Cambridge (CIE) IGCSE Biology

Your notes

Circulatory Systems, Heart & Blood Vessels

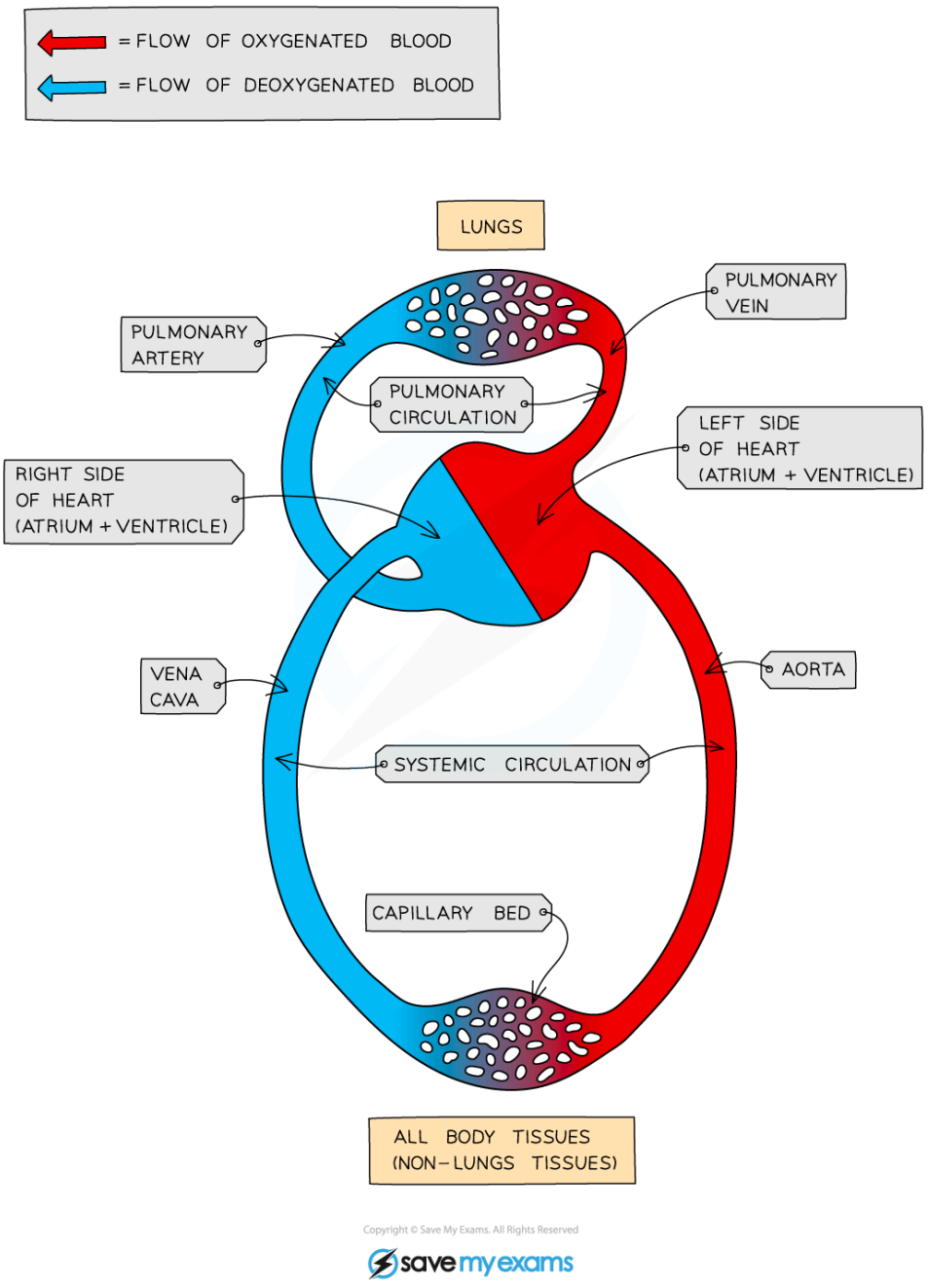
Contents

Your notes

Circulatory system

- The circulatory system is an **organ system**, the role of which is to **transport blood** around the body
- Components of the circulatory system include:
  - **blood vessels**
  - **a pump**
  - **valves** to ensure **one-way flow** of blood

Circulatory system diagram



The circulatory system consists of blood vessels and a pump, and one-way blood flow is ensured by the presence of valves

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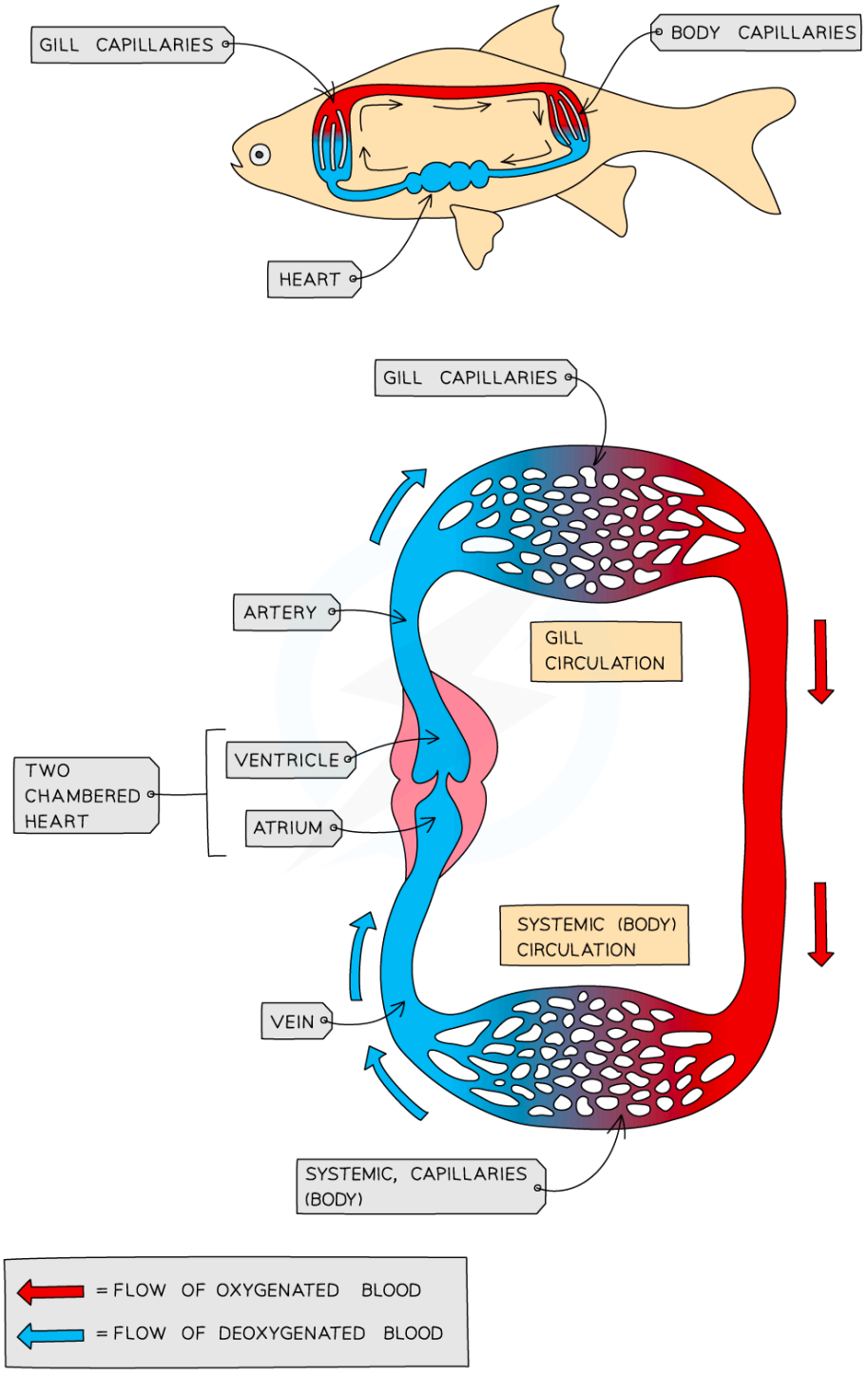
Circulatory Systems of Fish & Mammals: Extended

