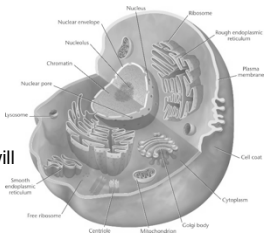
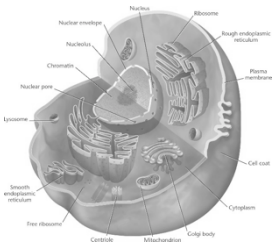
Cell Division and Mitosis

Parts of a Cell

- **Nucleus** - Controls the cell.
- **Nucleolus** - Makes ribosomes, maybe more than one in a cell, found in the nucleus.
- **Chromosomes**- Determines what traits a living thing will have, passes information from parent to offspring

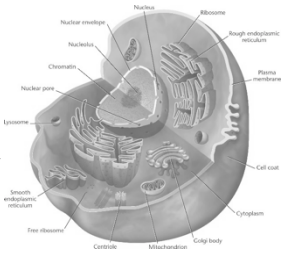


- **Cell Membrane** - Gives the cell shape and controls what moves into and out of the cell.
- **Cytoplasm** - Jellylike material where most organelles are found.
- **Vacuoles** - Liquid-filled, may store food, water, minerals, or wastes.



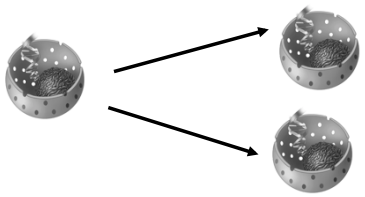
- **Mitochondria** - Produce energy when food is broken down, often called the "powerhouse of the cell".
- **Ribosomes** - Where proteins are made. A cell may have as many as 500,000.

Centrioles - Found only in animal cells, is used in cell reproduction to help the chromosomes arrange before cell division.



What is Mitosis?

- The process by which two new nucleii are formed, preceding cell division.



Purpose of Mitosis

- Produce two new cells with exactly the same:
- Kind of chromosomes
- Number of chromosomes as the parents.

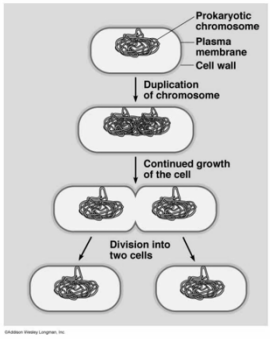
Why Do Cells Divide?

- Reproduction
- Growth
- Repair

Prokaryotic Cell Division

- Bacterial cells reproduce by binary fission
- Much simpler process than in eukaryotic organisms because of the lack of membrane bound organelles.
- Begins with DNA replication.
- Followed by elongation of cell, and formation of a septum (separation) between the two halves, forming two new cells
- Results in two cells that are identical (clones) of original cells.

Binary Fission



Eukaryotic Cell Division

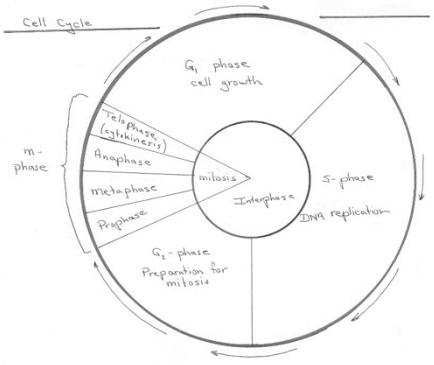
Two forms

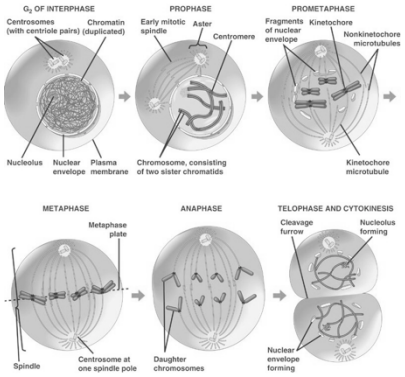
- Mitosis
  - grow, replace dead or worn out cells, or to repair wounds
  - Asexual reproduction in fungi, protists, some plants/animals
- Meiosis
  - Sexual reproduction

The Cell Cycle

The cell goes through several stages in its lifetime.

