

JURONG WEST SECONDARY SCHOOL
SECONDARY THREE – SCIENCE BIOLOGY
Chapter 6: TRANSPORT IN HUMANS

Learning Outcomes:

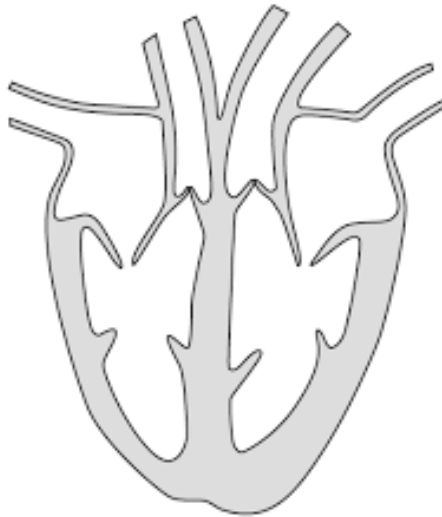
Candidates should be able to:

- (a) name (**label**) the main blood vessels to and from the heart, lungs, liver and kidney
- (b) state the functions of blood
 - red blood cells – haemoglobin and oxygen transport
 - white blood cells – phagocytosis, antibody formation and tissue rejection
 - platelets – fibrinogen to fibrin, causing clotting
 - plasma – transport of blood cells, ions, soluble food substances, hormones, carbon dioxide, urea, vitamins, plasma proteins
- (c) relate the structure of arteries, veins and capillaries to their functions
- (d) describe the structure and function of the heart in terms of muscular contraction and the working of valves (histology of the heart muscle, names of nerves and transmitter substances are **not** required) **Describe and explain the pathway of blood through the heart.**
- (e) describe coronary heart disease in terms of the occlusion of coronary arteries and list the possible causes, such as diet, stress, smoking, and the possible preventative measures

ACTIVITY:

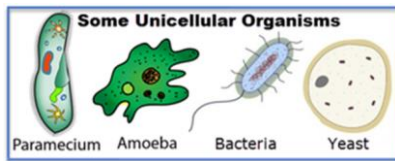
Remember in Secondary two you learnt all about parts of the heart? Let's see how many can you remember! Label the heart with the following labels provided.

1. right atrium
2. right ventricle
3. left atrium
4. left ventricle
5. pulmonary arteries
6. aorta
7. vena cava
8. pulmonary vein



Why the need for circulatory system?

- **Unicellular** organisms do not need a transport system for exchange or distribution of materials. **They rely on diffusion and active transport for movement of substances**
- No part of the cell is far from environment outside.
- Exchange of materials occurs easily by **diffusion**.



- What about multicellular organisms like us?
 - In multicellular organisms, numerous cells are situated deep in the body, far from external environment.
 - Simple diffusion alone **CANNOT** bring enough oxygen and food into the cells, and **CANNOT** remove waste products.
 - **So we need a transport system to transport these efficiently.**

Commented [PLX1]: In multicellular organisms, numerous cells are situated deep in the body, far from external environment. Simple diffusion alone **CANNOT** bring enough oxygen and food materials into the cells, and **CANNOT** remove waste products. So we need a transport system.

Functions of the circulatory system

1. Transporting substances around the body. These include **oxygen, glucose, carbon dioxide, nutrients, water and waste products (urea)**.
2. Controlling body temperature. **More blood can flow to the surface of your skin and release heat.**
3. Protecting the body. Blood contains **cells** and **anti-bodies** that fight infection and clotting agents to stop bleeding.

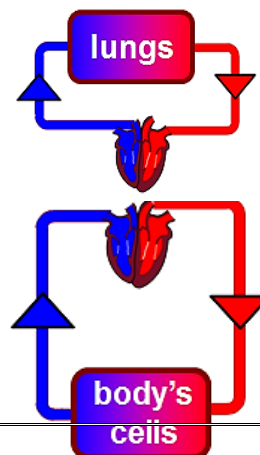
The **double** circulatory system

The **pulmonary circulation** carries:

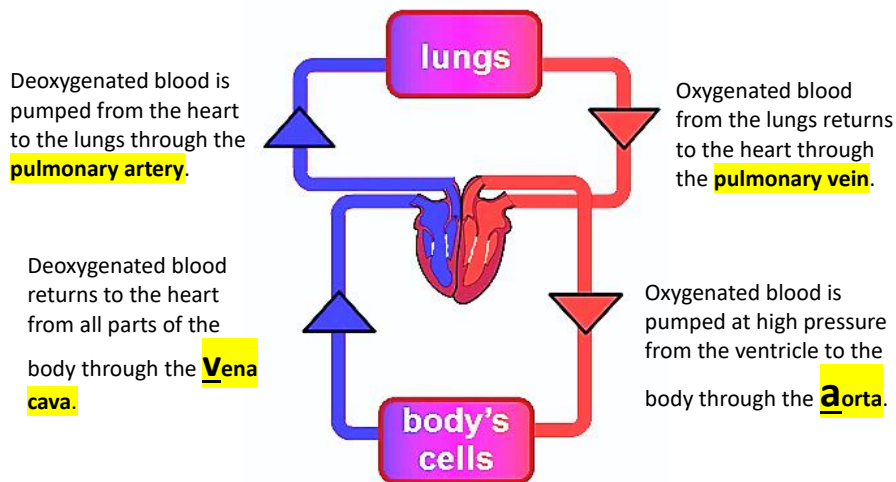
- **deoxygenated** blood from the heart to the lungs
- **oxygenated** blood back from the lungs to the heart, ready to be pumped to the body.

The **systemic circulation** carries:

- **oxygenated** blood to the rest of the body through the arteries
- **deoxygenated** blood back to the heart through the veins.



The circulatory system

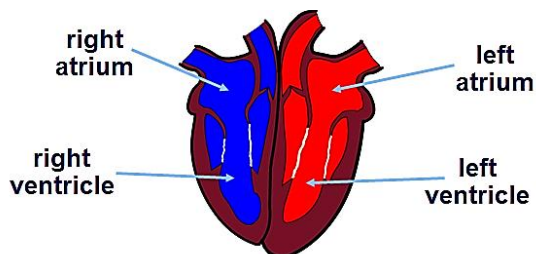


Components of the Circulatory System

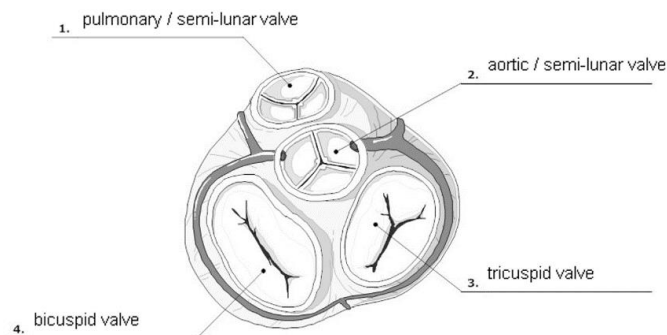
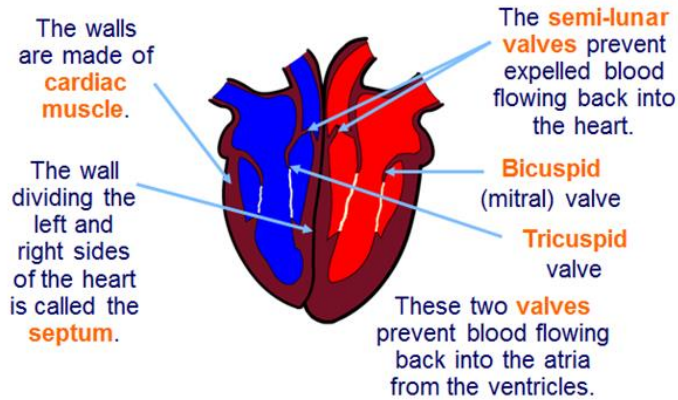
1. The Human **Heart**
2. The **Blood Vessels**

1. The Human Heart

- Located in the **thoracic cavity**, between the two lungs and slightly to the left.
- About the size of a clenched fist.
- Weighs around a ½ pound
- Made up of a special type of muscle i.e. **cardiac muscle**, which **contracts** rhythmically.
- The **four chambers** of the heart have special names:
 - An **upper** chamber is called an **atrium** (plural: **atria**).
 - A **lower** chamber is called a **ventricle**.



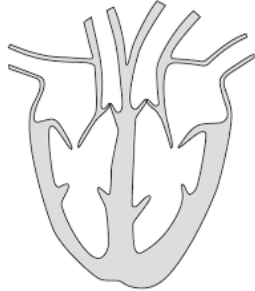
- Here are some other important parts of the heart:



Test yourself!

