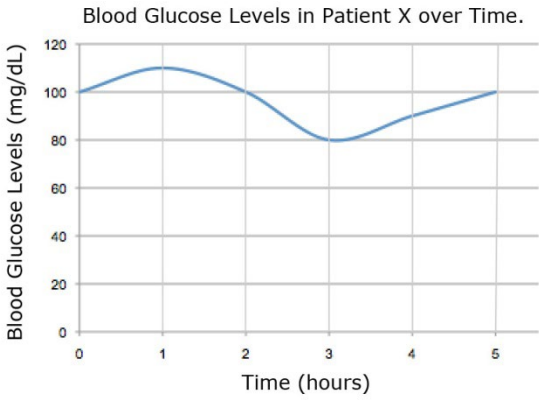
**UNIT 1 ANSWER KEY**

1. A woman is being tested for diabetes mellitus. Her blood glucose levels are measured and recorded over a period of time (data given below). Please graph the data and answer the associated questions. (4 marks)




**a.** The normal range for blood glucose levels is 70-110 mg/d. Does Patient X always remain within the normal range? (1 mark)

- Yes…ranges from 80-110 mg/dl

**b.** Does Patient X have any apparent problems with glucose regulation? Why or why not? (2 marks)

- No…blood glucose levels appear to remain within a normal range suggesting homeostatic mechanisms are functioning correctly to regulate blood glucose levels

**c.** Which type of feedback mechanism (positive or negative) is used to regulate blood glucose levels? Explain your reasoning. (2 marks)

- negative feedback loop as the process is maintaining normalcy (blood glucose between 70-110 mg/dL) as opposed to moving levels towards an extreme as would a positive feedback loop

2. Case Study

a) Define homeostasis and describe how it relates to hyperthermia. (Use the following terms in your response: receptors, set point, and effectors). (3 marks)

Homeostasis is the tendency of the body to seek and maintain a condition of balance within its internal environment. It relates to hyperthermia because hyperthermia occurs

when homeostasis is not capable of maintaining the body's temperature due to extreme external factors. When the set point is surpassed receptors respond by sending a message to the regulatory center which sends a message to the appropriate effectors to try to return the body to the set point.

b) Explain why elderly individuals with poor circulation would have a greater risk of suffering heat exhaustion or heatstroke. (4 marks)

There are a few reasons why senior citizens have trouble with extreme heat. Health issues like poor circulation, damaged skin, and inefficient sweat glands make it harder for older adults to adjust to changes in heat. Older adults are also more likely to have medical conditions that can be affected by changes in heat.

Similarly, older adults make take medications that can directly impact a person's ability to regulate temperature. For example, diuretics can cause water loss, which can inhibit perspiration and make dehydration even more likely during a summer heatwave.

c) Explain why spraying water on the skin while sitting in front of a fan would lower body temperature. (3 marks)
(Make sure to use and explain endothermic and evaporative cooling in your answer).

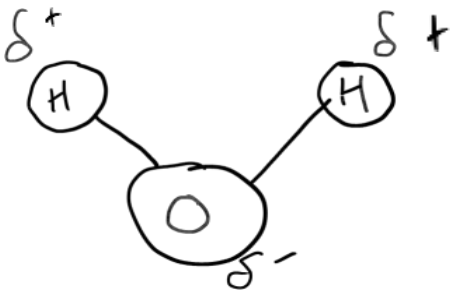
Evaporation is endothermic because water molecules must absorb heat from the surroundings to increase their kinetic energy. One familiar example is sweat, which cools the human body as it evaporates from the skin. Body heat is transferred to the water on the skin by conduction. The air movement that results from the fan increases the rate of evaporation resulting in evaporative cooling. As the water on the skin evaporates, it carries away the heat that it acquired from the body.

d) When attempting to lower a person's body temperature in response to hyperthermia one should avoid treatments that induce shivering or vasoconstriction. Why? (3 marks)

Shivering is initiated by the homeostatic mechanism that regulates body temperature in order to generate heat and raise the body temperature. Vasoconstriction occurs as a result of the same homeostatic mechanism and functions to retain warm blood within the core of the body and decrease heat loss across the skin. Both of these phenomena can occur if treatment for hyperthermia is too intense, and both would hinder the reduction of body temperature.

