WJEC Biology A-level

Topic 1.1: Biological Compounds

Notes

Inorganic ions

Inorganic ions occur in solution in the cytoplasm and body fluid of organisms, some in high concentrations and others in very low concentrations.

Ions required for plant growth and development include:

- **Nitrate ions** – they are required to make **DNA and amino acids**
- **Calcium ions** – they are needed to form **calcium pectate for the middle lamellae**
- **Phosphate ions** are required to make **ADP and ATP**
- **Magnesium ions** are needed to produce **chlorophyll**
- **Iron ions are a component of haemoglobin** which is an oxygen carrying molecule in red blood cells

Water

Water is a very important molecule which is a major component of cells, for instance:

- Water is a **polar molecule** due to **uneven distribution of charge** within the molecule – the oxygen atom attracts electrons a bit more strongly than the hydrogen atoms. The unequal sharing of electrons gives the water molecule a slightly negative charge near its oxygen atom and a slight positive charge near its hydrogen atoms.
- It is a **metabolite** in metabolic reactions such as **condensation and hydrolysis** which are used in forming and breaking of chemical bonds
- It is a **solvent** in which many metabolic reactions occur
- It has a **high heat specific capacity** meaning that a lot of energy is required to warm water up therefore **minimising temperature fluctuations** in living things therefore it acts as a **buffer**
- has a **relatively large latent heat of vaporisation**, meaning evaporation of water provides a **cooling effect** with little water loss
- **strong cohesion** between molecules enables effective transport of water in tube like transport cells as the **strong cohesion supports columns of water**, as a result of strong cohesion **the surface tension at the water-air boundary is high**

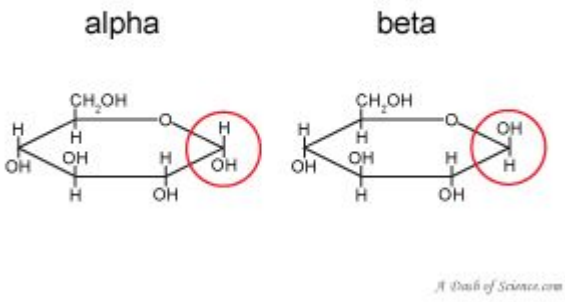
Carbohydrates

Carbohydrates are molecules which consist only of carbon, hydrogen and oxygen and they are long chains of sugar units called saccharides. There are three types of saccharides - **monosaccharides, disaccharides and polysaccharides**. Monosaccharides can join together to form disaccharides and polysaccharides by **glycosidic bonds** which are formed in **condensation reactions**.

Monosaccharides

Monosaccharides are small organic molecules used as building blocks of complex carbohydrates. Monosaccharides have a varying number of carbon atoms, for instance:

- **Glyceraldehyde** is a triose used in metabolic reactions.
- **Ribose** is a pentose sugar which is a component of nucleic acid.



- **Glucose** is a monosaccharide containing six carbon atoms in each molecule, it is the main **substrate for respiration** therefore it is of great importance. It has two isomers – alpha and beta glucose.

Disaccharides:

- **Maltose** is a disaccharide formed by condensation of **two glucose molecules.**
- **Sucrose** is a disaccharide formed by condensation of **glucose & fructose.**
- **Lactose** is a disaccharide formed by condensation of **glucose & galactose.**

Polysaccharides are formed from many glucose units joined together and include:

- **Glycogen** and **starch** which are both formed by the condensation of **alpha glucose.**
- **Cellulose** formed by the condensation of **beta glucose.**

Glycogen is the main energy storage molecule in animals and it's formed from many molecules of **alpha glucose** joined together by **1, 4 and 1, 6 glycosidic bonds**. It has a **large number of side branches** meaning that energy can be released quickly. Moreover, it is a relatively **large but compact** molecule thus maximising the amount of energy it can store.

Starch stores energy in plants and it is a mixture of two polysaccharides called **amylose and amylopectin**:

- **Amylose** – amylose is an **unbranched chain** of glucose molecules joined **by 1, 4 glycosidic bonds**, as a result of that amylose is **coiled** and thus it is a very **compact** molecule meaning it can store a lot of energy.

- **Amylopectin** is **branched** and is made up of glucose molecules joined by **1, 4 and 1, 6 glycosidic bonds**, due to the presence of many **side branches** it is **rapidly digested by enzymes** therefore energy is released quickly.

