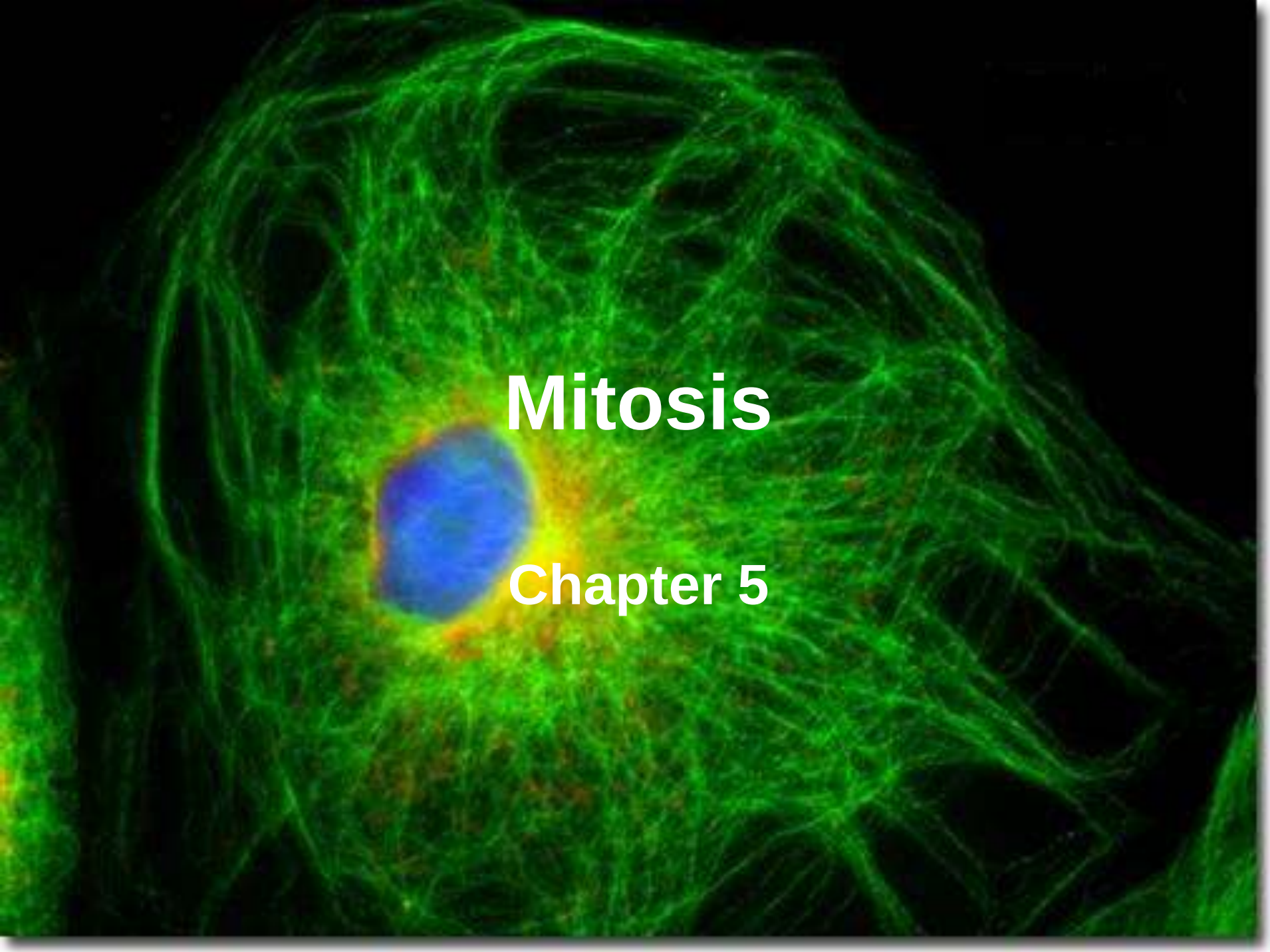


Mitosis

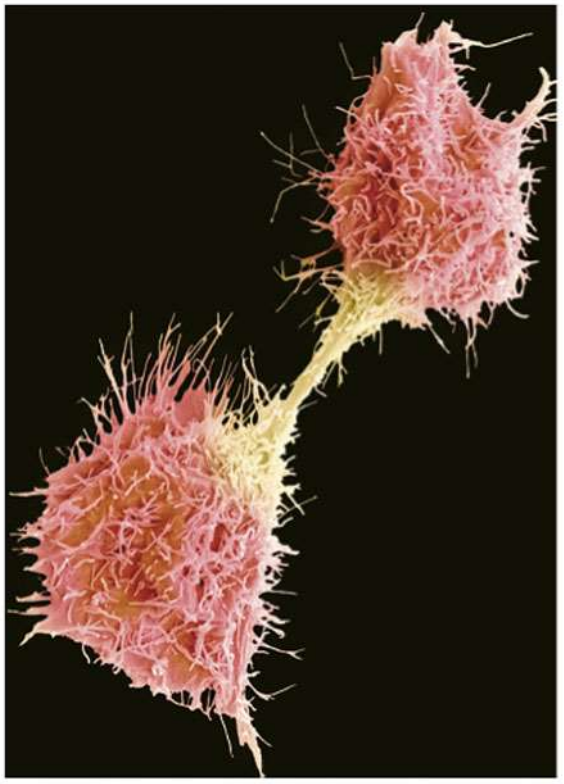
Chapter 5

Cells Divide, and Cells Die

Your cells are rapidly dying and being replaced.

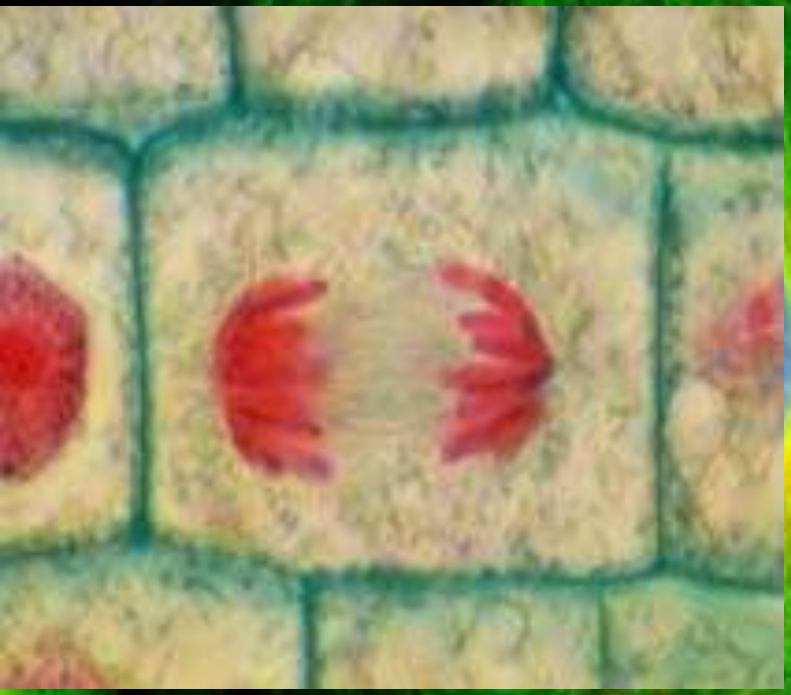
Cell division produces a continuous supply of replacement cells.

Cell division also has a role in reproduction, growth, and development.



