Edexcel GCSE Biology

Your notes

Circulatory System

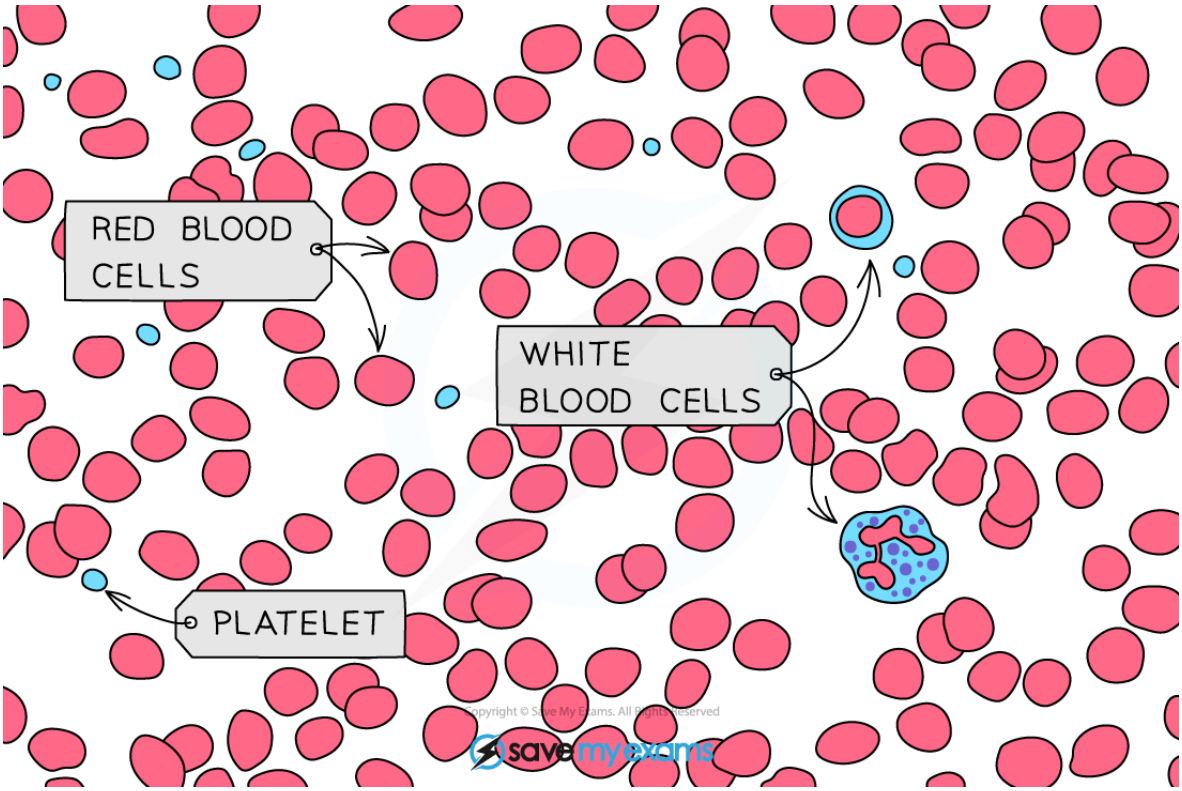
Contents

The Blood & Blood Vessels

Your notes

The Blood

- Blood consists of **red blood cells**, **white blood cells**, **platelets** and **plasma**
- Over half of the volume of the blood is made up of plasma
- The majority of the other half is made up of red blood cells
- The remaining fraction consists of white blood cells and platelets



