Review for Quiz #1: Biochemistry

1. Know and understand the definitions and meanings of the following terms. Be able to write complete definitions for the terms in **BOLD**:

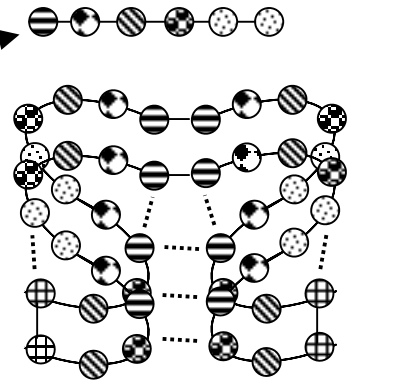
Biology
ionic compound
non-polar covalent compound
polar covalent compound
hydrogen bonding
organic compound
macromolecule
subunit
carbohydrate
monosaccharide
disaccharide
polysaccharide
lipid
triglyceride
fatty acid
saturated fat
unsaturated fat
phospholipid
steroid
protein
amino acid
essential amino acid
polypeptide
denature
nucleic acid
nucleotide
metabolism
anabolism
catabolism
condensation reaction
dehydration reaction
hydrolysis reaction
enzyme
substrate
active site
hydrophilic
hydrophobic

2. Compare and contrast the following terms (that is, know the similarities AND differences between the groups of terms):

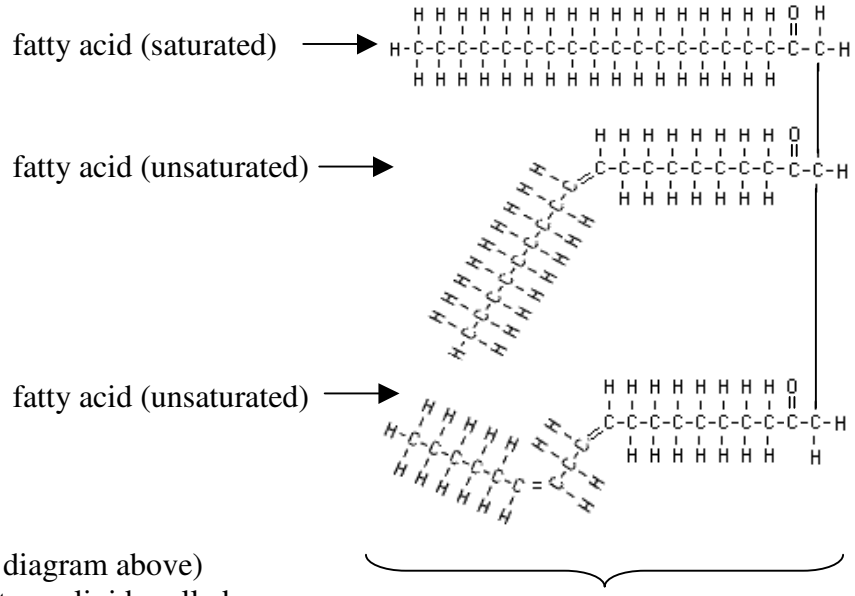
a) polar covalent and non-polar covalent compounds
- both are covalent compounds, so both contain only non-metal atoms that are held together by sharing electrons (covalent bonds)
- polar covalent compounds contain at least one polar bond. This is a bond in which the electrons are pulled significantly more strongly toward one of the atoms, giving this atom a partial (small) negative charge (δ–). The other bonded atom has its electrons pulled away from it, leaving this atom with a partial (small) positive charge (δ+). The partial charges created by the unequal sharing of electrons then attracts polar molecules to one another and to water molecules, so they are often liquid at room temperature and dissolve well in water.
- non-polar covalent compounds have no polar bonds. The bonds have no partial charges, so these molecules are not attracted to one another or to water. Non-polar molecules are often gases at room temperature (eg. N_2, O_2, H_2S, CH_4) and these substances do not dissolve well in water.

b) phospholipid and triglyceride
- both are lipids
- both are macromolecules that contain glycerol and fatty acids
- triglycerides contain glycerol and three fatty acids. They are non-polar and do not dissolve well in water.
- phospholipids contain glycerol, two fatty acids and one phosphate group. The fatty acid groups are non-polar while the phosphate group is polar. This means that one end of the phospholipid is non-polar and hydrophobic (water-fearing) while the phosphate end of the molecule is polar and hydrophilic (water-loving). This dual-polarity allows phospholipids to form "phospholipid bilayers" which are the basis for cell membranes and life.

