BIOLOGY 138

Semester 1 Study Guide – Version 1.20

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I. Scientific Units/Scientific Method

Scientific units	Length – m (meter), Mass – g (gram), Volume – L (liter)
Scientific prefixes	*Prefix* / *Multiplier* / *Abbreviation* mega / 1 000 000 / M kilo / 1 000 / k hecto / 100 / h deca / 10 / da — / 1 / — deci / .1 / d centi / .01 / c milli / .001 / m micro / .000 001 / μ nano / .000 000 001 / η
Scientific Method	1. Observation and description of a phenomenon 2. Formulation of a hypothesis to explain the phenomenon 3. Use the hypothesis to make predictions about the phenomenon 4. Test these predictions by experimentation 5. Conclude on your findings
Controlled experiment	Has a control group and an experimental group. Only one variable is being tested.
Variable	Something that can be changed in the experiment; any factor that influences a process
Control group	Everything is kept the same, i.e. not influenced by the variables
Experimental group	Variables are changed

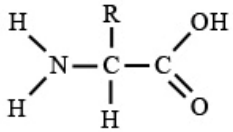
II. Introduction to Biology

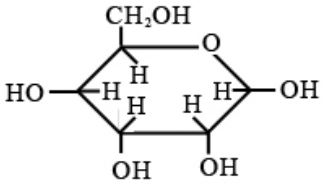
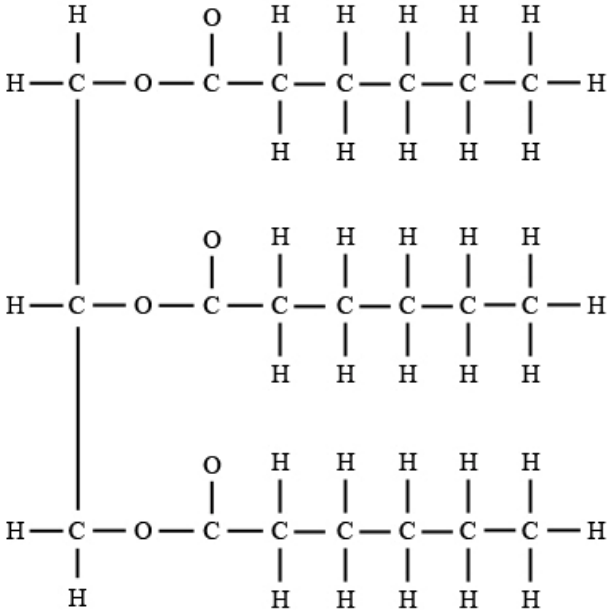
Themes of biology	1. Levels of organization 2. Flow of energy 3. Evolution 4. Cooperation 5. Structure determines function 6. Homeostasis
Biological properties	1. Complexity 2. Movement 3. Response to Stimulation 4. Cellular Organization 5. Metabolism 6. Homeostasis 7. Reproduction 8. Heredity

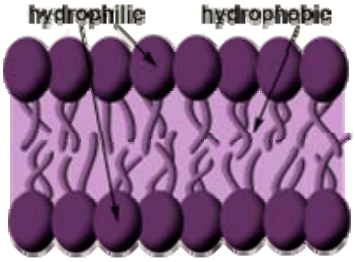
Homeostasis	The maintaining of a relatively stable internal physiological environment in an organic or steady-state equilibrium in a population or ecosystem
Adaptation	Any peculiarity of structure, physiology, or behavior that promotes the likelihood of an organism's survival and reproduction in a particular environment
Growth	A process of getting bigger (maturation)
Development	The process where a single cell becomes multicellular with many different kinds of cells
Reproduction	Where an organism makes copies of itself
Factor Label	Multiply what is given by fractions equal to one to convert units. Always be sure the unit to be eliminated is correctly placed in the conversion factor. If the unit to be eliminated is in the numerator of the given information, then the unit must be placed in the denominator of the conversion factor. Since the numerator and denominator of any conversion factor are equivalent, they may be flipped as needed. Here's an example: *Convert from 1000 grams to pounds.* $1000\,\cancel{g}\cdot\frac{1\text{ lb}}{454\,\cancel{g}}=2.2\text{ lb}$ Here's another example: *Convert from 65 miles per hour to meters per second.* $\frac{65\text{ mi}}{\text{hr}}\cdot\frac{1\text{ hr}}{60\text{min}}\cdot\frac{1\text{ min}}{60\text{ s}}\cdot\frac{5280\text{ ft}}{\text{mi}}\cdot\frac{12\text{ in}}{1\text{ ft}}\cdot\frac{2.54\text{ cm}}{1\text{ in}}\cdot\frac{1\text{ m}}{100\text{ cm}}\approx 29\text{ m/s}$