Blood micrograph

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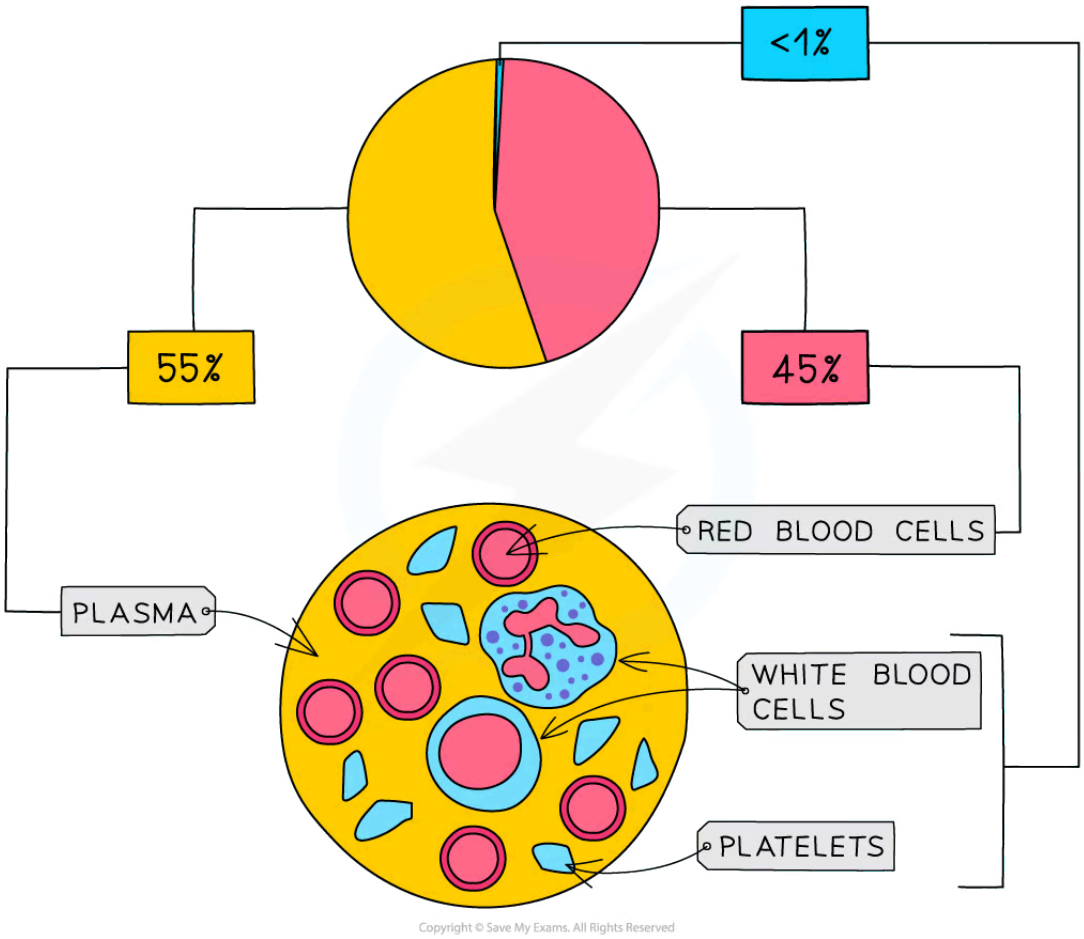

Composition of human blood

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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Red Blood Cells

- Red blood cells are **specialised cells** which carry **oxygen to respiring cells**
- They are adapted for this function in 3 key ways
  - They are full of **haemoglobin**, a protein that binds to oxygen to form oxyhaemoglobin
  - They have **no nucleus** which allows more space for haemoglobin to be packed in
  - The shape of a red blood cell is described as being a **'biconcave disk'** this shape gives them a **large surface area to volume ratio** to maximise diffusion of oxygen in and out

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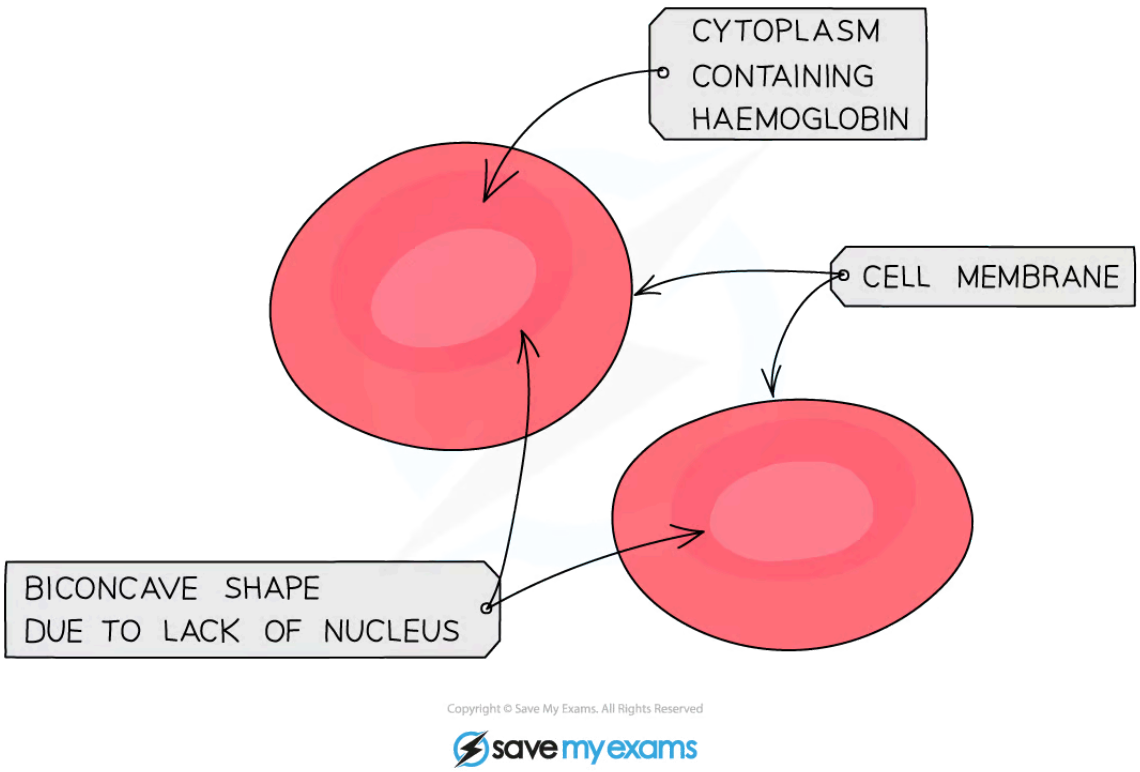