1	What is the consequence of having a hole in the septum?
	Deoxygenated blood will mix with oxygenated blood. Not enough oxygen transported to body cells. Respiration occurs slower. Lesser energy released. → feel tired / die
2	The left ventricle has the thickest walls. Why?
	To generate and withstand high pressure in order to pump blood from the heart to the rest of the body, which is a longer distance compared to transporting blood to the lungs

Pathway of blood through the heart



1. Deoxygenated blood from various parts of the body is returned to the right atrium via the superior **vena cava** and inferior **vena cava**.
2. **Muscles of the right atrium** contracts. **Pressure** in the **right atrium** is higher than the **right ventricle**. Tricuspid valve **opens**. Blood is **pumped** from the **right atrium** into the **right ventricle**.
3. **Muscles of the right ventricle** contracts. **Tricuspid valve closes** because **pressure** in the right ventricle is higher than pressure in the right atrium. This prevents the **backflow** of blood from the right ventricle back into the right atrium.
4. Blood is pumped into the **pulmonary arch**, which divides into two **pulmonary arteries**, **semi-lunar valves open**.
5. **Semi-lunar valves** in the **pulmonary arch** prevents the **backflow** of blood back into the **right ventricle**.
6. Blood enters the lungs for gaseous exchange. Deoxygenated blood becomes oxygenated (more details in the chapter of Respiration)
7. Oxygenated blood is brought back to **left atrium** via the **pulmonary veins**.
8. **Muscles of the left atrium** contracts, **Pressure** in the **left atrium** is higher than the **left ventricle**. bicuspid valve **opens**. blood is pumped into the **left ventricle**.
9. **Muscles of the left ventricle** contracts, **bicuspid valve closes** because pressure in the left ventricle is higher than pressure in the left atrium. This prevents the **backflow** of blood from the left ventricle back into the left atrium.
10. Blood is pumped out from the **left ventricle** into the **aorta**.
11. **Semi-lunar valves** in **aorta** prevent backflow of blood back into **left ventricle**.
12. **Blood is distributed to the rest of the body via the aorta. Blood is distributed to the rest of the body via the aorta.**



Questions:

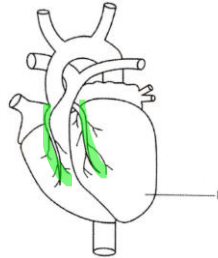
1. Does the whole heart pump together? Or does it have a order to which part of the heart contracts first?

No, the atria muscles will contract first, followed by the ventricle muscles.

.....

.....

.....



2. What do we call the blood vessels that are supplying oxygen to the heart muscles?

Coronary artery

3. The figure on the right shows an external view of the heart. State the *name* and *function* of the tissue that makes up the part labelled L.

Name: Cardiac muscle tissue of the left ventricle

Function: cardiac muscles can contract, which creates a force to move the blood in the left ventricle of the heart out of the aorta and then to the rest of the body.

.....

.....

.....

Commented [PLX2]: Name: Cardiac muscle tissue of the left ventricle
Function: it can contract, which creates a force to move the blood in the ventricle of the heart out of the aorta.

Blood Pressure changes in The Heart

Blood pressure is the **FORCE** that blood exerts on the walls of blood vessels.

Refer to Fig. 1.4. What can you deduce about this graph? What can you conclude?

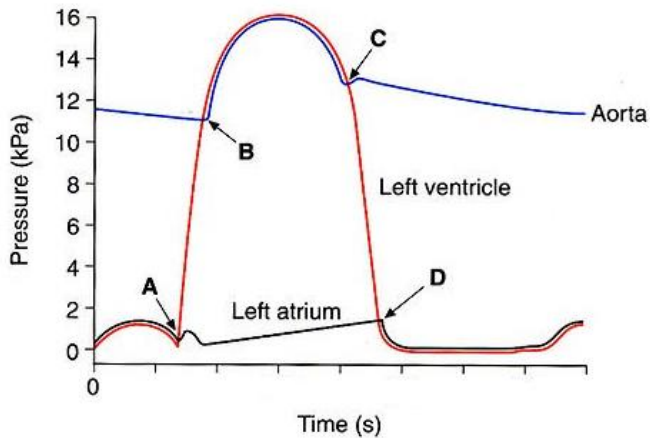


Fig. 1.4

BSSB:

A: Bicuspid, B: Semi-lunar,
C: Semi-lunar, D: Bicuspid

COCO:

A: Closed, B: Open,
C: Closed, D: Open

2. The Blood Vessels

There are three types of blood vessels, as shown in Fig. 2.1 and 2.2.

