Cell Bio Exam 1 Review Study Guide

- Protein Basics:
  - Composition:
    - Alpha-carbon (central)
    - Amino group
    - Carboxyl group
    - R group/side chain
  - Joined by peptide bonds in dehydration-synthesis reactions to form a polymer
    - Assembly starts at the amino-terminal end of the amino acid chain
- Cellular Structures and Functions (Basics):
  - Lysosomes: organelles dealing with cellular waste management, digestion, and disposal
  - Peroxisomes: organelles breaking down toxic hydrogen peroxide into H_2O
  - Vesicles: membrane-bound sacs transporting food particles, waste, etc. throughout the cell
  - Nuclear membrane: organelle regulating entry/exit to the nucleus and protecting genetic material inside
  - Nuclear pores: organelles allowing materials to enter or exit the nucleus
  - Phospholipid bilayer: cellular membrane protecting the inside of the cell and regulating entry and exit of materials, waste, etc.
  - Golgi apparatus: post-translational protein modifier and packager
  - Ribosomes: RNA-protein complexes synthesizing intracellular and extracellular proteins
  - Rough ER: endoplasmic reticulum with ribosomes attached to it synthesizing proteins; makes post-translational modifications to the proteins
  - Smooth ER: endoplasmic reticulum without ribosomes attached dealing with cellular detoxification
- Actin: protein important to cellular movement
  - Important in:
    - Cell motility
    - Cell structure
    - Cell division
    - Muscular contraction
  - Can be monomeric or filamentous
    - Monomeric actin is known as *G-actin* or *globular subunits*
    - Filamentous actin is known as *F-actin* or microfilaments
      - ❖ Important for cellular motility
        - ➢ G-actin is added to the plus end (end of microtubule where actin polymerizes) of F-actin
        - ➢ Polymerization of actin filaments occurs at the leading edge of a cell
        - ➢ Globular subunits tend to depolymerize at the minus end of a microfilament
          - ✓ Treadmilling: phenomenon occurring where the rate of actin polymerization at the plus end is equal to the rate of actin depolymerization at the minus end
        - ➢ Polymerization requires the binding of ATP (replaces bound ADP)
  - Actin structures:

        - Lamellipodia: flattened, sheet-like extensions of cell membrane formed by actin polymerization
        - Filopodia: spiked extensions of cell membrane formed by actin polymerization
    - Actin-Associated Structures:
        - Cortex: special region of actin filament-rich cytoplasm just beneath the cell membrane
        - Serves to support the cell membrane
- Cellular Movement:
    - Overall transduction pathway: signal → receptor → GTP proteins → ARP complex → actin polymerization
        - GTP proteins: proteins binding GTP acting as molecular switches for signal transduction pathways (*Rho protein family* most common)
            - Cdc42 regulates actin polymerization in filopodia
            - Rac regulates actin polymerization in Lamellipodia
                - Enhances nucleating activites of the ARP complex and promotes uncapping of plus ends of microfilaments
                - Powered by GTP hydrolysis
            - Loss of phosphate to become GDP turns off signaling pathways
        - ARP complex: actin-related proteins that promote branching points for actin polymerization
            - Activated via signal transduction pathways
    - Surface contacts:
        - Extracellular matrix: non-cellular proteins and other materials on the outside of the cell
            - Linked to the cytoskeleton via integrin proteins (esp. *vinculun*)
        - Focal contacts: adhesions by which a cell attaches to the underlying surface
- Muscle Contraction:
    - Sarcomere: basic unit of muscular structure
        - Bind in fibers to form *myofibrils*
        - Structure:
            - Thin filaments: filamentous actin chains stabilizing muscular contraction
            - Thick filaments: myosin filaments that contract and pull thin filaments during muscular contraction
- Cytokine Signaling: Integrated Example with CD8
    - T cells target infections/infected cells
        - Neutrophils: cells initiating and maintaining the immune response
            - First immune cells to migrate out of blood vessels and target infected tissues
            - Recruit T cells for bacterial and viral infections
            - Leave a molecular trail by depositing chemokine molecules for T cells to follow
                - Initiates a signal transduction pathway in T cells promoting actin polymerization and cellular movement
                - Chemokine molecule in question is CD8

- Angiogenesis: formation/sprouting of new blood vessels from existing ones
    - Growth stimulated by growth chemicals such as VEGF
        - Initiates a signal transduction pathway promoting actin polymerization and the growth of filopodia toward the source of the signal
            - ❖ VEGF Binds to an extracellular receptor
            - ❖ G-proteins are phosphorylated and activate ARP complexes
            - ❖ ARP complexes promote actin polymerization
            - ❖ Vesicles in the forming stem fuse to form a lumen
- Microtubules: strands of polymerized tubulin protein
    - Functions:
        - Gives the cell its polarity (shape/orientation in a given direction)
        - Cellular support and motility (helps form the cytoskeleton)
        - Separate chromatids during mitosis/meiosis
        - Helps form the mitotic spindle
        - Form the cilia and flagella (utilize a *9+2 structure*)
        - Transport of organelles and other materials along a microtubule track
        - Organize organelles
    - Structure:
        - Basic piece is an alpha-beta heterodimer tubulin protein
        - Heterodimers associate among themselves to form a protofilament
            - ❖ 13 protofilaments in a ring form a microtubule
    - Formation:
        - Beta subunit binds GTP and provides energy for polymerization (depolymerization caused by GTP hydrolysis)
            - ❖ Dynamic instability: rapid polymerization and depolymerization of tubulin subunits
        - Occurs at the microtubule organizing center (MTOC)
            - ❖ Centrosome along with a gamma-tubulin complex nucleates microtubules at the plus ends of the strands
                - ➢ Plus ends can be stabilized by the addition of capping proteins
            - ❖ Centrioles are not required for nucleation
                - ➢ Does assemble the *kinetochore* (protein complex found on chromosomes → utilized during cell division?)
- Motor Proteins: proteins transporting organelles and other materials along microtubules
    - Types:
        - Kinesins: motor proteins travelling toward the plus ends of microtubules
        - Dyneins: motor proteins travelling toward the minus end of microtubules
    - Move along the microtubule via "walking"
        - Driven by the binding of ATP molecules
- Intermediate Filaments: protein filaments giving vertebrate cells great tensile strength
    - Made up of 8 associated protein complexes
        - Dimers associate into tetramers in opposite directions to make a filament
    - Where they are located:
        - Desmosomes: cell-cell junctions