Red blood cells

White Blood Cells

- White blood cells are part of the body's **immune system**, defending against infection by pathogenic microorganisms
- There are two main types, **lymphocytes and phagocytes**
- **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**
- **Phagocytes:**
  - Carry out **phagocytosis** by **engulfing and digesting pathogens**
  - Phagocytes have a sensitive cell surface membrane that can detect chemicals produced by pathogenic cells

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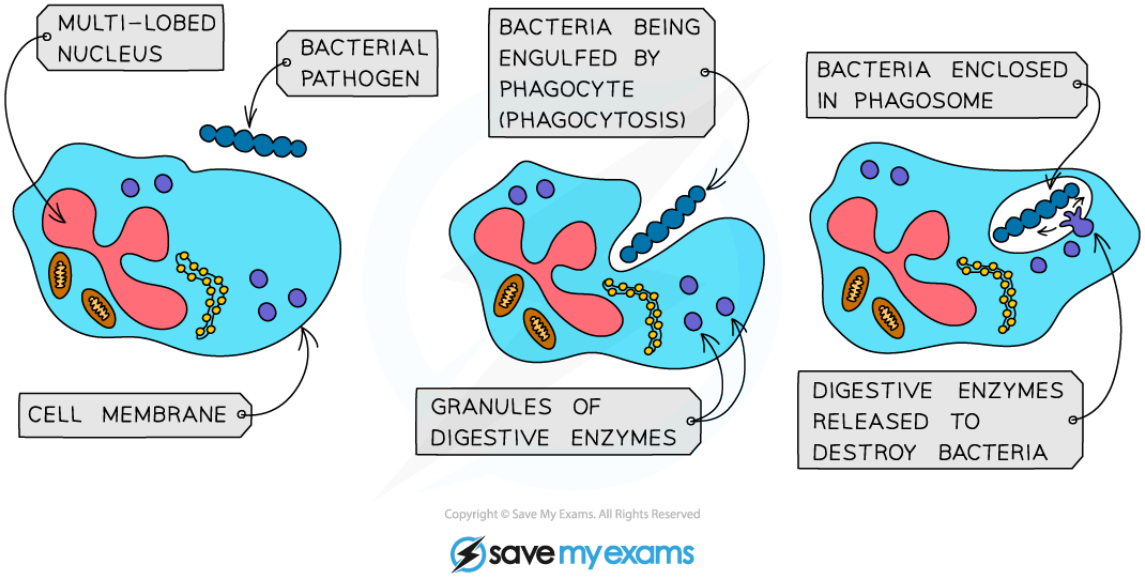
- Once they encounter the pathogenic cell, they will engulf it and **release digestive enzymes** to digest it
- They can be easily recognised under the microscope by their **multi-lobed nucleus** and their **granular cytoplasm**



