AP Biology Exam Review Part I: Biochemistry, Cells and Transport

2A3: Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.
2B1: Cell Membranes are selectively permeable due to their structures.
2B2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
2B3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.
4A1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.
4A3: The structure and function of subcellular components, and their interactions, provide essential cellular processes.
4C1: Variation in molecular units provides cells with a wider range of function.

A. Chemistry of Life

1. CHNOPS- most common elements in all living matter

2. Bonds- ionic (transfer electrons), covalent (sharing- polar/unequal sharing and non-polar/equal sharing), hydrogen (weak bonds between hydrogen and negatively charged items), hydrophobic interactions (how non-polar compounds congregate together- lipids)

3. pH
   a. acid-base/ 0-14, # of H ions determines scale; logarithmic- pH 3 = 10^{-3} = 1/1000
   b. blood- 7.4, stomach- 2, small intestine- 8; enzymes are specific to pH
   c. buffers such as bicarbonate handle slight pH swing

4. Water properties- polarity, cohesion(attraction to other water molecules), adhesion (attraction to other charged compounds) low density when frozen, versatile solvent, high heat of fusion/vaporization; surface tension

5. Organic molecules (monomers are simplest form of all; monomers join together via dehydration synthesis- loss of water- to make polymers; polymers are broken down via hydrolysis- input of water.)
   a. Carbohydrates- CHO 1:2:1 ratio, monomer= monosaccharides, 2=disaccharides, 3 or more= polysaccharides
   b. Used for energy (cell respiration)
   c. Examples
      (1) glucose- immediate energy to make ATP
      (2) starch- stored energy in plants
      (3) glycogen- stored energy in animals (stored in liver)
      (4) cellulose- plant cell wall

   d. Lipids – C, H, O (not a 1:2:1 ratio) *P only in phospholipids
      (1) fats, waxes, oils and sterols
      (2) Saturated fats have single bonds between carbons, unsaturated fats have at least one double bond between carbons (kinky); plants make polyunsaturated; animals make monounsaturated
      (3) Phospholipids make up cell membranes (double layer) and are amphipathic- hydrophilic and hydrophobic
      (4) uses- in all membranes, sex hormones, & corticoids; stored energy, protection, insulation, myelin sheath of nerves

e. Proteins- C, H, O, N (may have other elements in R group)
   (1) Monomer- amino acids (20 total types), 2=dipeptide, 3 or more= polypeptide
   (2) Parts of amino acid= carboxyl group (COOH) on one end, amino group on the other end (NH2), central carbon and variable R group (can be hydrophobic or hydrophilic) which determines chemical properties.
   (3) Protein Folding- shape determines function; primary= a.a. chain; secondary= beta pleated sheet or alpha helix(hydrogen bonds); tertiary=globular; folds in on itself (disulfide bridges, hydrogen bonds, hydrophobic interactions; ionic bonding); quartenary= more than one polypeptide.
   (4) Uses- protein carriers in cell membrane, antibodies, hemoglobin, enzymes, most hormones, muscle (actin and myosin)

f. Nucleic acids-
   (1) Monomer= nucleotide, 2 = dinucleotide, 2 or more polynucleotide
   (2) Nucleotide made up of sugar, phosphate and base
   (3) Used to store genetic information
   (4) DNA is double stranded, has deoxyribose, A, G, C, T
   (5) RNA is single stranded, has ribose, A, G, C, U
   (6) mRNA- copies genetic message; rRNA- attaches mRNA and makes up ribosomes (most common);tRNA- carries amino acids;DNA- carries genetic code

B. Cells

1. Prokaryotic (Bacteria) | Eukaryotic (all other living things)

no membrane-bound organelles	m.b.o, ex. Chloroplasts and nucleus
no nucleus(single; circular DNA)	multiple linear DNA
free ribosomes and cell wall	histones on DNA

2. Cell organelles

a. Nucleus- holds DNA and nucleolus(where ribosomal subunits are made)
b. Mitochondria- double membrane; outer is smooth and inside is folded with enzymes to make ATP (site of cellular respiration (glucose breakdown)
c. Ribosome- site of translation- protein synthesis; made of rRNA and protein
d. E.R.- connected to nucleus; allows for reactions, membranous; smooth= lipids; rough=proteins
e. Golgi complex- packaging in membrane and signals for export
f. Cytoskeleton: Microfilaments- contractile protein, gives shape, movement within cell; Microtubules- centrioles, cilia, flagella, spindle fibers
g. vacuoles/vesicles- water and solutes; large and central in plants

h. ANIMAL
   - Lysosomes- contain enzymes; used for intracellular digestion and apoptosis
   - Centrioles- used in cell division
   - Peroxisomes- contain enzymes to break down H_2O_2

- Extra Cellular Matrix (ECM)- collection of proteins and glycoproteins on outside of cell membrane; MHC

i. PLANT
   - Chloroplast- double membrane; site of photosynthesis (glucose synthesis)
   - Cell wall- middle lamella- pectin; primary cell wall- cellulose; secondary cell wall- lignin

j. Cell junctions- plasmodesmata (between plant cells); gap junctions (between animal cells); tight junctions (stitched animal cells); anchoring junctions (riveted together animals cells)
k. Endosymbiont theory- all eukaryotic cells came from bacterial cells that lived together; proof= all chloroplasts and mitochondria have own DNA and are autonomous

