Edexcel (A) Biology A-level

Topic 1: Lifestyle, Health and Risk

Notes

Transport of Substances

In order to survive, animals require essential substances (e.g. oxygen, carbon dioxide) to enter and leave the body in sufficient quantities and be transported around the body. The needs of small organisms can be served through **diffusion** (alone) due to the large **surface area to volume ratio** of the body. However, as the size of the organism increases:

- Surface area to volume ratio decreases
- Diffusion distance increases
- Metabolic rate (hence input and output requirements) increase

Diffusion becomes insufficient. As a result of that, larger organisms have a **mass transport system,** consisting of heart and circulation which moves the substances around the body and allows exchange of substances to take place.

Features of a mass transport system:

1. A network to move through (eg. vessels)
2. A medium for movement (a fluid eg. blood)
3. Controlled direction - to move substances to / from where they are needed (eg. blood is moved along a pressure gradient created by the heart, the direction of flow controlled by valves)
4. Maintenance of speed - (eg. contraction of the heart + elastic recoil of arteries helps to maintain the pressure gradient, thus speed)

Water

- Water is a **polar molecule,** due to **uneven distribution of charge** within the molecule – the hydrogen atoms have a partial positive charge and the oxygen atom has a partial negative charge due to the difference in electronegativity, causing one end of the molecule to be more positive than the other.

- Water is a polar **solvent** and can be used to **transport** many **biological molecules** (as many of them are also polar, thus can be dissolved in water).

- **Hydrogen bonding** between water molecules creates **cohesion** and **adhesion,** which enables effective transport of water and dissolved substances through xylem vessels.

- Hydrogen bonding is a relatively strong type of bonding, thus causing water to have a **high heat specific capacity** meaning that a lot of energy is required to change the temperature of water, therefore **minimising temperature fluctuations** in living things (an important part of homeostasis).

Blood Vessels

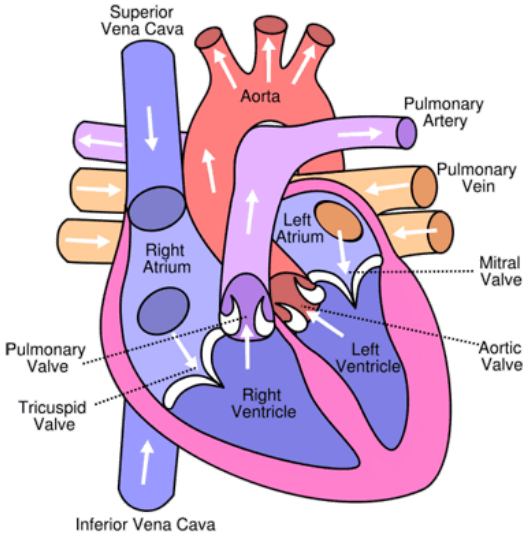
- **Arteries**
  - Carry oxygenated blood to the body tissues (other than the pulmonary artery)
  - Have a small **lumen** to maintain **high blood pressure**
  - **Smooth inner endothelial lining** (a smooth surface means there's **less resistance** to blood flow)
  - Thick layer of **smooth muscle** (**contract and relax** to dilate and constrict blood vessels - controlling their diameter) and **elastic fibres** (**stretch and recoil**)
  - **Lots of collagen fibres** (for **strength and support**)

- **Veins**
  - Carry deoxygenated blood to the lungs (except the pulmonary vein)
  - Large lumen (minimises resistance to flow)
  - Thinner layer of muscle and elastic fibres
  - Reduced collagen fibres
  - Valves (to prevent backflow)

- **Capillaries**
  - Very small (to fit between cells)
  - Narrow Lumen
  - Thin endothelium - one cell thick (to maintain **short diffusion distance** and fit between cells)

Heart and Cardiac Cycle

1. Four chambers - right and left **atria**, right and left **ventricles**
2. Four main blood vessels **pulmonary vein** (from lungs to left atrium), **aorta** (from left ventricle to body), **vena cava** (from body to right atrium), **pulmonary artery** (from right ventricle to lungs)
3. **Atrioventricular valves** - mitral or tricuspid/bicuspid - separate atria from ventricles
4. **Semilunar valves** - pulmonary/aortic - separate arteries from ventricles
5. **Tendinous chords**/valve tendons - prevent atrioventricular valves turning inside out due to pressure
6. **Septum** - muscle and connective tissue - prevents oxygenated/deoxygenated blood mixing



7. **Coronary arteries** - wrapped around the heart to supply blood to cardiac muscle
8. **Cardiac muscle** - thicker on the LHS because higher pressure is needed to pump blood further

There are 3 stages of the cardiac cycle:

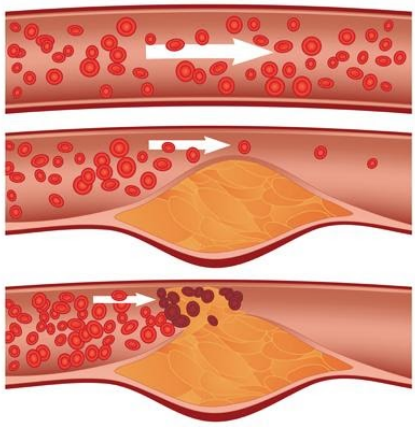
1) **Atrial systole** – during atrial systole the **atria contract** forcing the atrioventricular **valves open** and blood flows into the ventricles.