Phagocytosis

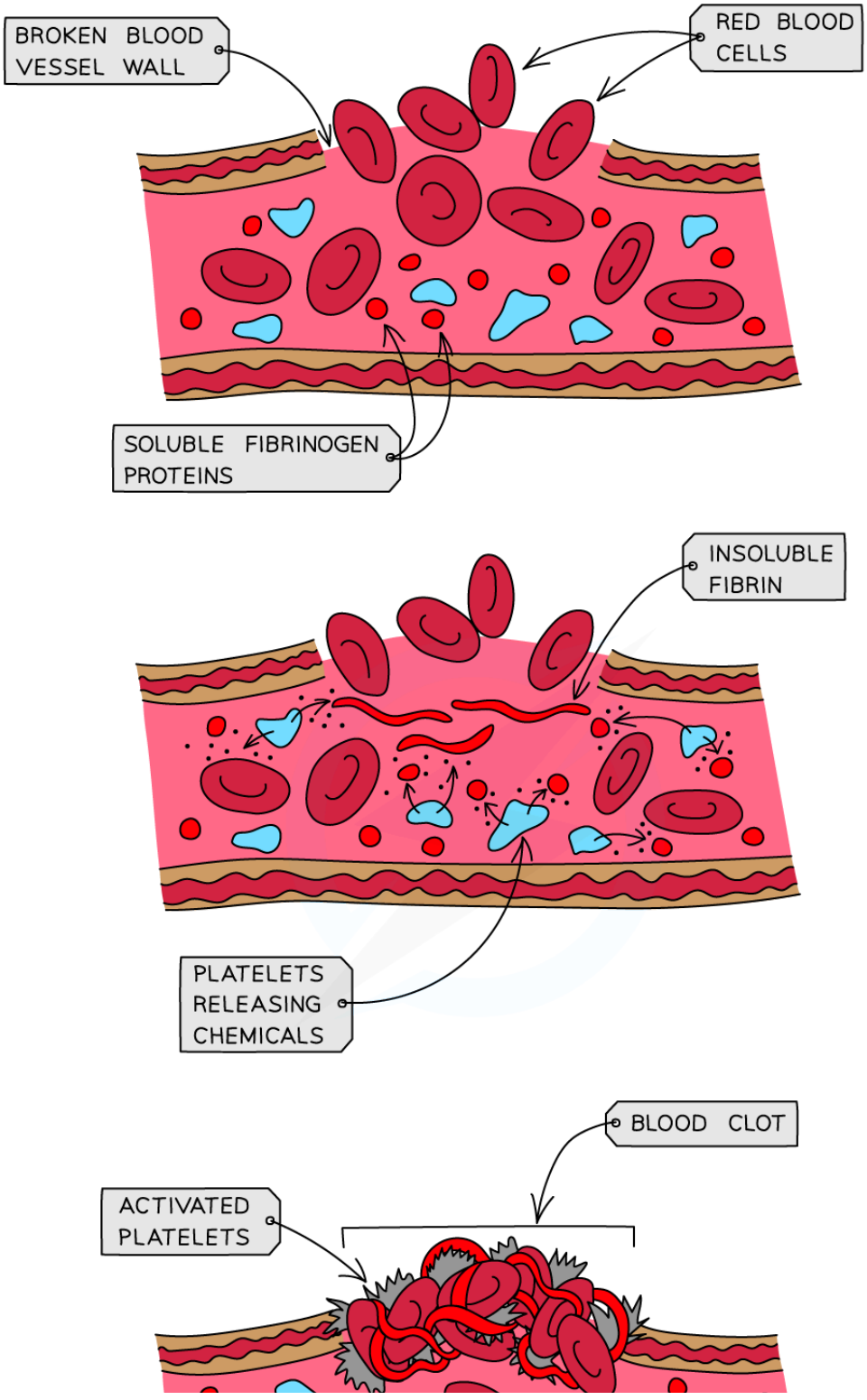
Platelets

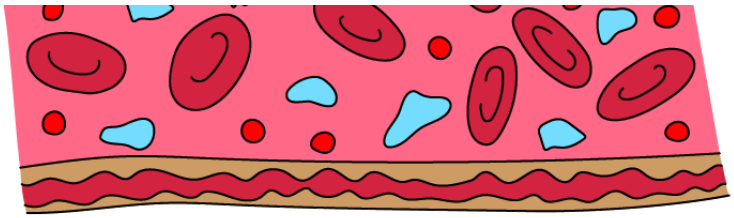
- **Platelets** are involved in **helping the blood clot**
- Platelets are **fragments of cells that are involved in blood clotting** and forming scabs where the skin has been cut or punctured
  - When the skin is broken (i.e. there is a wound) platelets arrive to stop the bleeding
  - A series of reactions 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
- **Blood clotting is important** because:
  - 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

Your notes





How the blood clots

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Plasma

- **Plasma** is a straw coloured liquid which the other components of the blood are suspended within
- Plasma is important for the transport of many substances including:
  - **Carbon dioxide –** the waste product of **respiration,** dissolved in the plasma as hydrogencarbonate ions and transported from **respiring cells** to the **lungs**
  - **Digested food and mineral ions –** dissolved particles absorbed from the small intestine and delivered to **requiring cells** around the body
  - **Urea** - the waste substance produced in the **breakdown of proteins** by the liver. Urea is dissolved in the plasma and transported to the **kidneys**
  - **Hormones – chemical messengers** released into the blood from the endocrine organs (glands) and delivered to **target tissues/organs of the body**
  - **Heat energy –** created in **respiration** (an exothermic reaction), heat energy is transferred to **cooler parts** of the body or to the **skin** where heat can be lost

Blood Vessels

- There are three main types of blood vessel:
  - **Arteries**
  - **Veins**
  - **Capillaries**
- Smaller vessels that branch off from arteries are called **arterioles** (small arteries) and those that branch into veins are called **venules** (small veins)
- Each vessel has a particular function and is **specifically adapted** to carry out that function efficiently

Arteries

- Key features:
  - Carry blood at **high pressure away from the heart**
  - Carry **oxygenated** blood (except the pulmonary artery)
  - Have **thick muscular walls** containing **elastic fibres**
  - Have a **narrow lumen**
  - Blood flows through at a **fast** speed
- The structure of an artery is **adapted to its function** in the following ways
  - Thick muscular walls containing elastic fibres **withstand the high pressure** of blood and **maintain** the blood pressure as it **recoils** after the blood has passed through
  - A narrow lumen also helps to **maintain high pressure**

Veins

- Key features:
  - Carry blood at **low pressure towards the heart**
  - Carry **deoxygenated** blood (other than the pulmonary vein)
  - Have **thin** walls
  - Have a **large lumen**
  - Contain **valves**
  - Blood flows through at a **slow speed**
- The structure of a vein is **adapted to its function** in the following ways:
  - A large lumen **reduces resistance** to blood flow under **low pressure**
  - Valves **prevent the backflow** of blood as it is under low pressure