c) polypeptide and protein
- polypeptides and proteins are both macromolecules made of many amino acids bonded together in a long chain
- polypeptides are simply long chains of amino acids
- proteins are long polypeptide chains that have folded and taken on a specific shape because of hydrogen bonds between the amino acids



d) fatty acid and fat (see diagram below)
- fatty acids and fats are both non-polar molecules
- fatty acids are one of the subunits that make up fats
- fats are triglyceride molecules which contain one molecule of glycerol with three fatty acid molecules attached to it



e) saturated fat and unsaturated fat (see diagram above)
- both saturated and unsaturated fats are lipids called triglycerides because they are made of three fatty acids attached to a glycerol molecule. Both saturated and unsaturated fats are non-polar so they do not dissolve well in water
- a saturated fat contains two or three fatty acid chains that are saturated. Saturated fatty acids do not contain any C = C double bonds, so the fatty acid chains are very straight and pack well together. Because of the tight packing of saturated fatty acids, saturated fats are solid at room temperature.
- an unsaturated fat contains two or three fatty acid chains that are unsaturated. Unsaturated fatty acids contain C = C double bonds, so the fatty acid chains have kinks in them and do not pack together very well. Because unsaturated fatty acids are unable to pack together tightly, unsaturated fats are liquid at room temperature

f) dehydration and hydrolysis reactions
- dehydration and hydrolysis reactions are both part of a cell's overall metabolism and both involve a molecule of water
- dehydration reactions are also called condensation reactions or dehydration synthesis reactions because two or more small molecules are joined together to form a larger molecule. These reactions release a molecule of water and are anabolic (building) reactions which form new chemical bonds so they require energy.
- hydrolysis reactions break a large molecule into smaller molecules. These reactions require a molecule of water in order to break the bond and are catabolic (break down) reactions which release energy.

g) anabolic reactions and catabolic reactions
- anabolic and catabolic reactions are both part of a cell's overall metabolism
- anabolic reactions combine two or more small molecules to make a larger molecule. These reactions form bonds so they require energy.
- hydrolysis reactions break a large molecule into smaller molecules. These reactions break bonds so they require energy.

h) photosynthesis and respiration
- these reactions are complementary (the reverse of one another). Both involve carbon dioxide, water, oxygen and glucose
- photosynthesis is an anabolic reaction. It takes place in the chloroplasts of plant cells and uses energy from the sun to drive the reaction:

  $6\,CO_2 + 6\,H_2O \rightarrow 6\,O_2 + C_6H_{12}O_6$ (this is the overall reaction, which takes place as a series of simpler reactions)
- cellular respiration is a catabolic reaction. It takes place in the mitochondria of BOTH plant and animal cells and releases energy that can be used by the cell:

  $6\,O_2 + C_6H_{12}O_6 \rightarrow 6\,CO_2 + 6\,H_2O$ (this is the overall reaction, which takes place as a series of simpler reactions)

3. Give two (2) examples for each of the following:

a) monosaccharides: any of glucose, fructose or galactose (ribose or deoxyribose are also correct)
b) disaccharides: any of sucrose, maltose or lactose
c) polysaccharides: any of glycogen, starch or cellulose
d) proteins: any of keratin, haemoglobin, immunoglobulins, collagen, any enzymes etc.
e) steroids: any of cholesterol, testosterone, estrogen, progesterone (also cortisone, prednisone etc)
f) unsaturated fats: any of olive oil, fish oil, corn oil, peanut oil (any plant or fish oil except coconut oil)
g) saturated fats: any of lard (pig fat), butter (milk fat), tallow (beef fat) or any other animal fat
h) nucleic acids: RNA or DNA
i) nucleotides: adenine (A), guanine (G), cytosine (C), thymine (T) or uracil (U, which is in RNA)
j) energy storage molecules: any of ATP, ADP, glucose, fats, starch or glycogen
k) enzymes: any of helicase, catalase, lipase, lactase, sucrase or any other enzyme you know of:)

4. What does the word "lysis" mean? lysis means to break apart or break down

5. What are four (4) functions of proteins? Any of:
   i) structural: they make the framework of our hair, teeth, fingernails and bones
   ii) transport: they carry specific substances; for example, haemoglobin carries oxygen through the blood and transport proteins carry sodium, potassium and calcium ions through the cell membrane
   iii) immune: antibodies and immunoglobulins help our body recognize and destroy viruses and bacteria
   iv) enzymes: biological catalysts that control the rate of chemical reactions in an organism without being used up themselves, eg. catalase, lactase etc
   v) polypeptide hormones that help to control processes in the body, such as insulin that is needed to help move sugar from the blood into the cell. Growth hormone and prolactin are other examples (there are lots)