*Water*

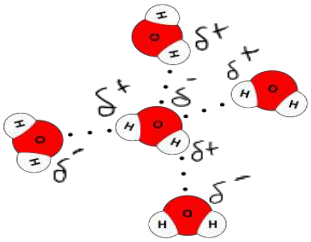
1. Sketch a ball and stick diagram of a water molecule. Label the atoms and indicate the partial charges that exist in a water molecule. (2 marks)




2. What type of bonds are found between hydrogen and oxygen atoms **within** a single water molecule? (1 mark)
   - Covalent bond

3. What type of bonds form **between** two or more water molecules? (1 mark)
   - Hydrogen bond

4. Use a diagram with 5 water molecules to illustrate hydrogen bonding between water molecules (start with one molecule in the middle). How many water molecules can hydrogen bond with a single water molecule? (3 marks)



4 water molecules can hydrogen bond with a single water molecule

5. List 3 everyday examples of the cohesive and/or adhesive properties of water. (3 marks)
   - answers may vary but may include;
     - movement of water up plant stems
     - the ability of water bugs to "stand" on water
     - water clinging to a surface such as blood vessels
     - rain gathers into puddles

6 Water is a polar molecule. Water dissolves many substances (especially other polar molecules). This property makes water an excellent solvent (2 marks)

7 Use several examples each to explain how water is essential to life on Earth as we know it with respect to the following properties: (7 marks)

a. Water acts as a Solvent
   - dissolves charged and polar molecules such as salts which can then be transported throughout the body
   - dissolves molecules such as salts that can then react with one another to form new compounds

b. Water acts as a Temperature Moderator
   - water absorbs and releases heat slowly. Because the human body is 70% water this property results in the maintenance of a relatively constant body temperature.
   - the polarity/hydrogen bonding of water also results in it having a high heat of evaporation making it (in the form of perspiration) an effective coolant on the surface of the skin. (evaporative cooling)

c. Water acts as a Lubricant and Transportation Facilitator
   - the polarity/hydrogen bonding of water makes it cohesive/adhesive such that it fills and flows through vessels easily making it an effective transport medium
   - water remains in a liquid state at body temperature as opposed to a gas (as is comparable for most similar molecules) making it an effective transport medium
   - the polar nature of water allows it to stick to other surfaces (adhesion) which provides lubrication required for the movement of joints, blinking of eyes etc.

8 Please indicate whether the statements below are true or false. Please correct any false statements. (5 marks)

T / F a. Water molecules can attract other water molecules by hydrogen bonding.

T / F b. Hydrogen bonds ions are ~~weaker~~ **Stronger** than or covalent bonds.

T / F c. The majority of our cellular reactions occur in water.

T / F d. Large lakes and oceans tend to moderate local temperatures.

T / F e. Water is an ~~organic~~ inorganic as does not contain carbon. molecule.

9. What happens in the human body when excessive water is consumed? (research) (4 marks)

At the onset of this condition, fluid outside the cells has an excessively low amount of solutes, such as sodium and other electrolytes, in comparison to fluid inside the cells,

causing the fluid to move into the cells to balance its concentration. This causes the cells to swell. In the brain, this swelling increases intracranial pressure (ICP), which leads to the first observable symptoms of water intoxication: headache, personality changes, confusion, irritability, and drowsiness followed by nausea, vomiting, thirst, and a dulled ability to perceive and interpret sensory information. The cells in the brain may swell to the point where blood flow is interrupted resulting in cerebral edema, which manifests as seizures, coma, respiratory arrest, brain stem herniation and death.

