Section 5.1 – The heart and heart disease

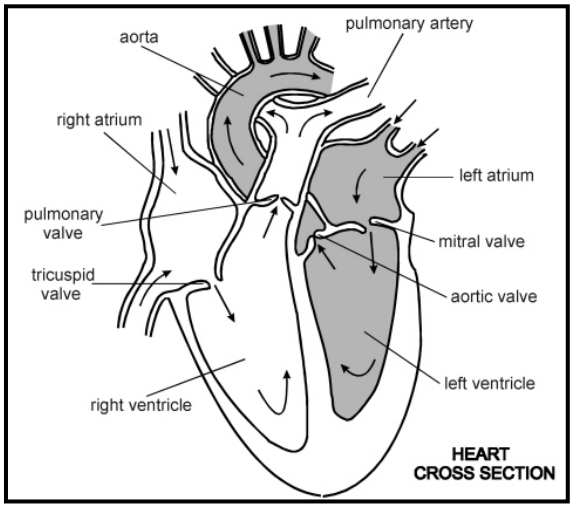
- Mammals are too large to rely on diffusion.
- They need a circulatory system to move substances around the body.
- Blood moves down pressure gradients, from high to low pressure.
- The heart produces the main pressure gradient, although contractions of skeletal muscles also push blood along veins.

The circulatory system

- Mammals have a double circulatory system as blood passes through the twice on one complete circulation of the body.
- The pulmonary circulation pumps blood to the lungs to be oxygenated.
- The systemic circulation pumps oxygenated blood to every other part of the body that uses oxygen.

The human heart

- Lies in the thoracic cavity
- Consists mainly of cardiac muscle
- Its pumping action ensures that fresh supplies of oxygen and nutrients are constantly being supplied to all living cells of the body.
- It is divided into a left and right side by a septum.



Pericardium

- The heart is covered by a double layer of tough, inelastic membranes which form the pericardium.
- Pericardium fluid is secreted by the membranes and reduces friction, allowing them to move freely over each other.

- This sac, protects the heart, anchors its surrounding structures and prevents overfilling of the heart with blood.

Heart Chambers

- The right side pumps oxygenated blood; the left side pumps oxygenated blood.
- Each side has two chambers.
- The two upper chambers are called the atria and the two lower chambers are called the ventricles.
- The atria receive blood from veins. The ventricles pump blood into arteries.

The right side of the heart

- The right atrium receives deoxygenated blood from the systemic circulation through the vena cava.
- Each atrium is elastic so it can stretch as it fills up with blood.
- Atria have only a thin muscular wall as they only need to pump blood a short distance to the ventricle.
- The right ventricle pumps deoxygenated blood through the pulmonary artery, to the pulmonary circulation.
- The pulmonary artery is the only artery to carry deoxygenated blood.

Left side of the heart

- The left atrium receives oxygenated blood from the pulmonary vein.
- The pulmonary vein is the only vein to carry oxygenated blood.
- The left ventricle pumps oxygenated blood through the aorta into the systemic circulation.
- Ventricle walls are thicker than that of the atria as they have to pump blood over a greater distance.

Ventricles

- The right ventricle pumps blood to the lungs where the left ventricle has to pump blood to the whole body.
- Although the volume of blood they hold is the same, the left ventricle has a thicker muscular wall.

- A thicker muscular wall will allow a stronger contraction to push blood further.

Valves

- There are 4 valves in the mammalian heart; one between each atrium and ventricle, and one at the base of each artery leading from the ventricles.
- The tricuspid valve between the right atrium and the right ventricle has three flaps.
- The bicuspid valve between the left atrium and the left ventricle has two flaps.
- The pulmonary semi-lunar valve is between the right ventricle and the pulmonary artery.
- The aortic semi lunar valve is between the left ventricle and the aorta.

How valves work

- They prevent the back flow of blood.
- Valves in the heart are designed to open when there is high pressure forcing the blood on the correct direction.
- If high pressure forces the blood in the wrong direction, the valves shut.
- Thin tendons join to the edges of the valve flaps to the wall of each ventricle.
- These tendons to not stretch, they stop the valves turning inside out.