SEM (false color) 5 µm

Cell Division

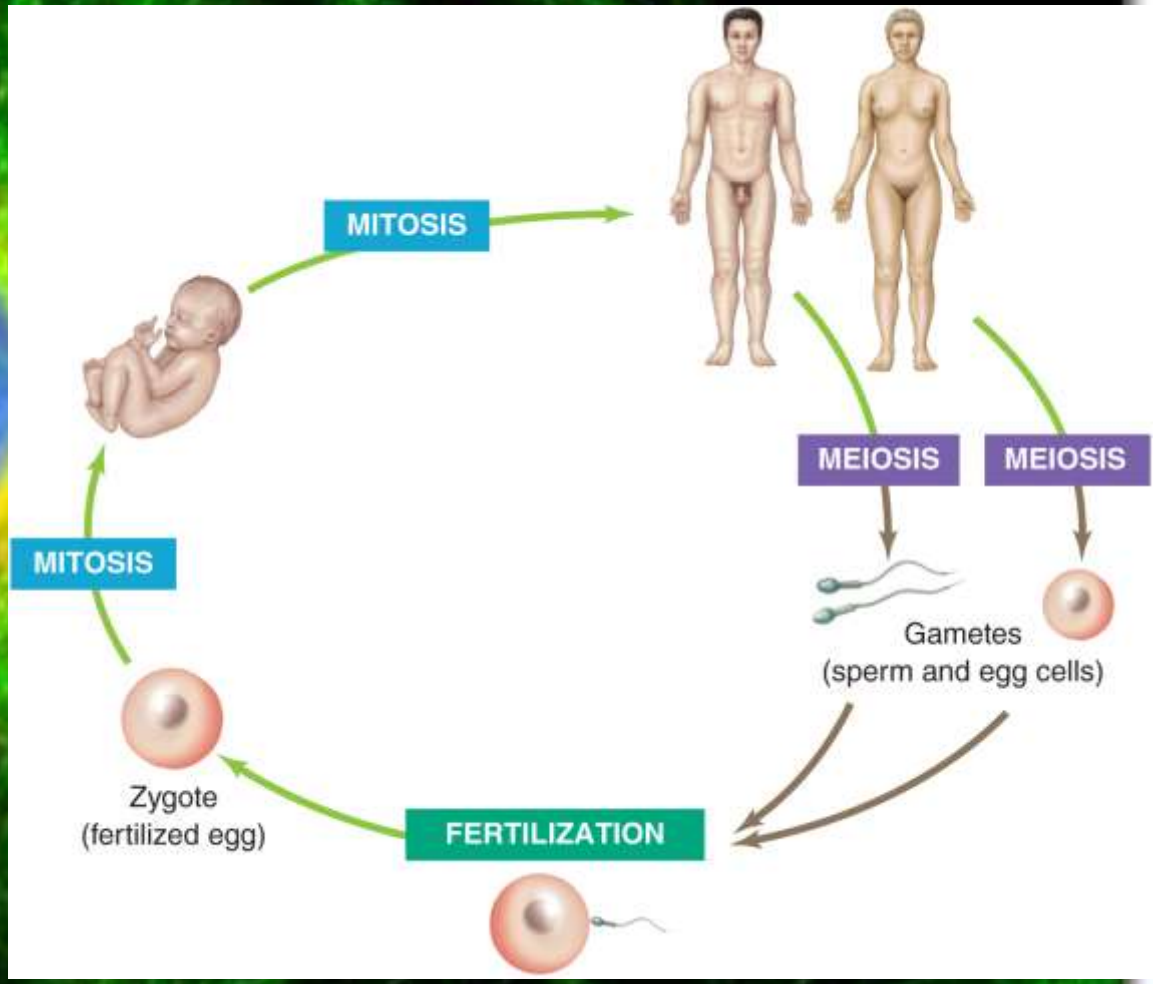


- Cells divide to make more cells. While all the other organelles can be randomly separated into the daughter cells, the chromosomes must be precisely divided so that each daughter cell gets exactly the same DNA.
- Mitosis is normal cell division, which goes on throughout life in all parts of the body. Meiosis is the special cell division that creates the sperm and eggs, the gametes.

Two Types of Cell Division Interact in the Sexual Life Cycle

Each mature individual produces sex cells by another form of cell division called **meiosis**.

Sex cells combine at **fertilization**.

