unbroken through the entire length of the chromosome.
  - A typical human chromosome contains about 140 million nucleotides.
  - Every 200 nucleotides, the DNA duplex is coiled around a core of eight histone proteins, forming a nucleosome.
- The particular array of chromosomes an individual possesses is its **karyotype**



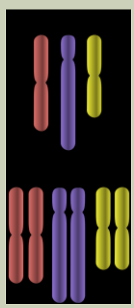
CHROMOSOME STRUCTURE

- Sister chromatids: identical chromosome halves that will be separated in mitosis
- Centromere: band that holds sister chromatids together
- Telomere: end section of a chromosome that repeats genetic code and prevents the chromosome from deteriorating
  - Important because they prevent DNA from being lost with each replication (DNA replication enzymes can't quite go all the way to the end of each strand)



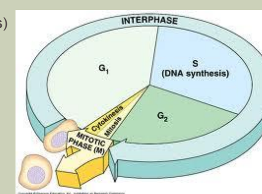
HAPLOID VS. DIPLOID

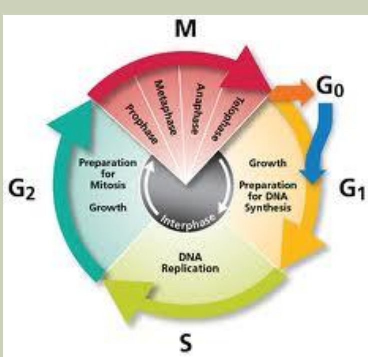
- **Haploid (n) number:** The number of different chromosomes a species contains
  - one complete set of chromosomes
- Humans are diploid, with **homologues** (corresponding chromosomes) coming from both the maternal and paternal lineages.



THE CELL CYCLE

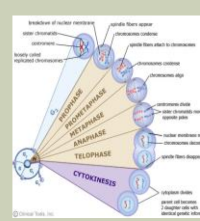
- Five phases:
  - G1 = growth or gap 1
  - S = DNA replication (synthesis)
  - G2 = growth or gap 2
  - M = mitosis
  - C = cytokinesis
- Also divided into phases
  - Interphase (G1 + S + G2)
  - Prophase
  - Metaphase
  - Anaphase
  - Telophase
  - Cytokinesis





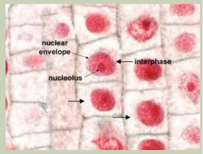
CELL CYCLE CONTINUED

- There is also a resting phase, sometimes called G_0 during which no growth or active division occurs
- Simply put:
  - Interphase: Cell is growing and storing nutrients to undergo mitosis
  - Mitosis: Cell is dividing itself into two identical daughter cells
- Organisms take different amounts of time to pass through the cell cycle, ranging from about 8 minutes to over a year



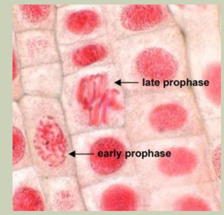
INTERPHASE

- Throughout the two growth phases:
  - Proteins synthesized
  - Cell gets larger
  - Organelles and extra membrane produced
- S phase:
  - DNA replication occurs so that half of what is created can go to each new daughter cell



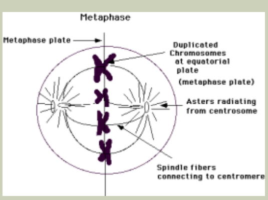
MITOSIS: PROPHASE

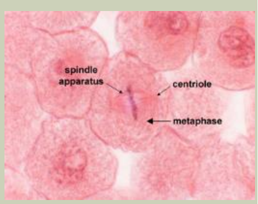
- Nucleolus disappears
- Chromatin condenses into chromosomes in early prophase
- The spindle apparatus is assembled—centrosomes (centrioles + protein) move to opposite ends of the cell
- Sister chromatids are linked to opposite poles of the cell by microtubules
- The nuclear envelope breaks down