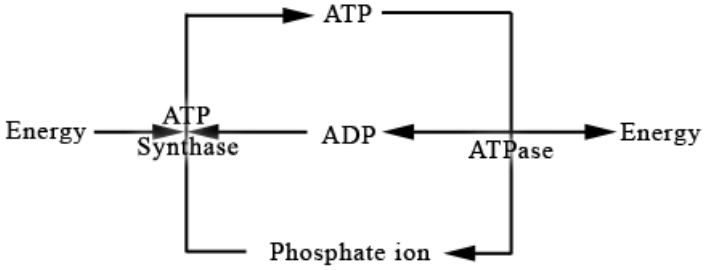
III. Biochemistry	
Properties of water	• High surface tension • Water is an universal solvent • Water has a high heat capacity • Ice floats because it's less dense than water • Ionic substances dissociate in water • Water has cohesion (it sticks to itself) • Water adheres to other molecules
Balancing equations	Make sure there's the same amount of each element on both sides.
Molecule	Two or more elements covalently bonded together
Compound	Two or more distinct elements bonded together
Ion	An ion in which the number of electrons does not equal the number of protons (carries an electron charge)
Element	A substance that cannot be divided by ordinary chemical methods
Ionic bond	A chemical bond formed between ions as a result of the attraction of opposite chemical charges. Salt is an example of an ionic bond. Na+ — Cl– — Na+ | | | Cl– — Na+ — Cl– | | | Na+ — Cl– — Na+

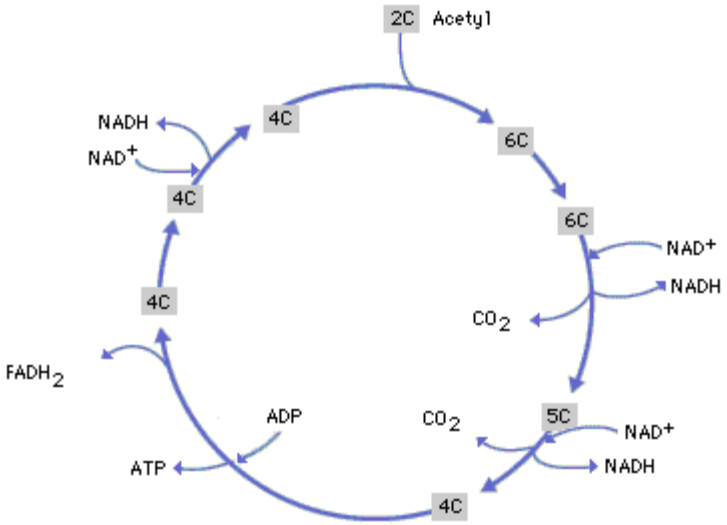
Covalent bond	A chemical bond formed by sharing on one or more than one pairs of electrons Water is an example of a covalent bond. O – H | H
Peptide bond	Removes an OH from an end of an amino acid and removes an H from the opposite end of another amino acid. Then, it joins the two amino acids together (the OH and H combine to form water).
pH scale	A way of measuring the concentration of hydrogen ions in water If pH is less than 7, the substance is an *acid*. If pH is greater than 7, the substance is a *base*. If pH is equal to 7, the substance is *neutral*. (i.e. water) The lower the pH, the more acidic; the higher the pH, the more basic.
Buffers	Chemical substances that minimize the changes in concentrations of H^+ and OH^- (helps with homeostasis in the blood)
Dehydration synthesis	Removal of H_2O to combine two monomers. Used in protein and carbohydrate metabolism.
Hydrolysis	Adding H_2O to break up chemical bonds (opposite of dehydration synthesis)
Stable number electrons	2, 10, 18, 36 Energy level 1 has a max of 2 electrons. Energy level 2 has a max of 8 electrons. Energy level 3 does something weird; it first has a max of 8 electrons, but after you finish the fourth energy level, you go back to energy level 3, and it then has a max of 18 electrons. So if the atom is in the third row or less, the max electron numbers are 2-8-8. If the atom is in the fourth row, the max electron numbers are 2-8-18-8.
Atom of chlorine	 2 electrons in innermost shell, 8 electrons in middle shell, 7 electrons in outermost shell.

