

Topic 1 – Biological molecules

Key words

Monomers – smaller units from which larger units are made

Polymers – made up of many monomers joined together.

Condensation reaction – when two molecules are joined together with the formation of a bond and a water molecule is eliminated.

Hydrolysis reaction – breaks a chemical bond between 2 molecules involving the use of a water molecule.

Isomer – Molecules with the same molecular formula but the atoms are arranged in different ways.

Biochemical tests

Reducing sugar – The Benedict's test: add Benedict's, Boil. A positive result will go from Blue to green, yellow, orange or brick red.

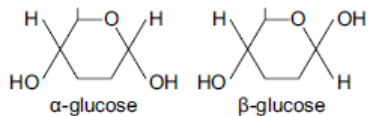
Non-reducing sugar – The Benedict's test: add hydrochloric acid and heat, then neutralise with hydrogen carbonate. Add Benedict's solution, boil. A positive result will go from Blue to green, yellow, orange or brick red.

Starch – Add iodine. A positive result will turn iodine from brown to blue-black.

Lipids – The emulsion test: add ethanol and then water. A positive result would be if a milky white emulsion is present.

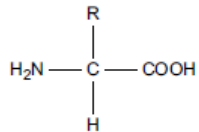
Proteins -The Biuret test: add Biuret solution, a positive test will go from Blue to purple.

- 1) **Monosaccharides**, amino acids and nucleotides are monomers
- 2) **Carbohydrates** are made of monosaccharides.
- 3) A condensation between monosaccharides forms a **glycosidic** bond. This is formed when H_2O is lost from the OH groups on each of the monosaccharides.
- 4) Disaccharides are formed from the condensation reaction of 2 monosaccharides.
 - a. Glucose + Glucose $\rightarrow$ **Maltose** ($+H_2O$)
 - b. Glucose + Fructose $\rightarrow$ **Sucrose** ($+H_2O$)
 - c. Glucose + Galactose $\rightarrow$ **Lactose** ($+H_2O$)
- 5) Glucose has two isomers **α -glucose** (where the OH groups are on the same side of the molecule) and **β -glucose** (where the -OH groups are on the opposite side)



- 6)
- 7) **Polysaccharides** are formed by the condensation of many glucose monomers.
 - a. **Glycogen** - Made of α -glucose, is highly branched and is used for storage in animals. Glucose is stored in these ways because it is insoluble, so the water potential isn't affected.

- b. **Starch** – found in plants is stored as α - glucose. There are 2 forms of starch:
 - i. **Amylose** – A linear helix, it allows cells to store glucose in a compact form.
 - ii. **Amylopectin** – branched
 - c. **Cellulose** – found in cell walls and is made of β -glucose. Straight chains are linked together with hydrogen bonds called microfibrils. This provides strength and support in cell walls.
- 8) There are two groups of **lipids** – neither are monomers or polymers (because they aren't made up of large numbers of monomers).
- a. **Triglycerides**
 - i. Formed from a condensation reaction between three fatty acids and a glycerol
 - b. **Phospholipids**
 - i. Formed from a condensation reaction between glycerol, 2 fatty acids and a phosphate
- 9) The bond between the glycerol and the fatty acid tail is called an **ester** bond.
- 10) The fatty acids can be **saturated** or **unsaturated**
- a. Saturated – there are no double bonds present between carbons.
 - b. Unsaturated – there are double bonds between carbons.
- 11) If there are more **saturated** fatty acid tails this means the lipid will be **liquid** – oil
- 12) If there are more **unsaturated** fatty acid tails the means the lipid will be more **solid**- butter
- 13) **Amino acids** are monomers from which the polymers proteins are made.



- 14)
- 15) The NH_2 group is an **amine group**
- 16) The COOH group is a **carboxyl group**.
- 17) The R represents a carbon containing variable group which is different for each of the 20 different amino acid.
- 18) A condensation reaction occurs between the **H** groups on the **NH_2** and the **OH** on the **COOH** to form a **peptide** bond.
- 19) **Dipeptides** are formed but the condensation reaction between two amino acids.
- 20) **Polypeptides** are formed from the condensation reaction of many amino acids.
- 21) Proteins have different levels of structure
- a. **Primary structure**
 - i. A single chain of amino acids.
 - b. **Secondary structure**
 - i. Hydrogen bonds cause α - helices and β - pleated sheets.
 - c. **Tertiary structure**
 - i. The protein will have more bonds
 - 1. Hydrogen bonds

- 2. Ionic bonds
- 3. Disulphide bridges

d. Quaternary structure

- i. This is when there is more than one polypeptide chain.

22) There are **globular** and **fibrous** proteins.

23) **Enzymes** have a **tertiary** protein structure.

24) Enzymes **lower the activation energy** of the reaction to catalyses.