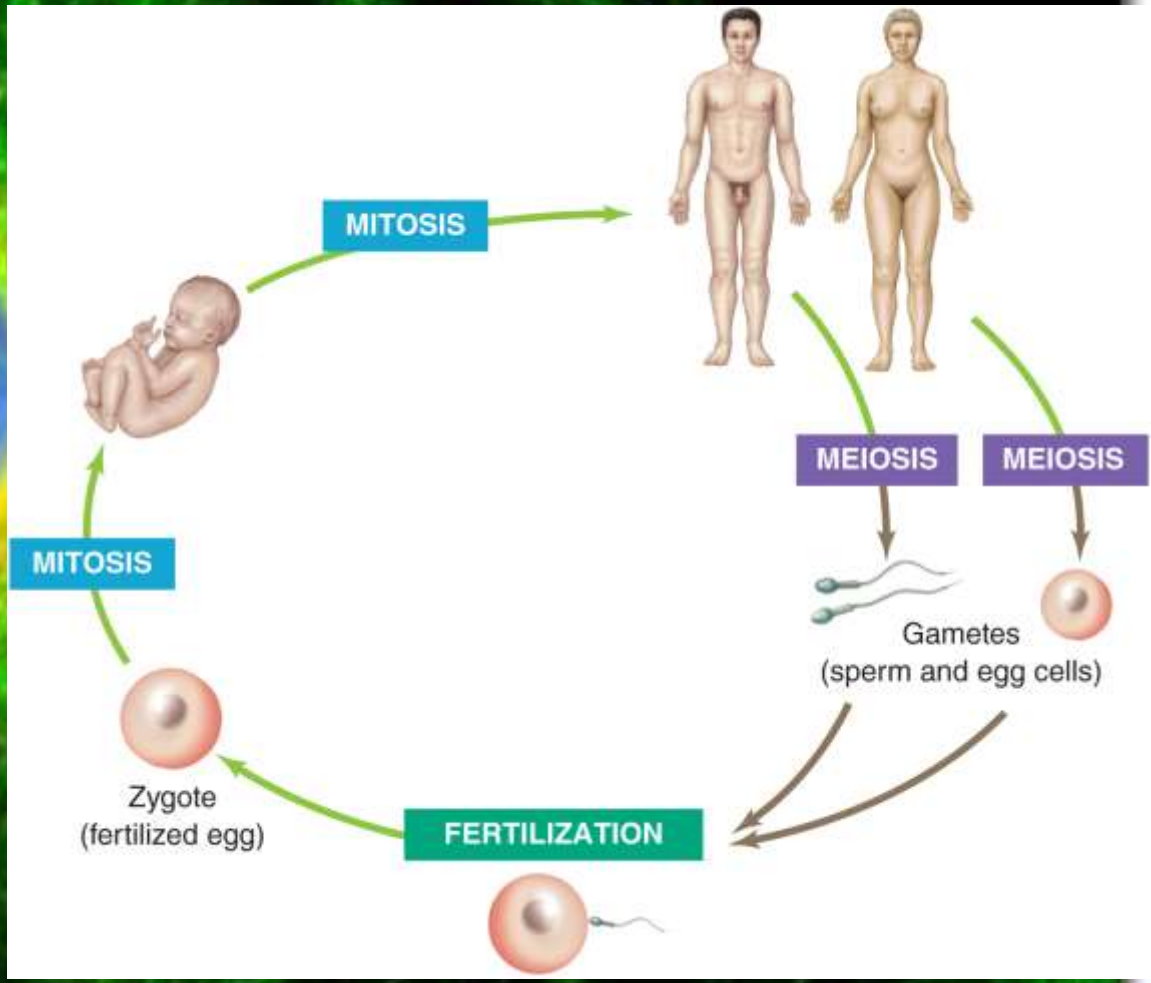


Section 8.1

Figure 8.1

Two Types of Cell Division Interact in the Sexual Life Cycle

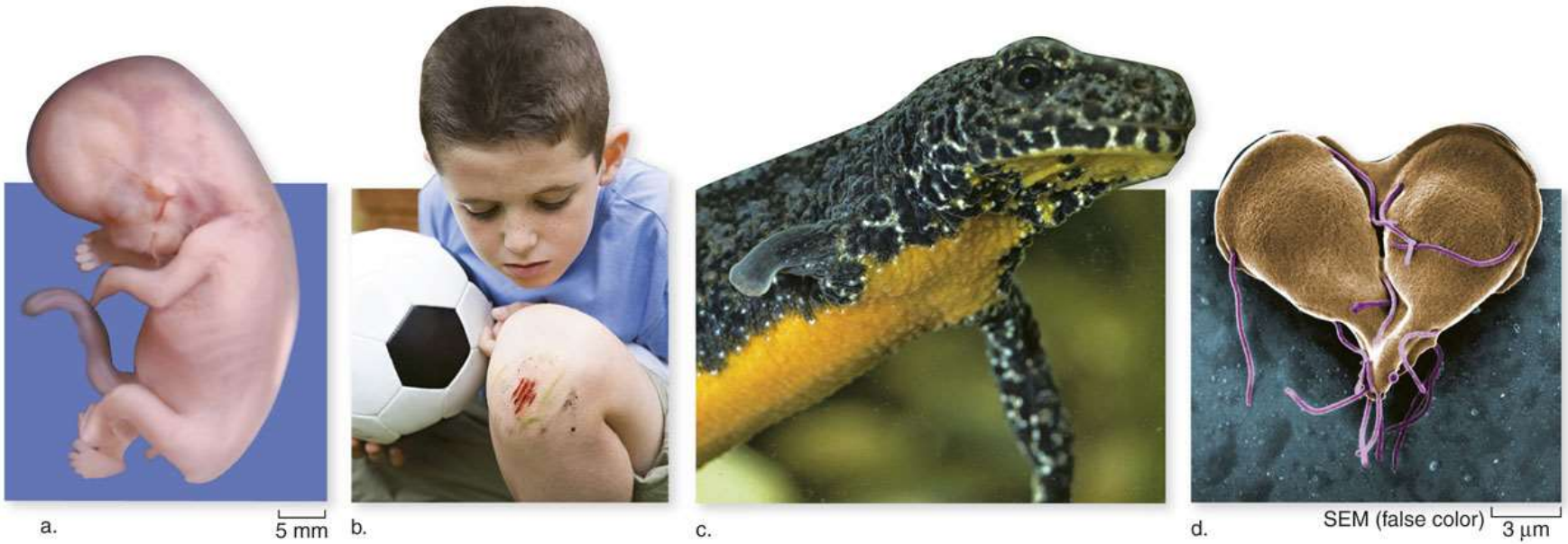
A fertilized egg, or zygote, divides by **mitosis**. The fetus grows and develops into a mature adult consisting of countless cells with identical DNA.



Section 8.1

Figure 8.1

Mitosis Has Many Roles

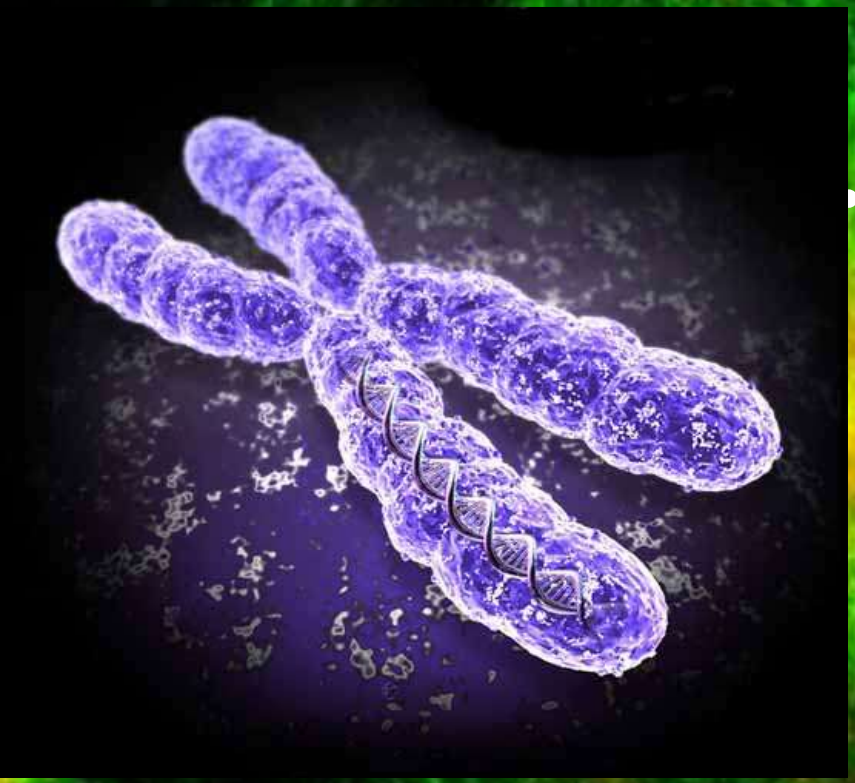


a: © Brad Smith, University of Michigan NICHD: NO1-HD-6-3257; b: "© Image Source (RF)/Getty Images;
c: © Hans Pfletschinger/Photolibrary; d: Centers for Disease Control and Prevention (CDC)

Mitotic cell divisions allow an organism to grow and develop, repair tissues, and regenerate lost body parts.
Some organisms reproduce asexually by mitosis.