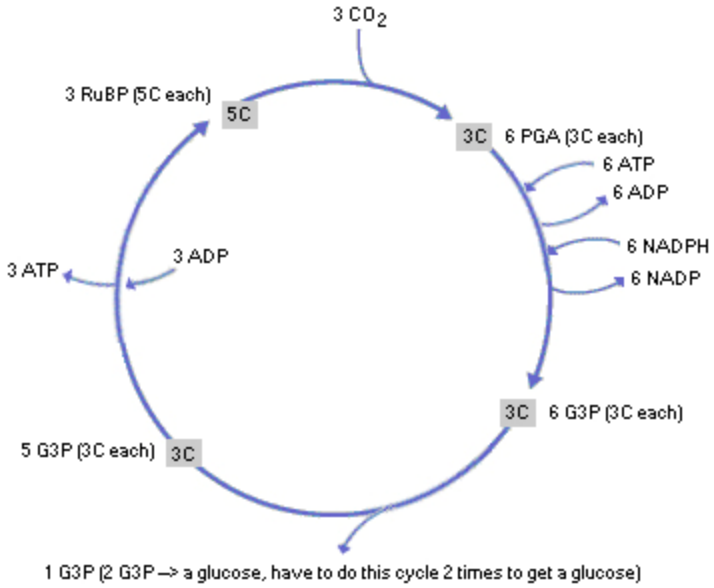
IV. Proteins, Sugars, Enzymes	
Catalase	Breaks down hydrogen peroxide. It is found in liver. Remember the liver lab?
Amino acids, etc	Amino acids combine using dehydration synthesis to form polypeptides. Some combinations of amino acids (polypeptides) form proteins.
Drawings	 Amino Acid (R is the rest of the molecule; it's different for each of the 20 amino acids)

	 Glucose (a monosaccharide)  Triglyceride (lipid)
Enzyme	A protein that helps to catalyze (speed up) a chemical reaction without any change to itself. It is a catalyst. They work by the inducted-fit model. Basically, a bunch of enzymes and substrates are floating around somewhere, and they bump into each other. If a substrate bumps exactly into an enzyme's "clutches", the enzyme acts on it. Functioning of an Enzyme: some factors that affect enzymes are temperature, pH, and substrate concentration. If the temperature or pH are too extreme, denaturization will occur; the protein in the enzyme will change shape or uncoil, making the enzyme unusable. If there is very little substrate, then there will be less collisions, making the reaction slower.
Determination of type of carbohydrates in a solution	Use two kinds of tests: Iodine Test and Benedict's Test. *Monosaccharide* – iodine stays brown, Benedict's turns yellow *Disaccharide* – iodine stays brown, Benedict's stays blue *Polysaccharide* – iodine turns blue, Benedict's stays blue
Examples of carbohydrates	*Monosaccharide* – glucose, fructose, galactose *Disaccharide* – sucrose, maltose, lactose *Polysaccharide* – starch, cellulose, glycogen
Levels of Protein Structure	*Primary structure* – sequence of amino acids *Secondary structure* – regularly occurring structure patterns in proteins. Formed through hydrogen bonds. There are two kinds: alpha-helix (looks like DNA) and beta-sheet (zig-zag sheet). These are shaped by hydrogen bonds. *Tertiary structure* – packing of alpha-helixes, beta-sheets and random coils of (structure is