Extended Tier Only

Circulatory systems in Fish

- Fish have a **two-chambered heart** and a **single circulation**
- This means that **for every one circuit of the body, the blood passes through the heart once**



The single circulatory system in fish

Circulatory systems in Mammals

- Mammals have a **four-chambered heart** and a **double circulation**

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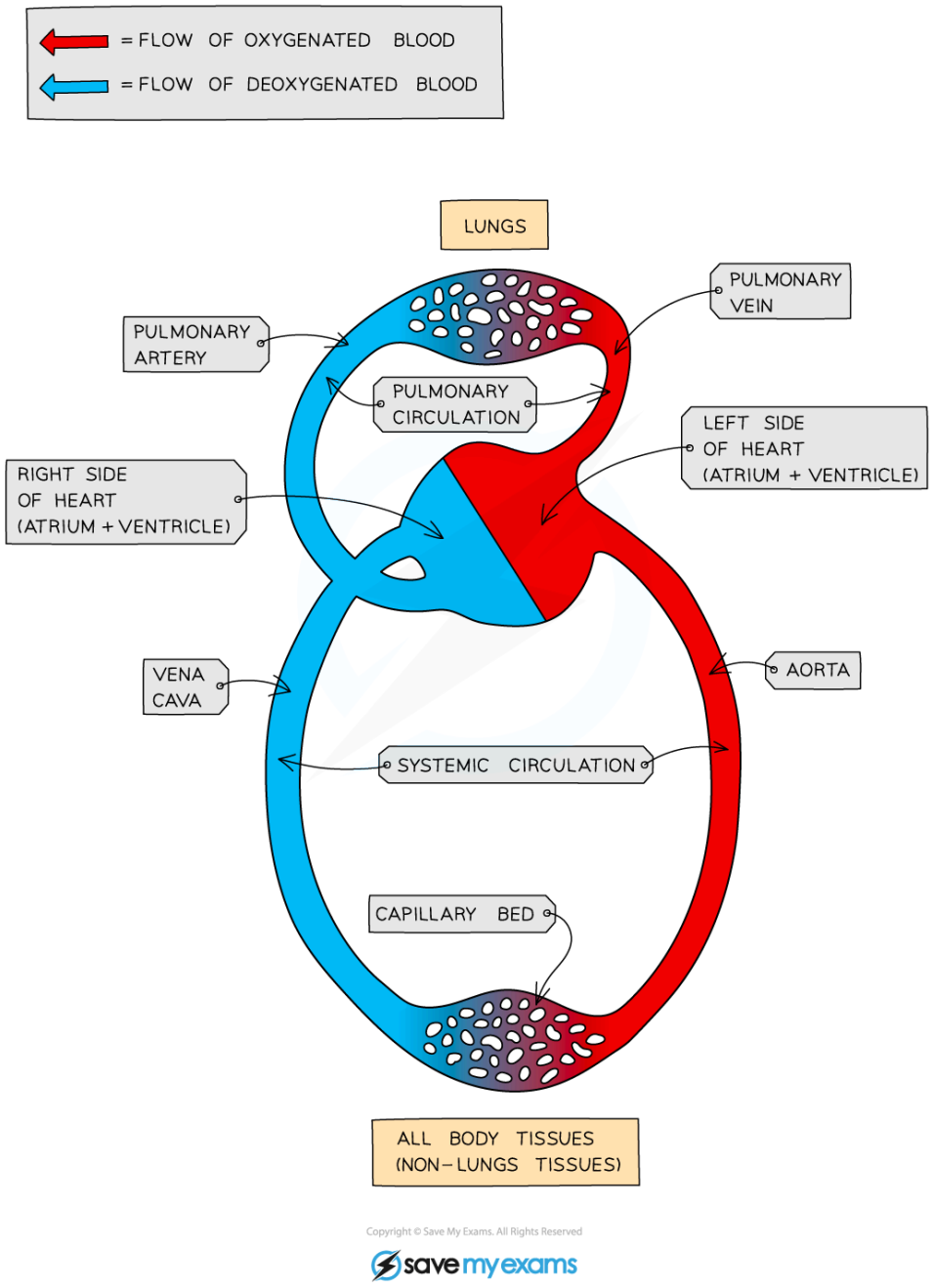
- This means that **for every one circuit of the body, the blood passes through the heart twice**
- The right side of the heart receives **deoxygenated blood** from the body and **pumps it to the lungs** (the **pulmonary circulation**)
- The left side of the heart receives **oxygenated blood** from the lungs and **pumps it to the body** (the **systemic circulation**)



The double circulatory system in mammals

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Advantages of Double Circulation: Extended

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Extended Tier Only

- Blood travelling through the small capillaries in the lungs **loses a lot of pressure** that was given to it by the pumping of the heart, meaning it **cannot travel as fast**
- By returning the blood to the heart after going through the lungs its **pressure can be raised again** before sending it to the body, meaning **cells** can be supplied with the **oxygen and glucose** they need for respiration **faster and more frequently**

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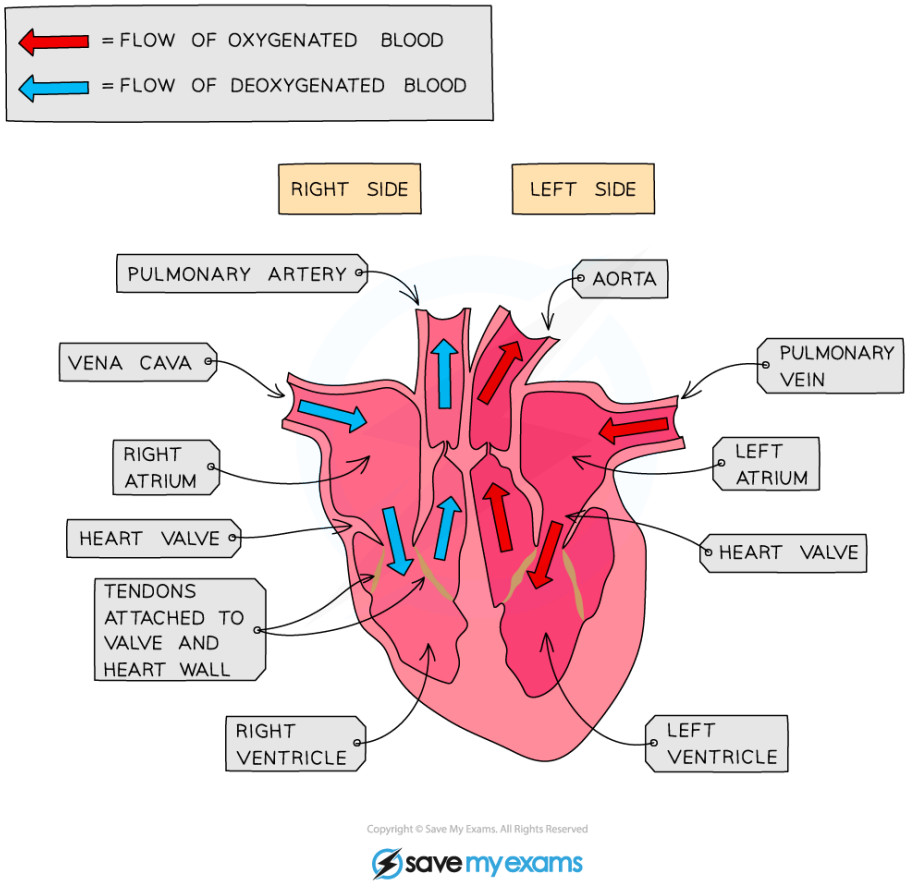
The Mammalian Heart

- The heart is **labelled as if it was in the chest** so what is your left on a diagram is actually the right hand side and vice versa
- The right side of the heart receives **deoxygenated blood** from the body and pumps it **to the lungs**
- The left side of the heart receives **oxygenated blood** from the lungs and pumps it **to the body**
- Blood is pumped **towards** the heart in veins and **away** from the heart in **arteries**
- The two sides of the heart are separated by a muscle wall called the **septum**
- The heart is made of **muscle tissue** which are supplied with blood by the **coronary arteries**



Structure of the heart

Examiner Tips and Tricks

Remember A-A: **A**rteries carry blood **A**way from the heart

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Monitoring Activity of the Heart