Figure 8.2

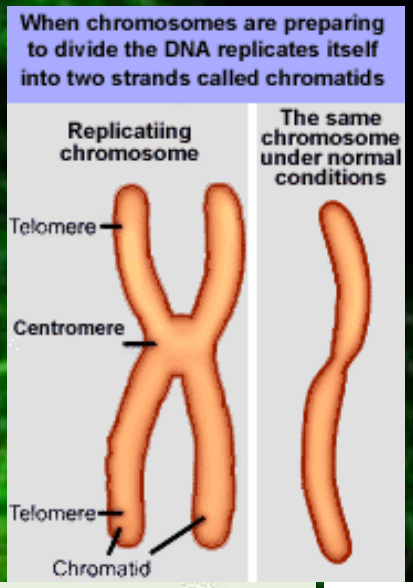
Chromosomes

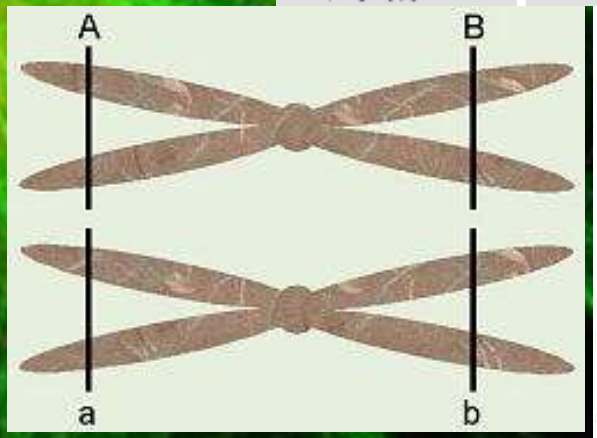


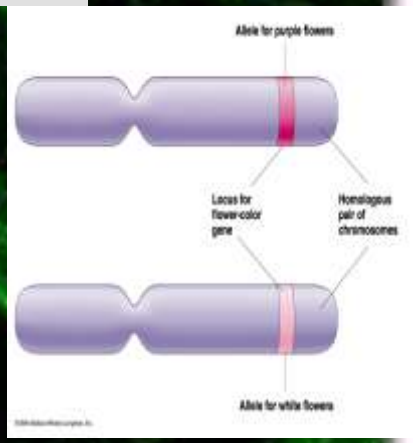
- Each chromosome has a central constricted region called a centromere that serves as an attachment point for the machinery of mitosis.
- Chromosomes exist in 2 different states, before and after they replicate their DNA. Before replication, chromosomes have one chromatid. After replication, chromosomes have 2 sister chromatids, held together at the centromere. Each chromatid is one piece of DNA with its supporting proteins.

More Chromosomes

- In mitosis, the two chromatids of each chromosome separate, with each chromatid going into a daughter cell.
- Remember that diploid cells have two copies of each chromosome, one from each parent. These pairs of chromosomes are NOT attached together.

