The Cell Cycle
Chapter 9

Good to Know
- Purpose of mitosis
- Cell Cycle
- Steps and events in mitosis
- Binary fission
- Relationship between mitosis and cancer

Role of Cell Division
- Prokaryote
  - Creates an entire organism
- Eukaryote
  - Why do we need cell division?
Organism Genomes

- Prokaryote
  - Single DNA molecule
- Eukaryote
  - Multiple DNA molecules
  - Chromosomes

Chromosomal Structure

- Each chromosome
  - Long linear DNA molecule
  - Associated with proteins
  - Contains several hundred to a few thousand genes
  - Human somatic cells – 46 chromosomes (23 pairs)
  - Human gamete cells – 23 chromosomes

Cell division and chromosomes

- Prior to and during DNA replication
  - Long thin chromatin fibers
- After DNA replication
  - Condensed
    - Densely coiled and folded
  - Two DNA molecules attached
    - Sister chromatids
Two methods of cell division

- Mitosis
  - Division of genetic material
  - 2 identical daughter cells
  - Somatic cells
- Meiosis
  - Reduction of genetic material
  - 4 unique daughter cells
  - Gametes

Phases of the Cell Cycle

- The cell cycle consists of
  - Mitotic (M) phase
    - Includes mitosis and cytokinesis
  - Interphase
    - Including cell growth and copying of chromosomes in preparation for cell division
• Interphase (about 90% of the cell cycle) can be divided into subphases
  – G₁ phase ("first gap")
  – S phase ("synthesis")
  – G₂ phase ("second gap")

• The cell grows during all three phases, but chromosomes are duplicated only during the S phase

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The Cell Cycle

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Stages of Mitosis

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video
The Mitotic Spindle

- Includes
  - Centrosomes
    - Microtubule organizing center
  - Spindle microtubules
  - Asters
  - Microtubule fibers and associated proteins
Cytokinesis (and the 1 becomes 2)
Binary Fission

1. Chromosome replication begins. Soon thereafter, one copy of the origin moves rapidly toward the other end of the cell.
2. Replication continues. One copy of the origin reaches each end of the cell.
3. Replication finishes. The plasma membrane invaginates each end and new cell wall is deposited.
4. Two daughter cells result.

Regulating Cell Division

- Timing and rate crucial to normal growth, development and maintenance
  - Frequency varies with cell type
    - Skin, hair follicles, gut lining – almost continuously
    - Nerve, brain, heart muscle and red blood cells – never (G0)
    - Liver and kidney – on an 'as needed' basis
Cell Cycle Control System

- Triggers and coordinates key events in cell cycle
- Checkpoints
  - Signal transduction pathways
    - Stop
    - Go ahead
- Regulated by regulatory proteins and protein complexes
  - Kinases (enzyme activate/inactivate protein - phosphorylation)
  - Cyclins

Three Major Checkpoints

- G0 Checkpoint
  - Check for:
    - Cell size
    - DNA replication
- G1 Checkpoint
  - Check for:
    - Nutrients
    - Growth factors
    - DNA damage
- G2 Checkpoint
  - Metaphase Checkpoint
    - Check for:
      - Chromosome spindle attachment
- DNA Synthesis

Figure 12.16 The effect of platelet-derived growth factor (PDGF) on cell division.

1. A sample of human connective tissue is cut up into small pieces.
2. Enzymes digest the extracellular matrix, resulting in a suspension of fibroblasts.
3. Cells are transferred to culture vessels.
4. PDGF is added to half the vessels.
5. PDGF is added to half the vessels.
6. PDGF is added to half the vessels.

10 μm
Cancer Cells – the outlaws of the cell cycle

- Behavior of cancer cells
  - Ignore all the normal cell signals
    - Divide excessively and indefinitely – immortal
      - HeLa Cells (Henrietta Lacks)
        - Reproducing in culture since 1951
    - Invade other tissue
    - Make their own growth factor
    - Abnormal cell cycle control system
  - Mutation in 1 or more genes that alter proteins
    - Faulty cell cycle control

Cancer

- It all starts with 1 transformed cell
  - Evades the immune system
- Proliferates to form a tumor
  - Benign
    - Not cancer – removed by surgery
  - Malignant
    - Cancer
    - Impair function of normal cells
    - Loss of ability to repair damaged DNA
    - Sole goal is to replicate
    - Metastasize
Treatment

- Radiation
  - Damages DNA of cancer cells
- Chemotherapy
  - Drugs toxic to rapidly dividing cells
    - Interfere with specific steps in the cell cycle
      - Taxol – prevents microtubule depolymerization (spindle fibers don’t shorten during, cell stuck in metaphase)

Progress in fighting cancer

- Better understanding of cell signaling pathways
- Genomic research
- Combination therapies