Biological Molecules

A. CARBOHYDRATES, LIPIDS AND GLYCOSIDIC BOND

- Each glycosidic bond is catalysed by enzymes specific to which OH groups are interacting
- As there are many different monosaccharides this results in different types of glycosidic bonds forming
- The glycosidic bond is broken when water is added in a hydrolysis (meaning 'hydro' – with water and 'lyse' – to break) reaction
- Disaccharides and polysaccharides are broken down in hydrolysis reactions
- Hydrolytic reactions are catalysed by enzymes, these are different to those present in condensation reactions
- Examples of hydrolytic reactions include
    1. Digestion of food in the alimentary tract
    2. The breakdown of stored carbohydrates in muscle and liver cells for use in cellular respiration

B. STARCH AND GLYCOGEN

- Starch is the storage polysaccharide of plants with formula $(C_6H_{10}O_5)_n$. It is stored as granules in plastids. Due to the many monomers in a starch molecule, it takes longer to digest than glucose
- Glycogen is the storage polysaccharide of animals and fungi
- It is highly branched and not coiled. Liver and muscles cells have a high concentration of glycogen, present as visible granules, as the cellular respiration rate is high in these cells (due to animals being mobile). Glycogen is more branched than amylopectin making it more compact which helps animals store more. The branching enables more free ends where glucose molecules can either be added or removed allowing for condensation and hydrolysis reactions to occur more rapidly – thus the storage or release of glucose can suit the demands of the cell
- Starch and glycogen are polysaccharides
- Polysaccharides are macromolecules that are polymers formed by many monosaccharides joined by glycosidic bonds in a condensation reaction to form chains. These chains may be
    1. Branched or unbranched
    2. Folded (making the molecule compact which is ideal for storage example starch and glycogen)
    3. Straight (making the molecules suitable to construct cellular structures) or coiled
- Starch and glycogen are storage polysaccharides because they are
    1. Compact (so large quantities can be stored)
    2. Insoluble (so will have no osmotic effect, unlike glucose which would lower the water potential of a cell causing water to move into cells, cells would then have to have thicker cell walls – plants or burst if they were animal cells)

C. CELLULOSE

- It is a polymer consisting of long chains of β-glucose joined together by 1,4 glycosidic bonds
- As β-glucose is an isomer of α-glucose to form the 1,4 glycosidic bonds, consecutive β-glucose molecules must be rotated 180° to each other

D. TESTING FOR BIOLOGICAL MOLECULES

- **Benedict Test for Reducing Sugars**
  Benedict's reagent starts out aqua-blue. As it is heated in the presence of reducing sugars, it turns yellow to orange. The "hotter" the final colour of the reagent, the higher the concentration of reducing sugar
- **Acid or Enzyme Hydrolysis Followed by Benedict Test for Non-reducing Sugars**
  Hydrochloric acid is added to the sample being tested in the ration of 1:2 respectively and heated in a water bath for approximately 2 minutes. A pinch of sodium hydrogen carbonate is added to make the solution alkaline. After this, benedict's solution is added in the same amount as the sample being tested

- **Biuret test used to detect the presence of proteins**
  A Biuret test is a chemical test used to determine the presence of a peptide bond in a substance. It is based on the biuret reaction in which a peptide structure containing at least two peptide links produces a violet colour when treated with alkaline copper sulphate.

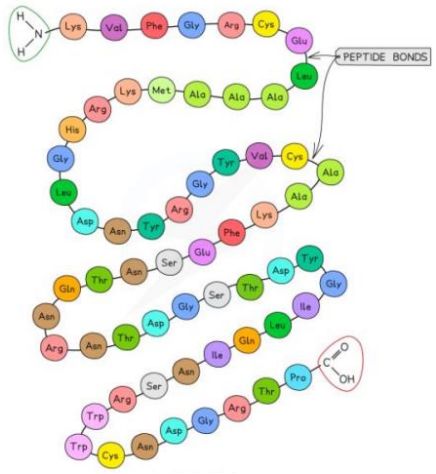
- **Emulsion Test for Lipids**
  The emulsion test is a method to determine the presence of lipids using wet chemistry. The procedure is for the sample to be suspended in ethanol, allowing lipids present to dissolve (lipids are soluble in alcohols). The liquid (alcohol with dissolved fat) is then decanted into water

- **Iodine Test for The Presence of Starch**
  Using iodine to test for the presence of starch is a common experiment. A solution of iodine (I2) and potassium iodide (KI) in water has a light orange, brown colour. If it is added to a sample that contains starch, such as the bread pictured above, the colour changes to a deep blue