6. What are four (4) functions of lipids?
   i) cushioning: they surround our internal organs as "shock absorbers"
   ii) insulation: lipids are found under the skin of many warm blooded animals to insulate them against heat and cold
   iii) nutrient and energy storage: lipids are important in long-term energy storage in animals and plants, especially in plant seeds. Also, substances that dissolve in lipids such as vitamins A, D, E and K can be stored by dissolving them in lipids in cells
   iv) structural: lipids (especially phospholipids and cholesterol) are the major component of cell membranes
   v) hormones: many hormones are lipids, especially the steroid hormones such as estrogen, testosterone and progesterone which control sexual and reproductive functions

7. What is the main function of each of the following carbohydrates?
   i) glycogen in animals: short term energy storage in liver and muscle cells (a quick source of energy)
   ii) starch in plants: short and long term energy storage in plants
   iii) cellulose in plants: makes up the structure of cell walls of plants, giving plants rigidity

8. Describe how you would test for each of the following macromolecules, including a description of both a positive and negative result:
   a) **starch**: add a few drops of Lugol's iodine solution. If starch is present, the solution will turn dark blue/black. If starch is not present, the iodine will remain yellow (not turn blue/black).
   b) **lipid**s: rub a small amount of the substance onto a clean piece of paper then let it dry. If lipids are present, the paper will go translucent. If lipids are not present, the dry paper will be opaque.
   c) **simple sugars**: add a few drops of Benedict's solution to the sample and then heat in a boiling water bath. If simple sugars are present, Benedict's will turn a yellow/orange colour. If there are no simple sugars, Benedict's solution will remain blue (not turn yellow/orange).
      - if there is only a small amount of simple sugars, Benedict's solution may turn green, a combination of blue and yellow
   d) **protein**: add a few drops of Biuret reagent to the substance. If proteins are present, Biuret solution will turn a pale purple colour. If no protein is present, Biuret will remain a pale blue colour (not turn purple).

9. Be able to classify reactions as anabolic or catabolic, and as hydrolysis or dehydration synthesis (condensation) reactions:

Description of Reaction	Anabolic or Catabolic?	Hydrolysis or Dehydration?
A protein is broken down into amino acids.	catabolic	hydrolysis
Glycerol and three fatty acids combine to form a triglyceride.	anabolic	dehydration
Lactose is separated into glucose and galactose.	catabolic	hydrolysis
Glucose molecules are bonded to form cellulose.	anabolic	dehydration
ATP breaks down into ADP, phosphate and energy.	catabolic	hydrolysis

10. For photosynthesis:
    a) Write the overall chemical reaction: $6\,CO_2 + 6\,H_2O \rightarrow 6\,O_2 + C_6H_{12}O_6$
    b) Is it anabolic or catabolic? anabolic
    c) Is energy required or released? energy is required to form bonds

11. For cellular respiration:
    a) Write the overall chemical reaction: $6\ O_2 + C_6H_{12}O_6 \rightarrow 6\ CO_2 + 6\ H_2O$
    b) Is it anabolic or catabolic? catabolic
    c) Is energy required or released? energy is released as bonds break

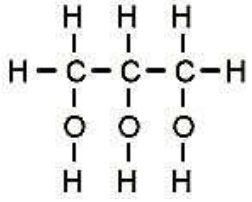
12. For enzymes, in general:
    a) What type of macromolecule are they? proteins
    b) What is their function (use)? they are catalysts which control the rate of chemical reactions
    c) Describe how they work: enzymes have an active site (a specific shape) which can bond the substrates(s) of the reaction. Substrates are the reactants.
        - If the enzyme is catabolic, a single reactant molecule (substrate) is attracted to and fits into the active site, forming the enzyme-substrate complex. The enzyme puts strain or stress on a certain bond in the substrate, which makes the bond break more easily and quickly. Once the bond is broken, the products of the reaction are released from the active site, making the enzyme available so it can be used again.
        - If the enzyme is anabolic, two or more reactant molecules (substrates) are attracted to and fit into the active site, forming the enzyme-substrate complex. The enzyme brings the reactants together in an orientation that makes it easier for bonds to form between them. Once the bond is formed, the product of the reaction is released from the active site, making the enzyme available so it can be used again.

    d) What does it mean to "denature" an enzyme?
        - An enzyme is denatured when some of the hydrogen bonds which help to keep the enzyme (which is a protein) folded into a certain shape are broken, so the active site of the enzyme loses its shape and the substrate(s) no longer fit into the active site. A denatured enzyme can no longer control the rate of any reaction.

    e) What are three ways to denature an enzyme?
        - enzymes can be denatured by excessive heat (cooking), changes in pH (more acidic or basic conditions) or by harsh chemicals that damage the protein