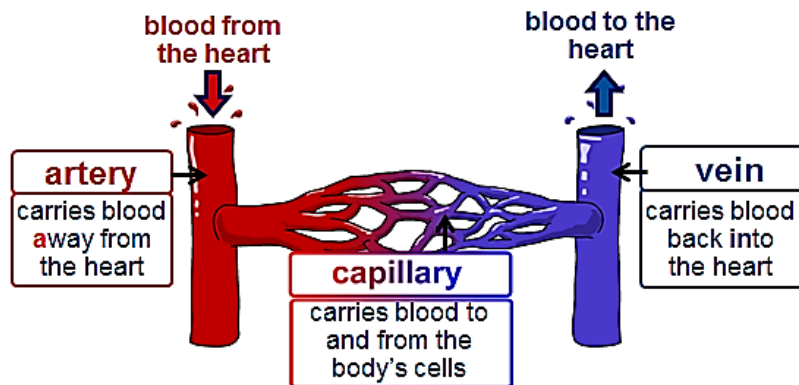


Fig. 2.1

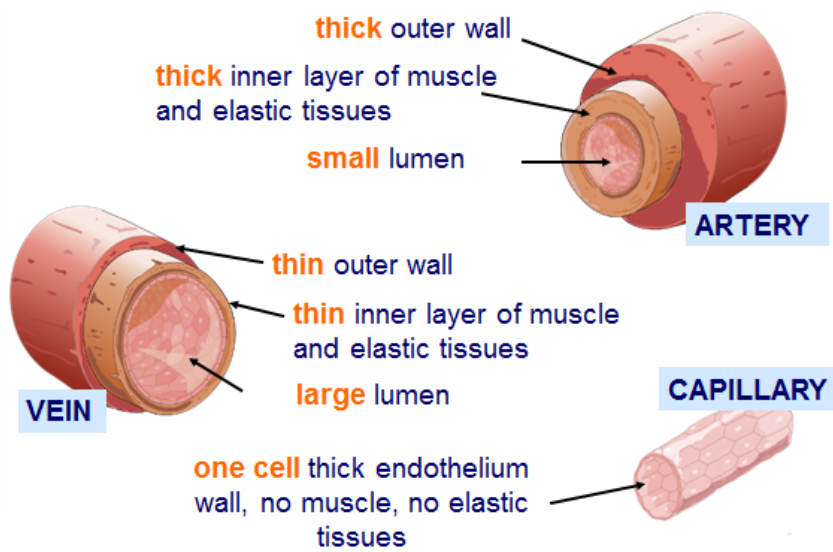
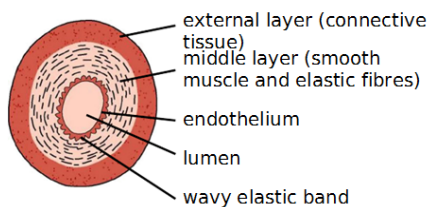


Fig. 2.2

2.1 The Blood Vessels – Arteries

- Transport **oxygenated blood** **away** from the heart to other organs in the body. **Except (pulmonary artery)**
- Have **thick, muscular walls** to withstand high blood pressure (10 – 16kPa*) from blood coming from the heart and to prevent it from bursting.
- Blood flows in pulses.
- Blood flows rapidly.

*SI unit for pressure: Kilopascal



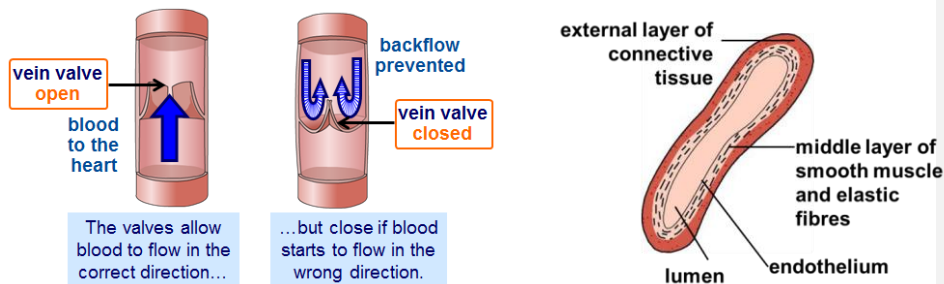
Common question:

Identify the blood vessel (artery, vein or capillaries) → a real micrograph

STRUCTURE	FUNCTION
Thick walls	To withstand high blood pressure
Elastic walls	Allows the walls to stretch and recoil , so that the blood is pushed in spurts . Elasticity also reduces the likelihood of the artery bursting.
bigger Muscular walls	Contraction and relaxation of muscles allow constriction and dilation of the artery . When artery constricts, lumen becomes narrower, blood pressure increases and less blood flows through. When artery dilates, lumen becomes wider, blood pressure decreases and more blood flows through.