Your notes

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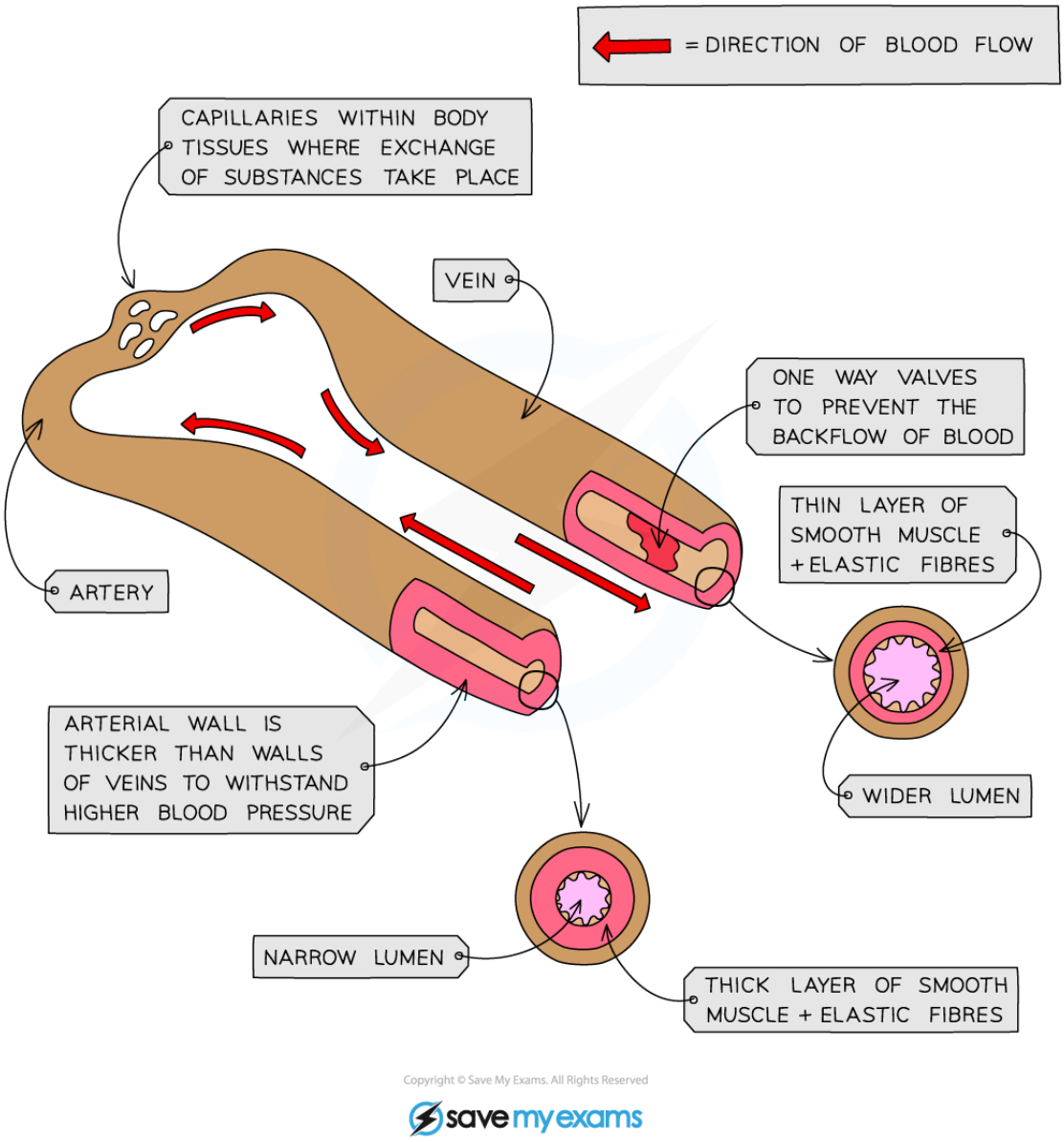