2) **Ventricular systole – contraction of the ventricles** causes the **atrioventricular valves** to close and **semilunar valves to open** thus allowing blood to leave the left ventricle through the **aorta** and right ventricle through the **pulmonary artery**.

3) **Cardiac diastole** – atria and ventricles relax and **pressure inside the heart chambers decreases** causing **semilunar valves** in the aorta and pulmonary arteries close, preventing backflow of blood.

Atherosclerosis

Atherosclerosis is the hardening of arteries caused by the build-up of fibrous plaque called an **atheroma**. Atheroma formation is the cause of many cardiovascular diseases and occurs as following:



- The **endothelium** which lines the arteries is damaged, for instance by high cholesterol levels, smoking or high blood pressure
- This **increases the risk of blood clotting** in the artery and leads to an **inflammatory response** causing white blood cells to move into the artery
- Over time, white blood cells, cholesterol, calcium salts and fibres build up and harden leading to plaque (atheroma) formation.
- The build-up of fibrous plaque leads to narrowing of the artery and restricts blood flow thus increasing the blood pressure which in turn damages the endothelial lining and the process is repeated - an example of **positive feedback**.

Atherosclerosis is **multi-factorial** and has **modifiable** and non-modifiable risk factors:

- **Genetics** (genetic predisposition to high blood pressure etc.)
- **Age** (arteries become less elastic with age)
- **Diet** (diet can increase cholesterol)
- **Gender** (oestrogen makes arteries more elastic)
- **High blood pressure** (can damage endothelium)

- **High cholesterol levels** (increases the likelihood of formation of plaque)
- **Smoking** (nicotine narrows arteries)
- **Physical inactivity** (increases obesity risk)
- **Obesity** (increases blood pressure etc.)

Thus risk of CVD can be reduced by stopping smoking, regular exercise, reducing consumption of alcohol, dietary changes and maintaining healthy body weight. Atherosclerosis can lead to **cardiovascular diseases** (CVD) including **angina, stroke, myocardial infarction and aneurisms.**

Blood Clotting

Thrombosis also known as blood clotting **prevents blood loss** when a blood vessel is damaged, it also **prevents the entry of disease causing microorganisms** and provides a **framework for repair**.

A series of reactions which lead to clot formation:

- When a blood vessels is damaged, **platelets attach to exposed collagen fibres**
- A protein called **thromboplastin is released from platelets** and this protein triggers the **conversion of inactive prothrombin** which is a protein **into active thrombin** which is an enzyme. In order for the conversion to occur **calcium ions and vitamin K must be present.** These are known as **clotting factors.**
- Thrombin **catalyses** the conversion of **soluble fibrinogen** into **insoluble fibrin**
- **Fibrin forms a network of fibres** in which **platelets & red blood cells are trapped** to form a blood clot.

Energy Balance

Energy balance is the balance of calories consumed through eating and drinking, compared to calories burned through physical activity. Therefore, if a greater number of calories is burned through physical activity than is consumed it leads to weight loss. If fewer calories are burned than consumed it leads to weight gain. The ways of determining whether an individual is overweight, underweight or healthy weight include:

$$\text{BMI} = \frac{(\text{weight in kilograms})}{\text{height in meters}^2}$$

- **BMI** is the body mass index which can be calculated by dividing the body mass in kilograms by height in metres squared. The value obtained is then compared to a chart, for instance a value below 18 indicates that the individual is underweight, while a value above 30 indicates the individual is obese.

- **Waist-to-hip ratio** can be used to determine how likely a person is to get heart disease based on the distribution of fat in the body. A value above 1 suggests a health risk.

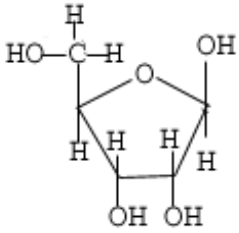
Carbohydrates

Carbohydrates are molecules which consist only of carbon, hydrogen and oxygen. They are long chains of sugar units called saccharides. There are three types of saccharides - **monosaccharides, disaccharides and polysaccharides**.

- Monosaccharide = simple sugar monomer
- Disaccharide = two monosaccharides
- Polysaccharide = many monosaccharides

Monosaccharides can join together to form disaccharides and polysaccharides by **glycosidic bonds** which are formed in **condensation reactions** (in which a molecule of water is removed)

Monosaccharides



Glucose is a monosaccharide containing six carbon atoms in each molecule and is the main **substrate for respiration**. There are two main **isomers** found in living organisms - Beta glucose (most common in plants) and alpha glucose (most common in animals)

Ribose is a monosaccharide containing five carbon atoms, it is a **pentose** sugar and **a component of DNA and RNA**.