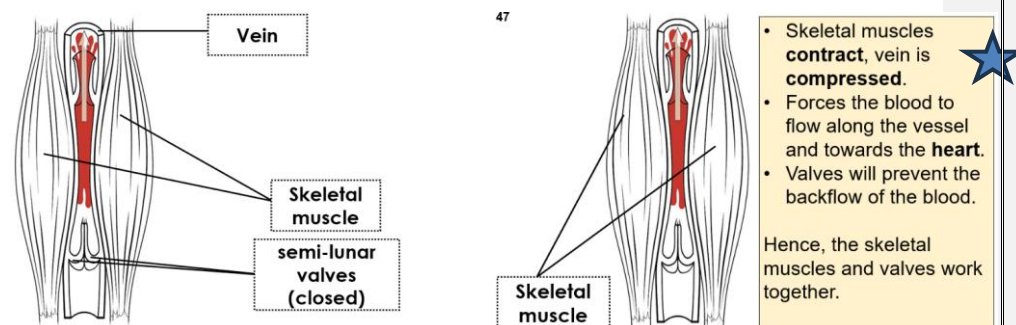
2.2 The Blood Vessels - Veins

- Transport deoxygenated blood **back to the heart**. Except (pulmonary vein)
- Have relatively **thin walls** with little elastic tissue as flow of blood is at **low pressure**. (1 kPa)
- Have **semi-lunar valves** present throughout (except the largest veins)



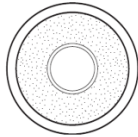
- Blood does not flow in pulses.
- Blood flow is slow.

STRUCTURE	FUNCTION
Semilunar valves	To prevent backflow of blood From where to where?
Thin walls	Blood flowing in the veins has low pressure , hence do not require a thick wall to withstand high pressure



- Skeletal muscles **contract**, vein is **compressed**.
- Forces the blood to flow along the vessel and towards the **heart**.
- Valves will prevent the backflow of the blood.

Hence, the skeletal muscles and valves work together.

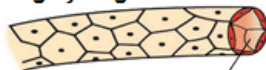
	artery	vein
		
direction of blood flow	carry blood away from heart	carry blood towards the heart
thickness of walls	thicker, muscular wall	thin, less muscular wall
elasticity of walls	more elastic	less elastic
size of lumen	smaller lumen	larger lumen
blood pressure	high blood pressure	low blood pressure
presence of valves	no semilunar valves	semilunar valves are present

2.3 The Blood Vessels - Capillaries

- No muscles
- No elastic tissues
- Links arteries to veins
- Blood changes from oxygenated to deoxygenated
- Blood pressure reducing. (4-1 kPa) – **WHY? (lumen is small)**
- Blood flows slowly.
- ★ Numerous and highly branched → provides a larger surface area to vol ratio for diffusion
- ★ One cell thick endothelium wall → allows rapid diffusion of materials between blood and cells due to the short distance

STRUCTURE	FUNCTION
endothelium is partially permeable	allows rapid diffusion of materials between blood and cells due to the short distance One-cell thick WALL
capillaries branch out repeatedly	Branching increases SA:V for efficient exchange of substances Branching decreases the blood pressure, allowing sufficient time for exchange of substances to occur.

Highly magnified



cut end of capillary showing single layer of endothelial cells

Blood Pressure changes in The Blood Vessels

Blood pressure is the **FORCE** that blood exerts on the walls of blood vessels.

- Blood pressure varies in different parts of the body.

CLASS DISCUSSION:

Where is the highest pressure in the body? Why do you think so? Write your thoughts here.

Aorta – it's where the heart muscles are contracting the hardest to create a pressure high enough to force the blood out of the ventricle and towards the rest of the body

Commented [PLX3]: Aorta

EXTENSION:

"High blood pressure may occur temporarily after 2.4km run."

