Circulatory System Notes

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This topic is regularly assessed in the exams, questions on this topic can range from short 1 mark multiple choice questions to 6 mark questions. Before we look at the blood vessels etc let's look at the blood itself.

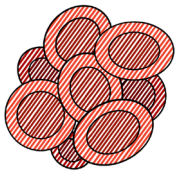
The Functions of Blood

Blood is essentially a transport medium. Blood transports the following:

1. Oxygen from the lungs to all other parts of the body.
2. Carbon dioxide from all parts of the body to the lungs.
3. Nutrients such as glucose from the small intestine to all parts of the body.
4. Urea from the liver to the kidneys.
5. Hormones, antibodies and many other substances are also transported by the blood as well as it distributing heat around the body.

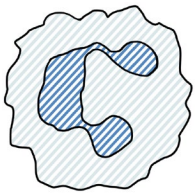
The Composition of the Blood

Red blood cells – contain **haemoglobin** to carry oxygen to all the cells in the body. When oxygen binds to haemoglobin it forms **oxyhaemoglobin**.



Red blood cells

Phagocytes – are cells that protect the body by **ingesting** harmful foreign particles, bacteria, and dead or dying **cells** (a process known as **phagocytosis**).



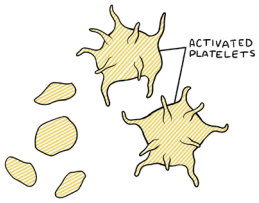
Phagocyte

Lymphocytes – produce antibodies against specific antigens to help destroy pathogens. They do not ingest cells.

Lymphocyte

Platelets – clump together to form clots.
These protect the body by stopping bleeding, preventing loss of blood.

Plasma: Fluid part of blood. It carries **carbon dioxide**, hormones and waste, e.g. Urea.



Blood Vessels

Blood vessels are **tubes** that carry the blood around the body. There are different types of blood vessels.

Arteries: carry blood **away** from the heart. These vessels split up into smaller ones called **arterioles**, which in turn split up into tiny blood vessels called **capillaries**.

Capillaries: are where **exchange of particles and gases takes place**. These then join together to form larger vessels called **venules** which join together to form **veins**.

Veins: carry blood **towards** the heart (usually deoxygenated blood, except for the pulmonary vein).

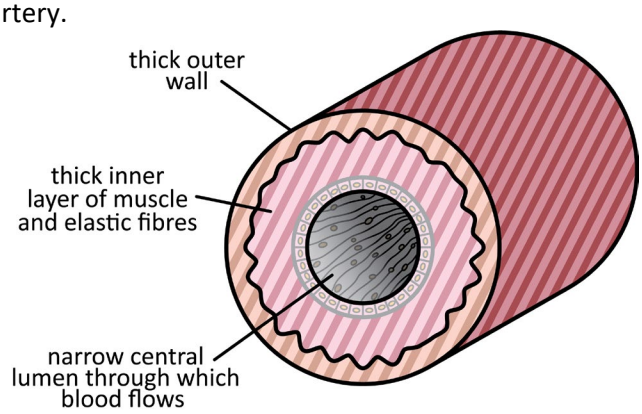
Arteries

Function: Carry blood **away** from the heart (always oxygenated apart from the pulmonary artery which goes to the lungs). The figure shows a labelled section through an artery.

Structure: Have thick muscular walls.

Lumen: Have small passageways for blood (internal lumen).

Pressure: Contain blood under high pressure.

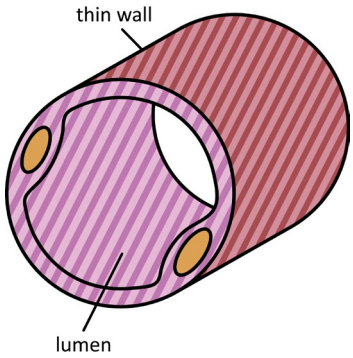


Capillaries

Function: Where exchange of substances takes place. Oxygen passes through the capillary wall and into the tissues, carbon dioxide passes from the tissues into the blood. The figure below shows a labelled section through a capillary.