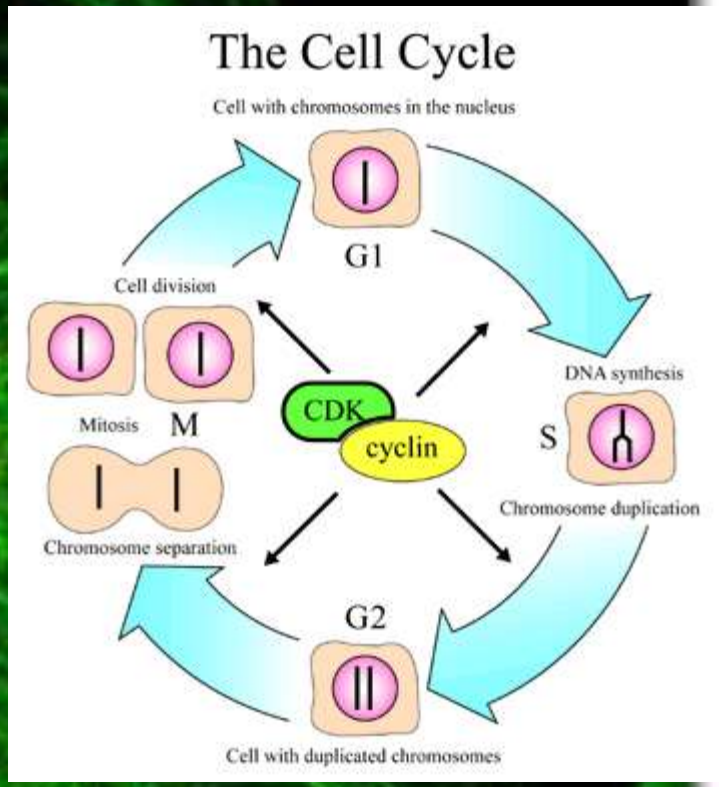


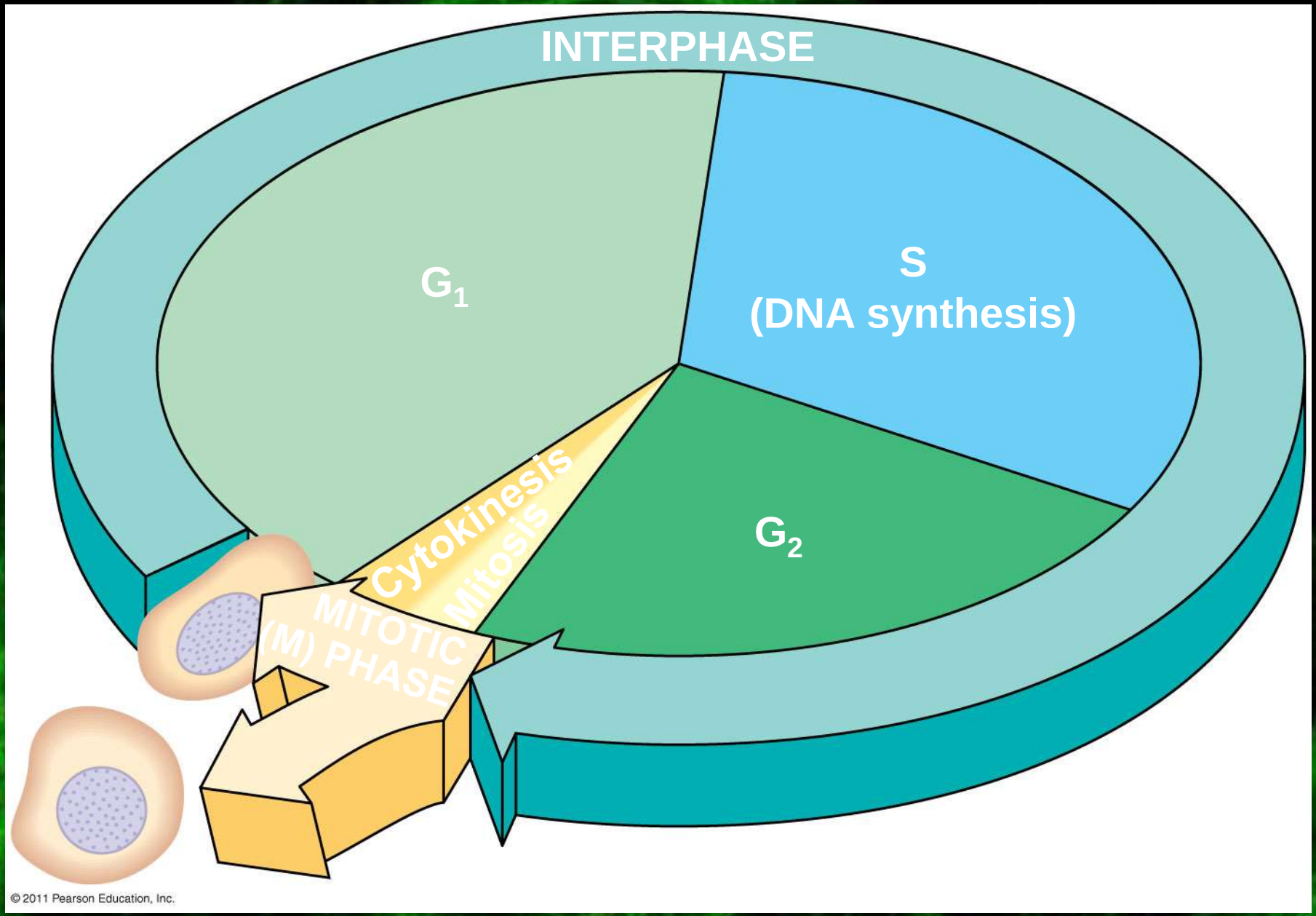




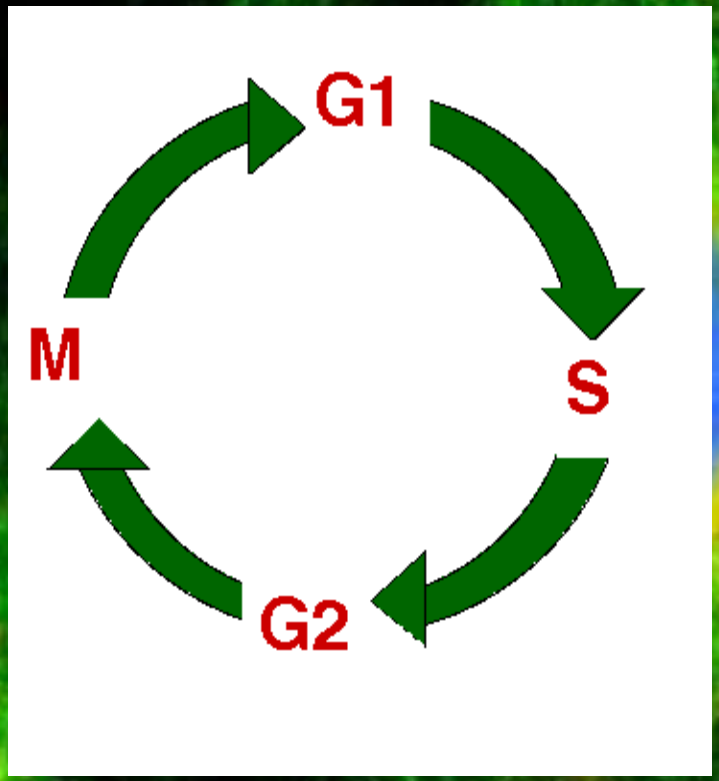
Cell Cycle

- Some cells divide constantly: cells in the embryo, skin cells, gut lining cells, etc. Other cells divide rarely or never: only to replace themselves.
- Actively dividing cells go through a cycle of events that results in mitosis. Most of the cycle was called “interphase” by the microscopists who first studied cell division. During interphase the cell increases in size, but the chromosomes are invisible.
- The 3 stages of interphase are called G1, S, and G2.



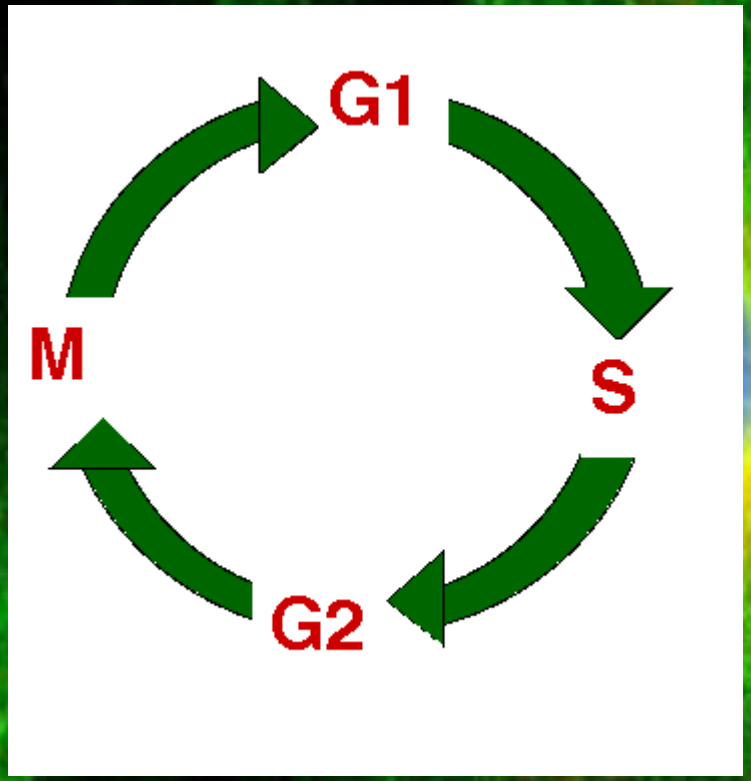


Interphase



- G1 (“Gap”) is the period between mitosis and S, when each chromosome has 1 chromatid. Cells spend most of their time in G1: it is the time when the cell grows and performs its normal function.
- The S phase (“Synthesis”) is the time when the DNA is replicated, when the chromosome goes from having one chromatid to having 2 chromatids held together at the centromere.

Interphase cont.

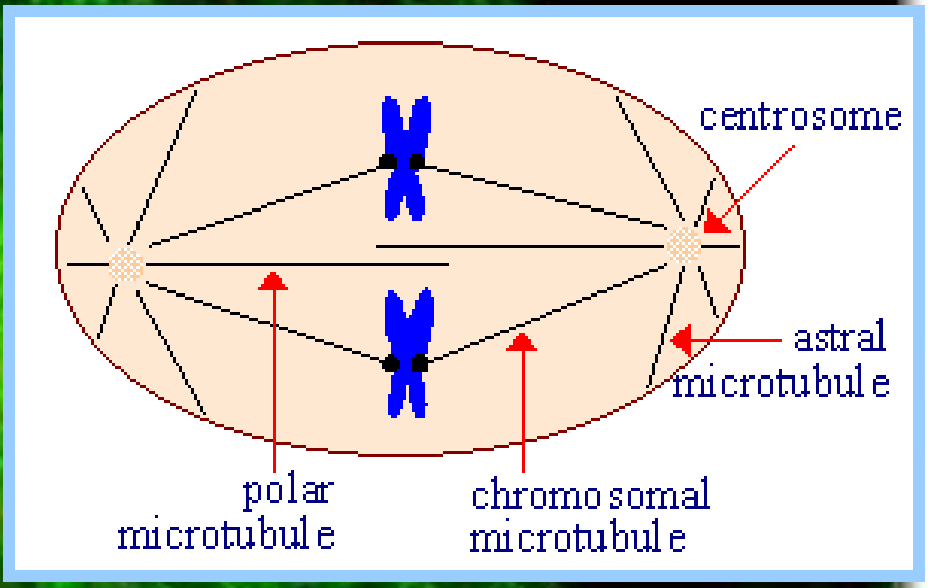


- Control of cell division occurs in G1: a cell that isn't destined to divide stays in G1, while a cell that is to divide enters the S phase.
- G2 is the period between S and mitosis. The chromosome have 2 chromatids, and the cell is getting ready to divide.

