Chapter 3: Cells

I. Overview

A. Characteristics
   1. Basic structural/functional unit
   2. Diameter is too small to see by the naked eye
   3. Can be over 3 feet long
   4. Trillions of cells in over 200 basic types

B. General structure

1. Nucleus: control center of cell
2. Cytoplasm: viscous fluid that fills cell
3. Organelles: structures that perform specific functions
4. Plasma membrane: *outermost boundary of cell*

**II. Plasma membrane (also called cell membrane)**

A. Describes the outer border of a cell

1. Separates the two main fluid compartments
   a. Intracellular: *fluid within the cell*
   b. Extracellular: *fluid outside the cell*

B. Fluid mosaic model

1. Membrane structure
   a. Phospholipids bilayer
      1) Polar heads:
      2) Fatty acid tails:
3) Cholesterol: stabilizes the membrane

4) Diagram:

2. Membrane proteins: *peripheral and integral*
   
a. Proteins float in a “sea” of phospholipids
   
b. Peripheral: *attached to the surface of the bilayer, inner or outer*
      
      1) Functions

   c. Integral: *inserted into bilayer*
      
      1) Functions

C. Specializations of plasma membrane
1. Microvilli: *finger-like extensions*

2. Cell to cell junctions: *most cells are tightly bound together*
   a. Tight junctions: *integral proteins are fused together*
   b. Desmosomes: *short linker proteins hold membranes together*
   c. Gap junctions: *protein tubes called connexons are found between cells*

D. Plasma membrane functions
   1. Definitions
      a. Interstitial fluid: *fluid between cells*
      b. Semi permeable: *only select substances pass through*
   2. Membrane transport
      a. Passive processes: *do not require energy*
         1) Diffusion: *movement of substances down it’s concentration gradient*
a) Simple diffusion: *small substances move directly through bilayer*

b) Facilitated diffusion: *diffusion using a carrier protein*

c) Osmosis (special case): *simple diffusion of H$_2$O*
(1) Osmotic pressure: (osmometer diagram)

(2) Tonicity: the ability of solution to change the shape of cell by altering intracellular H$_2$O level

(a) Isotonic
(b) Hypertonic
(c) Hypotonic
(d) Examples:

2) Filtration: a pressure gradient pushes fluid through a membrane
b. Active processes: *require energy*

1) Active transport: Na\(^+\)/K\(^+\) pump

2) Vesicular (bulk) transport: *Transport of large quantities of material*

a) Exocytosis: “exit the cell”

b) Endocytosis

(1) Phagocytosis: *cell “eating”*

(2) Pinocytosis: *cell “drinking”*
3. Membrane potential: *voltage is generated across a membrane*
   a. Voltage: *is defined as the separation of charged particles*

   b. Diagram:

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**III. Cytoplasm (cell forming material)**

A. Terminology

1. Cytosol: *viscous semitransparent fluid*

2. Organelles: *"little organs"*

3. Inclusions: *stored substances*

B. Organelles (membranous and non-membranous)

1. Mitochondria: *"powerhouse" of cell - provide most of the ATP*

2. Ribosomes: *protein factories*
3. Endoplasmic reticulum (ER): *sac-like network of membranes*

   a. Rough endoplasmic reticulum: *(RER)*

   b. Smooth endoplasmic reticulum: *(SER)*

4. Golgi: *a flattened stack of sac-like membranes*
   
   a. Processes proteins from the E.R.

   b. Forms the secretory vesicles for protein export

5. Lysosomes: *"suicide pack" of cell*
6. Cytoskeleton: *structural internal and external protein support*
   a. Microtubules: *hollow protein tubes*
   
   b. Microfilaments: *thin strands of protein*
   
   c. Intermediate filaments: *tough proteins*

7. Centrioles: *made of microtubules*

C. Cellular extensions formed of microtubules

1. Cilia: *hair-like extensions that move things*

2. Flagella: *only found in sperm cell tail*
IV. Nucleus

A. Nuclear envelope: double membrane
B. Nucleoli: site of rRNA synthesis
C. Chromatin: uncoiled chromosomes (DNA) plus protein

1. Chromosomes – tightly coiled chromatin (DNA)

V. Cell growth and reproduction

A. The cell life cycle: 2 main phases: interphase and cell division

1. Interphase (G1, S, G2): the time from cell formation to cell division

a. DNA Synthesis (replication) during “S” phase
   1) DNA uncoils
   2) Enzyme breaks H-bonds between DNA strands
   3) DNA polymerase builds the new DNA strands
4) Diagram of DNA synthesis (replication)

2. Cell division: essential for body growth and repair
   a. Divided into mitosis and cytokinesis
      1) Mitosis: (division of the nucleus)
         a) Prophase

         b) Metaphase
c) Anaphase

d) Telophase

2) Cytokinesis: (division of the cytoplasm)

VI. Protein synthesis
A. Terminology
1. Gene: segment of DNA coding for 1 RNA

2. Codon (triplet): specifies the placement of a single amino acid

3. Typical protein: contains 100-1000 amino acids

B. Types of RNA (3)
1. rRNA (ribosomal): forms the large and small subunits of ribosome
   a. Ribosome: the “workbench” for protein synthesis

2. mRNA (messenger)

3. tRNA (transfer)

C. 2 main steps in protein synthesis: transcription and translation
1. Transcription
2. Translation

a. Diagram of translation
   1) Start codon: is always AUG in every protein produced
   2) Stop codons: several, but we will use UAA and UGA
The correct amino acid is attached to each species of tRNA by a synthetase enzyme.

Amino acid corresponding to anticodon

Aminoacyl-tRNA synthetase

Initiation. Initiation occurs when four components combine:
- A small ribosomal subunit
- An initiator tRNA that carries the amino acid methionine
- The mRNA
- A large ribosomal subunit

Once this is accomplished, the next phase, elongation, begins.
2 Elongation. Amino acids are added one at a time to the growing peptide chain via a process that has three repeating steps.

2a Codon recognition. The anticodon of an incoming tRNA binds with the complementary mRNA codon (A to U and C to G) in the A site of the ribosome.

2b Peptide bond formation. The growing polypeptide bound to the tRNA at the P site is transferred to the amino acid carried by the tRNA in the A site, and a new peptide bond is formed.

2c Translocation. As the entire ribosome translocates, it shifts by one codon along the mRNA:
- The unloaded tRNA in the P site is moved to the E site and then released.
- The tRNA in the A site moves to the P site.
- The next codon to be translated is now in the empty A site ready for step 2a again.
b. Polyribosome

VII. Extracellular materials: Substances found outside the cell

A. Body fluids
   1. Extracellular fluid: all fluid outside cells
      a. Interstitial fluid: specifically between body cells
      b. Plasma: the fluid part of blood
      c. CSF: cerebrospinal fluid

B. Extracellular matrix: protein or polysaccharide substances that help hold the body together