Comparing the structure of arteries and veins

Capillaries

- Key features:
  - Carry blood at **low pressure** within tissues

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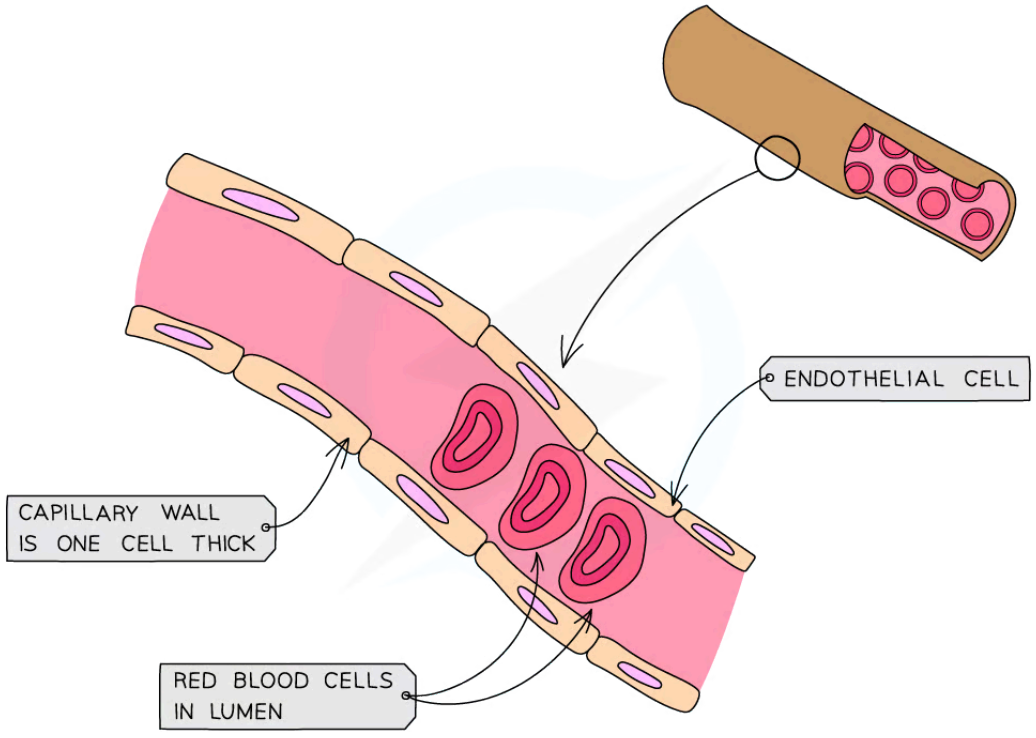
- Carry **both oxygenated and deoxygenated blood**
- Have walls that are **one cell thick**
- Have 'leaky' walls
- Speed of blood flow is **slow**

- The structure of a capillary is **adapted to its function** in the following ways:
  - Capillaries have walls that are **one cell thick** (short diffusion distance) so substances **can easily diffuse** in and out of them
  - The 'leaky' walls **allow blood plasma to leak out and form tissue fluid** surrounding cells



Structure of a capillary

Arterioles and venules

- As arteries get further away from the heart, they **divide more** and 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**

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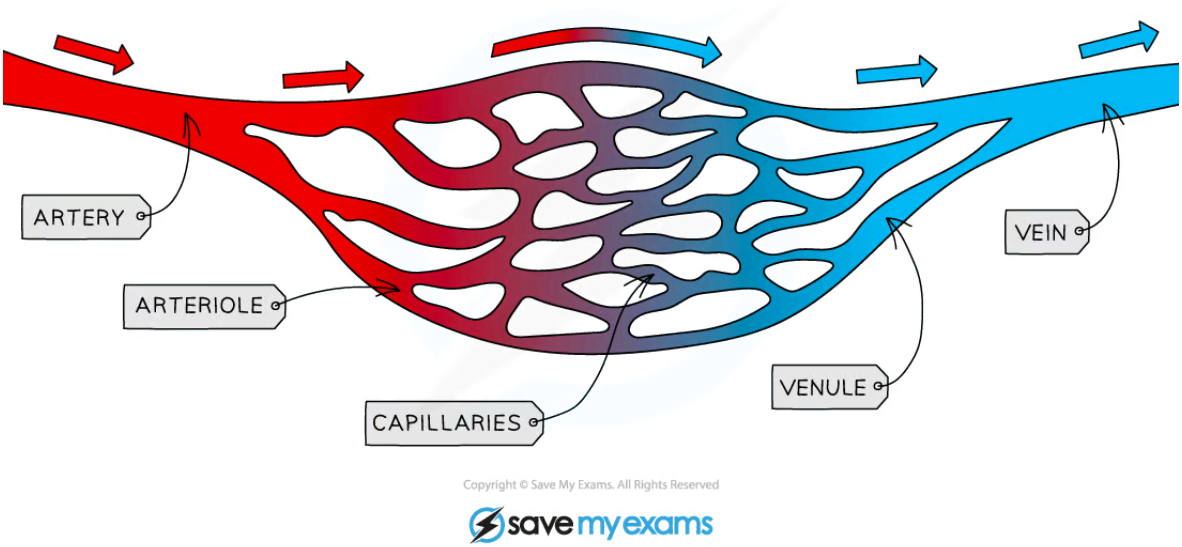