Cardiac Muscle

- A special type of muscle, unlike other muscles it never fatigues.
- Does not tolerate a lack of oxygen or nutrients and soon dies if its supply of blood is cut off.

Coronary arteries

- Some of the bloody leaving the left ventricle goes to the coronary arteries.

  These arteries branch out to supply the thick heart muscle with oxygen and nutrients.
- The coronary arteries are much narrower than many other arteries and so can become blocked more easily.

Section 5.2 – The cardiac Cycle

- The 4 chambers in the heart are constantly contracting and relaxing in a definite sequence.
- The cardiac cycle is the sequence of stages that take place in one heart beat.
- When a chamber is contracting it is in systole.
- When it is relaxing it is in diastole.

The stages of the cardiac cycle

- There are three stages of the cardiac cycle: atrial systole and ventricular systole and diastole.
- Atrial systole refers to the contracting of the atrial myocardium (heart muscle).
- Ventricle systole refers to the contraction of the ventricular myocardium.
- Between heart beats the myocardium of both atria and ventricles are relaxed. This is known as diastole.
- Both sides of the heart contract together. This means that the atria will contract and relax at the same time and so will the two ventricles.

Diastole

- Ventricular and atrial myocardium relaxes at the same time. Blood returning to the heart fills the atria.
- The higher pressure in the atria than the ventricles, forces the atrioventricular valves to open.
- Even though the atria aren't contracting, blood flows from the atria to the ventricles.

Atrial systole

- The myocardium of both atria contract.
- This raises the pressure in the atria, pushing more blood into the ventricles.
- The atrioventricular valves open.
- More blood passes through these valves into the ventricles.
- Both semi-lunar valves are closed.

Ventricular Systole

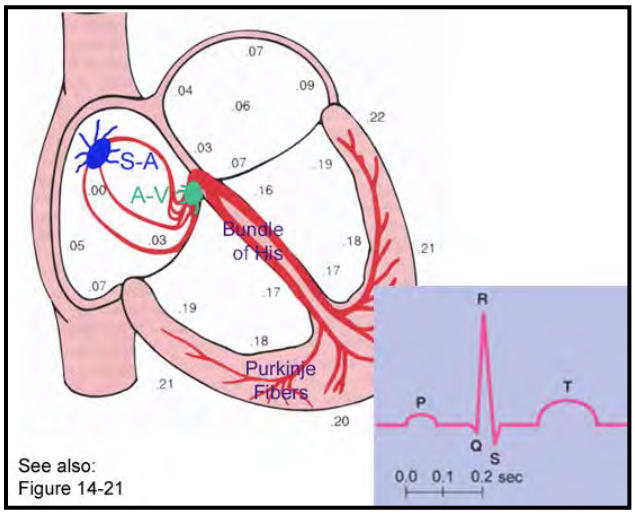
- The myocardium of both ventricles contract
- The atria are relaxed
- The ventricles continue to fill with blood
- This quickly raises the pressure of the ventricles higher than that of the atria.
- Both atrioventricular valves are forced closed
- When the pressure of the ventricles exceeds that of the arteries, the pulmonary and aortic valves are forced open.
- Blood is pushed out of the heart into the pulmonary artery and aorta.
- The semi-lunar valves close, stopping blood moving back into the heart.

Pressure changes

- The events of the cardiac cycle create pressure changes.
- Pressure changes are responsible for moving blood through the heart and into the systemic and pulmonary circulations.
- Valves open or close when the balance of pressure on opposite sides of the valves changes.

Controlling the cardiac cycle

- Myogenic contractions are contractions originating from within the muscle, rather than by the nervous system.
- Myogenic contractions of the myocardium are largely responsible for the cardiac cycle.
- The cardiac cycle starts at the sinoatrial node (SA node).



- The SA node is a group of cells found out the top of the right atrium which acts as a natural pacemaker and initiates the heart beat.

- The rate at which the SA node produces the waves determines the heart rate.
- The heart rate can also be controlled by nervous impulses and hormones such as during exercise and adrenalin.

