



## 9 TRANSPORT IN ANIMALS

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- 9.4 BLOOD VESSELS
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[VIEW EXAM QUESTIONS](#)

YOUR NOTES



## 9.1 CIRCULATION IN ANIMALS

## The Circulatory System

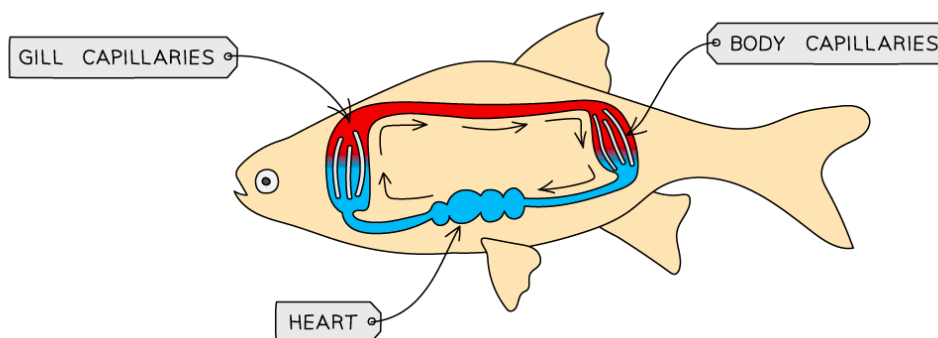
- The circulatory system is a system of blood vessels with a pump and valves to ensure one-way flow of blood



EXTENDED ONLY

## Circulation in Different Animals

- 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**



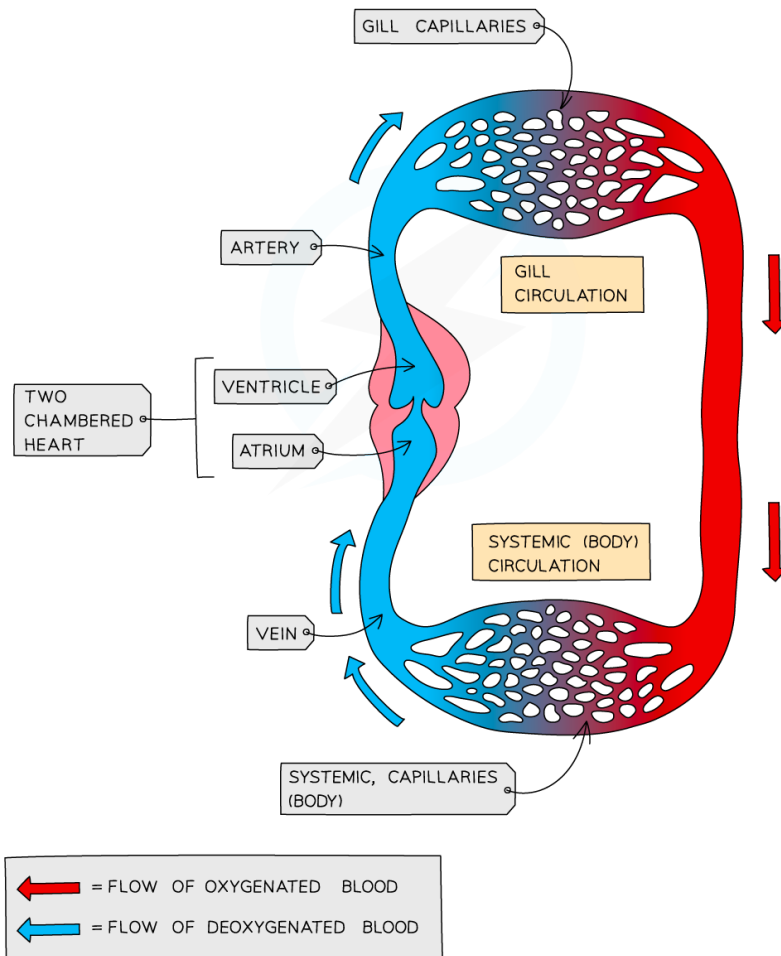
## 9 TRANSPORT IN ANIMALS

### 9.1 CIRCULATION IN ANIMALS cont...

YOUR NOTES



EXTENDED ONLY cont...



The single circulatory system in fish

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

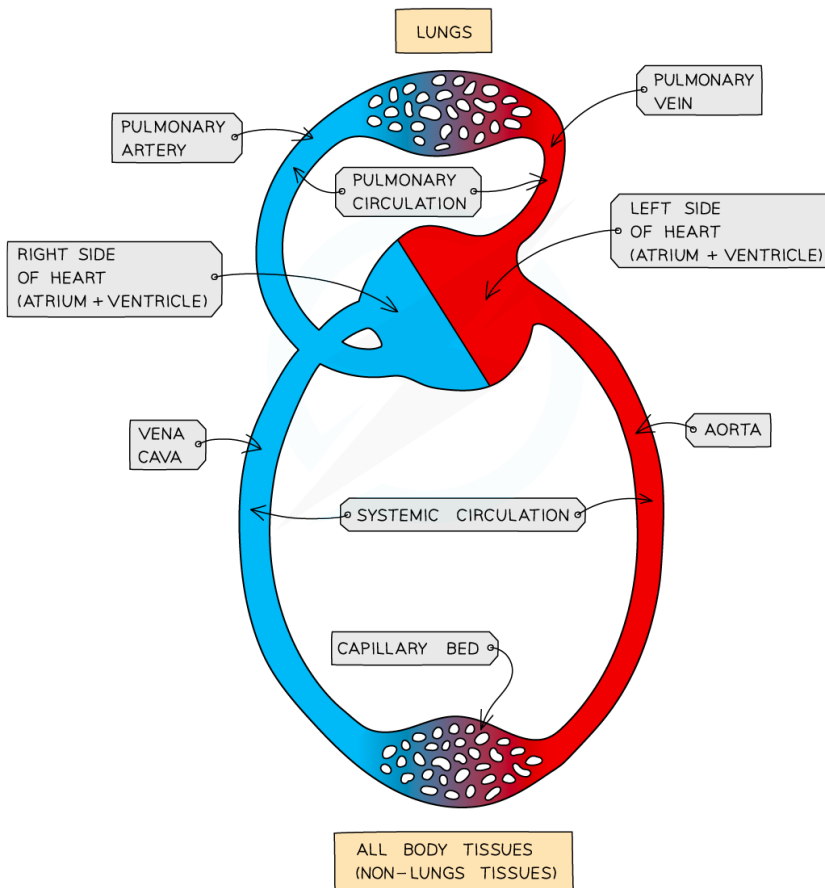
## 9 TRANSPORT IN ANIMALS

## 9.1 CIRCULATION IN ANIMALS cont...

YOUR NOTES



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The double circulatory system in mammals