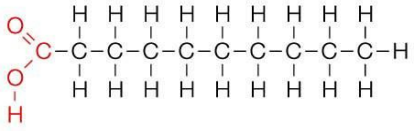
Cellulose is a component of cells wells in plants and it's composed of long, unbranched chains of **beta glucose** which are joined by glycosidic bonds. **Microfibrils** are strong threads which are made of long cellulose chains joined together by **hydrogen bonds** and they provide **structural support** in plants cells.

Chitin is a polysaccharide made of chains of **beta glucose** monomers **with amino acid side chains** - one OH group of each beta glucose molecule is replaced with an amino acid. Chitin is **lightweight but strong** and is used to form the **exoskeletons of insects.**

Lipids

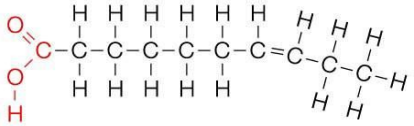
Lipids are biological molecules which are only soluble in **organic solvents** such as alcohols. There are two types of lipids:

Saturated



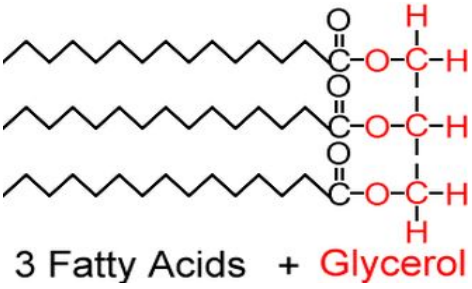
- **Saturated lipids** such as those found in **animal fats** – saturated lipids don't contain any carbon-carbon double bonds. Too much saturated fat can increase the cholesterol levels in blood thus increasing the risk of coronary heart disease.

Unsaturated



- **Unsaturated lipids** which can be found in **plants** – unsaturated lipids contain carbon-carbon **double bonds** and melt at lower temperatures than saturated fats. Unsaturated fats are healthy as they provide essential fatty acids.

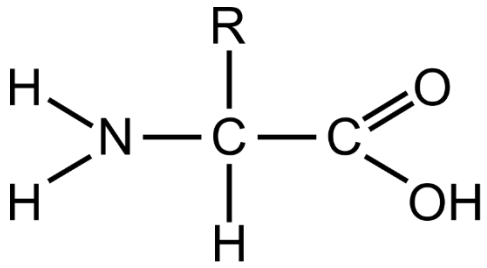
The greater the number of unsaturated bonds, the weaker the intermolecular bonds resulting in lower melting point, and as a result of that saturated fats which don't contain any double bonds are solid at liquid temperature and unsaturated lipids are liquid at room temperature.



Triglycerides are lipids made of one molecule of **glycerol** and **three fatty acids** joined by ester bonds formed in **condensation reactions**. There are many different types of fatty acids, they vary in chain length, presence and number of double bonds. Also, some triglycerides contain a mix of different fatty acids. Triglycerides are used as energy reserves in plant and animal cells.

In **phospholipids**, one of the fatty acids of a triglyceride is substituted by a phosphate-containing group. Phosphate heads are **hydrophilic** and the tails are **hydrophobic** and as a result phospholipids form **micelles** when they are in contact with water as heads are on the outside as they are attracted to water and tails are on the inside as they move away from water.

Proteins



Amino acids are the monomers from which proteins are made. Amino acids contain an amino group – NH2, carboxylic acid group and a variable R group which is a carbon-containing chain. There are 20 different amino acids with different R groups. Amino acids are joined by peptide bonds formed in condensation reactions. A dipeptide contains two amino acids and polypeptides contain three or more amino acids.

Structure of proteins is determined by the order and number of amino acids, bonding present and the shape of the protein:

- **Primary structure** of a protein is the order and number of amino acids in a protein.
- The **secondary structure** is the shape that the chain of amino acids makes – **either alpha helix** or **beta pleated sheet**. The shape is determined by the type of bonding present such as **hydrogen bonding, ionic bonds and disulphide bridges**.
- **Tertiary structure** of proteins is the 3D shape of the protein, it can be globular of fibrous. **Globular proteins** such as enzymes are compact whereas **fibrous proteins** such as keratin are long and thus can be used to form fibres.
- For instance, **collagen** is a **fibrous** protein of great strength due to presence of both **hydrogen and covalent bonds** in the structure. Collagen molecules wrap around each other and form fibrils which form strong collagen fibres. Collagen forms the structure of **bones, cartilage and connective tissue** and is a main component of **tendons** which connect muscles to bones.
- **Haemoglobin** is a **water soluble globular protein** which consists of two **beta polypeptide chains and a haem group**. It **carries oxygen** in the blood as oxygen can bind to the haem (Fe^{2+}) group and oxygen is then released when required.