Cell Division (Mitosis) and Death (Learning Objectives)

- The importance of Mitosis and cell death for regulation of cell numbers during development, growth, and repair of the human body (slides 2 & 3).
- Learn that different cells vary in how often they divide and examples of those who divide frequently, occasionally, or not at all. (slide 4)
- Explain the progression of events that leads from a single mother cell to two identical daughter cells (slide 5) and learn the names of the cell cycle stages with their specific events (slides 6-9).
- Learn the difference between the terms chromosome (un-replicated), centromere, and chromatid (slide 10).
- Learn the phases of mitosis and the events that occur in each (slides 11-15).
- Explain cytokinesis and its importance and purpose (slide 16).
- The importance of cell cycle control to ensure orderly passage through the sequence of stages to produce two daughter cells that are identical to their mother cell. Identify the place and purpose of each of the 4 check points (slides 17-18).
- The structure of telomeres, function of telomerase, and relationship between their length and the possible number of cell divisions for a cell. Relate that to human mortality (slides 19-21).
- The summary of Apoptosis as an orderly programmed cell death to disassemble the cells from the inside (slides 22-25).
Cell Division and Death

Normal growth and development require a balance between the rates of two processes

Cell division (Mitosis) of somatic cells

Apoptosis – Programmed Cell death

Cells division s also necessary to repair injury
Speed of cell division varies with the type of cell

All the time
   Outer layer of skin
   Bone marrow
   Lining of digestive system

Sometimes
   Liver cells

Specialized cells that do not divide
   Nerve cells (cannot repair themselves)
Cell Division

One mother cell divides into two identical cells following an ordered sequence of events (Cell Cycle)

Summary of event of dividing cells

- Replicate the genetic material
- Manufacture additional cellular content
- Divide the nucleus
- Separate the cytoplasm
Cell Cycle Stages

Interphase with gaps for growth

Mitosis - division of the nucleus

Cytokinesis - division of the cytoplasm

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The Cell Cycle

**G phase:** Gap for growth

**S phase:** DNA synthesis

**M phase:** Mitosis (nuclear division)

**Cytokinesis:** Cell division

*Figure 2.14*
Stages of the Cell Cycle

Interphase
- Prepares for cell division
- Replicates DNA and subcellular structures
- Composed of G₁, S, and G₂
- Cells may exit the cell cycle at G₁ or enter G₀, a quiescent phase

Mitosis – Division of the nucleus

Cytokinesis – Division of the cytoplasm
Replication of Chromosomes

Chromosomes are replicated during S phase prior to mitosis. The result is two sister chromatids held together at the centromere.

Figure 2.15
Mitosis

Used for growth, repair, and replacement

Consists of a single division that produces two identical daughter cells

A continuous process divided into 4 phases

- Prophase
- Metaphase
- Anaphase
- Telophase
Mitosis in a Human Cell

**Figure 2.15**

**Figure 2.16**

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Prophase

- Replicated chromosomes condense
- Microtubules organize into a spindle
- Nuclear envelope and nucleolus break down

Figure 2.16

Interphase
Chromosomes are uncondensed.

Prophase
Condensed chromosomes take up stain. The spindle assembles, centrioles appear, and the nuclear envelope breaks down.
Metaphase

- Chromosomes line up on the cell’s equator
- Spindle microtubules are attached to centromeres of chromosomes

Figure 2.16
Anaphase

- Centromeres separate
- Chromatids pulled away and become independent chromosomes
  - each moves to opposite ends of the cell

Figure 2.16
Telophase

- Chromosomes uncoil
- Spindle disassembles
- Nuclear envelope reforms

Figure 2.16
Cytokinesis

Cytoplasmic division occurs after nuclear division is complete

Organelles and macromolecules are distributed between the two daughter cells

Microfilament band contracts, separating the two cells
Cell Cycle Control

Checkpoints ensure that mitotic events occur in the correct sequence

Internal and external factors are involved

Many types of cancer result from faulty checkpoints
Progression through cell cycle is controlled by regulatory proteins.
Telomeres

Located at the ends of the chromosomes
Contain hundreds to thousands of repeats of a 6-base DNA sequence added by telomerase
Life span of dividing cells

Determined by length of telomeres

- Telomerase is active in sperm, eggs, stem cells (bone marrow), and cancer cells but not in somatic tissues
- Most cells lose 50-200 endmost bases after each cell division
- After about 50 divisions, shortened telomeres signal the cell to stop dividing

http://www.learner.org/courses/biology/units/cancer/images.html
Q: Why are we mortal with a limited life span?

A: Our cells have a limited life span (# of cell divisions)

Telomeres and stress?
Twin studies
Apoptosis

- Begins when a cell receives a “death signal”
- Killer enzymes called *caspases* are activated
  - Destroy cellular components
- Dying cell forms bulges called blebs
- Phagocytes digest the remains
Necrosis versus apoptosis

http://www.whfreeman.com/kuby/content/anm/kb04an01.htm
Programmed cell death is part of normal development.

Figure 2.18 Mitosis and apoptosis work together to form functional body.

Cancer can result from too much mitosis, too little apoptosis.

Figure 2.19