### Advantages of a Double Circulation

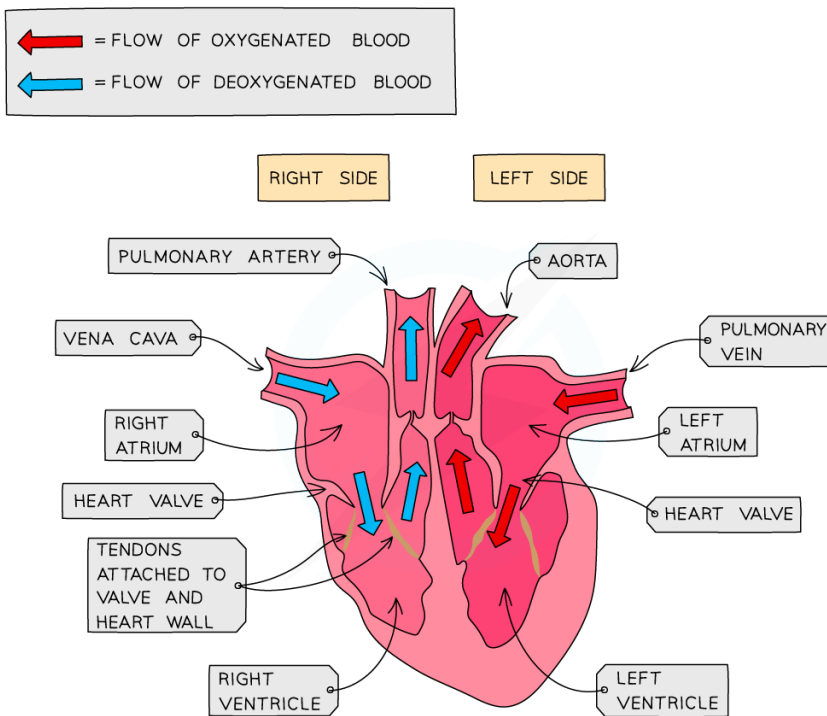
- Blood travelling through the small capillaries in the lungs **loses a lot of pressure** that was given to it by the pumping of the heart, meaning it **cannot travel as fast**
- By returning the blood to the heart after going through the lungs its **pressure can be raised** again before sending it to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

## 9 TRANSPORT IN ANIMALS

### 9.2 THE HEART

#### Structure: Basics

- 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 is supplied with blood by the **coronary arteries**



Structure of the heart



#### EXAM TIP

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

YOUR NOTES



## 9 TRANSPORT IN ANIMALS

### 9.2 THE HEART cont...



YOUR NOTES

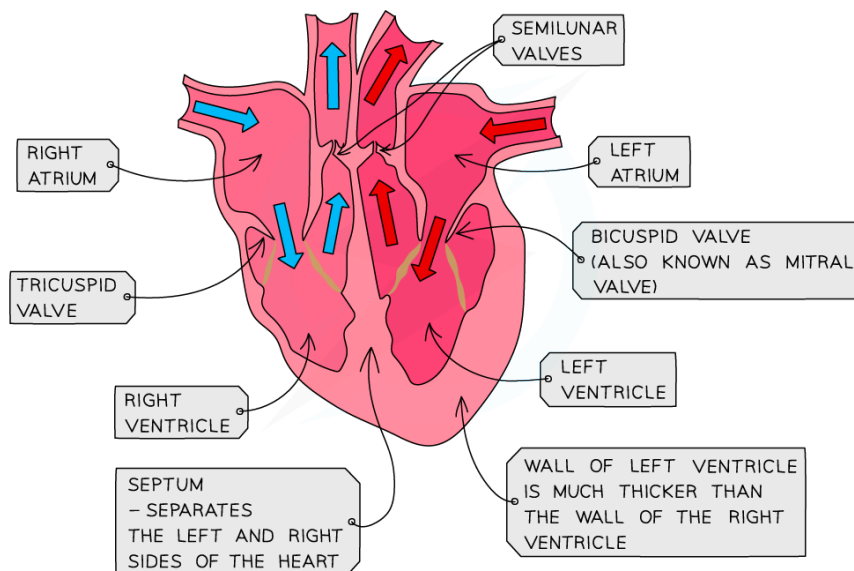


EXTENDED ONLY

### Structure

- 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**

 = FLOW OF OXYGENATED BLOOD  
 = FLOW OF DEOXYGENATED BLOOD



Structure of the heart showing the different valves



## 9 TRANSPORT IN ANIMALS

## 9.2 THE HEART cont...

YOUR NOTES



EXTENDED ONLY cont...

### The Function of the Valves

- The basic function of all valves is to **prevent blood flowing backwards**
- There are two sets of valves in the heart:
  - The **atrioventricular valves** separate the atria from the ventricles
  - The valve in the right side of the heart is called the **TRICUSPID** and the valve in 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 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

### Pathway of Blood through the Heart

- **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 **semi lunar 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 **semi lunar valve** in the aorta prevents the blood flowing back down into the heart



## 9 TRANSPORT IN ANIMALS

## 9.3 HEART DISEASE &amp; EXERCISE

YOUR NOTES



## Exercise &amp; Heart Rate

- 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



EXTENDED ONLY

## Why does Heart Rate Increase during Exercise?

- So that **sufficient blood** is taken to the working muscles to provide them with enough **nutrients and oxygen** for **increased respiration**
- An increase in heart rate also allows for **waste products to be removed 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
- It is also likely that muscle cells have been respiring **anaerobically** during exercise and so have built up an **oxygen debt**
- This needs to be 'repaid' following exercise and so the heart continues to beat faster to ensure that **extra oxygen is still being delivered to muscle cells**