Structure: Microscopic – one cell thick

Pressure: Contain blood under low pressure.



Veins

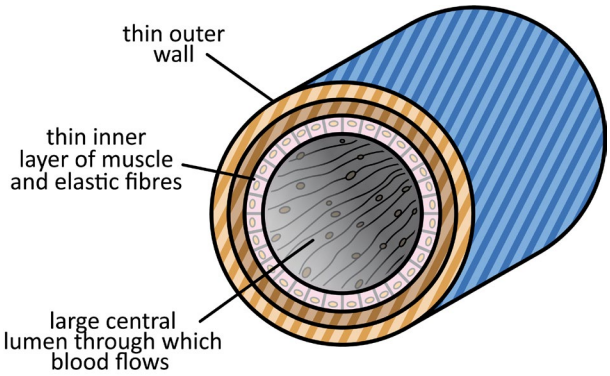
Function: Carry blood to the heart (always deoxygenated apart from the pulmonary vein, which carries **oxygenated blood** from the lungs to the heart). The figure shows a labelled section through a vein.

Structure: have thin walls

Lumen: have larger internal lumen.

Pressure: Contain blood under low pressure.

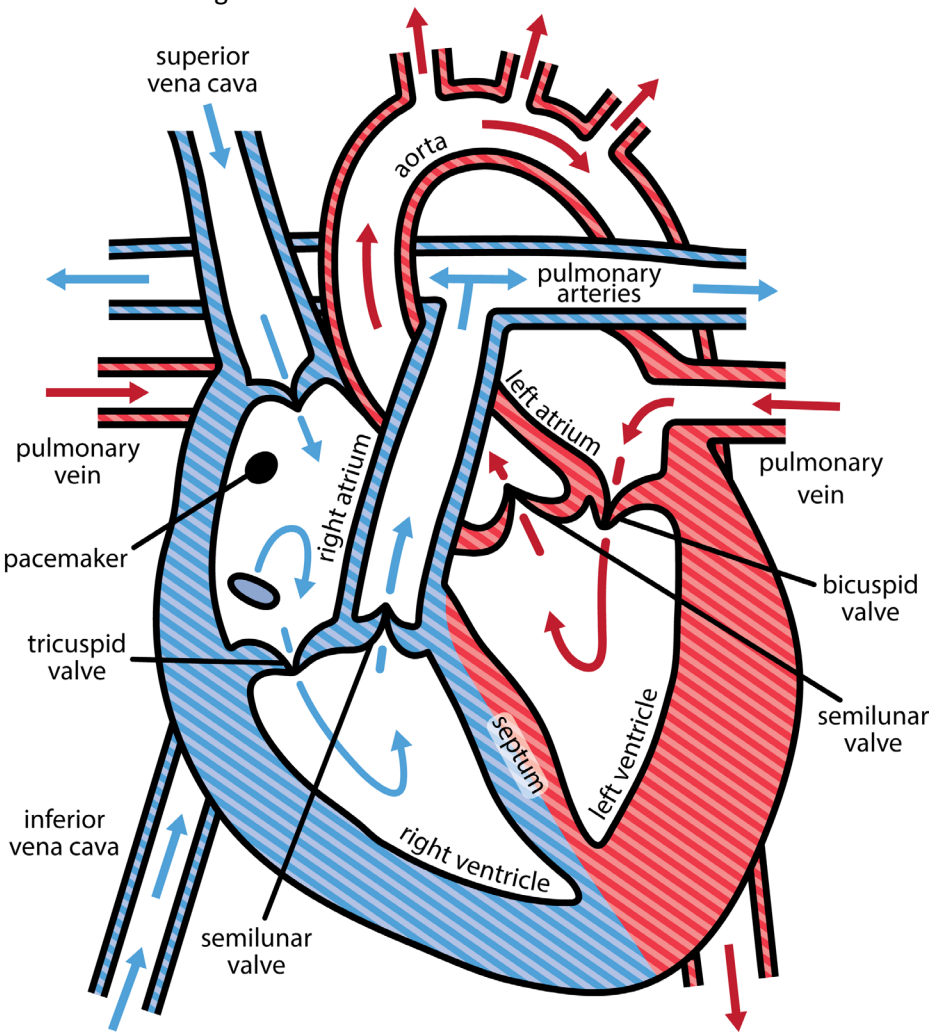
Valves: Have valves to prevent blood flowing backwards.
This is the function of valves 😊