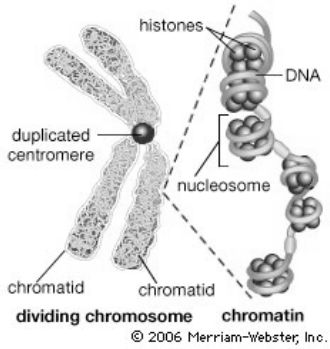
- 1. G_1- Growth and preparation for duplication
- 2. S- Synthesis of DNA (Replication)
- 3. G_2- Preparation for Mitosis
- 4. M- Mitosis





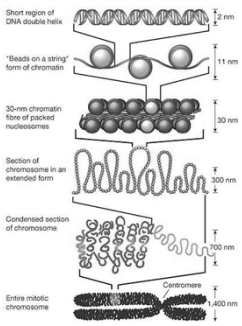
DNA and Cell Division

- During cell division, the genetic material DNA, needs to be copied and divided between the two new cells
- DNA in cells is divided into long chains called chromosomes ("volumes" of DNA)
- Chromosome DNA is wrapped around proteins called histones to organize it
- Nucleosome: unit of DNA wrapped around histones.



Eukaryotic Chromosome Structure

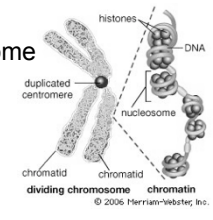
- Normally, chromosomes are spead out in a form called chromatin.
- During mitosis, chromosomes fold up and condense



Eukaryotic Chromosomes

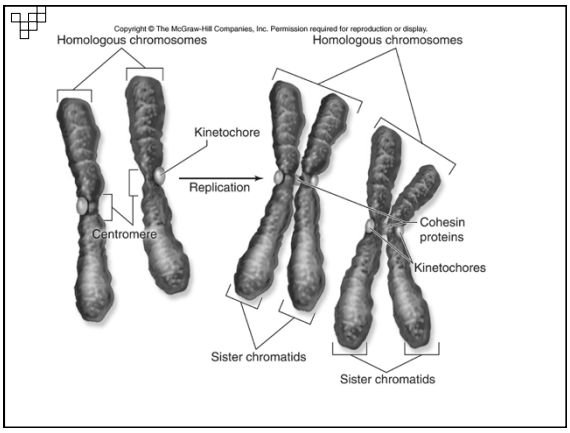
Chromosomes must be replicated before cell division.

--Sister chromatids:
2 copies of the chromosome within the replicated chromosome

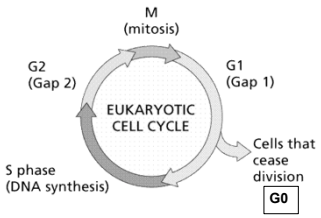


Chromosome structure

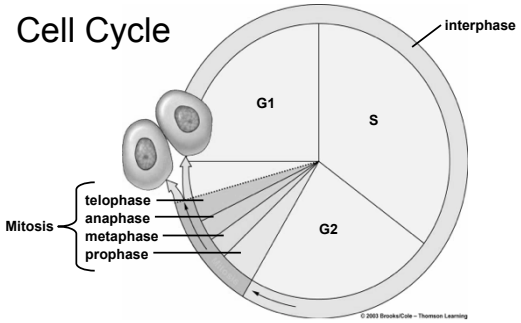
- Normally chromosomes are spread out & not identifiable (chromatin)
- At the start of mitosis they condense & take the form shown
- The replicated chromosomes stay together and are called sister chromatids
- Sister chromatids are attached at the centromere by proteins called cohesins



The Cell Cycle



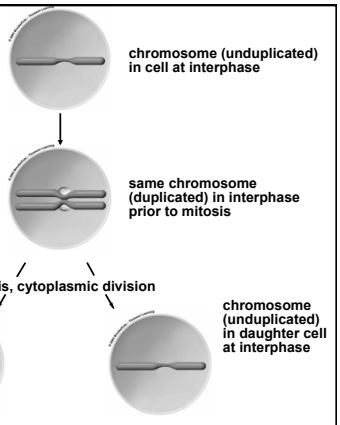
Cell Cycle



The Cell Cycle

- The length of time the cell cycle takes depends on the type of cell. Usually the more specialized the cell the less likely it is to divide.
- Red blood cells are replaced at a rate of 2-3 million/sec
- Nerve cells usually never divide, they enter G0 and remain there until they die.