*pH, ACIDS AND BASES*

**1.** Please define the following terms (4 marks):

**a.** Acid = compound that releases hydrogen ions in aqueous solutions (increase $H^+$ ions in solution)
**b.** Base = compound that releases hydroxide ions in aqueous solutions (increase $OH^-$ ions in solution)
**c.** pH scale = describes how acidic or basic a solution is, a negative log scale referring to the concentration of hydrogen ions ($H^+$) within a solution
**d.** buffer = a substance that resists changes in pH despite the addition of an acid or base

**2.** Please indicate whether the following pH values represent an acidic, basic or neutral solution. (2 marks)

**a.** pH 0: acid
**b.** pH 12: base
**c.** pH 7: neutral
**d.** pH 3: acid

**3.** Hydrochloric acid (HCl), a strong acid, is added to a beaker of pure water (3 marks)

**a.** What is the pH of the pure water in the beaker before the acid is added?

- by definition the pH of pure water is 7 (neutral)

**b.** How does the hydrogen ion concentration of the solution in the beaker change does after the acid is added?

- by definition acids increase the hydrogen ion concentration of a solution

**c.** What happens to the pH of the solution in the beaker as the acid is added?

- pH decreases

4. How much has the hydrogen ion concentration changed in a solution if its pH value goes from 6 to 4? Remember to indicate whether this change represents an increase or decrease n hydrogen ion concentration.

   Thus, the hydrogen ion concentration has increased a 100 fold when pH shifts from 6 to 4

5. pH balance is very important to biological systems. (5 marks)

   a. Why?
   - Because many cellular activities require the action of enzymes which are proteins whose three-dimensional structures and accompanying functions are dependent on a particular pH…changing the pH changes the structure and inhibits the enzyme's functions and therefore, inhibits cellular activities

   b. What prevents rapid or large changes in pH in biological systems? - buffers

   c. Give an example of where pH balance is important and regulated in a living organism. (2 marks)

      - Answers may vary but may include;
        - in the blood (pH ~7.4) to maintain protein structure such as that of hemoglobin…regulated using the bicarbonate buffer system and hemoglobin itself
        - in the stomach (pH ~ 2) to ensure activation of digestive enzymes such as pepsin while also beginning to denature (unfold) ingested proteins…regulated by parietal cells that release hydrochloric acid
        - in the small intestine (pH ~ 7) to ensure the activation of digestive enzymes such as trypsin…regulated by bicarbonate released into the small intestine by the pancreas

Introduction biomolecules

1. List the 4 major classes of carbon-containing life molecules that will be studied in this unit and throughout the course? (2 marks)

   a. carbohydrates

**b.** Proteins

**c.** Lipids

**d.** Nucleic acids

**2.** Define the following terms : (4 marks)

**a.** monomer – a single unit or building block that can be used to build polymers

**b.** polymer – a chain made up of monomers that are bonded together

**c.** dehydration synthesis – synthesis (building) reaction that bonds 2 molecules together while removing a H+ and OH- to produce water

**d.** hydrolysis – degradation (breaking) reaction that breaks apart polymers by adding water

Carbohydrates

**1.** What is the empirical formula for carbohydrates? **$CH_2O$**

**2.** Define the following terms and give two examples of each. (6 marks)

Monosaccharide- sugar containing a single ring structure (glucose, fructose, galactose)

Disaccharide- sugar containing 2 bonded ring structures (lactose=glucose+galactose) (sucrose= glucose+fructose) (maltose=glucose+glucose)

Polysaccharide- sugar containing many bonded monomers (starch, cellulose, glycogen)

**3.** Name the three disaccharides that you need to know for this course. (maltose, sucrose, lactose) (1 mark)

**4.** Identify the building blocks or monomers that come together to form each of the disaccharides that you listed above. (3 marks)
(lactose=glucose+galactose) (sucrose=glucose+fructose) (maltose=glucose+glucose)

**5.** Name the three polysaccharides that you need to know for this course**.** (starch, cellulose, glycogen) (1 mark)

**6.** Describe how you can distinguish the structures of each of these polysaccharides. Look at the examples closely and come up with a way to memorize which is which and then explain it (do not just simply draw each structure). (3 marks)
(starch – few side branches)

(cellulose – no side branches with alternating bonds)
(glycogen- many side branches)