Arteries and Veins Comparison Table	
Arteries	**Veins**
Carry blood away from the heart	Carry blood to the heart
Have a narrow lumen	Have a wide lumen
Have a thick muscular wall with lots of elastic fibres	Have a thin wall with few elastic fibres
Have a thick muscular layer	Have a thin muscular layer
Do not have valves	Have valves
Blood travels in pulses	Blood travels smoothly or at a steady flow.
Blood is under high pressure	Blood is under lower pressure

The heart is a muscular organ that pumps blood around the body. The heart is a double pump. The right side pumps deoxygenated blood to the lungs, and the left side pumps oxygenated blood to the rest of the body.

The figure below shows a labelled diagram of a heart.



Note: what is the best way to learn the structure of the heart?
Honestly, draw it out five times while looking at it. Then draw it once from memory. Check if anything is incorrect. If it is then draw it out five more times while looking at it and then once from memory.

Keep repeating this until it's perfect. Then do one a week until your exam 😊

If it was easy then everyone would do it! 😊

Now that we have looked at the key structures, let's follow the step by step journey of **blood flow** through the two separate circuits: one to the lungs and one to the rest of the body.

Blood Flow Through The Heart

Questions on blood flow through the heart pop up fairly commonly in paper 2, they're lovely questions to get 😊
If you know the structure of the heart really well then answering questions on this will be no problem at all.

The right side (pulmonary circuit which carries blood to the lungs):

1. Deoxygenated blood enters the right atrium from the body via the vena cava.
2. The right atrium contracts, pushing blood through the tricuspid valve into the right ventricle.
3. The right ventricle contracts, pumping the deoxygenated blood through the semilunar (pulmonary) valve into the pulmonary artery, which leads to the lungs.

The left side (systemic circuit which carries blood to the body):

1. Oxygenated blood returns from the lungs and enters the left atrium via the pulmonary vein.
2. The left atrium contracts, pushing blood through the bicuspid (Mitral) valve into the left ventricle.
3. The powerful left ventricle contracts, pumping the oxygenated blood through the semilunar (Aortic) valve into the aorta, which carries it to the rest of the body.

Thickness Of The Wall Of The Left Ventricle

It is very common to see questions asking about the different thicknesses of the left and right ventricle and to explain why there is this difference. This is usually a two or three mark question. Let's have a look at an example question and an ideal answer.

Example 1: **Explain why the wall of the left ventricle is much thicker than the wall of the right ventricle.**

Ideal answer:

Point 1: State the function of the left ventricle. (1 mark)

The left ventricle is responsible for pumping oxygenated blood to the entire body, from the head to the toes.

Point 2: State the function of the right ventricle. (1 mark)

In contrast, the right ventricle only has to pump deoxygenated blood a short distance to the lungs.

Point 3: Link the function to the required pressure and muscle mass. (1 mark)

Therefore, the left ventricle needs a thicker, more muscular wall to generate a much higher pressure, which is required to overcome the greater resistance and force blood all around the body.

Structures Of The Heart And Their Functions

Let's look at each structure of the heart. Being familiar with each is very important.

Atrium: the upper chamber on each side of the heart. The plural is atria.

Ventricle: the lower chamber on each side of the heart. The plural is ventricles.

Tricuspid valve: the valve found between the right atrium and the right ventricle. It is called tricuspid because it is made from three flaps (called cusps). It prevents the backflow of blood.