- Heart activity can be monitored by using an **ECG**, measuring **pulse rate** or **listening to the sounds of valves closing** using a stethoscope
- Heart rate (and pulse rate) is measured in beats per minute (bpm)
- To investigate the effects of exercise on heart rate, record the pulse rate at rest for a minute
- Immediately after they do some exercise, record the pulse rate every minute until it returns to the resting rate
- This experiment will show that during exercise the heart rate increases and may take several minutes to return to normal

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Investigating Effect of Physical Activity on Heart Rate

- It is relatively simple to investigate the effects of exercise on the body in the classroom
- Breathing rate can be measured by counting the number of breaths per minute, while heart rate can be measured by taking a pulse
- Either can be measured before and after an activity is performed and the results plotted on a bar chart
  - It is important that the time over which breathing rate and pulse rate are measured is consistent, and that individuals fully recover (rest) before starting a new activity
- Increased physical activity results in an increased heart rate and breathing rate
  - Heart rate remains high for a period of time after physical has stopped, there is a gradual return to resting heart rate

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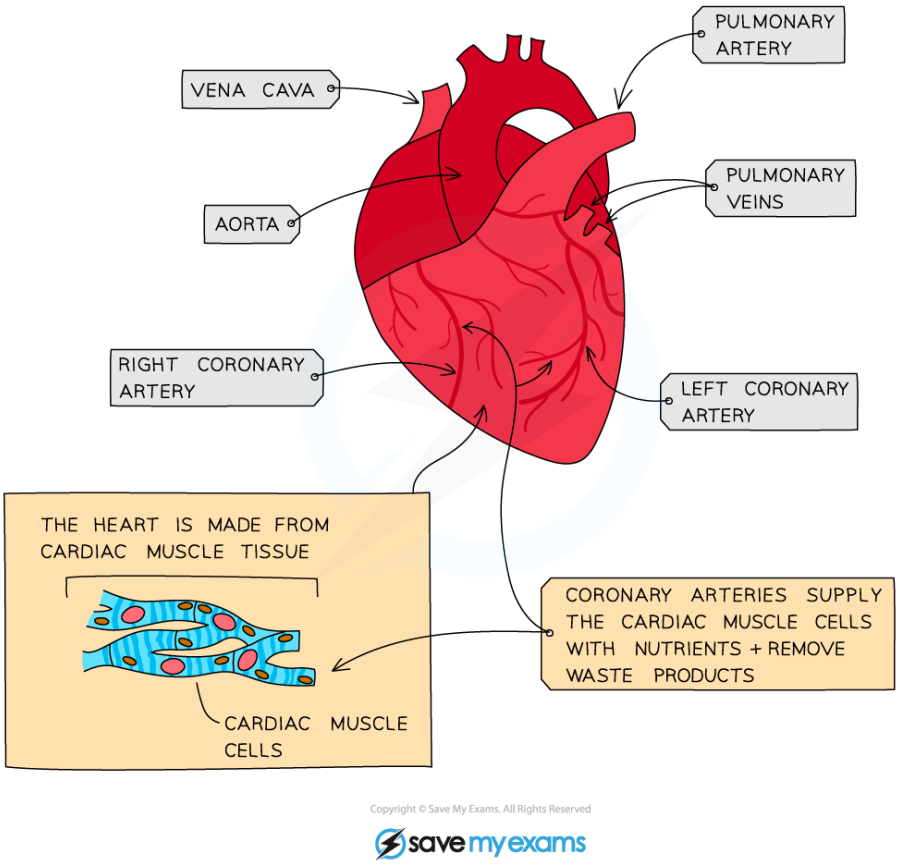
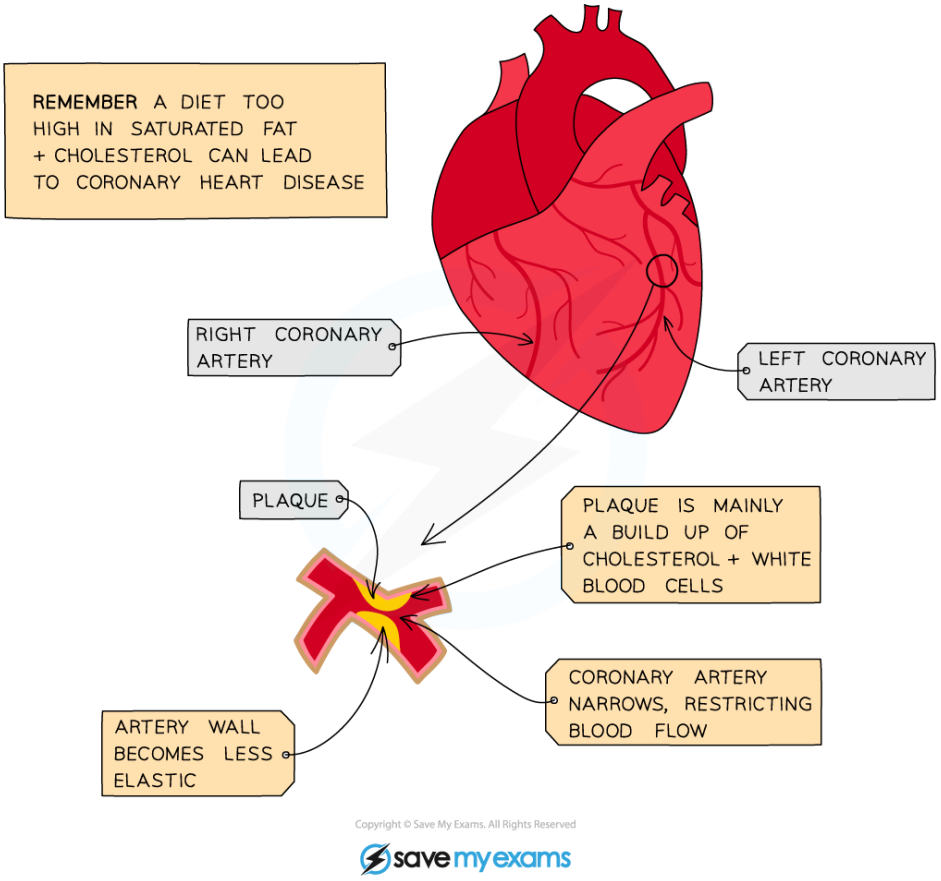
Coronary Heart Disease



The coronary arteries

- The heart is made of **muscle cells** that need their own supply of blood to deliver oxygen, glucose and other nutrients and remove carbon dioxide and other waste products
- The blood is supplied by the **coronary arteries**
- If a coronary artery becomes partially or completely **blocked by fatty deposits called 'plaques'** (mainly formed from **cholesterol**), the arteries are not as **elastic** as they should be and therefore cannot stretch to accommodate the blood which is being forced through them - leading to **coronary heart disease**
- **Partial blockage** of the coronary arteries creates a restricted blood flow to the cardiac muscle cells and results in severe chest pains called **angina**
- **Complete blockage** means cells in that area of the heart will not be able to respire and can no longer contract, leading to a **heart attack**



Buildup of plaque in the coronary arteries

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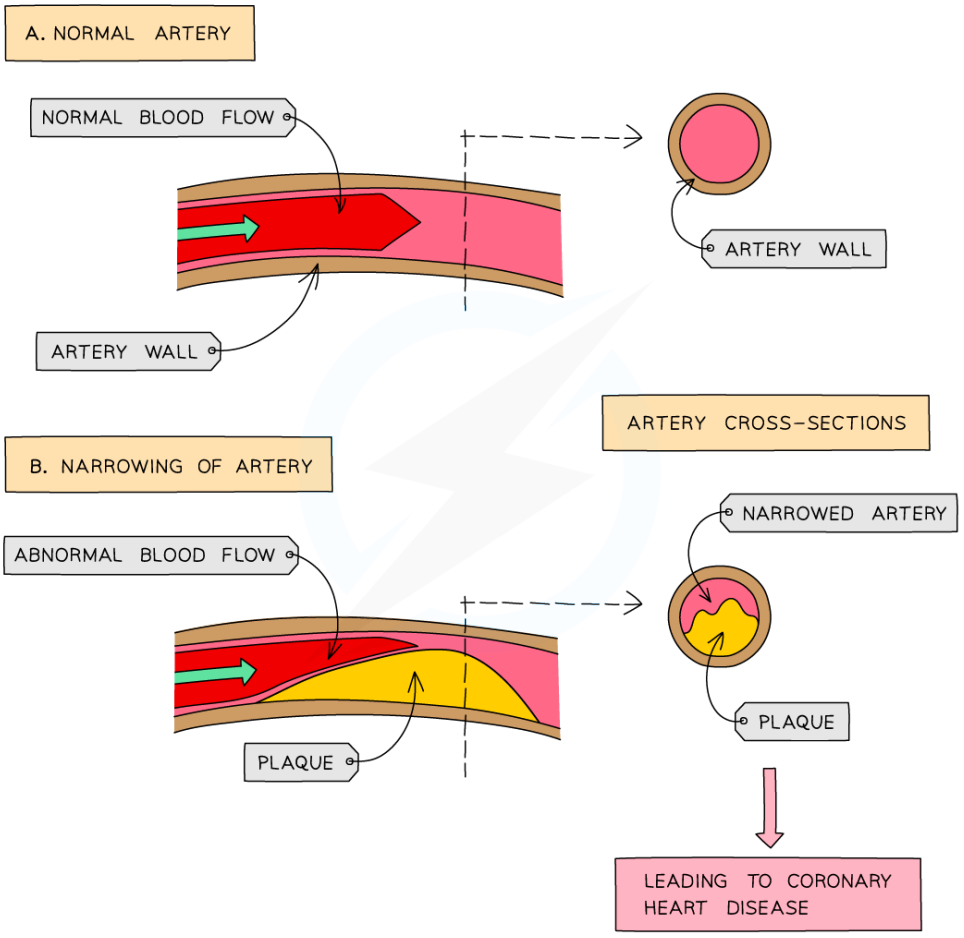