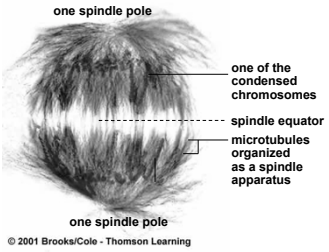
Maintaining Chromosome Number



The Spindle Apparatus

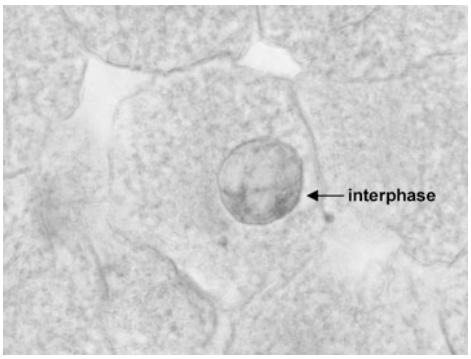
- Consists of two distinct sets of microtubules
  - Each set extends from one of the cell poles
  - Two sets overlap at spindle equator
- Moves chromosomes during mitosis
- In both plant and animal cells, spindle fibers originate from centrosomes; in animal cells, centrosomes are centrioles.

Spindle Apparatus



Interphase

- Normal cell function
- Time after mitosis to the time just before division.
- Nucleolus is visible
- Nuclear envelope visible
- Chromosomes NOT visible
- Interphase is NOT part of mitosis



Mitosis

Mitosis is divided into 4 phases:

1. Prophase
2. Metaphase
3. Anaphase
4. telophase

Mitosis

Prophase:

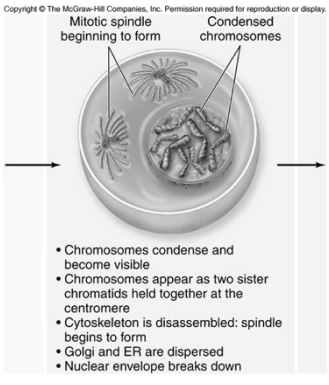
-chromosomes continue to condense

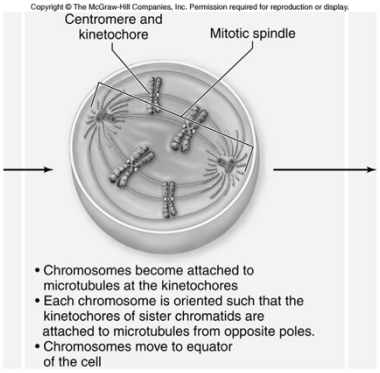
-centrioles move to each pole of the cell

-spindle apparatus is assembled

-nuclear envelope dissolves

- microtubules begin to pull each chromosome toward the center of the cell



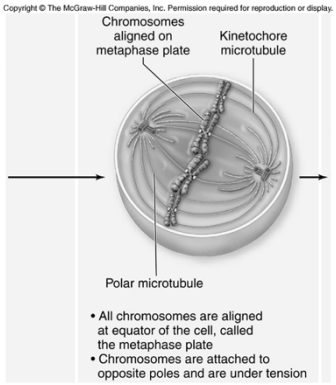


Mitosis

Metaphase:

-microtubules pull the chromosomes to align them at the center of the cell

-metaphase plate: imaginary plane through the center of the cell where the chromosomes align



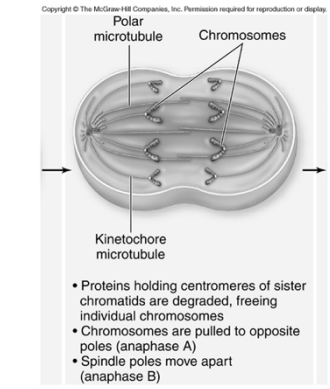
Mitosis

Anaphase:

-removal of cohesin proteins causes the centromeres to separate

-microtubules pull sister chromatids toward the poles

-chromosomes begin to move apart



Mitosis

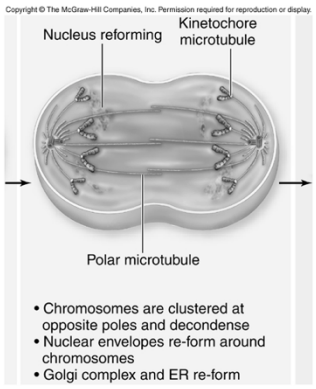
Telophase:

-spindle apparatus disassembles

-nuclear envelope forms around each set of sister chromatids

-chromosomes begin to uncoil

-nucleolus reappears in each new nucleus



Cytokinesis

- Cytoplasmic Division
- Usually occurs between late anaphase and end of telophase
- Two mechanisms
  - Cell plate formation (plants)
  - Cleavage (animals)