Bicuspid valve: the valve found between the left atrium and the left ventricle. It is called bicuspid because it is made from two flaps (called cusps). It also prevents the backflow of blood.

A trick to help you remember which side which valve is on… If you're right-handed you **try** things with your **right** hand. So, **try** with the **right** 😊 The **tricuspid valve** is on the **right hand side of the heart**.

Pulmonary artery: the artery that carries deoxygenated blood from the heart to the lungs where it can be oxygenated. It is the only artery that carries deoxygenated blood.

Pulmonary vein: carries oxygenated blood from the lungs to the left atrium of the heart. It is the only vein in the body that carries oxygenated blood.

Aorta: the artery which carries blood from the left ventricle to the rest of the body. It is the largest artery in the body. It carries oxygenated blood to the body.

Vena cava: a large vein responsible for carrying deoxygenated blood from the body back to the heart. It plays a crucial role in the circulatory system. There are two main parts of the vena cava, the **superior** and **inferior** vena cava.

Superior vena cava: brings deoxygenated blood from the upper body to the heart.

Inferior vena cava: brings deoxygenated blood from the lower body to the heart.

Septum: the wall of muscle that separates the left and right sides of the heart. It prevents the mixing of oxygenated and deoxygenated blood. This separation makes the circulatory system very efficient.

Semi lunar valves: are valves found at the exit of each ventricle, they're shaped like crescent moons.

There are **two and we can just call them both semi lunar valves!** Their correct names though are the pulmonary valve (exiting the right ventricle) and the aortic valve (exiting the left ventricle). They prevent blood from flowing back into the ventricles

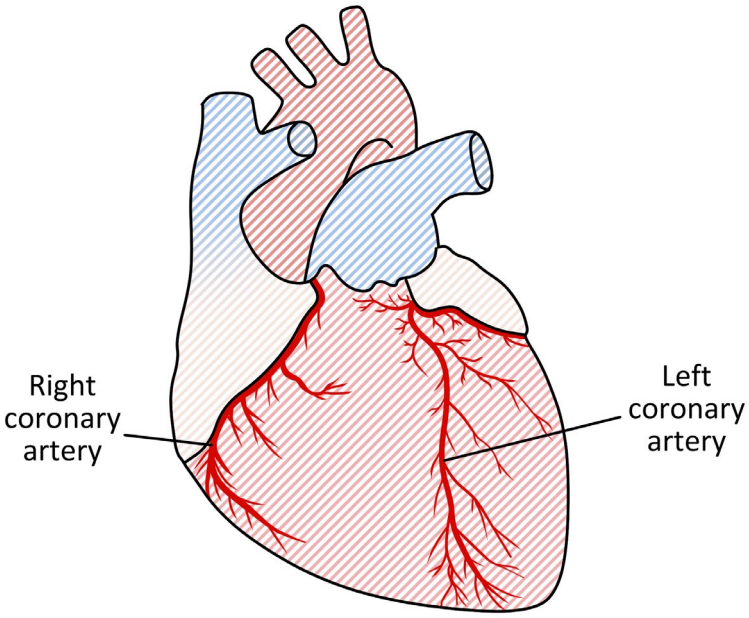
Pacemaker: a small group of cells in the wall of the right atrium. It produces small electrical impulses which spread across the heart muscle, causing it to contract. This controls the resting heart rate.

The Coronary Arteries

So far we have learned that the heart pumps deoxygenated blood to the lungs to get reoxygenated and then pumps this reoxygenated blood around the body to provide respiring cells and muscles with oxygen (and glucose).

But, the heart is also a muscle. So, how is the heart itself supplied with oxygenated blood? The coronary arteries 😊

The figure below shows the coronary arteries of the heart.