Mitosis

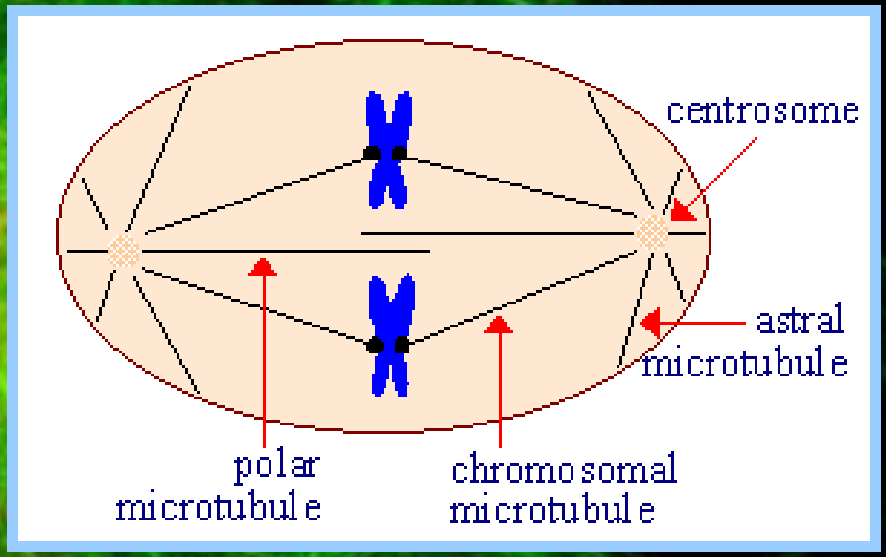
Machinery of Mitosis

- The chromosomes are pulled apart by the spindle, which is made of microtubules. The spindle fibers are attached to each centromere, and anchored on the other end to centrioles.
- There are 2 centrioles in animal cells, one at each end of the spindle. The chromosomes are lined up between the poles of the spindle.



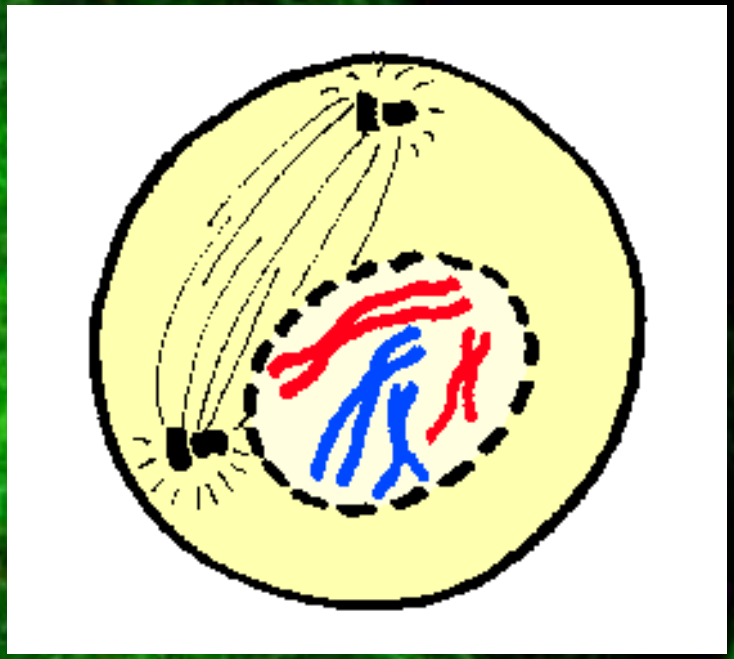
Machinery of Mitosis

- When the spindle fibers contract, the chromosomes are pulled to the opposite poles.
- The cell then divides to separate the two poles.
- Stages of mitosis: prophase, metaphase, anaphase, telophase.



Prophase

- In prophase, the cell begins the process of division.
- 1. The chromosomes condense. The proteins attached to the DNA cause the chromosomes to go from long thin structures to short fat one, which makes them easier to pull apart.
- 2. The nuclear envelope disappears. The double membrane that surround the nucleus dissolves into a collection of small vesicles, freeing the chromosomes to use the whole cell for division



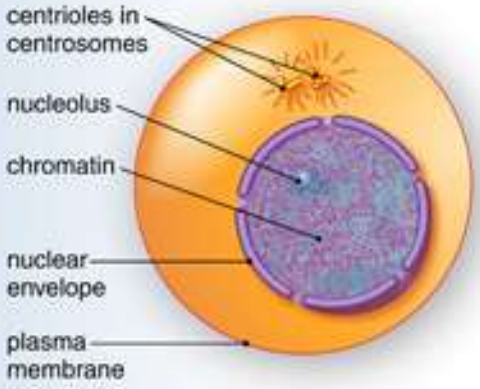
Prophase cont…

- 3. The centrioles move to opposite poles. During interphase, the pair of centrioles were together just outside the nucleus. In prophase they separate and move to opposite ends of the cell.
- 4. The spindle starts to form, growing out of the centrioles towards the chromosomes.

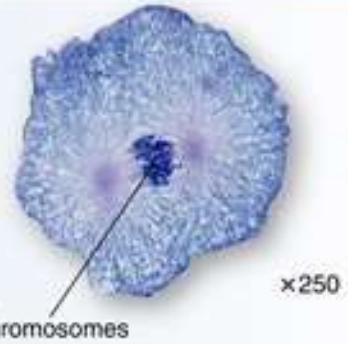
Cell cycle G_1, S, G_2

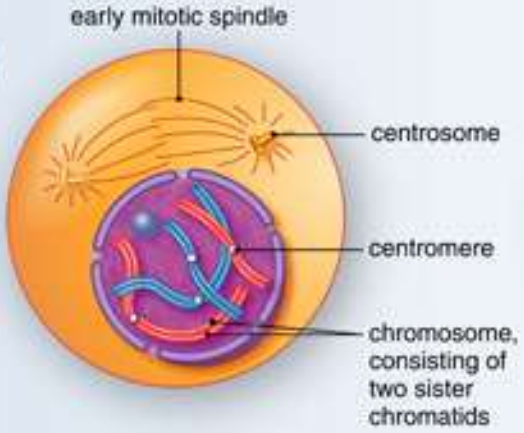
Cell cycle M: Phases of mitosis

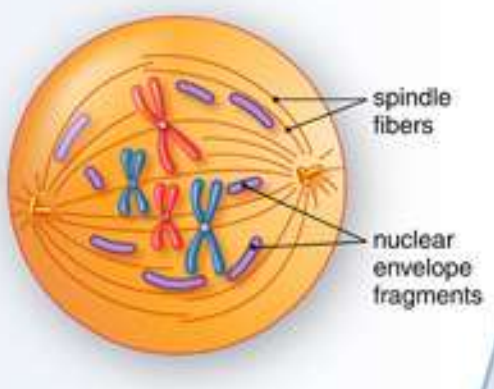
Interphase



Prophase







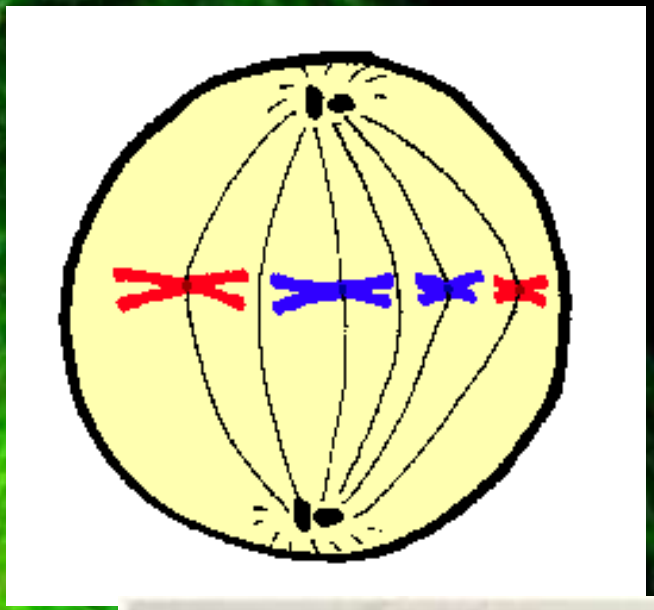
Interphase
During interphase, the eukaryotic cell duplicates the contents of the cytoplasm, and DNA replicates in the nucleus. The duplicated chromosomes are not yet visible. A pair of centrosomes is outside the nucleus.