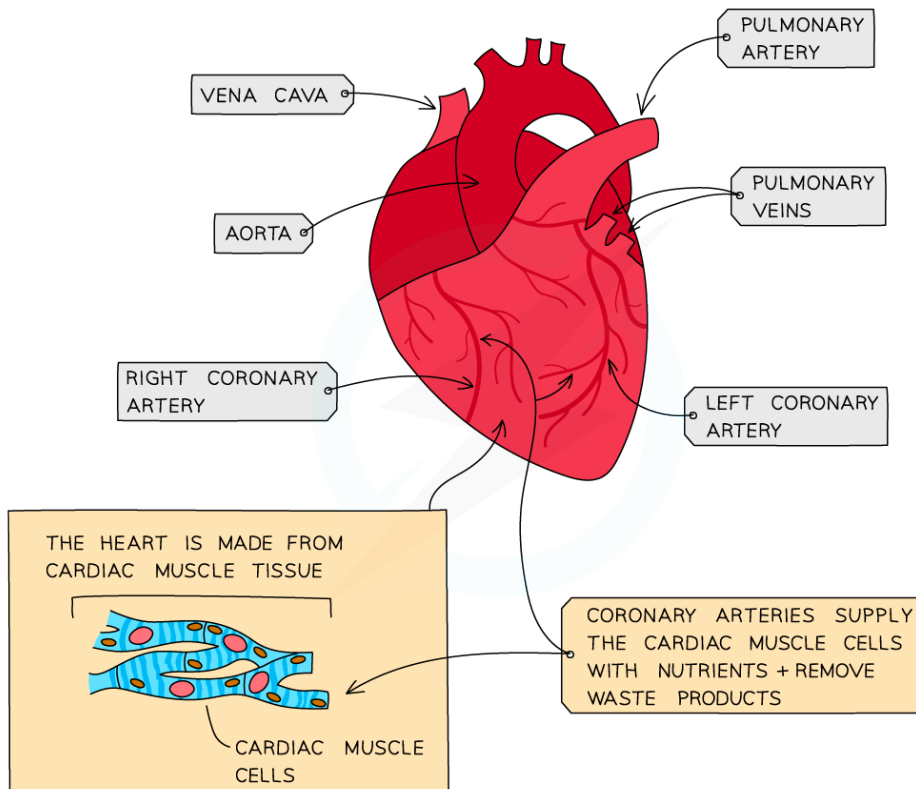
## 9 TRANSPORT IN ANIMALS

### 9.3 HEART DISEASE & EXERCISE cont...

YOUR NOTES



#### Coronary Heart Disease



#### The coronary arteries

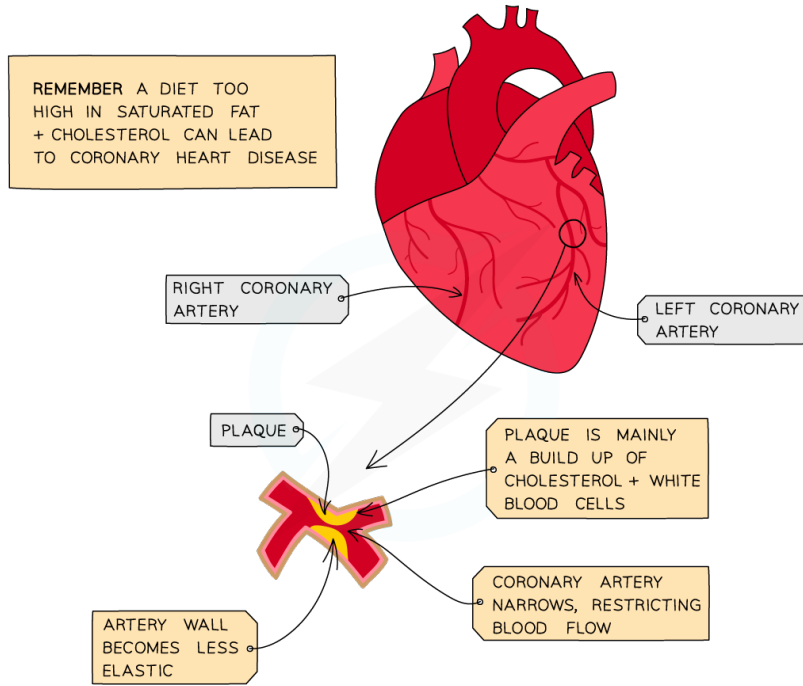
- The heart is made of **muscle cells** that need their own supply of blood to deliver oxygen, glucose and other nutrients and remove carbon dioxide and other waste products
- The blood is supplied by the **coronary arteries**
- If a coronary artery becomes partially or completely **blocked by fatty 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**