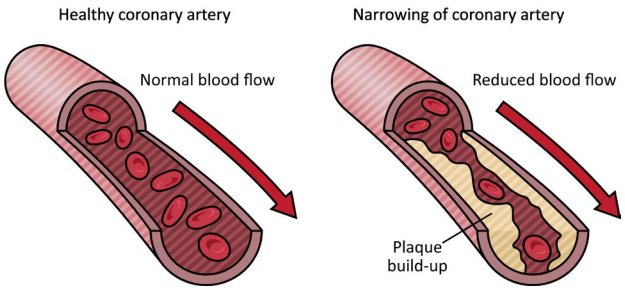


What are the coronary arteries? The coronary arteries are small blood vessels that supply the heart muscle itself with oxygenated blood.

What do the coronary arteries do? Their primary role is to supply the heart muscle itself with oxygen and glucose. The oxygen is from the lungs and the glucose is from the digestive system. These are needed for aerobic respiration**.**

Coronary Heart Disease

What is coronary heart disease? It's a condition where the coronary arteries can be narrowed or blocked, which can lead to a heart attack.



What causes coronary heart disease? It is caused by the buildup of plaque in the arteries. This "plaque" is a mixture of fat, cholesterol, calcium, and other substances found in the blood.

How can coronary heart disease be prevented? Eat a healthy diet and regular exercise. Avoid smoking and serious stress and keep an eye on your cholesterol levels.

How does smoking contribute to coronary heart disease?
Smoking damages arteries and promotes plaque buildup. It can also increase blood pressure, reduce the blood supply to the heart and increase the risk of a blood clot forming.

How can coronary heart disease be treated?
There are a number of different ways we can treat coronary heart disease once it has become an issue. These are:

1. Lifelong medication such as Statins. These are drugs which reduce the cholesterol levels in the blood.

2. Surgery – a small wire-mesh tube called a stent is inserted into a coronary artery to keep it open.

3. Change in lifestyle – this could mean a better diet and more regular exercise.

Cardiac Output and Stroke Volume

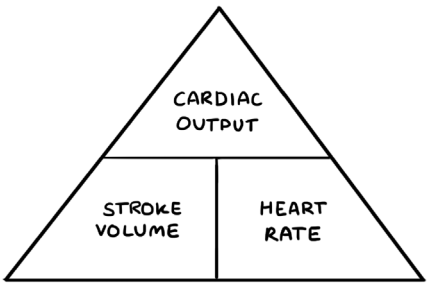
We could be asked to complete a calculation to determine stroke volume.

Stroke volume: the volume of blood pumped out of the heart with every beat. The average amount of blood per beat is 0.07 litres for a typical adult.

Cardiac output: the total volume of blood pumped by the heart in one minute usually measured in cm^3/min or litres/min.

Heart rate: number of beats per minute (bpm).

The equation for this calculation is:



$$\text{Stroke volume} = \frac{Cardiac\ Output}{Heart\ rate}$$

$$\text{Cardiac output} = \text{stroke volume} \times \text{heart rate}$$

Let's have a look at a few example calculations:

Example 1: The cardiac output of a person is measured to be 5.5 litres per minute, and their heart rate is 75 beats per minute. Calculate the stroke volume of the person's heart. Give your answer in millilitres.

Step 1: **substitute the values from the question into the equation**.

$$\text{Stroke volume} = \frac{5.5}{75}$$

Step 2: **convert the cardiac output into millilitres by multiplying by 1000.**

$$\text{Stroke volume} = \frac{5500}{75}$$

Step 3: solve.

$$\text{Stroke volume} = 73.3 \text{ ml}$$

Example 2: A person's cardiac output is measured to be 4.8 litres per minute, and their stroke volume is 80 millilitres per beat. Calculate the heart rate of the person in beats per minute.

Step 1: convert cardiac output to millilitres by multiplying by 1000.

$$4.8 \text{ litres} = 4800 \text{ ml}$$

Step 2: **substitute the values from the question into the equation**.

$$Heart\ rate = \frac{4800}{80}$$

Step 3: solve.

$$Heart\ rate = 60 \text{ beats per minute}$$