Prophase
During prophase, the chromosomes are condensing. Each consists of two sister chromatids held together at a centromere. Outside the nucleus, the spindle begins to assemble between the separating centrosomes.

Prophase continues with the disappearance of the nucleolus and the breakdown of the nuclear envelope. Spindle fibers from each pole attach to the chromosomes at specialized protein complexes on either side of each centromere. During attachment, a chromosome first moves toward one pole and then toward the other pole.

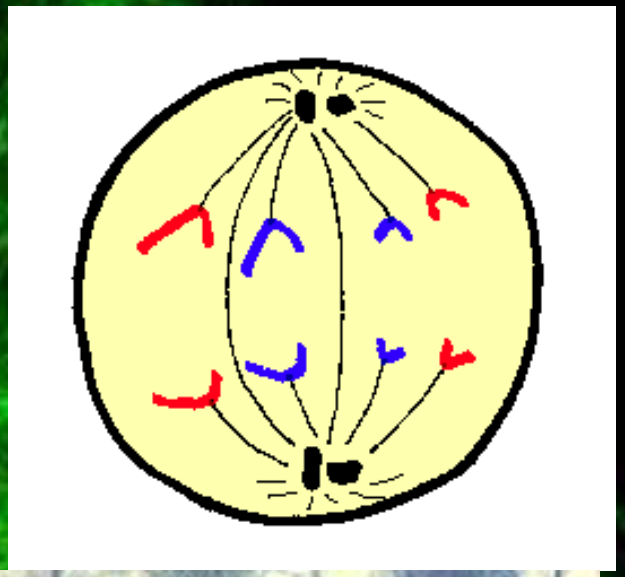
Metaphase

- Metaphase is a short resting period where the chromosomes are lines up on the equator of the cell, with the centrioles at opposite ends and the spindle fibers attached to the centromeres.
- Everything is aligned for the rest of the division process to occur.



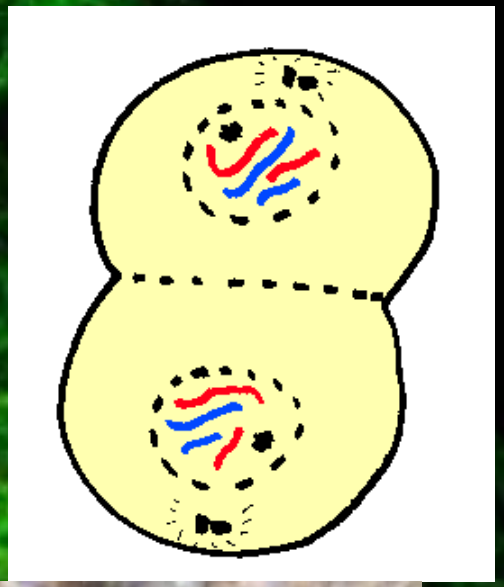
Anaphase

- In anaphase, the centromeres divide. At this point, each chromosome goes from having 2 chromatids to being 2 chromosomes, each with a single chromatid.
- Then the spindle fibers contract, and the chromosomes are pulled to opposite poles.



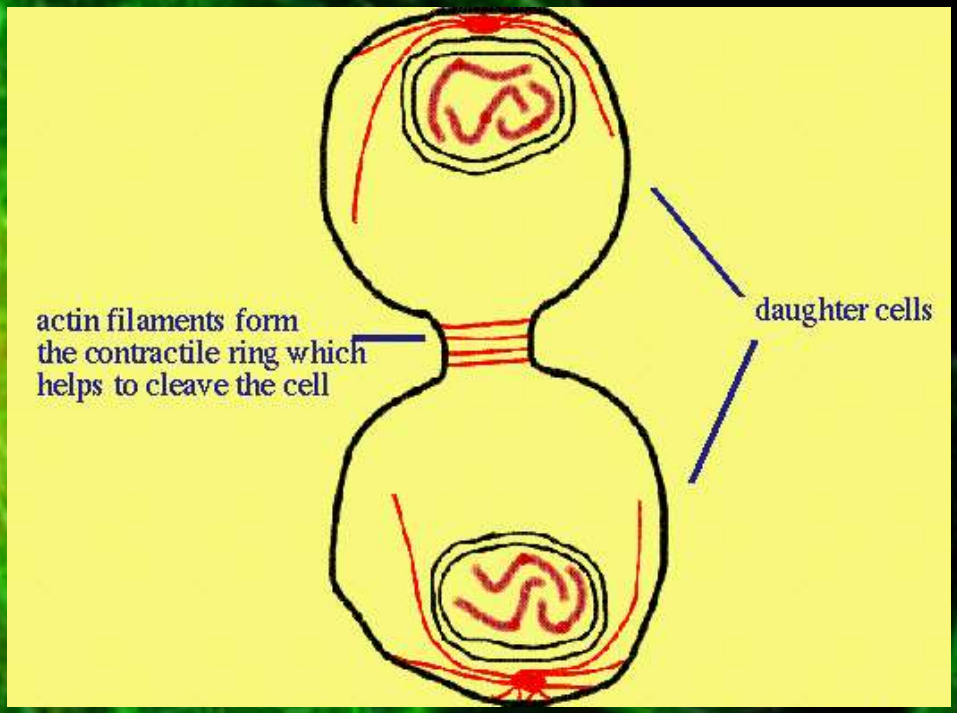
Telophase

- In telophase the cell actually divides.
- The chromosomes are at the poles of the spindle.
- The spindle disintegrates
- The nuclear envelope re-forms around the two sets of chromosomes.
- The cytoplasm divides into 2 separate cells.



Cytokinesis - Cytoplasmic Division

- The organelles (other than the chromosomes) get divided up into the 2 daughter cells passively: they go with whichever cell they find themselves in.
- Plant and animal cells divide the cytoplasm in different ways.

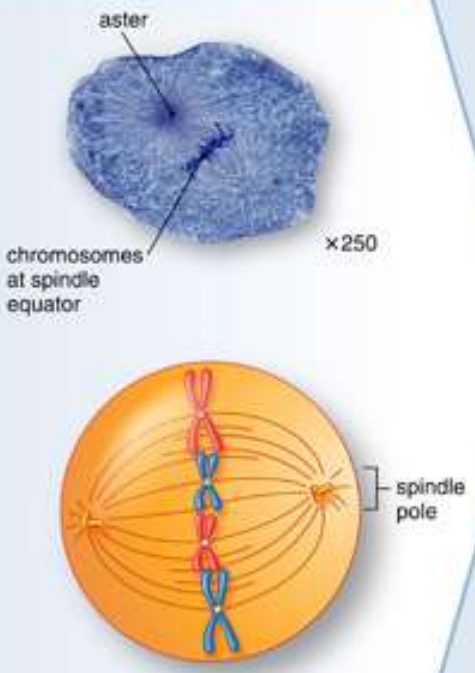


Cytokinesis cont…

- In plant cells, a new cell wall made of cellulose forms between the 2 new nuclei, about where the chromosomes lined up in metaphase. Cell membranes form along the surfaces of this wall. When the new wall joins with the existing side wall, the 2 cells have become separate.
- In animal cells, a ring of actin fibers (microfilaments are composed of actin) forms around the cell equator and contacts, pinching the cell in half.