Effect of narrowing of arteries

Risk Factors for CHD Table

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FACTOR	EXPLANATION
POOR DIET	EATING MORE **SATURATED FAT INCREASES CHOLESTEROL LEVELS**, INCREASING THE CHANCE OF THE BUILDUP OF FATTY PLAQUES
STRESS	WHEN UNDER STRESS, HORMONES PRODUCED CAN **INCREASE BLOOD PRESSURE**, INCREASING THE CHANCE OF A BLOCKAGE IN THE CORONARY ARTERIES
SMOKING	NICOTINE IN CIGARETTES WILL CAUSE BLOOD VESSELS TO BECOME NARROWER, **INCREASING BLOOD PRESSURE** WHICH WILL CAUSE THE BUILDUP OF FAT GLOBULES. IF THIS OCCURS IN THE CORONARY ARTERY, THIS WILL CAUSE CORONARY HEART DISEASE
GENETIC PREDISPOSITION	STUDIES SHOW THAT PEOPLE WITH A **HISTORY OF CORONARY HEART DISEASE IN THEIR FAMILY ARE MORE LIKELY TO DEVELOP IT THEMSELVES**, SUGGESTING IT PARTLY HAS A GENETIC BASIS
AGE	THE RISK OF DEVELOPING CORONARY HEART DISEASE **INCREASES** AS YOU GET OLDER
GENDER	**MALES** ARE **MORE LIKELY** TO DEVELOP CORONARY HEART DISEASE THAN FEMALES

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Diet, Exercise & Coronary Heart Disease

Reducing the risks of developing coronary heart disease

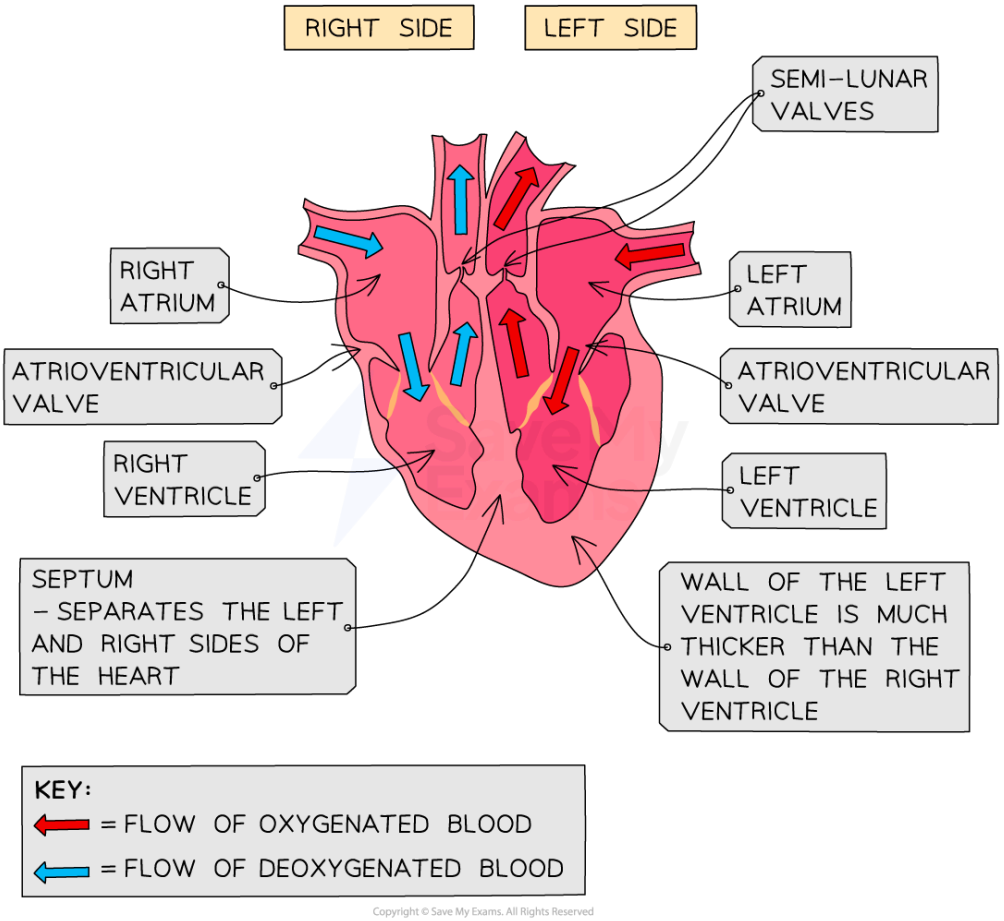
- **Quit smoking**
- **Diet – reduce animal fats** and eat more fruits and vegetables - this will reduce cholesterol levels in the blood and help with weight loss if overweight
- **Exercise regularly** - again, this will help with weight loss, decrease blood pressure and cholesterol levels and help reduce stress

Your notes

Identifying Structures in the Heart: Extended

Extended Tier Only

- The **ventricles** have thicker muscle walls than the atria as they are pumping blood out of the heart and so need to generate **a higher pressure**
- **The left ventricle has a thicker muscle wall than the right ventricle** as it has to pump blood at high pressure around the **entire body**, whereas the right ventricle is pumping blood at lower pressure to the **lungs**
- The **septum** separates the two sides of the heart and so **prevents mixing of oxygenated and deoxygenated blood**



The structures in the heart maximise the efficiency with which it can pump blood around the body

The function of valves

- The basic function of all valves is to **prevent blood from flowing backwards**
- There are two sets of valves in the heart:
  - The **atrioventricular valves** separate the atria from the ventricles
  - The valve on the right side of the heart is called the **TRICUSPID** and the valve on the left side is called the **BICUSPID**
  - These valves are pushed **open when the atria contract** but when the **ventricles contract they are pushed shut** to prevent blood from flowing back into the atria
  - The **semilunar valves** are found in the two blood arteries that come out of the top of the heart
  - They are unusual in that they are the **only two arteries in the body that contain valves**
  - These valves **open when the ventricles contract** so blood squeezes past them out of the heart, but then shut to avoid blood flowing back into the heart

Your notes

Your notes

Functioning of the Heart: Extended

Extended Tier Only

- **Deoxygenated blood** coming from the body flows into the **right atrium** via the **vena cava**
- Once the right atrium has filled with blood the heart gives a little beat and the blood is pushed through the **tricuspid (atrioventricular) valve** into the **right ventricle**
- The walls of the ventricle **contract** and the blood is pushed into the **pulmonary artery** through the **semilunar valve** which prevents blood flowing backwards into the heart
- The blood travels to the lungs and moves through the capillaries past the alveoli where gas exchange takes place (this is why there has to be low pressure on this side of the heart – blood is going directly to capillaries which would burst under higher pressure)
- **Oxygen-rich blood** returns to the **left atrium** via the **pulmonary vein**
- It passes through the **bicuspid (atrioventricular) valve** into the **left ventricle**
- The thicker muscle walls of the ventricle contract strongly to push the blood forcefully into the **aorta** and all the way around the body
- The **semilunar valve** in the aorta prevents the blood flowing back down into the heart