The blood vessel network

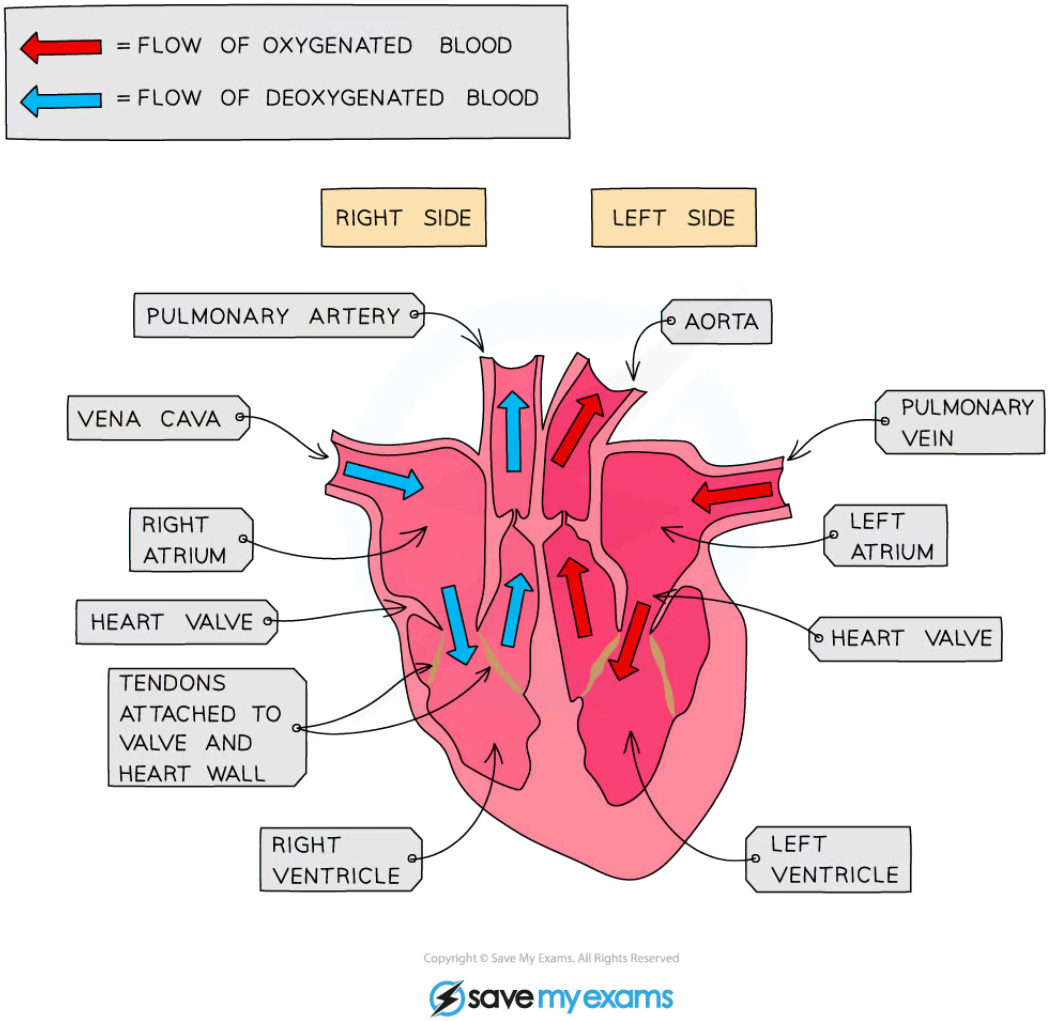
The Circulatory System


Your notes

The Heart

- The heart organ is a **double pump**
  - **Oxygenated blood** from the lungs enters the **left** side of the heart and is pumped **to the rest of the body (the systemic circuit)**
    - **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**,
  - **Deoxygenated blood** from the body enters the **right** side of the heart and is pumped **to the lungs (the pulmonary circuit)**
    - The right ventricle is pumping blood at lower pressure to the **lungs**
  - A muscle wall called the **septum** separates the two sides of the heart
- Blood is pumped **towards** the heart in **veins** and **away** from the heart in **arteries**
- The **coronary arteries** supply the **cardiac muscle tissue** of the heart with oxygenated blood
  - As the heart is a muscle it needs a constant supply of oxygen (and glucose) for aerobic respiration to release energy to allow continued muscle contraction
- **Valves** are present to **prevent blood flowing backwards**

Your notes



Structure of the Heart

The pathway of blood through the heart

- **Deoxygenated blood** coming from the body flows through the **vena cava** and into the **right atrium**
- The **atrium contracts** and the blood is forced through the **tricuspid (atrioventricular) valve** into the **right ventricle**
- The ventricle **contracts** and the blood is pushed through the **semilunar valve** into the **pulmonary artery**
- The blood travels to the **lungs** and moves through the capillaries past the alveoli where **gas exchange** takes place

- **Low pressure** blood flow on this side of the heart prevents damage to the capillaries in the lungs
- **Oxygenated blood** returns via the **pulmonary vein** to the **left atrium**
- The **atrium contracts** and forces the blood through the **bicuspid (atrioventricular) valve** into the **left ventricle**
- The ventricle **contracts** and the blood is forced through the **semilunar valve** and out through the **aorta**
  - Thicker muscle walls of the left ventricle produce a **high enough pressure** for the blood to travel around the whole body

Examiner Tips and Tricks

Remember : **A**rteries carry blood **A**way from the heart. When explaining the route through the heart we usually describe it as one continuous pathway with only one atrium or ventricle being discussed at a time, but remember that in reality, both atria contract at the same time and both ventricles contract at the same time. Also, the heart is **labelled as if it was in the chest** so the left side of a diagram is actually the right hand side and vice versa

The Circulatory System

- The **circulatory system** consists of a closed network of **blood vessels** connected to **the heart**
  - **Oxygenated** 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
  - In the organs, **respiring cells** use up the oxygen from the blood
  - The **capillaries** widen to **venules** and finally **veins** as they move away from the organs
  - **Veins** carry **deoxygenated** blood **back** towards the heart
- A different network of **lymphatic vessels** collect all the excess tissue fluid that leaks out of the capillaries and delivers it back to the **circulatory system**