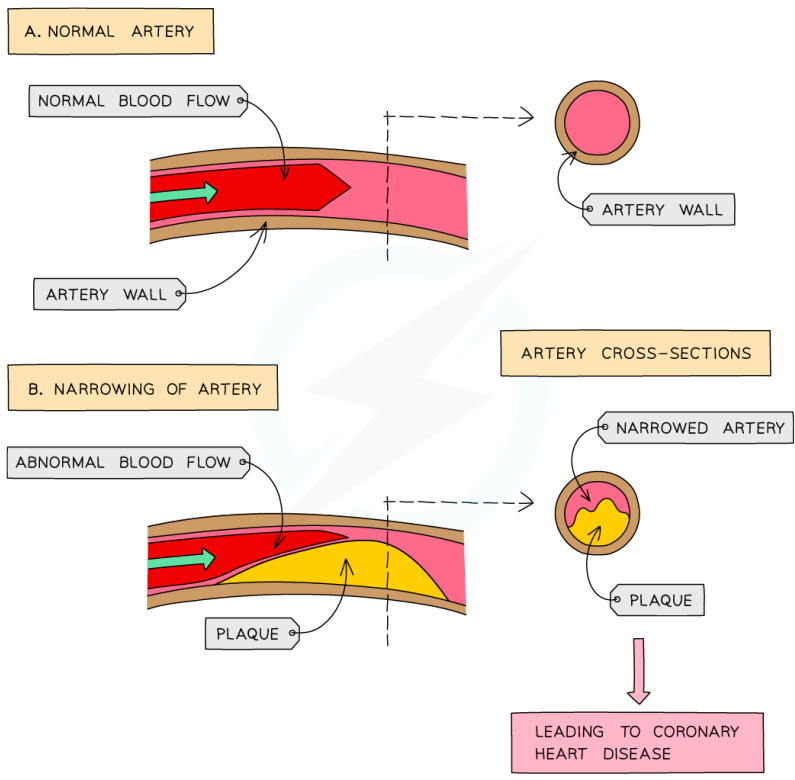
9 TRANSPORT IN ANIMALS

9.3 HEART DISEASE & EXERCISE cont...

YOUR NOTES



Buildup of plaque in the coronary arteries



Effect of narrowing of arteries

## 9 TRANSPORT IN ANIMALS

### 9.3 HEART DISEASE & EXERCISE cont...

YOUR NOTES



#### Risk Factors for Coronary Heart Disease

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



EXTENDED ONLY

#### Prevention & Treatment

Reducing the risks of developing coronary heart disease:

- **Quit smoking**
- **Reduce animal fats** in diet 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

## 9 TRANSPORT IN ANIMALS

## 9.3 HEART DISEASE &amp; EXERCISE cont...

YOUR NOTES



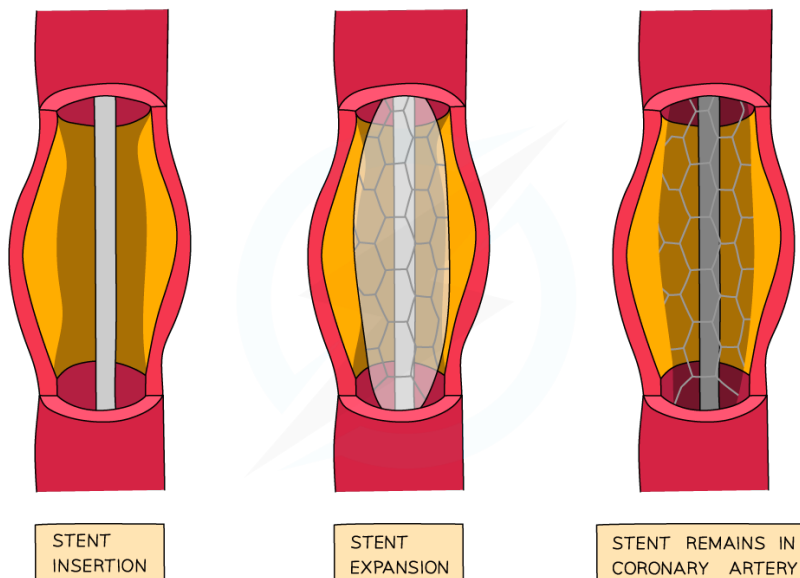
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**Treatment of coronary heart disease:**

- **Aspirin** can be taken daily to **reduce the risk of blood clots** forming in arteries
- Surgical treatments include:

**1. Angioplasty**

- A narrow catheter (tube) is threaded through the groin up to the blocked vessel
- A tiny balloon inserted into the catheter is pushed up to the blocked vessel and then inflated
- This flattens the plaque against the wall of the artery, clearing the blockage
- To keep the artery clear, a **stent** (piece of metal / plastic mesh) is also inserted which pushes against the wall of the artery
- Sometimes the stent is coated with a drug that slowly releases medication to prevent further build up of plaque



Inserting a stent into a blocked artery

 9 TRANSPORT IN ANIMALS

## 9.3 HEART DISEASE &amp; EXERCISE cont...

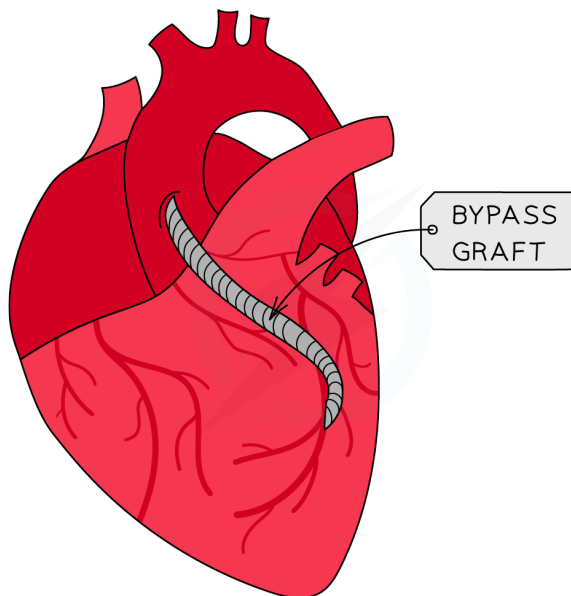
YOUR NOTES



EXTENDED ONLY cont...

**2. Coronary bypass surgery**

- A piece of blood vessel is taken from the patient's leg, arm, or chest and used to **create a new passage for the flow of blood** to the cardiac muscle, bypassing the blocked area
- The number of bypass grafts gives rise to the name of the surgery, so a 'triple heart bypass' would mean three new bypass grafts being attached