Your notes

Explaining the Effect of Physical Activity on Heart Rate: Extended

Extended Tier Only

- Heart rate increases during exercise to increase blood flow to the working muscles
- This is important for several reasons:
  - To provide them with enough **nutrients and oxygen** for **increased respiration**
  - To **remove waste products at a faster rate**
- Following exercise, the heart continues to beat faster for a while
  - to ensure that **all excess waste products are removed** from muscle cells
  - to deliver extra oxygen to the muscle cells to pay off the oxygen debt accumulated when oxygen levels are not high enough to support aerobic respiration
    - The extra oxygen is used to break down the **lactic acid** that has been built up in cells as a result of anaerobic respiration

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Arteries, veins & capillaries

- The blood vessels are a system of closed tubes within which blood flows
- Different types of blood vessels transport blood in different directions, and to different parts of the body

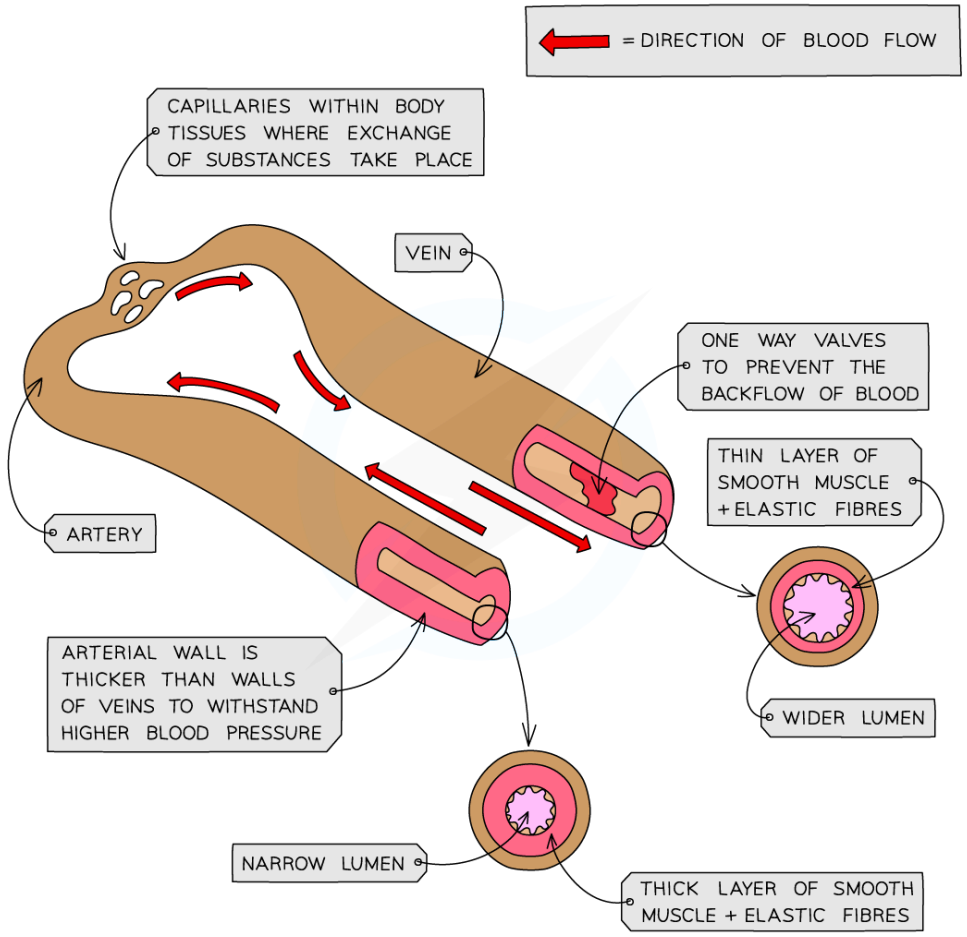
Arteries

- These blood vessels carry blood **away from the heart** at high pressure
- Arteries transport **oxygenated**
  - The single exception to this is the pulmonary artery
- The walls of arteries are **thick** and **muscular** and contain **elastic fibres**
- Arteries have a **narrow lumen**

Veins

- These blood vessels carry blood **towards the heart** at low pressure
- Veins transport **deoxygenated** blood away from the body
  - The single exception to this is the pulmonary vein
- The walls of veins are **thin** in comparison to arteries
- Veins have a **wide lumen**
- **Valves** in veins prevent blood from flowing backwards

Arteries and veins diagram



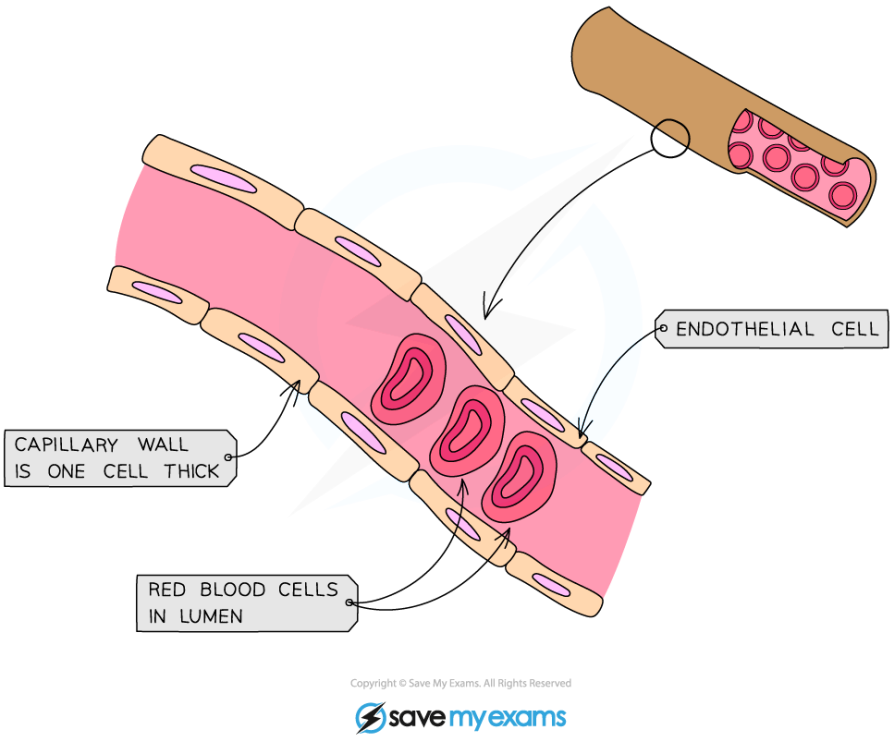
Arteries carry blood away from the heart at high pressure, while veins carry blood towards the heart at low pressure

Capillaries

- These blood vessels carry blood **to the cells** of the tissues
- Capillaries transport **oxygenated** blood from the arteries to the cells, and **deoxygenated** blood from the cells to the veins
- The walls of capillaries are **one cell thick** and contain gaps to allow fluid to leak out
- Capillaries have a very **narrow lumen**