3. Cell membrane (separates the internal environment of cell from external environment).

a. Phospholipid bilayer (selectively permeable; amphipathic)
b. Fluid mosaic model (in motion; proteins, cholesterol, glycoproteins and glycolipids among phospholipids). Membrane is hydrophilic on inside and outside, hydrophobic within membrane
c. Simple diffusion- from high to low concentration- small and uncharged move freely through phospholipids ex. CO_2, O_2 (passive; no energy;no protein carrier)
d. Facilitated diffusion- large or charged from high to low, passive; with protein carrier: ex. glucose, K+,
e. Active transport- from low to high concentration; uses ATP; uses a protein
f. Endocytosis- phagocytosis (solid) and pinocytosis (liquid); membrane surrounds and forms vesicles; receptor mediated endocytosis has receptors on surface
g. Exocytosis- release of material using vesicles fusing with membrane
h. Osmosis- diffusion of water using a selectively permeable membrane; passive; no proteins
i. Water potential= pressure potential plus pressure potential; water moves from high water potential to low water potential; solutes always lower water potential; pressure can increase or decrease depending on if it is negative or positive.
j. Plant cells have pressure related to cell wall and vacuole; turgor pressure
k. Hypertonic (high solute), hypotonic (low solute), and isotonic solutions(equal concentration)
l. Plasmolysis (plant cells; membrane pull away from cell wall); crenation (animal cell shrivels)

AP Investigation 4: Diffusion and Osmosis

<u>Part I- Diffusion in Agar Cubes</u>

Overview: Various size cubes of phenolphthalein agar were placed in NaOH and then diffusion rates were calculated.

IV- Size of cube

DV- percent diffusion

Equations: Volume = L x W x H, volume diffused = total volume – volume not pink, % diffusion = Volume diffused /total volume x 100, surface area of a cube = L x W x # of sides, surface area/volume ratio.

Part II- Osmosis in Living Cells (Potatoes)

Overview: Potato cylinders placed in sucrose (sugar) solutions and massed before and after to get percent change in mass.

IV- Sucrose solutions (varying molarities)

DV- percent change in mass

Equations: $\psi = \psi_p + \psi_S$, Water Potential = Pressure Potential + Solute Potential,

Determined by graphing percent changes in mass versus molarity of solution

The solute potential of a sucrose solution can be calculated using the following formula:

$\psi_S = -iCRT$

where

i = ionization constant (for sucrose this is 1 because sucrose does not ionize in water)

C = molar sucrose concentration at equilibrium (determined above)

R = pressure constant (handbook value R = 0.0831 liter bar/mole°K)

T = temperature °K (273 + °C of solution)

Part III- Design Your Own Experiment (Dialysis Bags)

Overview: Students were provided with dialysis bags, colored sucrose solutions of unknown molarities, and basic lab equipment to use to design an experiment on how to determine the molarities of the colored solutions.

IV- unknown molarities

DV- for most groups it was percent change in mass

Equations: (final mass-initial mass)/ initial mass

Biochemistry:

amino acid
amphipathic
carbohydrate
carbon
denaturation
disaccharide
ester bond
fibrous protein
globular protein
glycosydic bond
hydrogen bond
ion
lipid
macromolecule
monomer
monosaccharide
nitrogen
non-polar molecule
nucleic acid
nucleotide
organic molecule
peptide bond
phospholipid
polar molecule
polymer
protein
water

Cells:

active transport
amphipathic
apoptosis
aquaporin
carrier protein
cell wall
centrioles
channel protein
chloroplast
concentration gradient
cytoplasm
cytoskeleton
diffusion
electron microscope
endocytosis
endoplasmic reticulum
glycolipid
glycoprotein
Golgi apparatus
hypertonic
hypotonic
ion pump
isotonic
ligand
light microscope
lysosome
magnification

membrane
mitochondrion
nuclear envelope
nuclear pore
phospholipid
pinocytosis
plasma membrane
plasmolysis
prokaryotic cell
resolution
ribosome
rough ER
selectively permeable
smooth ER
exocytosis
eukaryotic cell
facilitated diffusion
flagella
fluid mosaic model
nucleus
organelles
osmosis
passive transport
phagocytosis
surface area:volume ratio
transmembrane protein
turgor
vacuole

Questions and Practice

1. How do the unique chemical and physical properties of water make life on earth possible?

2. What is the role of carbon in the diversity of life?

3. How do cells synthesize and breakdown macromolecules?

4. How do structures of biological molecules account for their function (carbs, proteins, lipids, DNA)?

5. What are the similarities and differences between prokaryotic and eukaryotic cells?

6. What the evolutionary relationships between prokaryotic and eukaryotic cells?

7. How does compartmentalization organize a cell's functions?

8. How are the structures of the various subcellular organelles related to their functions?

9. How do organelles function together in cellular processes?

10. What is the current model of molecular architecture of membranes?

11. How do variations in this structure account for functional differences among membranes?

12. How does the structure of membranes provide for transport and recognition?

13. What are various mechanisms by which substances can cross the membrane?

14. In osmosis and diffusion lab, how was osmosis measured in both living and artificial?

15. What was the IV in the dialysis bag part of the lab? DV? Control? Controlled variables?

16. What was the IV in the potato part of the lab? DV? Control? Controlled variables?

17. Draw concept map showing the connections between the following terms: Atom, Compound,

    Carbohydrate, Lipid, Protein, Nucleic Acid, Organelles, Nucleus, Mitochondria, Cell membrane, Golgi

    Apparatus, ER, prokaryotic cell, eukaryotic cell