Coronary bypass graft



## 9 TRANSPORT IN ANIMALS

## 9.4 BLOOD VESSELS

YOUR NOTES



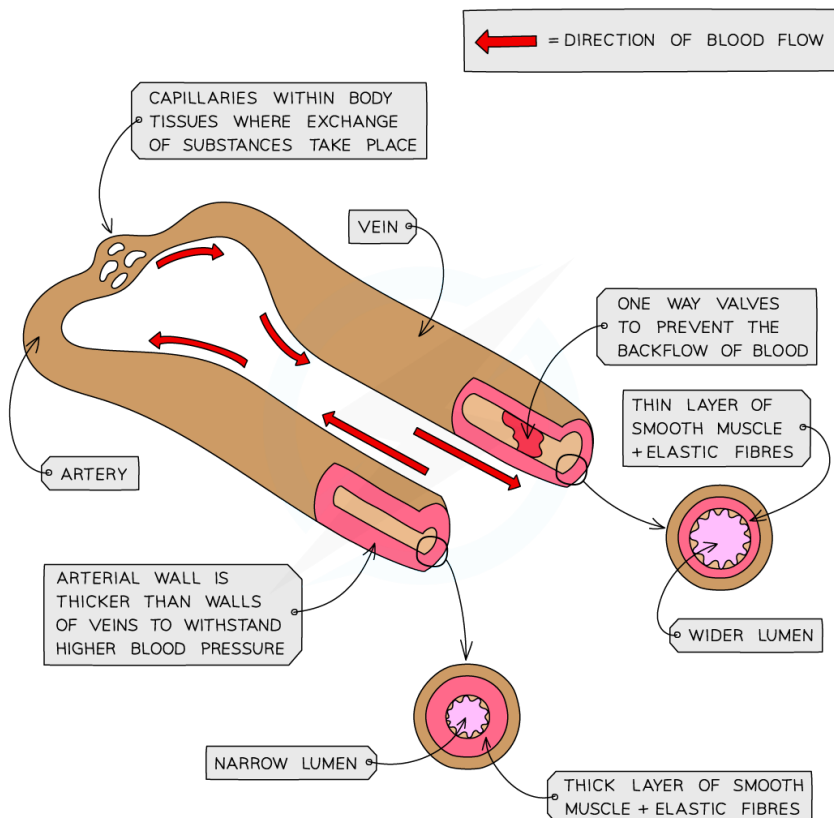
## Arteries, Veins &amp; Capillaries

## Arteries

- Carry blood at **high pressure away from the heart**
- Carry **oxygenated** blood (other than the pulmonary artery)
- Have **thick muscular walls** containing elastic fibres
- Have a **narrow lumen**
- Speed of flow is **fast**

## Veins

- 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**
- Speed of flow is **slow**



Comparing arteries and veins



## 9 TRANSPORT IN ANIMALS

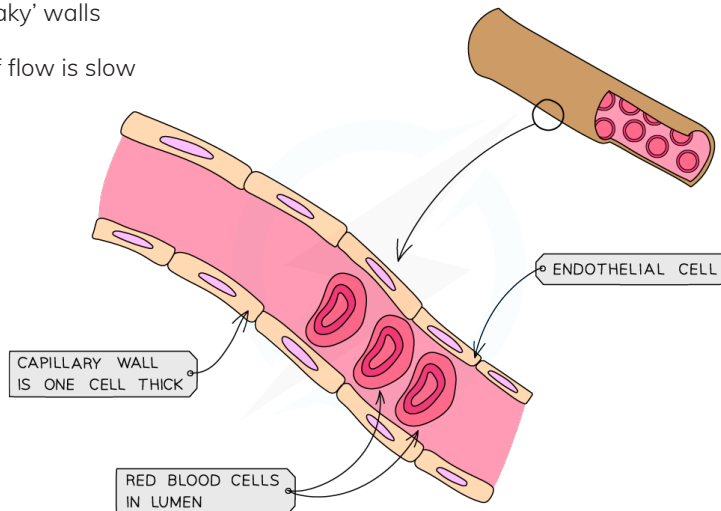
### 9.4 BLOOD VESSELS cont...

YOUR NOTES



#### Capillaries

- Carry blood at low pressure within tissues
- Carry both oxygenated and deoxygenated blood
- Have walls that are one cell thick
- Have 'leaky' walls
- Speed of flow is slow



Structure of a capillary



EXTENDED ONLY

#### How Structure of Blood Vessels is Adapted to their Function

##### Arteries

- Have thick muscular walls containing elastic fibres **to withstand 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**

## 9 TRANSPORT IN ANIMALS

## 9.4 BLOOD VESSELS cont...

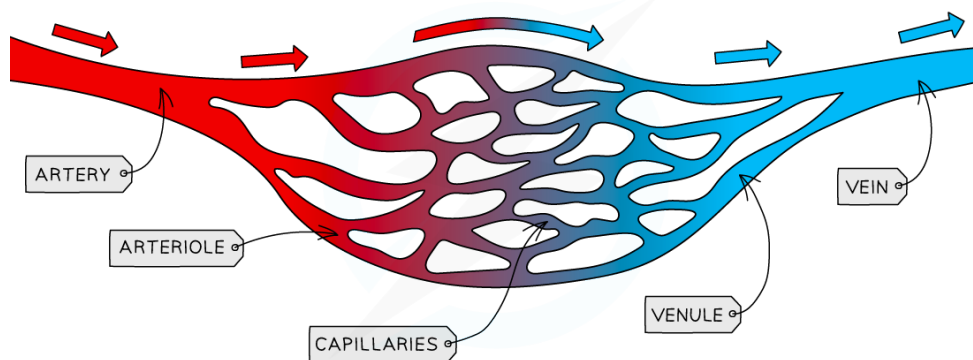
YOUR NOTES



EXTENDED ONLY

## Arterioles &amp; 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**



The blood vessel network

## Shunt Vessels

- Sometimes the cardiovascular system need to redistribute the blood to specific areas of the body
- For example:
  - During exercise, more of it goes to the working muscles and less of it goes to other body organs such as the digestive system
  - When we are hot, more blood flows through the surface of the skin and when we are cold less blood flows through the surface of the skin
- This redirection of blood flow is caused by the use of a vascular shunt vessel
- The shunt vessels can open or close to control the amount of blood flowing to a specific area