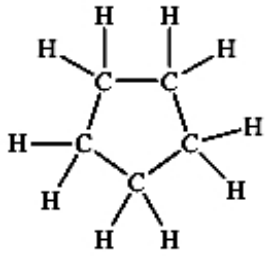
13. Hydrogen bonding is critical to biology. In what two types of macromolecules is hydrogen bonding important in determining the shape or structure of the molecule?
- the two strands of nucleic acids are held together by hydrogen bonds (A to T, C to G)
- the shape of protein molecules is maintained by hydrogen bonds between different amino acids

14. Glycerol, shown to the right, is one of the subunits of both triglycerides and phospholipids.
    a) Will glycerol dissolve in water? Explain why or why not.
        - glycerol will dissolve well in water
        - glycerol has C – O and O – H bonds, both of which are polar
        - the partial charges on these bonds will be attracted to the partial charges on water molecules, so glycerol and water will mix well



    b) Is glycerol organic? Explain why or why not.
        - glycerol is an organic molecule because it contains C – H bonds

15. Repeat the questions in #14 for cyclopentane, shown to the right:
    - cyclopentane will not dissolve well in water
    - cyclopentane has only C – C and C – H bonds, both of which are non-polar
    - there are no partial charges on these bonds so there will be no attraction to the partial charges on water molecules, so cyclopentane and water will not mix
    - cyclopentane is an organic molecule because it contains C – H bonds



cyclopentane

16. Be able to explain:

a) why water is a polar molecule
    - the O – H bonds in water are very polar. This means that the electrons are pulled significantly more strongly toward the oxygen atom, giving the oxygen atom a partial (small) negative charge (δ–). The hydrogen atom has its electrons pulled away from it, leaving the hydrogen atom with a partial (small) positive charge (δ+). The partial charges created by the unequal sharing of electrons then attracts one water molecule other water molecules. This attraction is called hydrogen bonding and explains why water is liquid at room temperature

b) the importance of water to living things
    - water stays liquid over a large range of temperatures
    - water is very polar so it can dissolve a huge number of different substances that are important for life
    - water changes temperature very gradually so it maintains a relatively constant temperature for living things
    - water expands when it freezes, so it floats and this protects the living things in lakes and oceans
    - because water molecules are strongly attracted to one another, this enables water to climb up thin tubes such as those inside trees and pull other water molecules along with it. This is how water from a tree's roots can be transported to its leaves

c) why unsaturated fats are liquid at room temperature
    - unsaturated fats (triglycerides) contain two or more unsaturated fatty acids
    - unsaturated fatty acids have C = C double bonds, which introduce a bend or "kink" in the long carbon chain
    - because of the bends in the chain, unsaturated fatty acids do not pack together tightly which makes the fat less dense and a liquid at room temperature

17. For each type of macromolecule, know:
 a) the main types of each macromolecule
 b) the subunits from which they are made
 c) their function
 d) their standard chemical test (except for nucleic acids) and what a positive and negative test look like

Macromolecule and Examples	**Names of Subunits with Examples**	**Function(s) of this Macromolecule**	**Standard Test**
Polysaccharides • Starch • Glycogen • Cellulose	Made of simple sugars: • glucose • galactose • fructose	**In plants:** • starch is for short and long term energy storage; • cellulose is structural – makes cell walls and gives plants rigidity **In animals:** • glycogen is for short term energy storage	**simple sugars**: add a few drops of Benedict's solution to the sample and then heat in a boiling water bath. **Positive**: Benedict's will turn a yellow/orange colour. **Negative**: Benedict's solution will remain blue. **starch**: add a few drops of Lugol's iodine solution. **Positive**: solution will turn dark blue/black. **Negative**: the iodine will remain yellow.
Lipids • Triglycerides (saturated, solid fats and unsaturated fats (oils) • Phospholipids • Steroids	Triglycerides made of glycerol + 3 fatty acids Phospholipids made of glycerol + 2 fatty acids + 1 phosphate group	• Long term energy storage • Insulation • Cushions and protects internal organs • Act as hormones to send messages around the body (steroids) • Main structural component of cell membranes (phospholipids)	**lipid**s: rub a small amount of the substance onto a clean piece of paper then let it dry. **Positive**: the paper will go translucent **Negative**: the dry paper will be opaque
Proteins • Antibodies • Enzymes • Transport proteins • Structural proteins • Polypeptide hormones	amino acids (glycine, alanine, serine etc.)	• Help fight infections • Help control and speed up chemical reactions • Carry specific substances through the body • Support the body eg. collagen, keratin • Carry messages and control processes in the body	**protein**: add a few drops of Biuret reagent to the substance. **Positive**: Biuret solution will turn a pale purple colour **Negative**: Biuret will remain a pale blue colour.
Nucleic Acids • DNA • RNA	Made of nucleotides (A, T, C, G) nucleotides made of sugar + phosphate + nitrogen base)	• DNA stores all genetic information in the nucleus • RNA copies the information from the DNA to make specific proteins	Not required.