Anatomy and Physiology 1
Chapter 3 Outline

Cells

- Cells—smallest living subunits of a multicellular organism
  - Work together with other cells
  - Vary greatly in size and shape—usually need a microscope
  - More than 200 kinds of cells in humans
- Cell structure
  - Cell membrane (plasma membrane)
    - Selectively permeable
    - Phospholipids, cholesterol, proteins
    - Phospholipid bilayer—double layer
      - Allows lipid-soluble compounds to move in and out by diffusion
  - Cholesterol
    - Decreases fluidity stabilizing the membrane
  - Proteins
    - Pores/channels
    - Carrier enzymes
    - Antigens when combined with oligosaccharides
    - Receptor sites for hormones or other compounds—triggers certain reactions in the cell
  - Nucleus
    - All cells except mature RBCs
    - Double layered nuclear membrane
    - Nucleolus (one or more)
      - Bundle of DNA, RNA, & protein
      - Forms RNA (rRNA, tRNA, & mRNA)
    - Contains chromosomes
      - 46 (double set)
      - Made of threads of chromatin—usually uncoiled
      - Coils during cell division
      - Gene = genetic code for 1 protein
      - Only genes for that cell are active
  - Cytoplasm
    - Liquid solution of dissolved minerals, gases, and other molecules
    - Contains organelles
- Organelles (Table 3-1, functions of organelles)
  - "Organs" of the cell
  - Ribosomes
    - Made of protein and rRNA
    - On ER or floating in cytoplasm
    - Synthesize protein
  - Endoplasmic reticulum (ER)
    - Membranous tubules that extend from the nuclear membrane to the cell membrane
    - 2 types
    - Rough ER—ribosomes on the surface
      - Synthesizes proteins in the ribosomes
    - Smooth ER—no ribosomes on the surface
      - Synthesizes lipids
    - Tunnels that transport materials around the cell including lipids and proteins produced by the ER
  - Golgi apparatus
    - Flat membranous sacs stacked like pancakes
    - Synthesize and package carbohydrates
    - Small sacs containing carbohydrates break off and fuse with the cell membrane where it is released out of the cell
  - Mitochondria (mitochondrion)
    - Power house of the cell
    - Double membrane—cristae
    - Aerobic reactions of cell respiration
    - ATP production
    - Cells requiring more energy have more mitochondria (muscle, liver)
    - Have their own separate genes
    - Duplicate during cell division
  - Lysosomes
    - Contain digestive enzymes called lysozymes
    - Digest bacteria during phagocytosis of WBCs
    - Digest worn out or damaged cells and parts
    - Cause inflammation that can damage healthy tissue if not controlled
  - Centrioles
    - Rod-shaped
    - Organize spindle fibers that separate chromosomes during cell division
  - Cilia (cilium)
    - Many hair-like projections on certain cells
    - Beat in unison causing a wave-like motion to move things across the surface (DOES NOT move the cell)
    - Fallopian tubes, airways in lungs
- Flagella (flagellum)
  - Mobile thread-like projection through the cell membrane
  - Provides motility (moves THE CELL)
  - Sperm is the only human cell with flagellum—has one
- Microvilli
  - Folds of the cell membrane that increase surface area (like an air filter in a car)
  - Increase absorption—small intestine, kidney tubules
- Vacuoles—pinched off plasma membrane during phagocytosis and pinocytosis (see below)