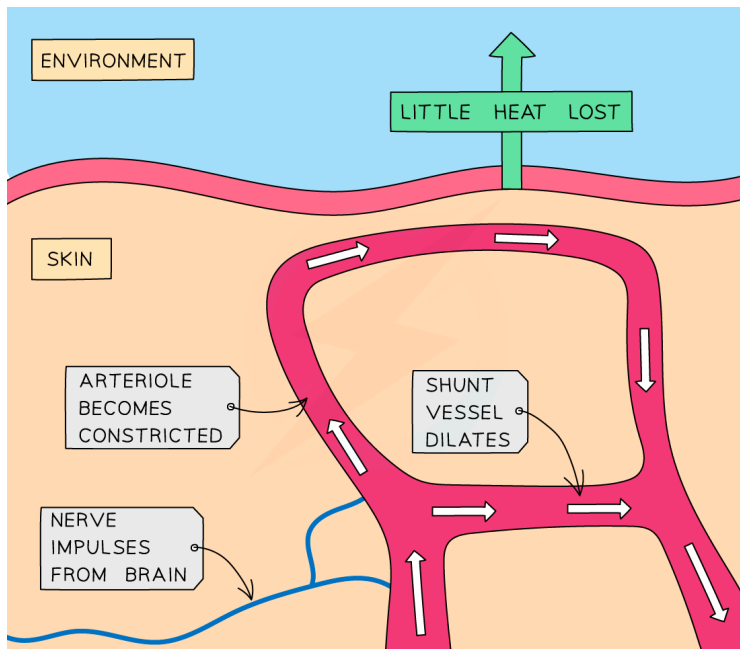
9 TRANSPORT IN ANIMALS

9.4 BLOOD VESSELS cont...

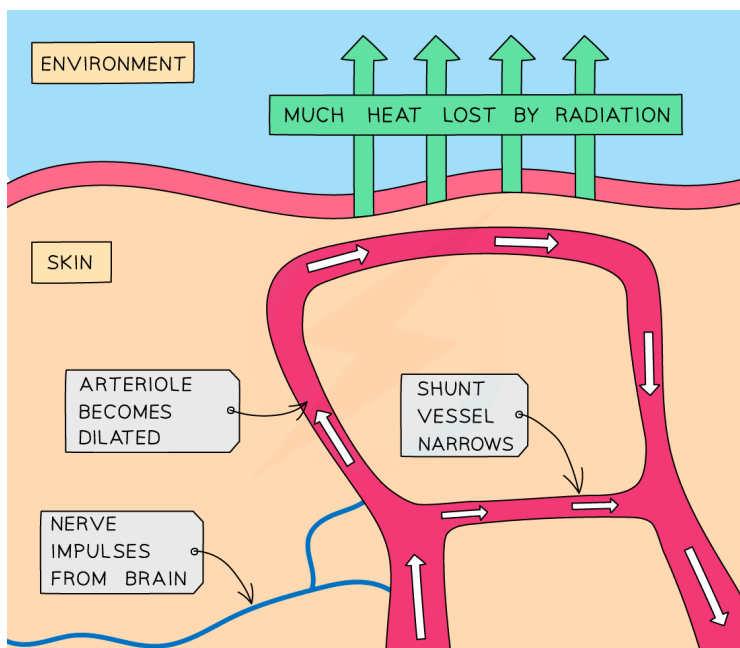
YOUR NOTES



EXTENDED ONLY cont...



A shunt vessel in the skin when we are cold



A shunt vessel in the skin when we are hot



9 TRANSPORT IN ANIMALS

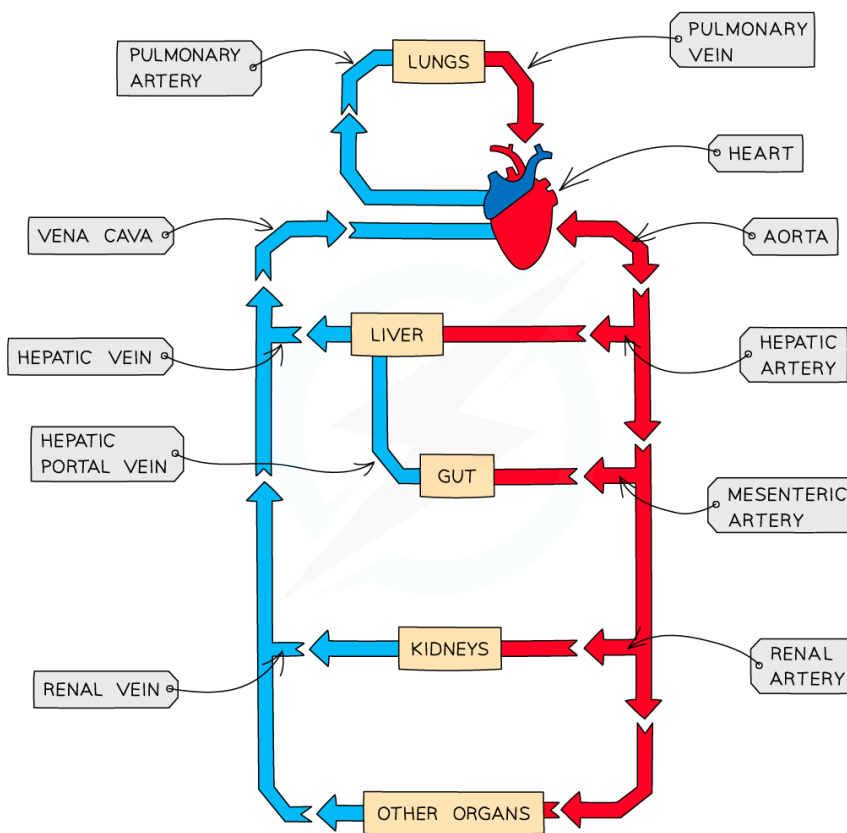
9.4 BLOOD VESSELS cont...

YOUR NOTES



Circulation around 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 **towards the heart**