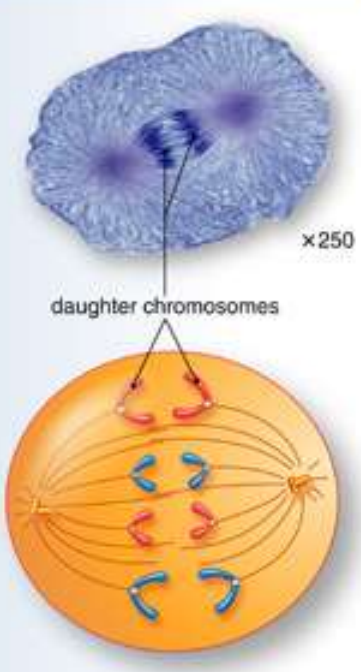
Phases of mitosis

Metaphase



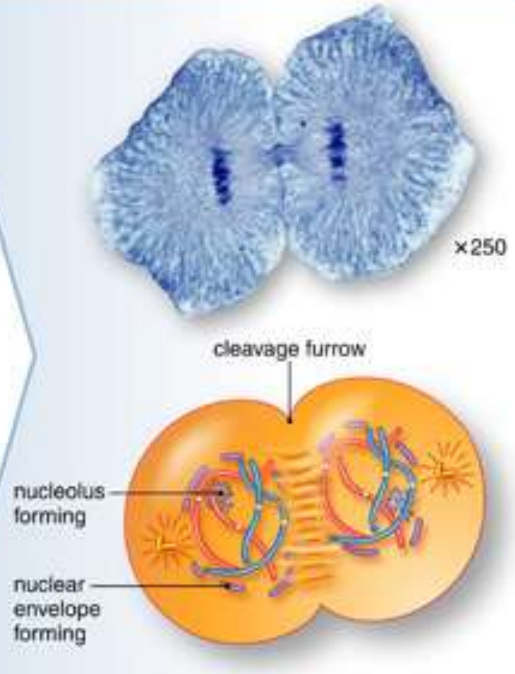
Metaphase
During metaphase, the chromosomes are aligned at the spindle equator midway between the spindle poles. The spindle fibers on either side of a chromosome extend to opposite poles of the spindle. Unattached spindle fibers reach beyond the equator and overlap.

Anaphase



Anaphase
During anaphase, the sister chromatids separate and become daughter chromosomes. As the spindle fibers attached to the chromosomes disassemble, each pole receives a set of daughter chromosomes. The spindle poles move apart as the unattached spindle fibers slide past one another. This contributes to chromosome separation.

Telophase and Cytokinesis

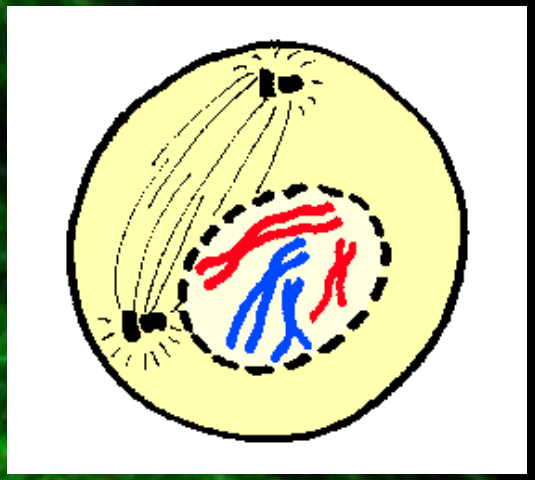


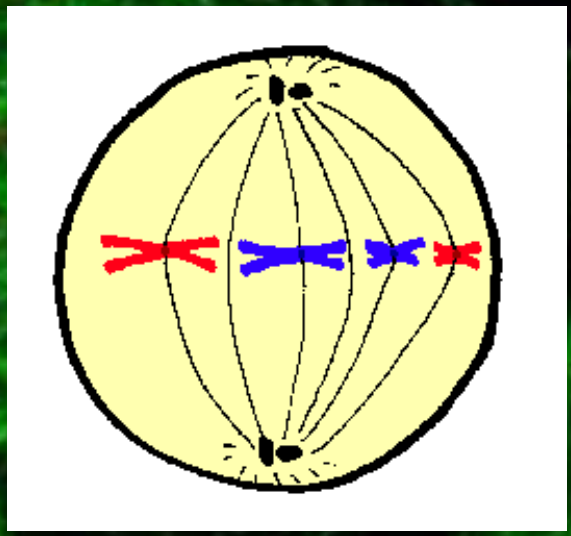
Telophase and Cytokinesis
During telophase, the spindle disappears as new nuclear envelopes form around the daughter chromosomes. Each nucleus contains the same number and kinds of chromosomes as the original parent cell. Remnants of spindle fibers are still visible between the two nuclei. Division of the cytoplasm begins.

BioFlix
Mitosis

Summary of Mitosis

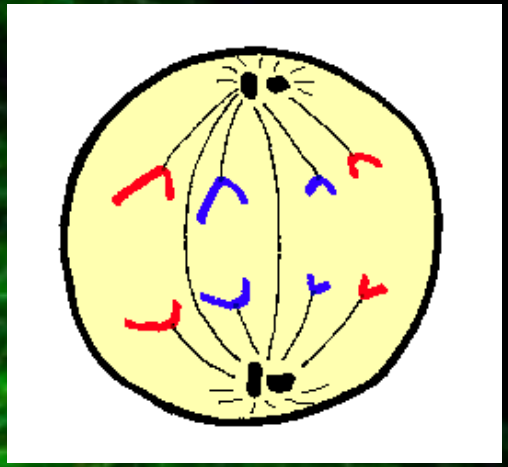
- Prophase:
  - Chromosomes condense
  - Nuclear envelope disappears
  - Centrioles move to opposite sides of the cell
  - Spindle forms and attaches to centromeres on the chromosomes
- Metaphase
  - Chromosomes lined up on equator of spindle
  - Centrioles at opposite ends of cell

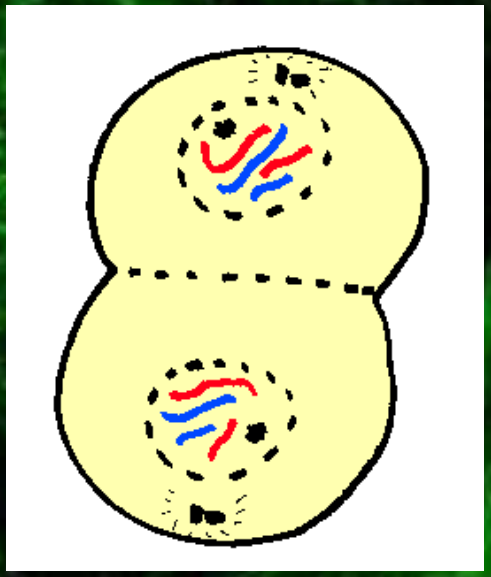




Summary of Mitosis cont…

- Anaphase
  - Centromeres divide: each 2-chromatid chromosome becomes two 1-chromatid chromosomes
  - Chromosomes pulled to opposite poles by the spindle
- Telophase
  - Chromosomes de-condense
  - Nuclear envelope reappears
  - Cytoplasm divided into 2 cells





8.5 The Cell Cycle and Cancer

- Cancer- disease of the cell cycle.

- The regulation of the cell cycle is lost and uncontrolled cell division occurs.

- Cancers classified by their location.
  - Carcinomas- cancers of organs.
  - Sarcomas- cancers of muscles.
  - Leukemias- cancers of blood.