MITOSIS: METAPHASE

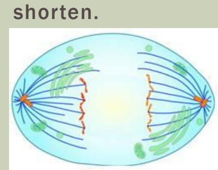
- Chromosomes align in the center of the cell along the metaphase plate
  - Pulled by mitotic spindles

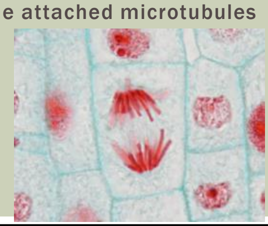




MITOSIS: ANAPHASE

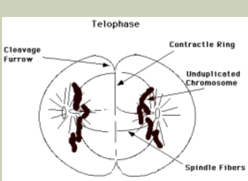
- Centromeres divide, freeing the two sister chromatids from each other
- Sister chromatids are pulled to opposite poles of the large cell as the attached microtubules shorten.

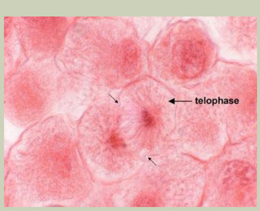




MITOSIS: TELOPHASE

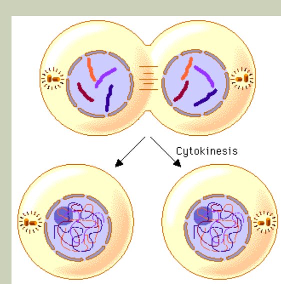
- Spindle apparatus disassembles
- Nuclear membrane begins to re-form around each bundle of separated chromosomes





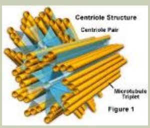
CYTOKINESIS

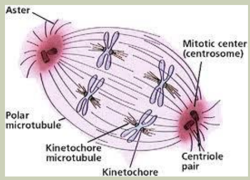
- Phase of the cell cycle when the cell actually divides
- Cytokinesis generally involves the cleavage of the cell into roughly equal halves, forming two daughter cells
- Each new daughter cell is a clone of the original parent with the same DNA



DIFFERENCE BETWEEN PLANTS AND ANIMALS

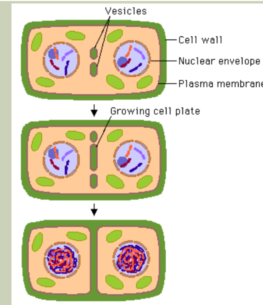
- Recall that plant cells don't have centrioles
  - Centrioles help direct mitotic spindles, but aren't necessary. Plants just rely on protein centrosomes to pull and direct chromosomes





DIFFERENCE BETWEEN PLANTS AND ANIMALS

- In cytokinesis…
  - Animal cell pinches in the middle
  - In plants "cell plate" forms between two layers of cell wall and the membranes divide after
    - Followed by elongation

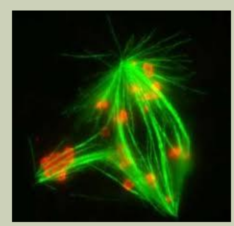


CELL CYCLE CONTROL

- The cell cycle is carefully controlled
- Three main checkpoints to both assess the internal state of the cell and integrate external signals.
  - G_1/S checkpoint = primary point at which the cell decides to divide
  - G_2/M checkpoint represents a commitment to mitosis
  - Spindle checkpoint (end of metaphase) ensures that all chromosomes are attached to the spindle in preparation for anaphase.

MOLECULAR MECHANISMS OF CELL CYCLE CONTROL

- Two groups of proteins, cyclins and Cyclin-dependent kinases, interact and regulate the cell cycle
  - Kinase: enzyme that transfers phosphates→ energy!
- Cells also receive protein signals (growth factors) that affect cell division.



CANCER AND THE CONTROL OF CELL PROLIFERATION

- Cancer is failure of cell division control
- It is believed that a malfunction in the p53 gene may allow cells to go through repeated cell division without being stopped at the appropriate checkpoints
- Proto-oncogenes are normal cell genes that become oncogenes when mutated.
  - can encode growth factors, protein relay switches, and kinase enzyme.
- Other tumor-suppressor genes can also lead to cancer when they are mutated.