Midterm 2 Review
PPT 7-13

- The endomembrane system
- Chromosome territory: nonoverlapping regions
- Ribosome: RNA + proteins
- Proteins are broken down in lysosome and proteasome tagged by ubiquitin
- Rough ER: with ribosomes; protein synthesis
- Smooth ER: lacks ribosomes; modification of lipids, detoxification
- Golgi: cis, medial, and trans; cis is closer to ER; secretion processing and protein sorting; packages into secretory vesicles that fuse with the plasma membrane
- Secretory pathway: proteins are synthesized in the ER; travel to the Golgi, transported by vesicles to the plasma membrane, and secreted to the outside the cell
- Palade: pancreatic cells (secrete insulin); pulse and chase with radioactive amino acids; used osmium tetroxide to stain the cell components; first evidence that secreted proteins are synthesized into the rough ER and move through a series of compartment before secretion
- Lysosomes: small organelles of endomembrane system; contain acid hydrolases that perform hydrolysis; pH is 4.8; if it breaks the enzymes don't cause damage because cytoplasm pH is 7.2 (will not digest components of the cell)
- Peroxisomes: contain catalase; catalyze reactions that break down molecules by removing hydrogen or adding oxygen; important for breaking down toxins (brain, liver has the highest level of peroxisomes because chemicals and drugs are broken down, skin, stomach)
- Hydrogen peroxide is a by-product of toxic breakdown; dangerous; catalase breaks down dangerous H_2O_2 into water and oxygen
- Plasma membrane: membrane transport, signaling, adhesion
- Selective permeability: transport of molecules
- DNA nucleus, mitochondria, chloroplast
- Semiautonomous organelles: grow and divide to reproduce themselves; not completely autonomous because they depend on the cell for synthesis of internal components
- Mitochondria: make ATP, number can change, hundreds/thousands per cell; outer and inner membrane space; intermembrane space; mitochondrial matrix; inner membrane is highly invaginated in folds called cristae
- Binary fission: split into two (mitochondria, chloroplasts, bacteria)
- Sunlight exposure changes the number of chloroplasts

- Cytosolic and extracellular leaflets of the membrane; asymmetrical, glycolipids are more abundant on the outside
- Integral proteins: Transmembrane proteins: inserted into phospholipid; alpha helix; nonpolar amino acids; very difficult to extract; requires harsh treatments. Lipid-anchored proteins: lipid tail is inserted into the hydrophobic part of the membrane (requires harsh treatments)
- Peripheral: covalently bonded to integral proteins; easier to extract

- 20-30% are transmembrane proteins, appx. 6,600 genes out of 20-24000 protein-encoding genes
- Membranes are semifluid, lipids can rotate freely around their long axes and laterally within the membrane leaflet, 10^7
- Flippase requires ATP to transport lipids between leaflets, energetically unfavorable (sensitive to temperature and pH)
- Lipid rafts: composition of lipid raft is different than the rest of the membrane; high concentration of carbohydrates and proteins
- What is the fluid mosaic model?
- Presence of cholesterol, length of chain, kinks affect membrane fluidity
- Transmembrane proteins can also rotate laterally but cannot flip
- Passive transport: down concentration gradient; simple or facilitated (transport protein)
- Active transport: against concentration gradient; ATP hydrolysis
- Gases (O_2, N_2, CO_2) and uncharged small molecules high permeability; water and urea moderate permeability; very low permeability ions, charged polar molecules, large molecules
- Isotonic vs. hypertonic vs. hypotonic
- Osmosis: water movement across membranes
- Red blood cell in hypotonic can swell and even burst
- Channel: open passageway; allows the facilitated diffusion
- Aquaporin: transporter for water (kidney cells and water cells) discovered by Peter Agre
- What is the CHIP28?
- Uniporter – one molecule in one direction; symporter- two molecules in same direction; antiporter- two molecules in opposite directions (know examples of each)
- Active Transport: requires energy; ATP
- Secondary active transport: uses ATP; uses a gradient generated somewhere else (Na/glucose symporter powered by Na/KATPase antiporter at another site)
- 3 Na^+ move outside and 2 K^+ move inside the cell
- Endocytosis (large molecules brought into cell); receptor-mediate endocytosis uses receptors, LDL receptors; pinocytosis transports liquid; phagocytosis engulfs materials can help recycle components
- Gibbs free energy; if negative the reaction is spontaneous
- Activation energy; enzyme lowers activation energy; brings reactants closer; helps straining of the bonds in preparation for breakage
- Active site: location where reaction takes place
- What role does ATP play in cellular reaction?
- What are enzymes?
    - Describe the relationship between K and substrate affinity
- Michaelis constant: substrate concentration where velocity is half the maximal value
- Reversible inhibition
    - competitive
        - adding more substrate can <u>reverse</u> competitive inhibition
    - noncompetitive (allosteric site)
        - adding more substrate does not help