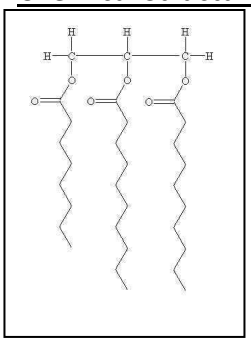
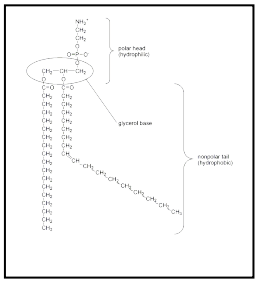
**7.** State the functions of each of these polysaccharides (3 marks)
Starch – storage form of glucose in plants
Cellulose – structural component of plant cell walls
Glycogen – storage form of glucose in animals

**8.** Why is cellulose considered "roughage" in our diets? (1 mark)
Humans lack the enzyme necessary to break the bonds in cellulose – necessary as roughage to maintain healthy digestive system. No nutritive value.

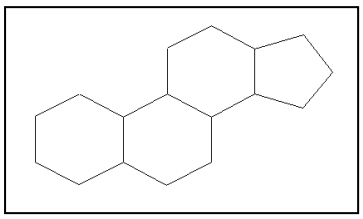
Lipids

1. What are the three major types of lipids that you need to know for this course? (1 mark)
   Neutral fats (triglycerides), phospholipids, steroids

2. (6 marks)

| Lipid | Chemical Structure | Biological Function |
|---|---|---|
| neutral fats |  | -long term energy source<br>-insulation<br>-padding |
| Phospholipid |  | -forms phospholipid bylayer of the cell membrane |

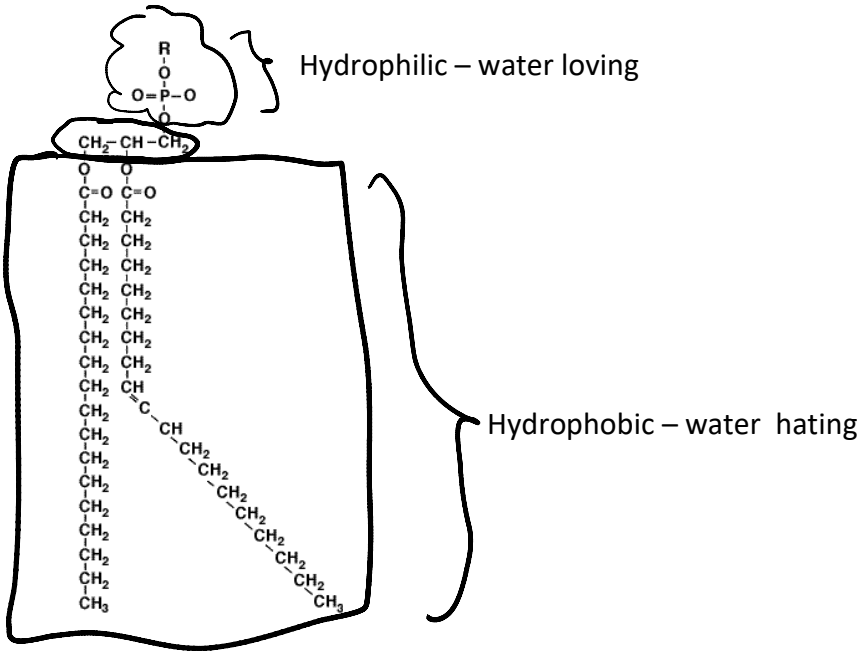
Steroids



-biological messenger that travel through blood such as estrogen and testosterone

3. How do the bonds differ in a saturated versus unsaturated fatty acid tail? (2 marks)
   Saturated fatty acids hold all the hydrogen it can and have single bonds between the carbon atoms. Unsaturated fatty acids have double bonds between one or more carbon atoms.