"My heart rate is 188 beats per minute during 2.4km run."

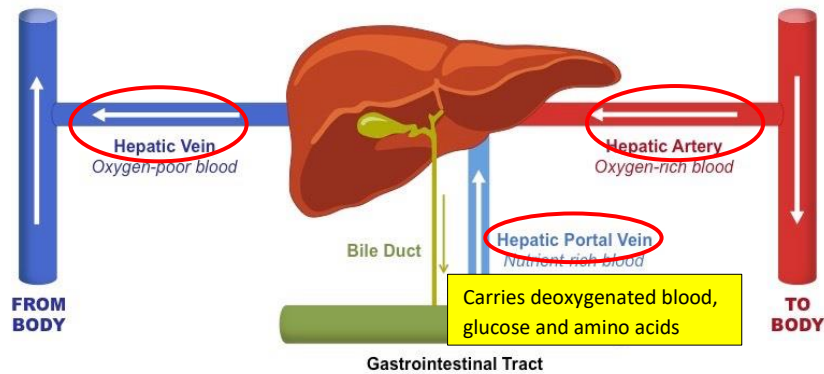
Do you think these statements are true? Talk about it with your partner.



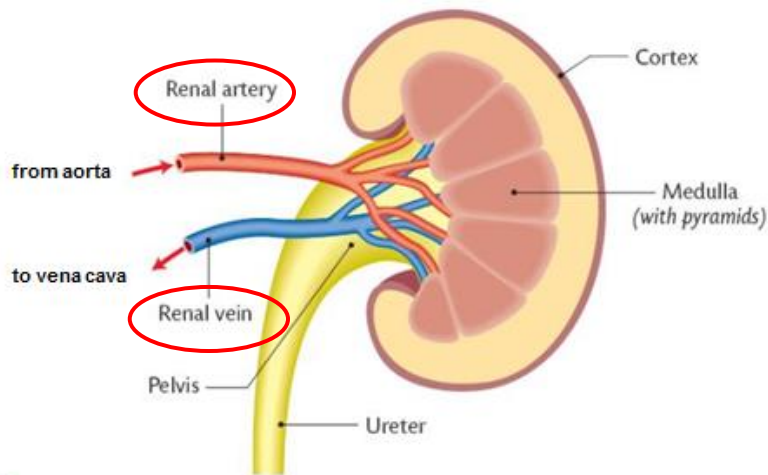
Commented [PLX4]: •2.4 km run; Need more energy
•Faster rate of respiration to release energy required
•Need more glucose and oxygen
•Heart need to pump faster (increased heart rate) and harder (high pressure) to deliver glucose and oxygen to the muscle cells.

2.4 The MAIN Blood Vessels

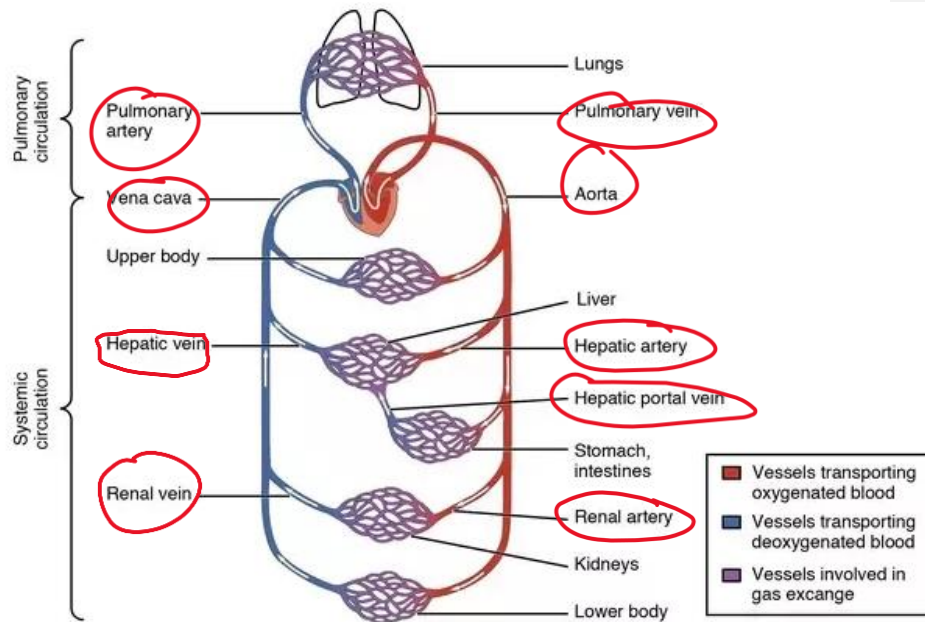
To and from the liver:



To and from the kidney:



2.4 The Main Blood Vessels - Overview

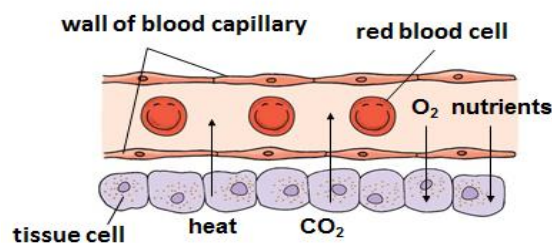


The BLOOD

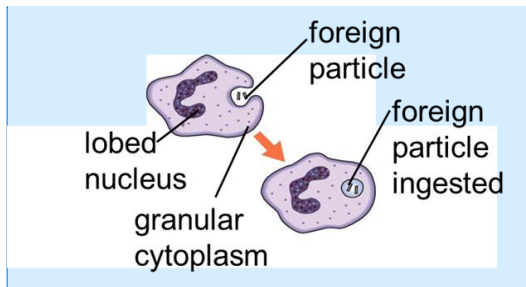
- It is made up of plasma, red blood cells, white blood cells and platelets.

Function:

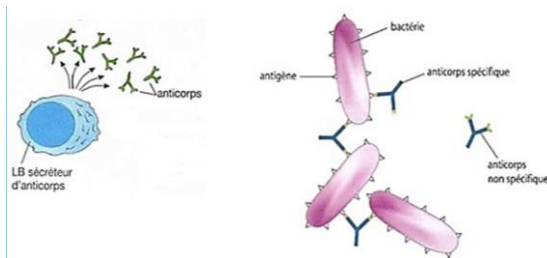
- Blood is the body's means of **transporting substances** around. It transports:
 - oxygen** from the **lungs** to the **heart** and then to the body's tissues by red blood cells.
 - materials like **hormones** (e.g. **insulin**) from one organ to another by plasma.
 - nutrients** (e.g. **glucose**) and **minerals** (e.g. **sodium**) from the intestines to the tissues by plasma.
 - metabolic waste products** such as **urea** and **carbon dioxide** to the kidneys.



- 2. Blood is the body's means of **protecting** the body. It protects the body by:
 - defence mechanism of white blood cells.
 - Phagocytosis** & production of **antibodies**



Commented [PLX5]: phagocyte

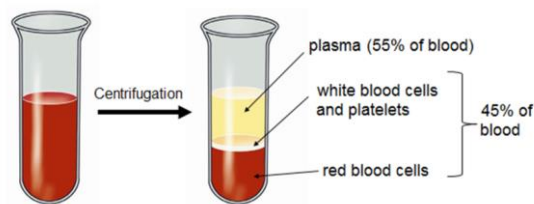


Commented [PLX6]: lymphocyte

The BLOOD – PLASMA

The blood cells and platelets are suspended in a substance called plasma. Plasma is made up of:

- 90% water
- inorganic salts
- glucose
- antibodies
- urea and other waste products
- plasma proteins.



The BLOOD - RED BLOOD CELLS

- Also called erythrocytes.
- Made in the bone marrow.
- Transport oxygen to the tissues.



<u>Red blood cells (RBC)</u> 	a) Contains pigment haemoglobin. b) It is circular, flattened biconcave disc. c) To does not possess a nucleus. d) <i>It is elastic and can turn into a bell shape. (weak point. Avoid using)</i>	a) Haemoglobin combines reversibly with oxygen to form oxyhaemoglobin to enable RBC to transport oxygen from the lungs to all cells in the body. b) This increase surface area to volume ratio to absorb and release oxygen at a faster rate. c) It is to carry more haemoglobin and thus more oxygen. d) <i>This ensures it is able to squeeze through blood vessels smaller than itself in diameter. (weak point. Avoid using)</i>
---	---	--

EXTENSION:

Role of blood in achieving sports potential



HOW CAN LIVING AT ALTITUDE IMPROVE ATHLETES PERFORMANCE?

Red blood cells carry oxygen, which is vital to muscle action, it is advantageous for a performer to have a **high red blood cell count**, especially in endurance events.