Capillaries diagram

Your notes



Capillaries are tiny blood vessels that carry blood to the cells of the body

Your notes

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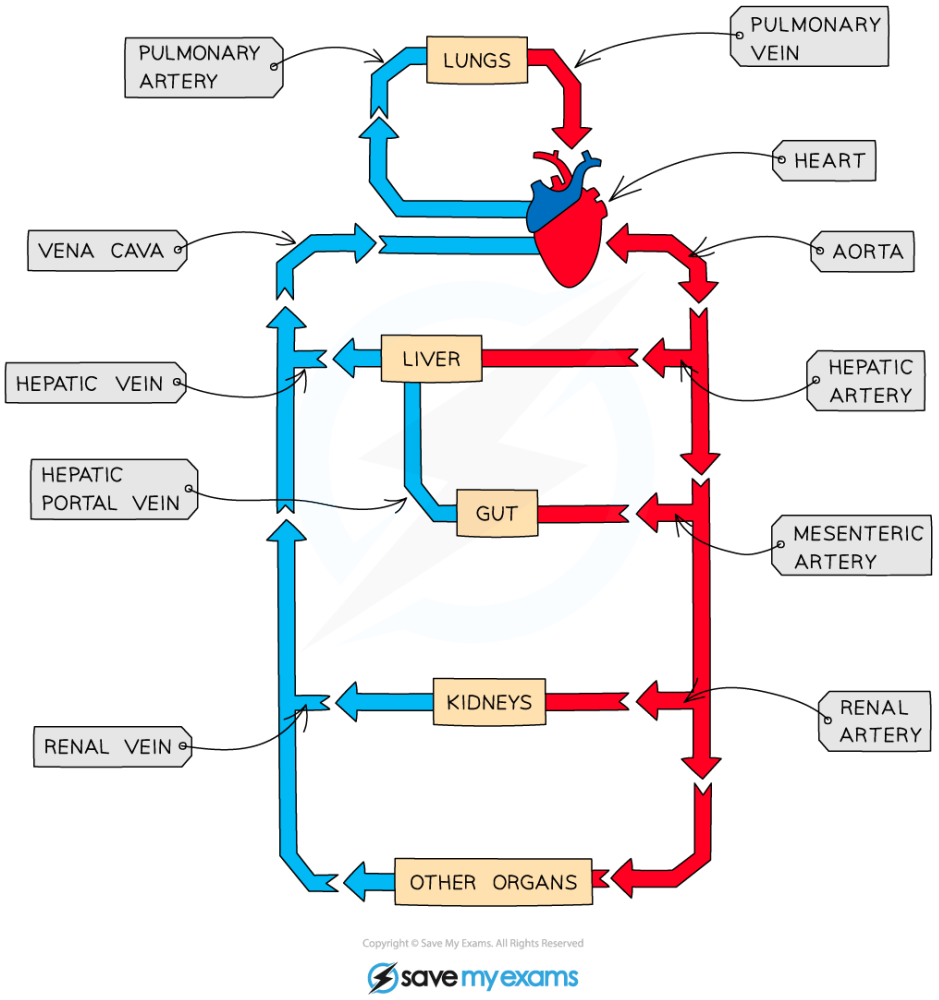
Main Blood Vessels in the Body

- Blood is carried **away from the heart** and towards organs in **arteries**
- These narrow to arterioles and then capillaries as they pass through the organ
- The capillaries widen to venules and finally veins as they move away from the organs
- **Veins** carry blood back **toward the heart**



The circulatory system

Important Blood Vessels Table

ORGAN	TOWARDS ORGAN	AWAY FROM ORGAN
HEART	VENA CAVA, PULMONARY VEIN	AORTA, PULMONARY ARTERY
LUNG	PULMONARY ARTERY	PULMONARY VEIN
KIDNEY	RENAL ARTERY	RENAL VEIN

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How Structure of Blood Vessels is Adapted to their Function: Extended

Extended Tier Only

Arteries

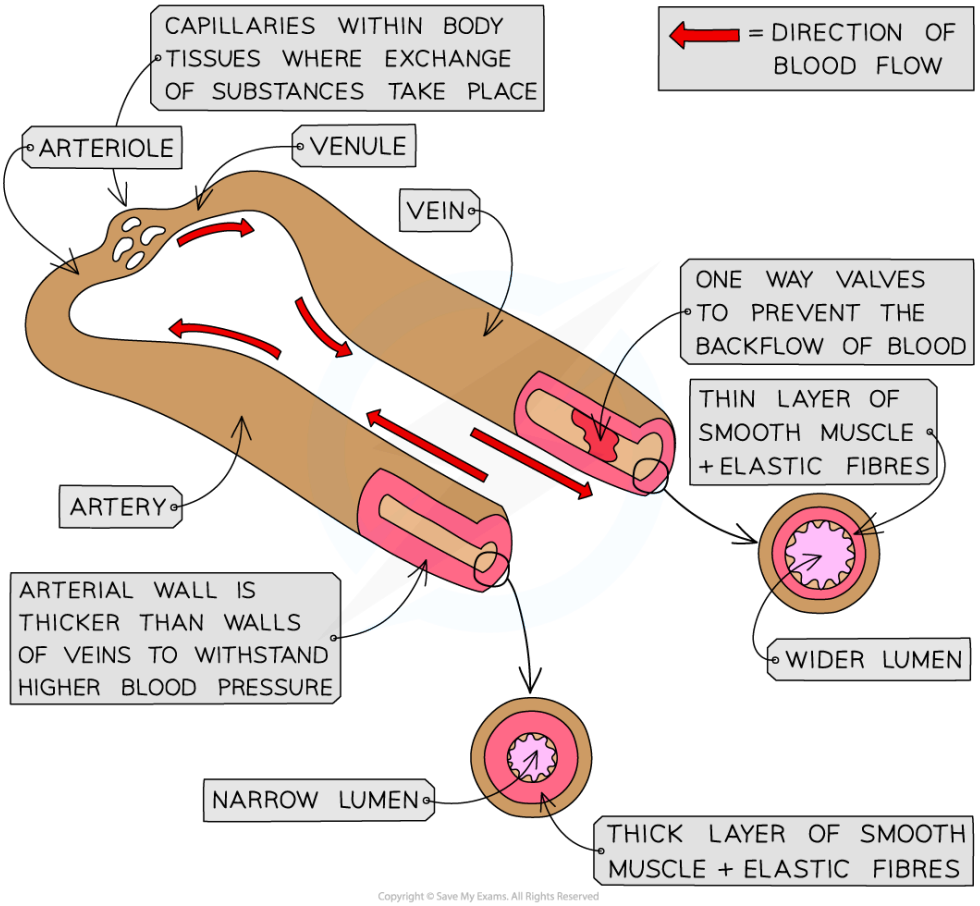
- Have thick muscular walls containing elastic fibres **to withstand the high pressure of blood and maintain the blood pressure as it recoils after the blood has passed through**
- Have a narrow lumen **to maintain high pressure**

Veins

- Have a large lumen **as blood pressure is low**
- Contain valves **to prevent the backflow of blood as it is under low pressure**

Capillaries

- Have walls that are one cell thick **so that substances can easily diffuse in and out of them**
- Have 'leaky' walls **so that blood plasma can leak out and form tissue fluid surrounding cells**

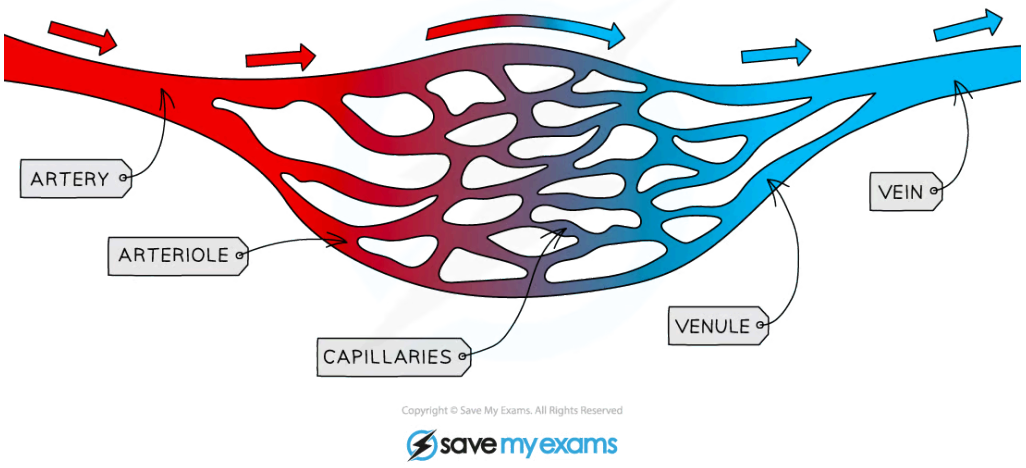


Adaptations of blood vessels

Arterioles and venules

- As arteries **divide more** as they get further away from the heart, they get **narrower**
- The narrow vessels that connect arteries to capillaries are called **arterioles**
- Veins also get narrower the further away they are from the heart
- The narrow vessels that connect capillaries to veins are called **venules**