- Irreversible covalent bonding
  nerve gas inhibits acetylcholinesterase
  aspirin inhibits cyclooxygenase
- Ribozymes: perform catalytic activity without protein
  - Do enzymes always have to be proteins?

- Gene regulation: turns genes on or off (example: bacteria cell does not bind to specific sugar to turn off genes that encode enzymes needed to break down that sugar)
- Cellular regulation: cell-signaling pathways like hormones
- Biochemical regulation: feedback inhibition - the product of pathway inhibits early steps in the pathway to prevent overaccumulation
- Cholesterol production is partially regulated by negative feedback; inhibits its own synthesis
- Slowest steps: rate-limiting step; where feedback inhibition happens
- Proteasome: breaks down proteins using complexes of proteases; peptide bonds are broken
- Ubiquitin is attached to the target protein to help navigate to the proteasome

- Cellular respiration is the process by which living cells obtain energy from organic molecules and release waste products
- Aerobic vs. anaerobic and fermentation
- High energy intermediates: small molecules that provide energy during cellular respiration ATP, NADH, $FADH_2$
- Locations: glycolysis (cytosol); breakdown of pyruvate (mitochondrial matrix); citric acid cycle (mitochondrial matrix); Oxidative phosphorylation (inner mitochondrial membrane)
- Cancer cells exhibit unusually high levels of glycolysis
  - What is the Warburg effect?
- What is the pathway of cellular respiration and what are the intermediates for each step?
- $FADH_2$ and NADH provide electrons for the citric acid cycle
- CO_2, ATP, NADH, $FADH_2$ are produced from citric acid cycle
- Pyruvate is generated in the cytosol and pumped into mitochondrial matrix by the H^+/pyruvate symporter
- Direction of electron flow; have higher and higher electronegativities until oxygen is reached; proteins in the chain transfer electrons
- Electrons from NADH and $FADH_2$ can enter the ETC
- Cyanide inhibits cytochrome oxidase (complex IV)
- What is the proton gradient and across which membrane does it flow?
- Protons flow back through ATP synthase
- ATP synthase is a rotary machine; allows motion because of subunits
  - not entirely in the membrane (if it were entirely in the membrane it would not be able to rotate)

- ATP synthase makes ATP by converting the H^+ gradient to chemical bond energy in the ATP; captures free energy of H^+
- How much ATP is generated at the end of cellular respiration?

- Photosynthesis: light reactions in the thylakoid membranes, Calvin cycle in the stroma of the chloroplast
- Light reactions make ATP, O2, NADPH
- Calvin cycle uses the ATP and NADPH and makes glucose from CO2, also called carbon fixation
- PSII and PSI; electron transport; protons pumped to create a gradient; ATP synthesis
- Linear and cyclic electron flow
- Linear electron flow makes O2, ATP and NADPH
- Cyclic electron flow only makes ATP
- O2 only made at the level of PSII; means that only linear (and not cyclic) photophosphorylation makes O2

- Mitosis versus meiosis
- Karyotype
- Cytogenetics
- Humans: 46 chromosomes in diploid cells, 23 chromosomes in haploid cells
- Humans: 22 autosomes (1-22) and 1 pair of sex chromosomes (XX or XY)
- Homologous chromosomes have the same genes but 99% identical, 1% differences

- Interphase: G1, S, G2
    - G1: first gap
    - S: DNA synthesis
    - G2: second gap

- M: mitosis and cytokinesis
- G0: optional, non-replicative phase

- G1 checkpoint or restriction point: checks to make sure no mutations in the DNA
- G2 checkpoint: checks to make sure that chromosomes entirely replicated and that there are sufficient nutrients for mitosis
- Mitotic checkpoint: checks to make sure that kinetochores attached to microtubules

- MPF: maturation promoting factor, mitotic cyclin + cdk
- MPF made under the influence of progesterone, promotes maturation (G2 to M transition)
- MPF was discovered in frog oocytes