25) Enzymes work by **induced-fit**

- a. The Substrates bind to the active site of the enzyme this will change shape of the active site meaning it becomes fully complementary and an enzyme substrate complex is formed.

26) The rate of an enzyme-controlled reaction can be altered depending on pH, temperature, substrate concentration, enzyme concentration and the presence of competitive and non-competitive inhibitors.

a. pH

- i. Each enzyme will work at an optimum pH. If the pH is too high or too low the bonds in the tertiary structure will be affected so the active site will change shape and enzyme-substrate complexes won't form.

b. Temperature

- i. If it is too cold there will not be enough energy to overcome the initial activation energy of the reaction.
- ii. If it is too hot the bond in the tertiary structure will be broken and therefore the active site will change shape meaning no enzyme-substrate complexes can form. The enzyme has been denatured.

c. Substrate concentration

- i. The higher the substrate concentration the faster the rate of reaction
- ii. Until all the active sites are occupied with substrate at any one time and the rate will stay the same.

d. Enzyme concentration

- i. The higher the enzyme concentration the faster the rate of reaction
- ii. Until all the substrate has been used up and the rate of reaction starts to fall.

e. Competitive inhibitor

- i. A competitive inhibitor binds to the active site using temporary bonds.
- ii. This will slow the rate of reaction down.
- iii. However, if you increase the substrate concentration the rate of reaction will eventually reach that same rate as a reaction with no competitive inhibitor. This is because it will be more likely for an enzyme to form an enzyme-substrate complex with the substrate and not an inhibitor.

f. Non-competitive inhibitor

- i. A Non-competitive inhibitor will bind elsewhere on the enzyme – not the active site and alters the shape of the active site.
- ii. This means the rate of reaction is slowed down as enzyme-substrate complexes cannot form.
- iii. Because the change to the active site is permanent (unless the inhibitor is removed) even if more substrate is added the rate of reaction will never be the same as without a non-competitive inhibitor.

27) **DNA** – Deoxyribonucleic acid is made up of DNA nucleotides. The monomer has a phosphate group, a deoxyribose sugar and a nitrogen containing organic base.

28) **RNA** – ribonucleic acid is made up of RNA nucleotides. The monomer has a phosphate group, a ribose sugar and a nitrogen-containing organic base.

29) The nitrogen-containing organic bases are

- a. **Adenine**
- b. **Cytosine**
- c. **Guanine**
- d. **Thymine in DNA / Uracil in RNA**

30) Specific **complementary** bases are held together with **hydrogen** bonds between nitrogen-containing bases. Adenine pairs with Thymine (or Uracil in RNA) and Cytosine pairs with guanine.

31) To join nucleotides to form a sugar-phosphate backbone there is a **condensation** reaction to form a **phosphodiester bond**.

32) DNA is in a double helix structure with 2 polynucleotide chains. They run in opposite directions – **antiparallel**.

33) RNA is a relatively short strand in comparison.

34) DNA needs to be replicated (copied) before mitosis and meiosis.

- a. DNA is replicated by **semi-conservative** replication (this means that one strand is newly synthesised, and one strand is from the original DNA).
- b. The double helix is unwound with a **helicase** enzyme and the hydrogen bonds are broken between complementary nitrogen-containing bases.
- c. New complementary DNA nucleotides bind to the DNA nucleotides on the template strand.
- d. **DNA polymerase** joins the adjacent nucleotide on the new strand with a condensation reaction to form a phosphodiester bond.

35) **ATP** – adenosine triphosphate is made up of an Adenine, a ribose sugar and 3 phosphates.

36) ATP is hydrolysed to ADP by losing one of the inorganic phosphate groups (Pi) – this happens using the enzyme **ATP hydrolases**.

37) ATP can be made from ADP and Pi using the enzyme **ATP synthase**.

38) When ATP is converted to ADP and Pi:

- a. A **small amount of energy** is released for reactions within the cell.
- b. The inorganic phosphate can join to other compounds and **phosphorylate** them to make them **more reactive**.

39) **Water** is a polar molecule and is important for several things in biology

- a. A **metabolite** – involved in condensation and hydrolysis reaction
- b. A **solvent** – to allow molecules to dissolve so metabolic reactions can take place.
- c. It has a **relatively high heat capacity** – this buffers changes in temperature.
- d. **Large latent heat of vaporisation** – this provides a cooling effect when water is lost through evaporation.
- e. **Strong cohesion between water molecules** – this supports columns of water in xylem and creates surface tension when water meets air.

40) **Inorganic ions**

- a. **Hydrogen ions** – the more hydrogen ions the lower the pH.
- b. **Iron ions** – are in haemoglobin that bind to oxygen in red blood cells.
- c. **Sodium ions** – are used in cotransport of glucose and amino acids.
- d. **Phosphate ions** – are components of DNA, RNA and ATP.