Starting the Cardiac cycle

- The SA node produces waves of electrical impulses called cardiac impulses.
- The impulses are not carried by nervous tissue but by specialised muscle fibres called purkinje fibres.
- This tissue conducts the impulses throughout the atria, stimulating the myocardium of the atria to contract.
- The contraction spreads outwards and downwards, from the top of the atria, squeezing blood towards the ventricles.

Continuing the cardiac cycle

- The electrical activity cannot pass from the walls of the atria to the walls of the ventricles, because it is stopped by a wall of fibrous tissue called the atrioventricular system.
- This stops the waves of the atrial muscle contraction continuing through the ventricle muscles as the blood would be forced to the bottom of the heart.
- There is only one location where the impulse can travel from atrium to ventricle – through the atrioventricular node. (av node)
- The AV node is another specialised group of cells.
- The cells in the AVN can conduct electricity but only shortly after a slight delay.
- The delay allows time for the atria to complete their cycle.

Contraction of the ventricles

- From the AVN two specialised bundles of purkinje tissue run down the atrioventricular septum and up the ventricular wall.
- Bundles of his conduct electrical impulses rapidly down the atrioventricular septum, to the bottom of the heart.
- These fibres stimulate the muscles of the ventricles to contract rapidly, from the base of the heart upwards.

The heart beat

- First heart beat sound “lub” occurs when the atrioventricular valves close.
- Second heart sound “dub” occurs when the semi lunar valves close.

Cardiac output

- The volume of blood from ventricles in one minute.
- Measured in $dm^3\ min^{-1}$
- The volume pumped by both ventricles pumped is the same.
- The cardiac output depends on two features: how quickly the heart is beating, and the stroke volume (amount of blood in one beat).
- Cardiac output =heart rate (min^{-1}) X stroke volume (dm^3)

Section 5.3 – Heart Disease

Atheroma is the build up of fatty deposits that can impair blood flow.

If blood flow to the heart muscle is interrupted it can cause a myocardial infarction.

Atheroma

Begins as fatty streaks which are deposits of white blood cells that have taken up low density lipoproteins

These streaks enlarge to form an irregular patch, or athermanous plaque.

Athermanous plaques are made up of cholesterol, fibres and dead muscle cells.

Thrombosis

If an Atheroma breaks through the endothelium of the blood vessel, it forms a rough surface that interrupts the otherwise smooth flow of blood.

This may cause a thrombus (blood clot), which will stop the flow of blood.

The region of tissue deprived of blood due to the thrombus will not be able to respire as a result of no oxygen, glucose and other nutrients being transported to the tissue.

Aneurysm

Atheromas that form thrombosis can weaken artery wall, causing them to swell to form a balloon like, blood filled structure called an aneurysm.

Myocardial infarction

Occurs when the hear stops beating, otherwise known as a heart attack.

Smoking

Carbon monoxide combines easily, but irreversibly with haemoglobin, thus reducing the oxygen carry capability of the blood. In order to supply tissue with the same amount of oxygen the heart must work harder, thereby increasing blood pressure.

Nicotine stimulates the production of adrenalin which will increase heart rate and blood pressure.

Blood pressure

If the blood pressure in the arteries is high, the heart must work harder to pump blood into them.

High blood pressure in the arteries means there is more chance of an aneurysm forming and bursting causing a haemorrhage.

To resist the high pressure the walls of the arteries tend to become thickened and may harden, restricting blood flow.

Blood Cholesterol

High density lipoproteins remove cholesterol from tissue and transport it to the liver for excretion. They help protect arteries against heart disease.

Low density lipoproteins which transport cholesterol from the liver to the tissue, including the artery walls, which they infiltrate, leading to the development of Atheroma and hence a heart attack.

Diet

High levels of salt raise blood pressure.

High levels of saturated fat increase low density lipoprotein levels and hence blood cholesterol concentration.

Foods that act as antioxidants, e.g. vitamin c, reduce the risk of heart disease, and so does non-starch polysaccharide (dietary fibre).