The circulatory system

Important Blood Vessels

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

## 9 TRANSPORT IN ANIMALS

## 9.5 THE LYMPHATIC SYSTEM

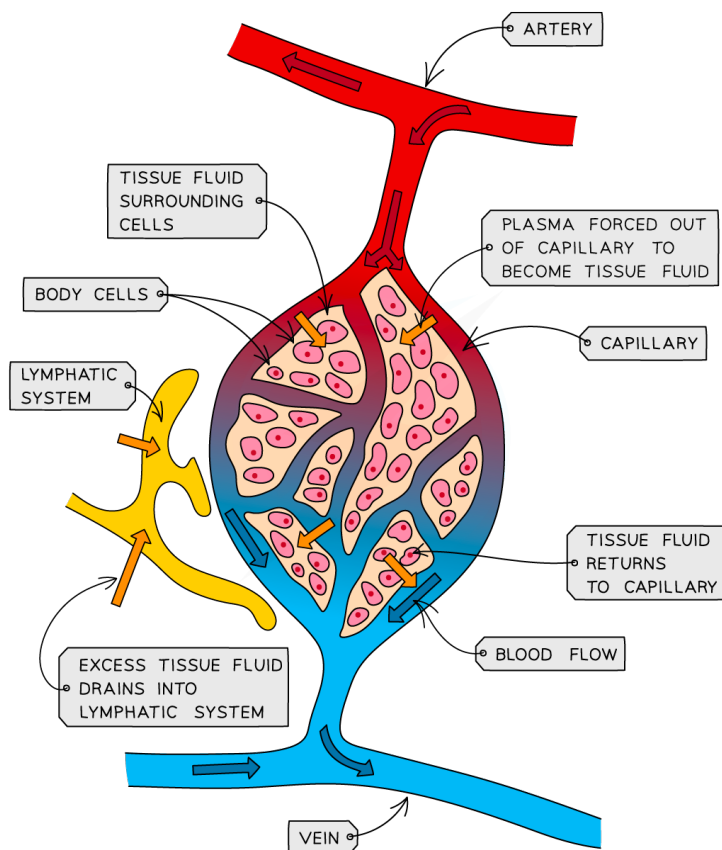
YOUR NOTES



EXTENDED ONLY

## Lymph Fluid

- The walls of the capillaries are so thin that water, dissolved solutes and dissolved gases easily leak out of them / pass through the walls from the plasma into the **tissue fluid** surrounding the cells
- Cells **exchange materials** (such as water, oxygen, glucose, carbon dioxide, mineral ions) **across their cell membranes** with the tissue fluid surrounding them by diffusion, osmosis or active transport
- More fluid leaks out of the capillaries than is returned to them and this excess fluid passes into the lymphatic system and becomes **lymph fluid**



How lymph forms



## 9 TRANSPORT IN ANIMALS

## 9.5 THE LYMPHATIC SYSTEM cont...

YOUR NOTES



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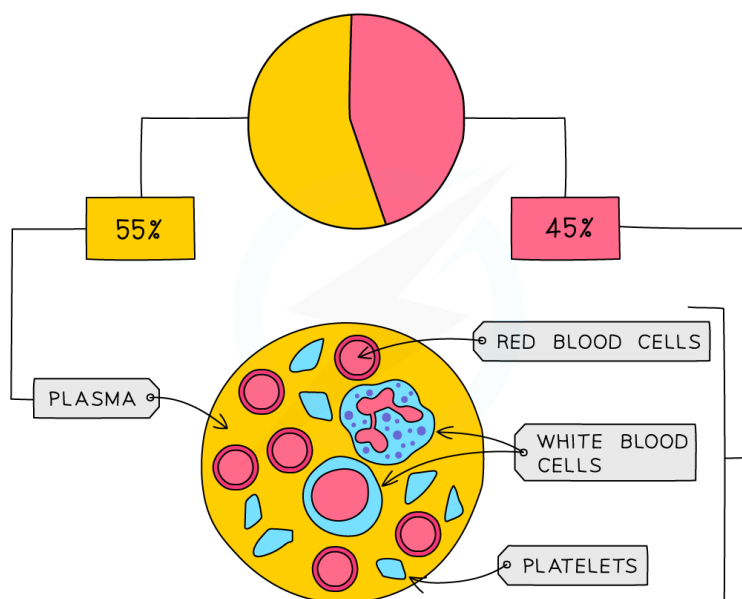
## Lymph Vessels &amp; Nodes

- The lymphatic system is formed from a **series of tubes which flow from tissues back to the heart**
- It connects with the blood system near to the heart, where lymph fluid is **returned** to the blood plasma
- **Lymph nodes** are small clusters of lymphatic tissue found throughout the lymphatic system, especially in the neck and armpits
- Large numbers of **lymphocytes** are found in lymph nodes
- Tissues associated with the lymphatic system, such as **bone marrow**, produce these lymphocytes
- Lymphocytes play an important role in **defending the body against infection**

## 9.6 BLOOD

## Components of Blood

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



Composition of human blood

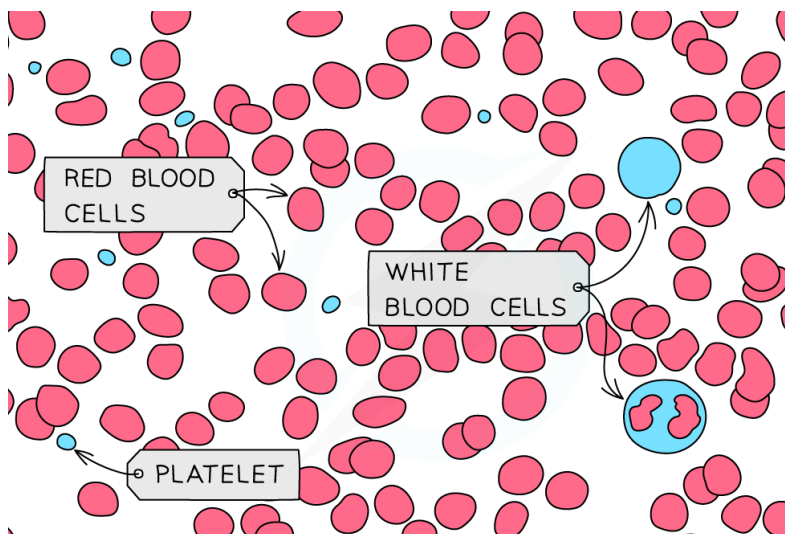
9 TRANSPORT IN ANIMALS

9.6 BLOOD cont...

YOUR NOTES



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



Blood micrograph

## 9 TRANSPORT IN ANIMALS

### 9.6 BLOOD cont...

YOUR NOTES



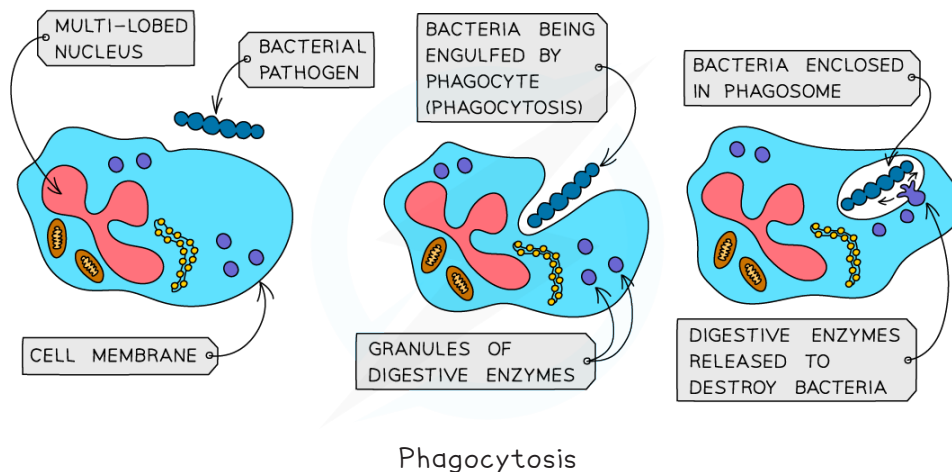
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### Types of White Blood Cell