- Cellular transport mechanisms (Table 3-2)
  - Mechanisms to move substances in and out of the cell
  - Diffusion, osmosis, facilitated diffusion, active transport, filtration, phagocytosis, and pinocytosis
  - Diffusion—movement of molecules from an area of greater concentration to an area of lesser concentration along a concentration gradient until equilibrium is reached
    - Molecules randomly move until evenly dispersed in a solid, liquid, or gas
    - CO₂ and O₂ diffuse across the capillary/alveolus junction in the lungs
    - Movement occurs in all substances involved (except solids)
  - Osmosis—diffusion of water through a selectively permeable membrane
    - Water moves from area of high concentration to low concentration until equilibrium is met (regardless of volume)
    - Same as saying moves from area of low concentration of solutes to low concentration of solutes (high concentration of water = low concentration of solutes and vice versa)
    - Isotonic—equal concentration of solutes (Box 3-1)
      - e.g., saline during plasma donation
    - Hypotonic—lower concentration of solutes
    - Hypertonic solution—higher concentration of solutes
    - This occurs because the membrane will not allow anything but water to cross
    - Small intestine and kidneys
  - Facilitated diffusion—diffusion of molecules through a membrane with help from proteins in the cell membrane called transporters or carrier enzymes
    - e.g., glucose, AAs
  - Active transport—energy requiring process of moving molecules against a concentration gradient (lesser to greater concentration)
    - Requires ATP
    - Na⁺ pumps in nerve and muscle cells pump Na⁺ out
  - Filtration—substances are forced through a membrane by mechanical pressure
    - Blood pressure created by heart pumping forces fluids out of capillaries into the interstitial spaces
    - Brings nutrients to cells and waste products out of the blood in the kidneys
  - Phagocytosis—moving cell engulfs something
    - WBCs engulf bacteria
    - Makes vacuoles
- **Pinocytosis**—stationary cell engulfs something
  - Kidney cells engulf proteins to reabsorb them
  - Makes vacuoles
- **DNA**—double strand of nucleotides twisted into a double helix made up of A, T, G, C
  - Sequence of A, T, G, C determines the genetic code
  - The entire code is called the genome
  - Gene—the genetic code for one protein (oversimplified)
  - Each amino acid comes from a triplet of 3 bases called a codon
  - Example: 100 AAs = 100 codons = 300 bases
- **Protein synthesis** (Table 3-3)
  - Occurs in the ribosomes
  - **Transcription**—DNA → mRNA
    - Messenger RNA (mRNA)—a mirror image of DNA made in the nucleus
    - Leaves the nucleus and attaches to a ribosome
  - **Translation**—mRNA → protein (via tRNA)
    - Transfer RNA (tRNA) attaches to the mRNA at a site called the **anticodon** complimentary to the codon
    - tRNA picks up the corresponding AA and forms peptide bonds to make a protein
    - DNA → mRNA → tRNA → protein
- **Genetic disease**—illness due to mistake in DNA
- **Cell division**
  - 2 types—mitosis & meiosis
  - **Mitosis**—one cell divides into 2 identical cells both having a full set of chromosomes
    - How we grow and repair
    - Always happening in certain tissues
      - Skin, stomach epithelium, red bone marrow
      - **Side note:** red bone marrow has **stem cells**
        - Unspecified cell that can develop into different kinds of cells like RBC, WBC, or platelet
        - Hardly or never happens in some tissues like cardiac muscle and nerve tissue
  - **Meiosis**—one cell divides into 4 cells each having have of the chromosomes
    - How we reproduce
  - **Mitosis**
    - Diploid number—full set of chromosomes (46 in humans)
      - Double set of chromosomes although not identical
**Stages** of mitosis (Table 3-4, Fig 3-5)

1. (Interphase)
2. Prophase
3. Metaphase
4. Anaphase
5. Telophase
   a. Cytokinesis
   b. IPMAT
   c. Interphase—**NOT a phase**
   - DNA replication
   - Resting stage—not dividing (not actually resting)

**Prophase**
- Chromosomes (2 chromatids—original DNA plus its copy) coil up
- Nuclear membrane disappears
- Centrioles move to opposite ends (poles) and extend spindle fibers to the chromosomes

**Metaphase**
- Chromosomes line up in the middle
- Centromeres attach to the spindle fibers and divide (2 complete sets of chromosomes)

**Anaphase**
- Spindle fibers pull chromosomes to each pole

**Telophase**
- Chromosomes uncoil to become chromatin
- Nuclear membrane reforms
- Cytokinesis—cytoplasm divides and cell membrane closes off

**Meiosis**
- Results in gametes (egg and sperm)
- One diploid (2n – 46 chromosomes) cell divides twice to form 4 haploid (1n – 23 chromosomes) cells
- Haploid cells have ½ of the DNA (one set) of a normal diploid (2 sets) cell
- Women—ovaries
  - Oogenesis (generate egg)
- Men—testes
  - Spermatogenesis (generate sperm)
- Phases—same as mitosis, but all happen twice except for Interphase

**Fertilization**—egg and sperm (both haploid) meet and join chromosomes to form a 2n diploid zygote