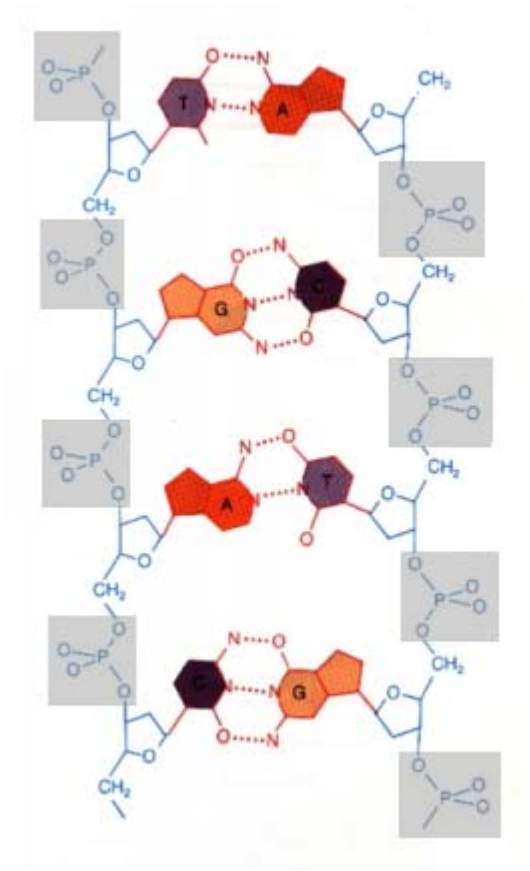
	determined by ionic bonds between R groups of amino acids) *Quaternary structure* – only exists if there is more than one polypeptide chain. It depicts the spatial organization of the chains.
Lipid	A lipid is formed from fatty acids, etc connected to a glycogen. Triglycerides have three fatty acids; phospholipids have two fatty acids and a phosphate group.
Saturated/unsaturated lipids	*Saturated* means all the carbons on the fatty acids (tails) have as many hydrogen atoms connected to them as possible. *Unsaturated* means that some carbons don't have the maximum number of hydrogen atoms they can possibly have. There are double bonds between carbon atoms that replace C-H bonds. *Polyunsaturated* means that there is more than one double bond. *Monounsaturated* means that there is only one double bond.
Phospholipid bilayer	Two layers of phospholipids form the cell membrane, as follows:  The two fatty acid tails are both hydrophobic, and the phosphate/glycogen are hydrophilic. For this reason, the phosphate/glycogen are on the outside (since there's water outside) and the tails are between the two layers of phosphate/glycogens, away from the water on the outside.
Miscellaneous	Sugars end in *–ose*, enzymes end in *–ase*.

V. Respiration/Photosynthesis	
ATP vs ADP	*ATP* – Adenosine triphosphate – provides energy *ADP* – Adenosine diphosphate – made by cell respiration, not as much energy
ATP/ADP cycle	
Cellular Respiration	*Stage 1 – Glycolysis* (takes place in cytoplasm) Glucose ($C_6H_{12}O_6$) 2 ATP → | → 2 ADP 2 NAD+ (coenzyme) → | → 2 NADH 4 ADP → | → 4 ATP V 2 Pyruvic Acid (3 carbons each) Through glycolysis, you produce 2 ATP, 2 NADH *Stage 2 – A transfer stage with No Name* (takes place in cytoplasm) 2 Pyruvic Acid (3 carbons each)

	| V Coenzyme A (CoA) (x2) NAD+ → | → NADH | → CO_2 (carbon dioxide) V Acetyl CoA (x2) (2 carbons each) | → CoA V Acetyl (➔ Krebs Cycle) *Stage 3 – Krebs Cycle* (takes place in matrix of mitochondria)  Through Krebs Cycle, you produce 4 CO_2, 6 NADH, 2 FADH, 2 ATP (two Acetyls) *Summary* 10 NADH → 30 ATP 2 FADH → 4 ATP Glycolysis → 2 ATP Krebs Cycle → 2 ATP } Total of 38 ATP
Aerobic Respiration Formula	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 38$ ATP Glucose + oxygen → carbon dioxide + water + energy
Fermentation	Glucose goes through glycolysis (the same as aerobic respiration), yielding 2 pyruvic acids (3 carbons each), 2 ATP, and 2 NADH. Then, the pyruvic acids go through a "recycling stage", where they are changed to either ethyl alcohol or lactic acid and the NADHs resulting from glycolysis turns back to NAD^+s, for use in the next fermentation.
Fermentation Formula	Alcoholic fermentation: $C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2 + 2$ ATP Lactic acid fermentation: $C_6H_{12}O_6 \rightarrow 2\ CH_3CHOHCOOH + 2$ ATP
Photosynthesis	*The Light Reaction* (takes place in thylakoid) The light strikes Photosystem I, making an electron "excited", which is then passed through an electron transport chain. The energy from the electron is used to make NADPH from NADP+. Light then strikes Photosystem II, "exciting" another electron which is passed through an

	electron transport chain. The energy from this electron is used to make ATP. The electron then replaces the electron lost from Photosystem I. The electron from Photosystem II is replaced by an electron from water, which is split when light strikes Photosystem II. So now we have some NADPH and ATP. The reaction then moves to the stroma. *The Dark Reaction* (takes place in stroma) – also called the Calvin Cycle 
Photosynthesis Formula	$6\ CO_2 + 12\ H_2O \xrightarrow{light} C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$