E. PROTEINS

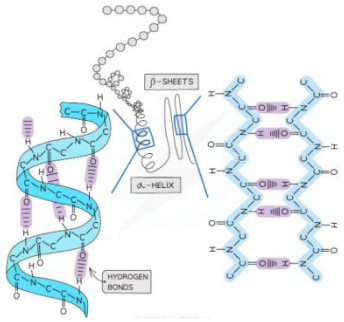
- Proteins are polymers (and macromolecules) made of monomers called amino acids. The sequence, type, and number of the amino acids within a protein determines its shape and therefore its function

- **Primary Structure**



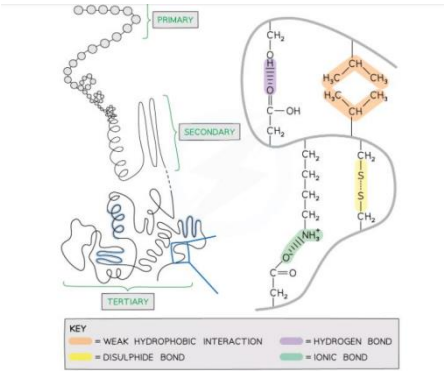
The sequence of amino acids bonded by covalent peptide bonds are the primary structure of a protein. DNA of a cell determines the primary structure of a protein by instructing the cell to add certain amino acids in specific quantities in a certain sequence. This affects the shape and therefore the function of the protein. The primary structure is specific for each protein (one alteration in the sequence of amino acids can affect the function of the protein)

- **Secondary Structure**



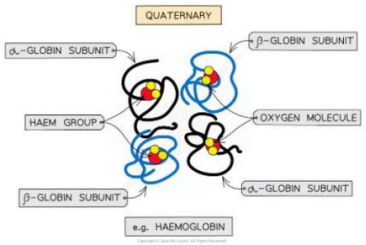
The secondary structure of a protein occurs when the weak negatively charged nitrogen and oxygen atoms interact with the weak positively charged hydrogen atoms to form hydrogen bonds. There are two shapes that can form within proteins due to the hydrogen bond which are α-helix and β-pleated sheet

- **Tertiary Structure**



The tertiary structure of a protein refers to the overall three-dimensional arrangement of its polypeptide chain in space. It is generally stabilized by outside polar hydrophilic hydrogen and ionic bond interactions, and internal hydrophobic interactions between nonpolar amino acid side chains

Quaternary Structure



Further conformational change of the secondary structure leads to additional bonds forming between the R groups (side chains).
The additional bonds are

1. Hydrogen (these are between R groups)
2. Disulphide (only occurs between cysteine amino acids)
3. Ionic (occurs between charged R groups)
4. Weak hydrophobic interactions (between non-polar R groups)
5. This structure is common in globular proteins

F. EXERCISE

1. The most common monomer of carbohydrates is…
   (A) Sucrose
   (B) Fructose
   (C) Maltose
   (D) Glucose

   Solution
   The answer is **(D)**. Glucose is the common monomer of carbohydrates. Carbohydrate helps in providing energy to the body mainly through glucose. Glucose is a simple sugar present in all basic foods

2. Carrier ions like Na^+ facilitate the absorption of substances like…
   (A) Amino acids and glucose
   (B) Glucose and fatty acids
   (C) Fatty acids and glycerol
   (D) Fructose and some amino acids

   Solution
   Massive ions like Na^+ facilitate the absorption of substances like amino acid and glucose through Co transport and thus, the answer is **(A)**

3. The fastest enzyme known is…
   (A) DNA polymerase
   (B) Carbonic anhydrase
   (C) Carbonic dehydrogenase
   (D) DNA ligase

   Solution
   Carbonic anhydrase is one of the fastest enzymes known. Each enzyme molecule can hydrate 10^6 molecules of CO_2 per second. This catalyzed reaction is 10^7 times as fast as the uncatalyzed one.
   So, the correct answer is **(B)**

4. **Assertion:**
   Arachidic acid is an unsaturated fatty acid
   Reason:
   There are one or more double bonds between carbon atoms in unsaturated fatty acids

   Are both assertion and reason true?
   (A) Both Assertion and Reason are true and Reason is the correct explanation of the Assertion
   (B) Both Assertion and Reason are true but the Reason is not the correct explanation of Assertion
   (C) Assertion is true, but Reason is false
   (D) Both Assertion and Reason are false

   Solution
   Unsaturated fatty acids are those which have the presence of one or more double bonds in the fatty acid chain. According to the assertion, arachidic acid is an unsaturated fatty acid. But arachidic acid is a saturated fatty acid and the correct answer is **(D)**

5. Metabolic intermediates found in the living system which are essential for growth and life is called…
   (A) Saponins
   (B) Tannins
   (C) Secondary metabolite
   (D) Primary metabolite

   Solution
   Primary metabolites are the essential metabolic intermediates of the plants because it helps in the growth and development of the plant and thus, the correct answer is **(D)**