Your notes

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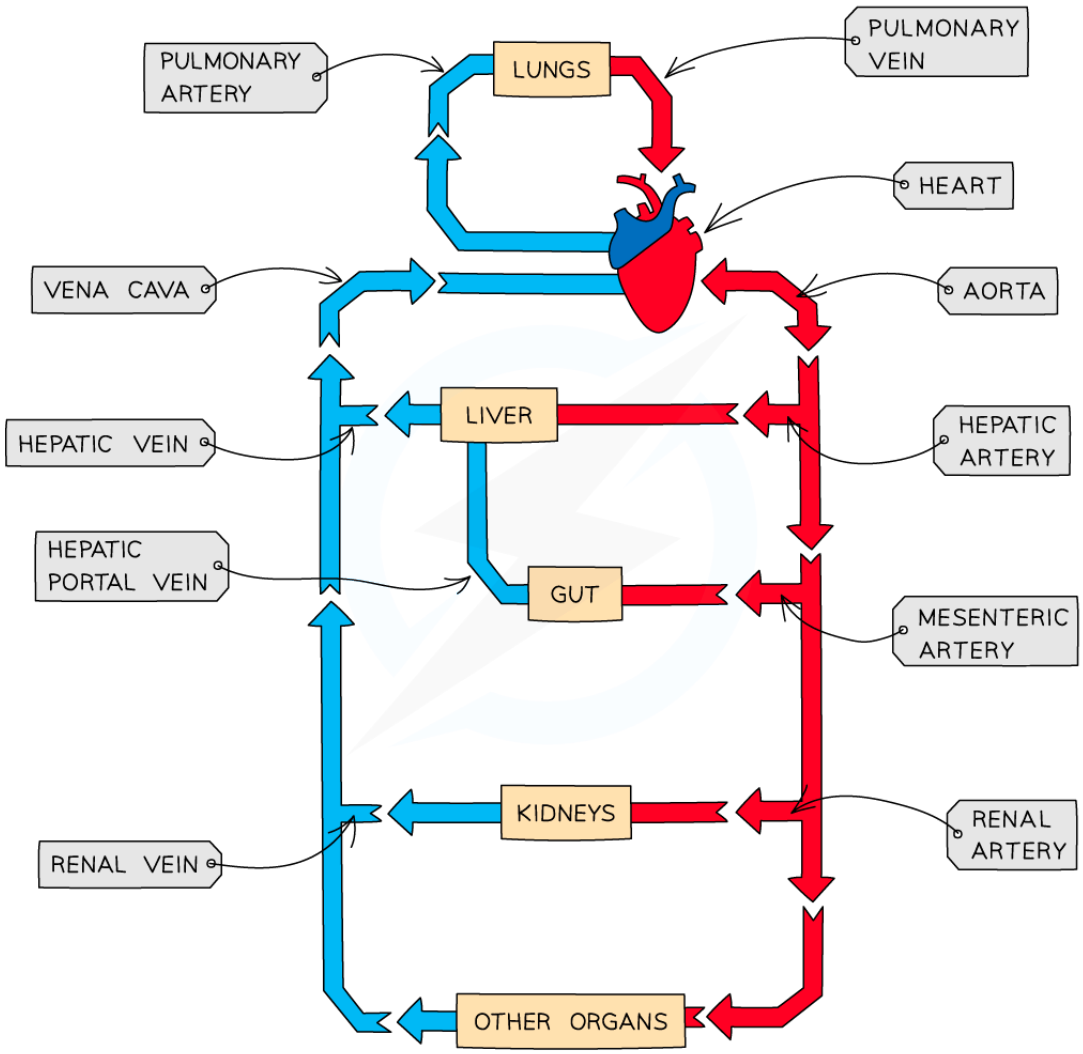

The circulatory system

Main Blood Vessels of the Circulatory System 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

Your notes

Cardiac Output

- **Cardiac output** (CO) is the term used to describe the volume of blood that is pumped by the heart (the left and right ventricle) per unit of time
  - An average adult has a cardiac output of roughly 4.7 litres of blood per minute when at **rest**
- Individuals who are **fitter** often have **higher cardiac outputs** due to having thicker and stronger ventricular muscles in their hearts
- Cardiac output **increases** when an individual is **exercising**
  - In order to supply oxygen and glucose for respiration
- The CO of an individual can be calculated using their heart rate and stroke volume
  - **Heart rate** is the number of times a heart beats per minute
  - **Stroke volume** is the volume of blood pumped out of the left ventricle during one cardiac cycle

Calculating cardiac output

- Cardiac output is found by multiplying the heart rate by the stroke volume:

$$\textbf{Cardiac output } (cm^3 min^{-1}) = \textbf{heart rate (bpm) x stroke volume } (cm^3)$$

- The equation can be rearranged to find the heart rate and stroke volume if require