Your notes



The blood vessel network

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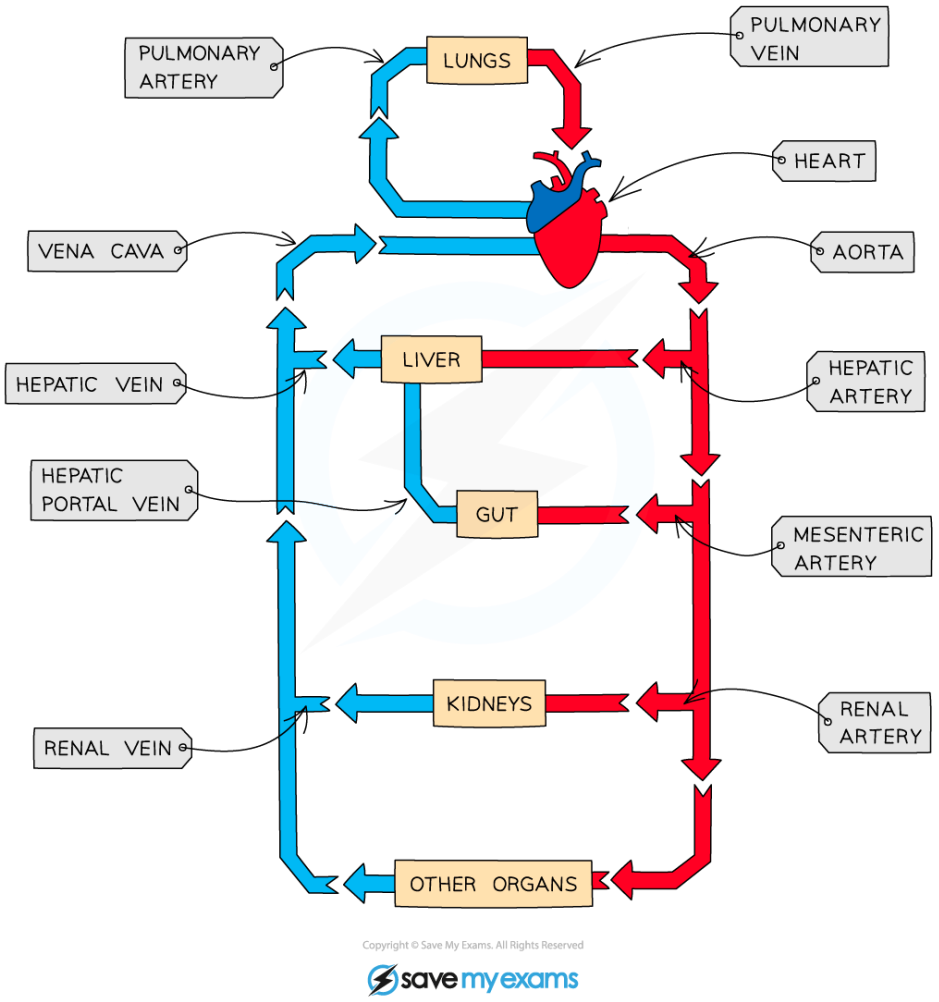
Blood Vessels & the Liver: Extended

Extended Tier Only

- You must be able to identify the main blood vessels to and from the liver
  - The **hepatic artery** brings oxygenated blood from the heart to the liver
  - The **hepatic vein** brings deoxygenated blood from the liver back to the heart
  - The **hepatic portal vein** transports deoxygenated blood from the gut to the liver



The liver is supplied with blood by the hepatic artery and the hepatic portal vein, and blood is carried away from the liver in the hepatic vein

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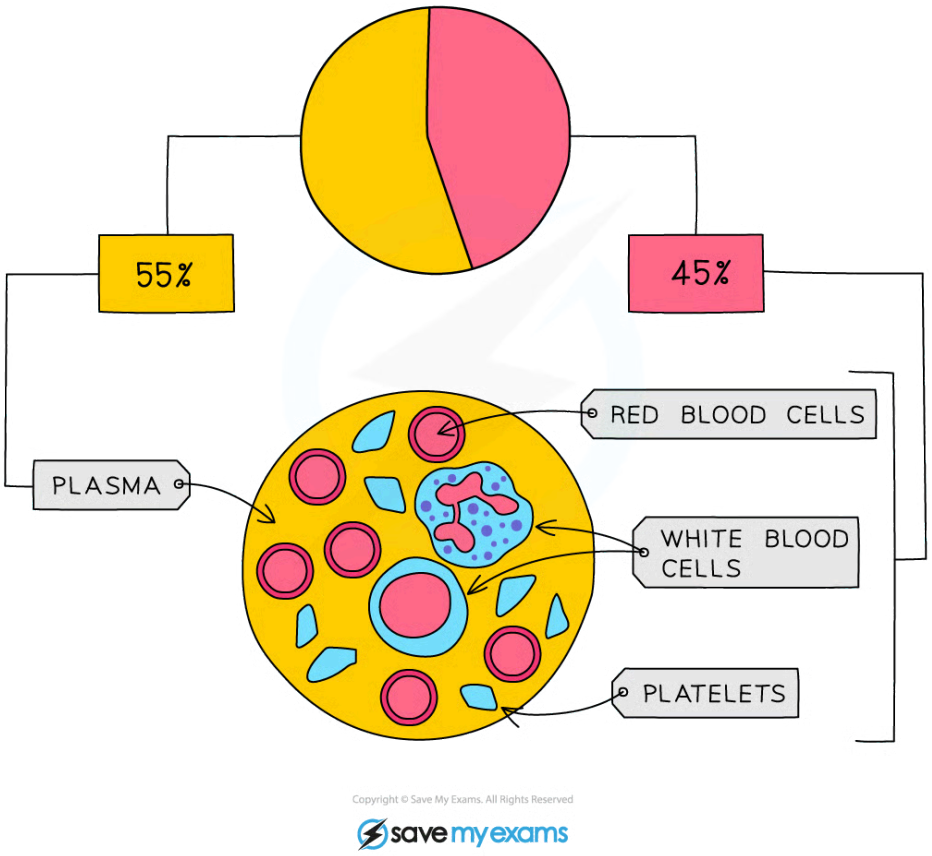
Components of Blood

- Blood consists of **red blood cells, white blood cells, platelets and plasma**



Composition of human blood

Components of the Blood Table

COMPONENT	STRUCTURE
RED BLOOD CELLS	BICONCAVE DISCS CONTAINING NO NUCLEUS BUT PLENTY OF THE PROTEIN HAEMOGLOBIN
WHITE BLOOD CELLS	LARGE CELLS CONTAINING A BIG NUCLEUS, DIFFERENT TYPES HAVE SLIGHTLY DIFFERENT STRUCTURES AND FUNCTIONS
PLATELETS	FRAGMENTS OF CELLS
PLASMA	STRAW COLOURED LIQUID

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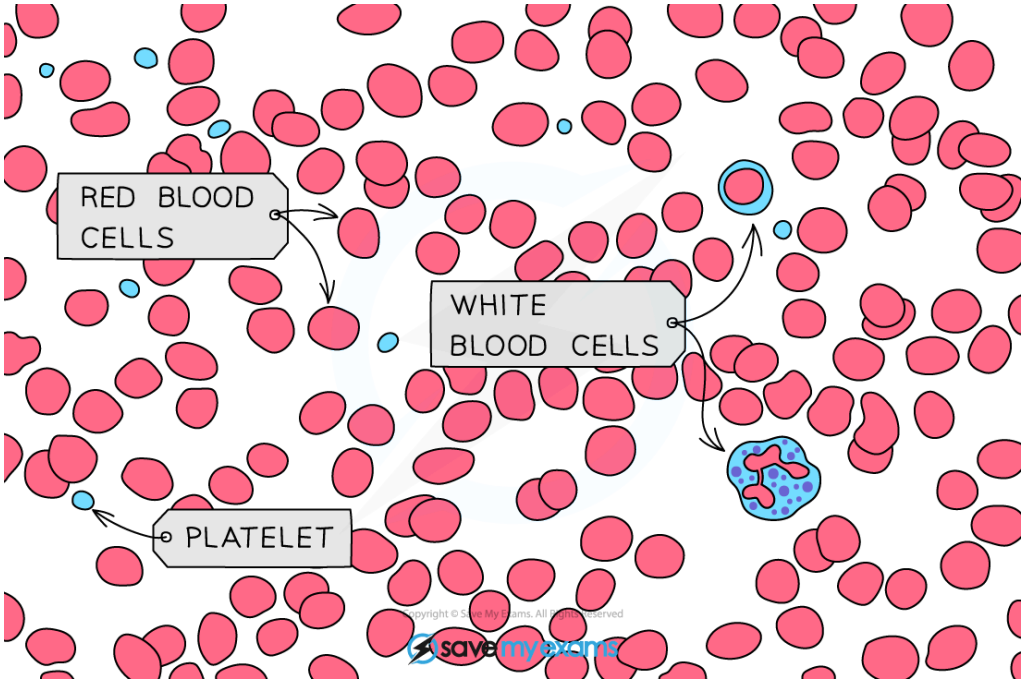
Identifying Red & White Blood Cells