VI. DNA/Cell Replication	
Protein synthesis	A DNA molecule breaks into two strands. Then, transcription yields a mRNA molecule. It then leaves the nucleus and attaches to the ribosomes. Then, tRNA carries proteins (they're anticodon, so they get matches for the mRNA). Finally, translation links all the amino acids together, forming a protein.
Transcription	mRNA molecule is synthesized from a gene within the DNA
Translation	mRNA is used to direct the production of a protein
DNA	Double-stranded, contains genetic information
mRNA	Single-stranded, carries instruction from DNA and brings it to the cytoplasm
tRNA	Contains anticodon which pair up with the proper codon on the mRNA strand, also contains amino acid
Mitosis	*Interphase* – replication of DNA (in chromatin form), condensation into chromosomes *Prophase* – Nucleus, nucleolus disappears, nuclear membrane breaks, spindle fibers begin to form *Metaphase* – Chromosomes are lined up in the center of the cell *Anaphase* – Sister chromatids separate and move to opposite sides as they are being pulled apart *Telophase* – Nucleus, nucleolus, and nuclear membrane reappear, also, cytokinesis occurs

Meiosis	*Interphase* – replication of DNA, condensation into chromosomes *Prophase I* – homologous chromosomes pair and form synapses ⨯ Pairs of chromosomes side by side are called tetrads. Crossing over may occur. Formation of chiasmata. The nuclear membrane disappears, centrioles begin to form spindle fibers *Metaphase I* – Tetrads align at the center plate. *Anaphase I* – chiasmata separate. Chromosomes move to sister poles. *Telophase I* – cytokinesis occurs. *Prophase II* – centrioles move to sides *Metaphase II* – spindle fibers connect to chromosomes; chromosomes align at center plate *Anaphase II* – chromosomes are pulled apart *Telophase II* – cytokinesis Result: 4 daughter cells, each half the chromosome number of the parent cell.
Comparison	*Mitosis* – cell division that occurs in somatic (body) cells. Yields two daughter cells identical to the parent cell. *Meiosis* – cell division that occurs in sex cells. Yields four daughter cells, each half the chromosome number of the parent cell. End products of this process are called *gametes*.
DNA Structure	 DNA is made of a ribose and phosphate backbone and side groups of adenine (A), cytosine (C), guanine (G), and thymine (T). Phosphate groups are highlighted in grey; ribose groups are the unhighlighted pentagons. A only attaches to T, and vice versa. C only attaches to G, and vice versa. Notice that A and G have two rings, and C and T only have one.

VII. Organelles	
Cell membrane	Transparent wall around the cell which encloses the cytoplasm
Nucleus	Spherical structure bounded by double membrane, controls center of the cell and directs protein synthesis and cell respiration
Nuclear membrane	2 membranes combined; covers the surface of the nucleus. Covered with pores.

Chromosome	Long threads of DNA which contain hereditary information, only present during mitosis/meiosis
Chromatin	Loose, unwinded form of DNA
Nucleolus	Site of chromosome and rRNA synthesis which assembles ribosomes
Rough endoplasmic reticulum	"Holds" the ribosomes during protein synthesis. The proteins are then put into sacs called *cisternae*, and then into vesicles and sent to the Golgi complex.
Smooth ER	Involved in synthesis of lipids. Also manufactures carbohydrates, stores carbohydrates and lipids, and detoxifies alcohol and drugs.
Golgi apparatus	Stacks of membrane where molecules are modified, sorted, and packaged for transport.
Lysosome	A jelly-like structure filled with enzymes that break down macromolecules. It "recycles" old cell parts.
Mitochondria	Sausage-shaped power house, extracts energy from organic substances. It is the site of aerobic respiration.
Ribosomes	Located on the Rough ER. It makes ribosomal RNA and reads mRNA to make protein.
Cytoskeleton	Made of hollow microfilaments which are made of protein. It supports the shape of the cell.
Cell wall	Protects the cell (only on plant cells)
Chloroplast	Bacteria-like organelles found in plants. It's the site of photosynthesis and makes plant cells green. (only on plant cells)
Vacuole	Storage space for water and nutrients
Centriole	Anchor and assemble microtubules during cell reproduction. It has two tubes called centrosomes in it.
Cilia and flagella	Help to move the cell around. They stick out from the side of the cell.
Peroxisome	It takes care of harmful chemicals in the cell.