Cytokinesis: Animal Cell

- Cleavage furrow

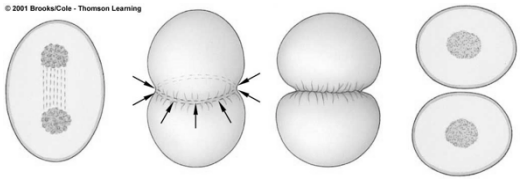


Figure 9.9
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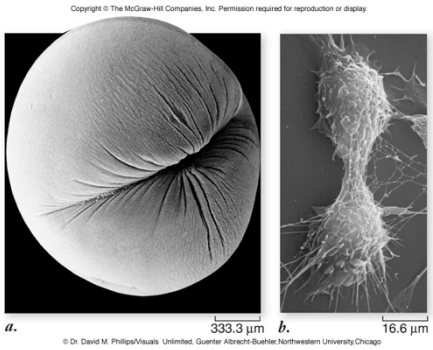

Cytokinesis: Plant Cells

- Cell Plate Formation

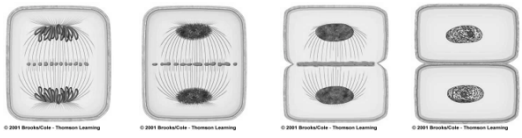

Figure 9.8
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Mitosis/Cytokinesis outcome

- 1 parent cell → 2 identical daughter cells
- Chromosome number remains the same from one generation to the next

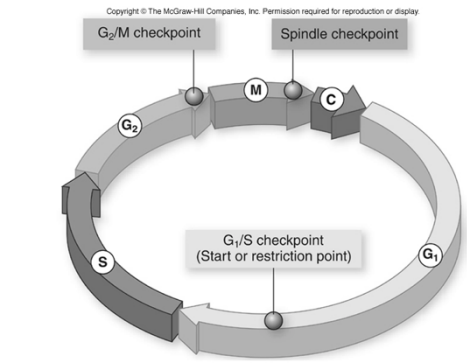
Mitosis: plant vs. animal cells

	Plant cell	Animal Cell
Centrioles	Absent	Present
Cytokinesis	Cell plate formation	Cleavage furrow

Control of the Cell Cycle

The cell cycle is controlled at three checkpoints:

1. G_1/S checkpoint
   -the cell "decides" to divide
2. G_2/M checkpoint
   -the cell makes a commitment to mitosis
3. late metaphase (spindle) checkpoint
   -the cell ensures that all chromosomes are attached to the spindle



Control of the Cell Cycle

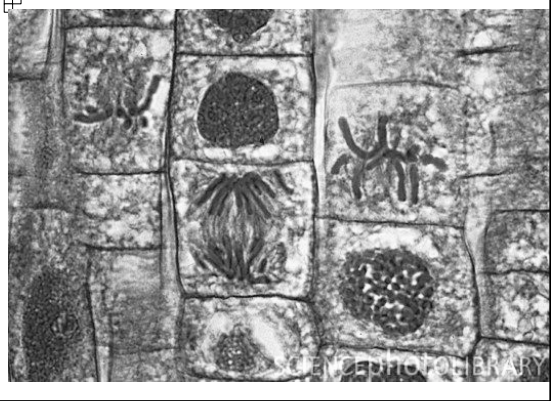
Growth factors:

-can influence the cell cycle

-trigger intracellular signaling systems

-can override cellular controls that otherwise inhibit cell division

platelet-derived growth factor (PDGF) triggers cells to divide during wound healing



Control of the Cell Cycle

Cancer is a failure of cell cycle control.

Two kinds of genes can disturb the cell cycle when they are mutated:

1. tumor-suppressor genes
2. proto-oncogenes

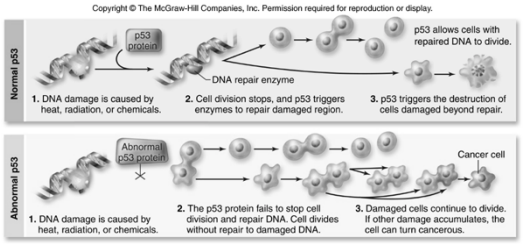
Control of the Cell Cycle

Tumor-suppressor genes:

-prevent the development of many cells containing mutations

-for example, *p53* halts cell division if damaged DNA is detected

-*p53* is absent or damaged in many cancerous cells



Control of the Cell Cycle

Proto-oncogenes:

-some encode receptors for growth factors

-some encode signal transduction proteins

-become oncogenes when mutated

-oncogenes can cause cancer when they are introduced into a cell