- You need to be able to identify red and white blood cells in photomicrographs and diagrams
  - Red blood cells have a concave disc shape with no nucleus
  - White blood cells are usually round in shape with a nucleus



Blood micrograph

Components of Blood: Function

- Plasma is important for the **transport** of carbon dioxide, digested food (nutrients), urea, mineral ions, hormones and heat energy
- Red blood cells **transport oxygen** around the body from the lungs to cells which require it for aerobic respiration
  - They carry the oxygen in the form of oxyhaemoglobin
- White blood cells **defend** the body against infection by pathogens by carrying out **phagocytosis** and **antibody production**
- Platelets are involved in helping the **blood to clot**

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Blood Clotting

- Platelets are **fragments of cells which are involved in blood clotting** and forming scabs where the skin has been cut or punctured
- Blood clotting **prevents continued / significant blood loss** from wounds
- Scab formation seals the wound with an insoluble patch that **prevents entry of microorganisms** that could cause infection
- It remains in place until new skin has grown underneath it, sealing the skin again

Your notes

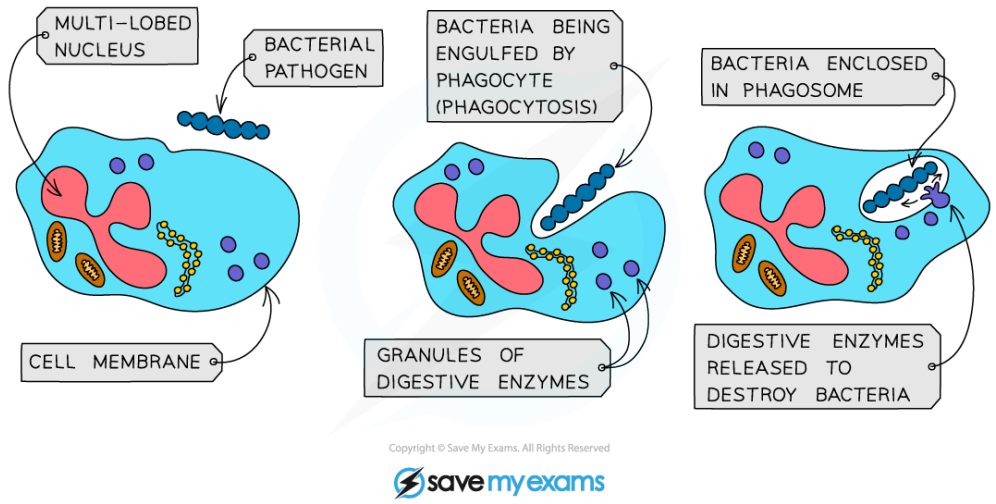
Lymphocytes & Phagocytes: Extended

Extended Tier Only

- White blood cells are part of the body's **immune system**, defending against infection by pathogenic microorganisms
- There are two main types, **phagocytes and lymphocytes**

Phagocytes

- Carry out **phagocytosis** by **engulfing and digesting pathogens**



Phagocytosis

- Phagocytes have a sensitive cell surface membrane that can detect chemicals produced by pathogenic cells
- Once they encounter the pathogenic cell, they will engulf it and **release digestive enzymes** to digest it
- They can be easily recognised under the microscope by their **multi-lobed nucleus** and their **granular cytoplasm**

Lymphocytes

- Produce **antibodies** to destroy pathogenic cells and **antitoxins** to neutralise toxins released by pathogens
- They can easily be recognised under the microscope by their **large round nucleus** which takes up nearly the whole cell and their **clear, non-granular cytoplasm**

Your notes

Conversion of Fibrinogen: Extended

Extended Tier Only

- Platelets are **fragments of cells which are involved in blood clotting** and forming scabs where the skin has been cut or punctured
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- Scab formation seals the wound with an insoluble patch that **prevents entry of microorganisms** that could cause infection
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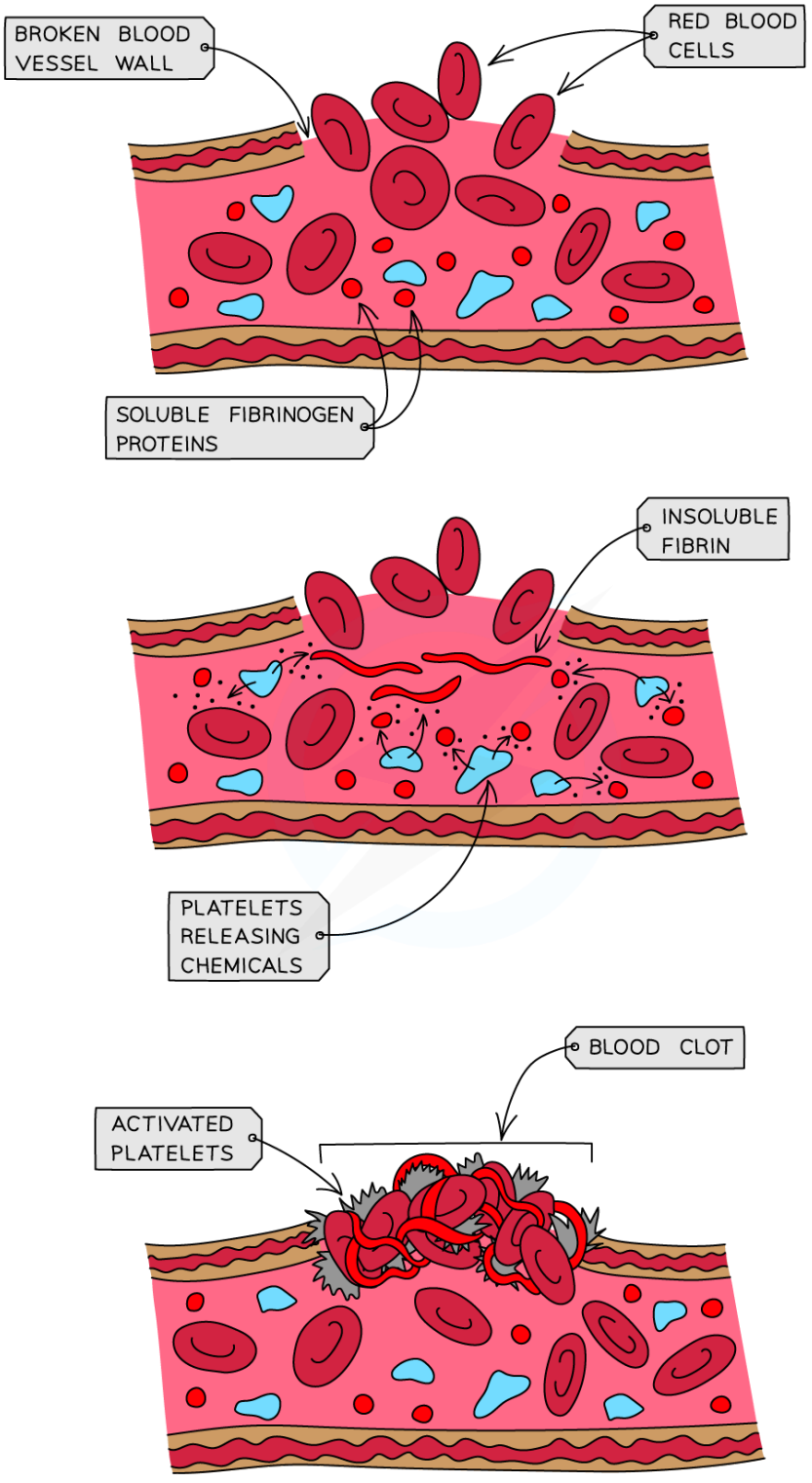

How the blood clots

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- When the skin is broken (i.e. there is a wound) platelets arrive to stop the bleeding
- A series of reactions occur within the blood plasma
- Platelets release chemicals that cause **soluble fibrinogen proteins** to convert into **insoluble fibrin** and form an **insoluble mesh** across the wound, trapping red blood cells and therefore **forming a clot**
- The clot eventually dries and develops into a **scab** to protect the wound from bacteria entering

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