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

Polysaccharides are formed from many glucose units joined together.

Glycogen is the main energy storage molecule in animals and is 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 the molecule can be hydrolysed and 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. It is also a compact molecule, although not as compact as amylose.

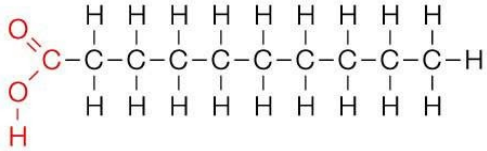
Lipids

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

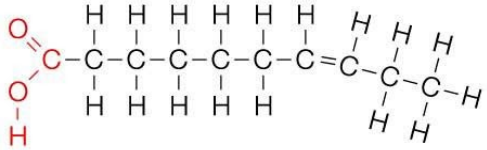
- **Saturated lipids** such as those found in **animal fats** – saturated lipids don't contain any carbon-carbon double bonds.

- **Unsaturated lipids** which can be found in **plants** – unsaturated lipids contain carbon-carbon **double bonds** and melt at lower temperatures than saturated fats.

Saturated



Unsaturated



Intermolecular forces are weaker in unsaturated lipids and therefore they have a lower **melting point** The double bonds in unsaturated lipids reduce the strength of these intermolecular forces (as they create a 'kink' in the hydrocarbon chain, so molecules cannot pack together as closely). As a result, saturated fats are solid at liquid temperature and unsaturated lipids are liquid at room temperature. Animal fats are normally saturated whereas plant oils are often unsaturated.

Properties of lipids:

- Lipids are **waterproof** because the fatty tail is hydrophobic.
- Very compact, and better gram-for-gram energy release than carbohydrates or proteins because more energy is stored in C-O bonds that are hydrolysed.
- Lipids are **non-polar** and **insoluble** in water, therefore they are good for storage - they don't interfere with the water-based reactions in the cytoplasm.

- Lipids **conduct heat slowly** therefore they provide **thermal insulation.**

  Triglycerides are lipids made of one molecule of **glycerol** and **three fatty acids** joined by ester bonds formed in **condensation reactions**. Different fatty acids have different R groups, and 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 a **bilayer** in the cell membrane as heads face watery environments whereas the tails move away from them.

High and Low Density Lipoproteins

Cholesterol is a **soluble lipid** made in the body and is transported by proteins in soluble complexes called lipoproteins consisting of proteins and lipids. There are two types of lipoproteins:

- **High density lipoprotein** ('good' cholesterol) is formed from **unsaturated fats, protein and cholesterol** and **transports cholesterol from body tissues to the liver** where it's broken down. It **reduces the cholesterol levels** and reduce the risk of atherosclerosis.

- **Low density lipoprotein** ('bad' cholesterol) is formed from **saturated fats, protein and cholesterol** and **transports cholesterol from the liver to the blood,** thus causing the **cholesterol level to increase,** hence why it is linked to atherosclerosis. #

The proportion of protein is higher in HDL whereas the proportion of cholesterol & fat in HDL is lower.

There's a **correlation** between high levels of saturated fats and high blood cholesterol as saturated fats are one of the components of low density lipoproteins. However, the link between cholesterol and cardiovascular diseases is **causal** because cholesterol is involved in plaque formation.

Treatment of CVD

There are various types of medical treatments of CVD such as:

- **Anticoagulants,** such as warfarin, reduce the risk of clot formation. However, they dosage needs to be carefully controlled as taking too much can lead to uncontrolled bleeding.

- **Statins,** which reduce blood cholesterol levels by blocking the enzyme which produces cholesterol in the liver. There are various side effects and risks of statins such as nausea, inflammation, diarrhoea and constipation. It's important not to solely rely on statins to lower the cholesterol levels – they're most effective when combined with a healthy diet.

- **Platelet inhibitors** make platelets less sticky, thus reducing the risk of blood clots and atheroma formation. Aspirin is a platelet inhibitory drug, however it can cause stomach bleeding as it irritates the stomach lining.

- **Antihypertensives,** which reduce blood pressure. They include:

- **Beta blockers,** which reduce the frequency of heart contractions and make them less powerful by blocking response of heart to hormones. However, taking beta blockers might increase risk of **diabetes**.

- **Diuretics,** which increase the volume of urine, thus lowering blood volume and pressure. Possible side effects include nausea, muscle cramps and dizziness.

- **ACE inhibitors** reduce blood pressure by blocking the conversion of Angiotensin I to Angiotensin II, which causes arterial constriction. Side effects of ACE inhibitors include dizziness, cough and heart arrhythmia.