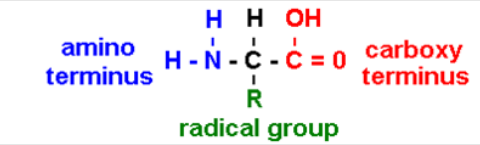
4. The diagram below represents an important type of lipid: (9 marks)
   a. What type of lipid does the diagram represent? Phospholipid
   b. What cell structure is this lipid primarily responsible for forming? Cell membrane/organelle membranes
   c. Please place a **circle/oval** (⬭) around the glycerol backbone, a **rectangle** (▭) around the fatty acid tails and a **cloud** (☁) around the phosphate/nitrogen group.
   d. Identify/label which portion of the molecule is hydrophobic and which portion is hydrophilic.
   e. Define hydrophobic and hydrophilic.



5. Steroids have a very different structure than the other types of lipids: (6 marks)
    a. Please describe the characteristic structure of a steroid. 3 six carbon rings bonded to 1 - 5 carbon ring
    b. Please explain why steroids are classified with other lipids. Insoluble in water – hydrophobic
    c. Please identify two important steroids in the human body and briefly explain their functions.
    Testosterone – regulates sperm production – important in the development of secondary sex characteristics
    Estrogen – female reproductive hormone – regulating female cycle
    Cholesterol – precursor for many steroids

Proteins

1. Identify the basic building block (monomer) of all proteins. (1 mark) Amino acids
2. Draw the generic structure of the basic building block of proteins and clearly labeling its 4 key parts. (4 marks)




3. A dipeptide is: 2 amino acids bonded together by a peptide bond (2 marks)
    a) formed by what type of reaction? Dehydration synthesis
    b) held together by what type of bonds? Peptide bonds

4. Please describe the following levels of protein structure including the types of bonds that are involved: (3 marks)
    a. Primary – linear chain of amino acids bonded together by peptide bonds
    b. Secondary – alpha helix held together by hydrogen bonds between amino and carboxyl groups within a chain
    c. Tertiary – 3 dimensional globular structure held together by ionic, covalent, hydrogen and sometimes sulfur bonds

5. Describe what is meant when we say a protein/enzyme is denatured? (3 marks)
    High temperatures or extreme pH changes cause the enzyme to lose its tertiary shape unraveling the enzyme, destroying the active site so that it can no longer bond to its substrate – no chemical reaction

6. Identify at least three factors that can denature proteins/enzymes. (3 marks)
    Extreme increase in temperature, extreme pH change, heavy metals

7. Define enzyme and give two examples of enzymes and their functions in the human body. (2 marks) answers can vary but two examples are given here.

   Biological catalysts that speed up chemical reactions – maltase – digests maltose, carbonic anhydrase – helps maintain blood pH

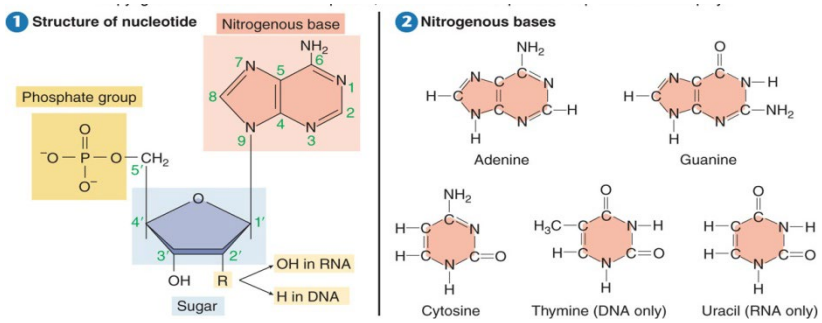
8. Describe what is meant by a structural protein and provide two examples in the human body. (2 marks)

   Used to build or support body structures – keratin – hair and nails, collagen – connective tissues, actin/myosin – muscle tissue

Nucleic acids

1. Identify the basic building block (monomer) of nucleic acids. (1 mark) Nucleotides

2. Draw the generic structure of the basic building block of nucleic acids and label its three key parts. (2 marks)




3. ATP is a key nucleotide in the human body: (3 marks)
   a) What does "ATP" stand for? Adenosine triphosphate
   b) What is ATP's primary function? Energy molecule of the cell
   c) Does ATP release energy when it is being formed (dehydration synthesis) or broken down (hydrolysis)? Releases energy when a phosphate is released by breaking its bond during hydrolysis reaction