        - Hemidesmosomes: linkages between the cell to the extracellular matrix
    - Help prevent cellular lysis (rupture)
- Phagocytosis: "cellular eating"
    - Process:
        - Chemical signal received by the cell
        - Molecular switch activated by GTP protein activation
        - ARP complex activated
        - Actin polymerization powers creation of filopodia
        - Filopodia come together to form a phagosome (vesicle enclosing material formed by the closing of filopodia
        - Phagosome carried by the endocytic pathway to endosomes
        - Material reached lysosomes and is digested
    - Lysosomes:
        - Contain many different kinds of digestive enzymes (sulfatases, proteases, etc.) that work at a low pH
        - Hydrolyze ATP into ADP to power a proton pump that creates the low intra-lysosomal pH
        - Produce H_2O_2 as a byproduct
    - Peroxisomes:
        - Break down fatty acids and hydrogen peroxide
        - Also involved in the synthesis of cholesterol and myelin lipids
- DNA→RNA→Protein Basics:
    - DNA consists of regulatory, coding, and noncoding regions
        - RNA polymerase binds to a promotor sequence to begin the transcription of a template strand
            - Made 5' to 3'
            - Creates a complementary and antiparallel sequence of mRNA (uracil instead of thymine)
            - 3-letter codons (methionine start codon)
    - Ribosomes use tRNA to "read" and translate mRNA into protein
        - tRNA anticodons bind to mRNA
- Mutation Basics:
    - Tyoes:
        - Silent: no change in the amino acid sequence
        - Missense: mutation causing a single amino acid change
        - Nonsense: mutation causing the insertion of a premature stop codon
        - Frameshift: mutation causing the reading frame of the mRNA to be shifted and the entire amino acid sequence following the mutation to be altered
- Ribosomes:
    - Consist of a large and small subunit:
        - mRNA binds to the small subunit
        - Three major sites in the large subunit:
            - A site: aminoacyl-tRNA binding site
            - P site: peptidyl-tRNA binding site where the polypeptide chain is made

        - ❖ E site: tRNA exit site
- tRNA:
    - Structure:
        - Amino acid attached to the 3' end by an ester bond
        - Anticodon located on the *anticodon loop*
    - Charged with the proper amino acid by aminoacyl-tRNA synthases (enzymes)
- In-Depth Translation:
    - Small subunit binds to translation initiation factors
        - mRNA binds to the small subunit and *initiator tRNA* moves along the mRNA looking for the first AUG start codon
        - Initiation factors dissociate and the large subunit binds after the first AUG is found
    - Aminoacyl tRNA binds to the A as initiator tRNA moves to the P site
        - Peptide bonds form at the P site
        - Elongation factor tu brings in the aminoacyl tRNA to the A site
    - Large subunit displaces as peptide bonds are formed
        - Moves tRNA at A site to P site, and P site to E site
        - Elongation factor G restores the normal ribosomal conformation and allows another aminoacyl tRNA to bind at the A site
    - Often many ribosomes translate the same mRNA molecule at one time (polyribosomes)
- DNA Packaging:
    - Packaged in the nucleus with histone proteins as chromatin
    - Nucleosome: combined DNA-protein loop
        - 6 nucleosomes are packed on top of each other to form chromatin → condenses into chromatics and chromosomes
- DNA Replication:
    - Occurs at multiple replication forks in eukaryotes
    - Creates two DNA strands identical to that of the parents
        - Nucleotides added 5' → 3' at the 3' hydroxyl end
    - Process:
        - Helicase enzyme separates the single DNA strands
        - DNA polymerase III binds to each strand along with a sliding clamp to relieve pressure
        - RNA primase and single-stranded binding proteins bind to the lagging strand to make *Okazaki fragments* on the lagging strand
        - DNA polymerase I replaces the RNA primers
        - Ligase joins the parental and daughter strands together
    - End-replication problem: gap of the end of the lagging strand cannot be coped (no primer)
        - Solved by the use of telomerase enzyme
    - Hayflick limit: differentiated cells in culture divide about 50 times before dying
        - Associate with shortening of telomeres
        - Cellular life:
            - ❖ Rapid cell division
            - ❖ Mitosis slows
            - ❖ Senescence (ceasing of cell division)

- Apoptosis (programmed cellular death)
  - Cancerous cells fail to undergo apoptosis