VIII. Microscope	
Eyepiece	Contains a magnifying lens
Arm	Supports the body tube
Stage	Supports the slide being observed
Fine Adjustment	Moves the body tube slightly to sharpen focus
Coarse Adjustment	Moves the body tube up and down for focusing
Base	Supports the microscope
Illuminator	Produces light or reflects light up through the body tube
Diaphragm	Regulates the amount of light entering the body tube
Diaphragm lever	Opens and closes the diaphragm
Stage clips	Holds the slide in position
Low power Objective	Provides a magnification of 10x and is the shorter of the objectives
High power Objective	Provides a magnification of 43x and is the longer of the objectives

Revolving nosepiece	Contains the low and high power objectives and can be rotated to change magnification
Body tube	Maintains a proper distance between the eyepiece and the objective
High power field of view	Narrower (looks at a smaller area) than the low power field of view. Advantage is that you can see more detail in the object. Disadvantage is that you can't see as many objects since the field of view is narrower.
Low power field of view	Wider (looks at a larger area) than the high power field of view. Advantage is that you can see more stuff. Disadvantage is that the things you see aren't as detailed.
Magnification of lens	There's two parts to it: the ocular lens and the objective lenses. There are four types of objective: wide angle, low power, high power, and oil immersion. You find the total magnification by multiplying the ocular magnification by the objective magnification. For example, if the ocular magnification is 7x, the magnifications are as follows: Wide angle (by itself 3x) *7 = 21x Low power (by itself 12x) *7 = 84x High power (by itself 20x) *7 = 140x Oil immersion (by itself 30x) *7 = 210x

IX. Miscellaneous	
Kinetic energy	Energy of motion; the energy an object has when it is moving For example, a ball dropping has kinetic energy.
Potential energy	Energy of position; has potential to move. For example, a ball held in the air has potential energy.
Liver lab	*Enzyme properties:* 1. Enzymes do not change after catalyzing a reaction 2. Enzymes can be reused 3. Only the substrate is changed by the enzyme 4. Each enzyme only works on one specific substrate 5. Each enzyme has a specific pH range in which it functions best. 6. Each enzyme have a temperature in which it functions best.
Cells in solution	*Hypotonic solution* (higher concentration inside the cell) – water rushes in; animal cells explode, plant cells become turgid and fat and happy *Hypertonic solution* (higher concentration outside the cell) – cell shrivels up *Isotonic* (equal concentrations) – no change Remember water goes from less concentration to higher concentration to even things out.
Plasmolysis	The cells shrivel up because they lack pressure inside.
Turgor pressure	Pressure in a cell (directed towards the outside). If the pressure in a cell is bigger than the pressure outside, the cell will expand and maybe blow up.
Diffusion	Movement of molecules into areas of lower concentration. This is natural and does not require energy. It is caused by *Brownian motion* (random movement of particles).
Active transport	A cell uses energy to bring a molecule into an area of higher concentration.
Passive transport	A cell lets a molecule move to an area of lower concentration (this is natural)
Osmosis	Diffusion of water across a semi-permeable membrane
Permeable	A membrane that lets stuff through.

Semi-permeable	A membrane that only lets some stuff through, i.e. water
Facilitated diffusion	Diffusion of a molecule through a protein channel in or out of a cell. Since a cell's membrane isn't very permeable, it has to have these channels to become semi-permeable.
U-tube problem	The concentrations of the things on both sides have to be equal. For example, if on the left side, there's a high concentration of solute, and on the right side, there's a low concentration of solute, and the semi-permeable membrane is only permeable to water, water will move from the right side to the left side until the *concentrations* of the two sides are the same. One side will usually have water higher than the other side because of the nature of these problems. *To do these problems*: 1) First determine the balance of solutes that can't pass through the membrane. For example, if on one side, there's 2M glucose, and on the other side, there's 1M glucose, you know that there has to be twice as much water on the first side. 2) Then, "move" the water to balance the solutes. 3) Finally, figure out how much of the other solutes you need on both sides. This ratio is the same as the ratio of the water on both sides. Just "move" the solute so the concentrations are the same on both sides. 4) The final balance that you get is your equilibrium. Important stuff to remember: 1) Stuff flows from higher to lower concentration. 2) Some solutes can't go through the membrane, and you have to see their ratios first. 3) You want the same concentration of solutes on both sides. 4) You'll usually end up with more on one side than the other. 5) M means moles per liter of water, so 6M HCl will have 6 moles of HCl per liter of water.

This is the end of the study guide. If you find any errors or have any questions or comments about this study guide, feel free to email me at fenguin@gmail.com. Thanks a lot for reading, and good luck on finals!

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