- 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**



## 9 TRANSPORT IN ANIMALS

## 9.6 BLOOD cont...

YOUR NOTES



## Functions of the Parts of Blood

- **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**



EXTENDED ONLY

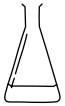
## Blood Clotting

- Platelets are **fragments of cells which are involved in blood clotting** and forming scabs where 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
- 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

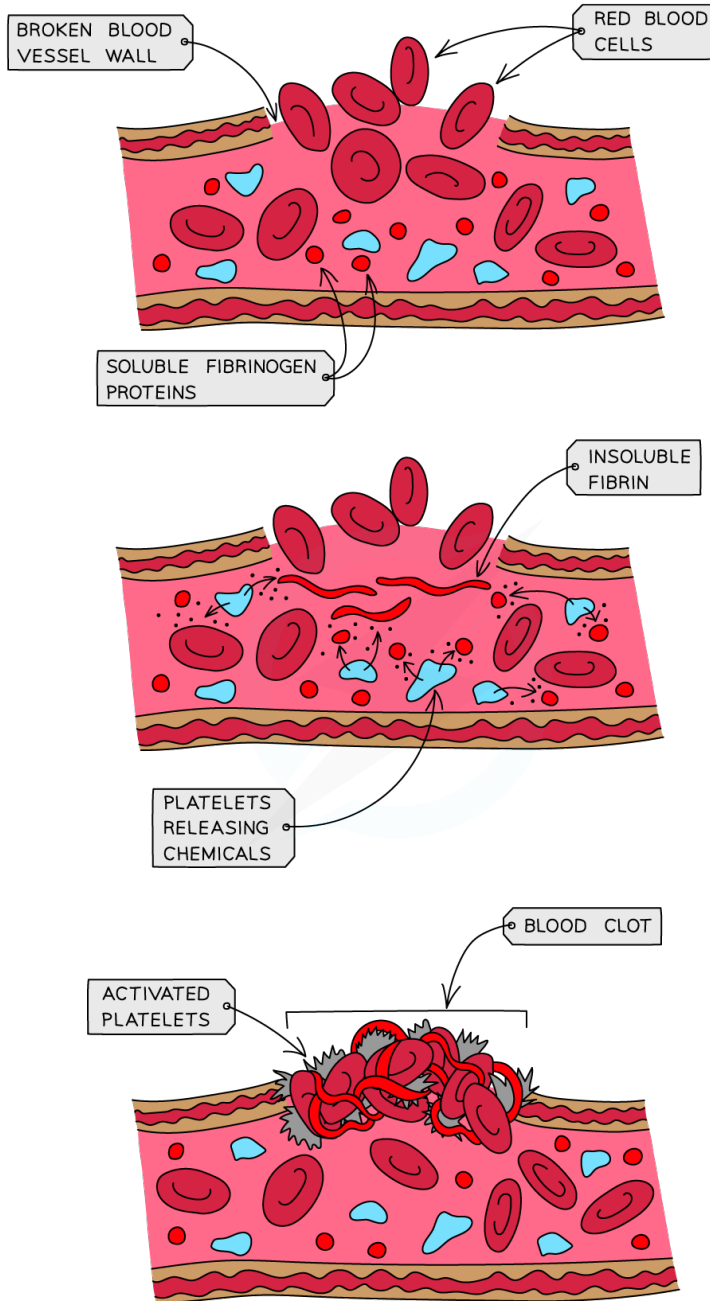
9 TRANSPORT IN ANIMALS

9.6 BLOOD cont...

YOUR NOTES



EXTENDED ONLY cont...



How the blood clots

> NOW TRY SOME EXAM QUESTIONS



## 9 TRANSPORT IN ANIMALS

## EXAM QUESTIONS

YOUR NOTES

**?** QUESTION 1

Which of the following would be found dissolved in the blood plasma of a human?

- A Glucose, urea and hormones
- B Oxygen, urea and starch
- C Carbon dioxide, hormones and haemoglobin
- D Carbon dioxide, oxygen and urea

**?** QUESTION 2

Which blood vessel has a relatively low carbon dioxide concentration, a high oxygen concentration and a low blood pressure?

- A Pulmonary artery
- B Pulmonary vein
- C Aorta
- D Vena cava

**?** QUESTION 3

Which of the following is a method that a doctor would suggest to a patient to reduce their risk of developing coronary heart disease?

- A Inserting a stent into a coronary artery
- B Coronary heart bypass surgery
- C Angioplasty
- D Controlled exercise





## 9 TRANSPORT IN ANIMALS

## EXAM QUESTIONS cont...

YOUR NOTES

**? QUESTION 4**

Which row of the table below shows the correct chambers of the heart, from those with the thinnest walls to those with the thickest?

	thinnest	→	thickest
<b>A</b>	left ventricle	right ventricle	left atrium
<b>B</b>	left atrium	left ventricle	right ventricle
<b>C</b>	right ventricle	left atrium	left ventricle
<b>D</b>	left atrium	right ventricle	left ventricle

**? QUESTION 5**

Which of the following is a correct explanation as to why mammals have a double circulatory system?

- A** To reduce pressure of blood returning from the lungs to supply cells of the body most efficiently with the reactants for respiration
- B** To increase the pressure of blood sent to the lungs to supply cells of the body most efficiently with the reactants for respiration
- C** To increase the pressure of blood returning from the lungs to supply cells of the body most efficiently with the reactants for respiration
- D** To reduce pressure of blood sent to the lungs to supply the cells most efficiently with the products for respiration

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for more questions and revision notes