When athletes train and live at altitude, where there is **less oxygen in the air**, their bodies compensate by producing **extra red blood cells**.

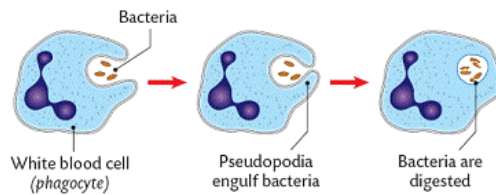
This means that they can perform at a higher intensity than other athletes when performing at sea level.

The BLOOD - WHITE BLOOD CELLS

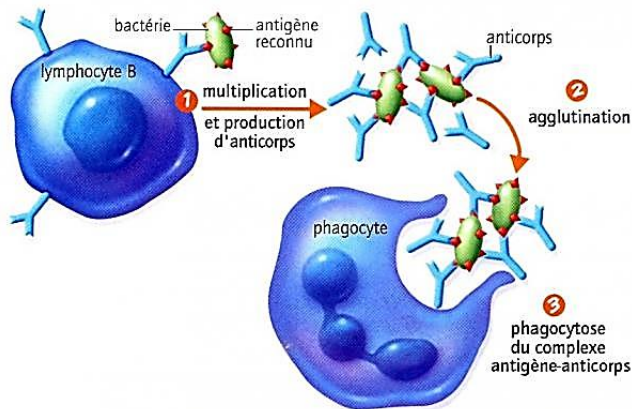
- Also called leucocytes.
- They are bigger than red blood cells and have large nuclei.
- Act as the body's defence systems.
- Some white blood cells **surround and engulf harmful microbes**. They will then be **digested**. –

PHAGOCYTES

- Process: **Phagocytosis**

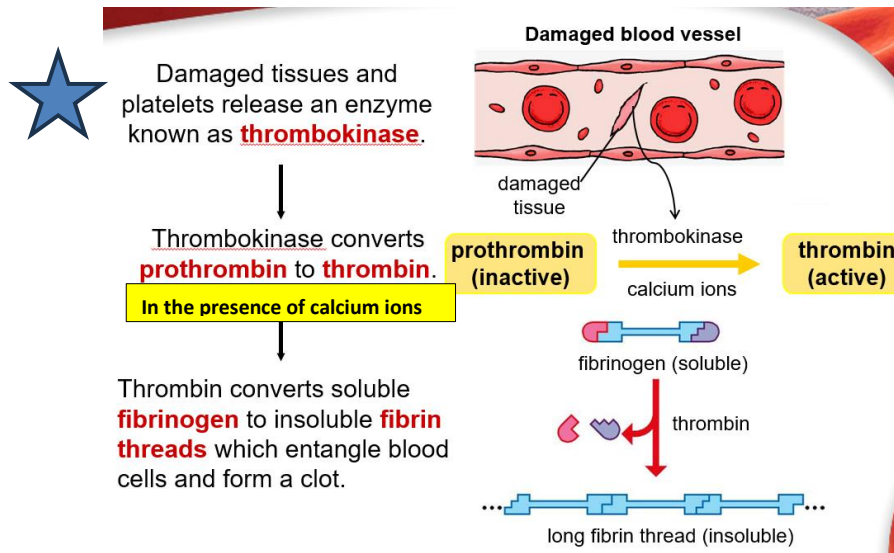
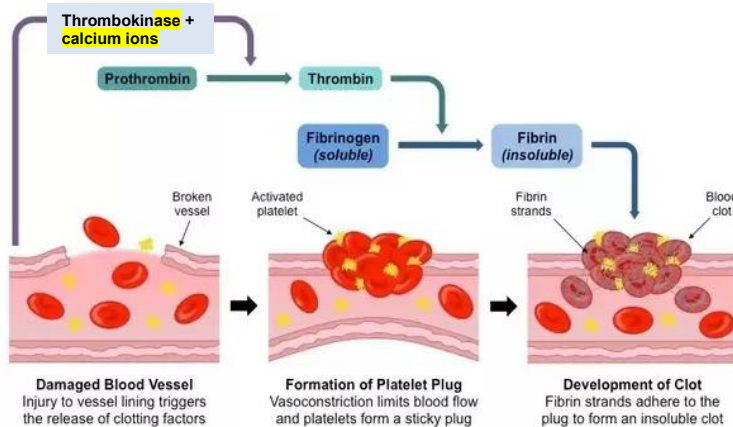


- Some produce chemicals called **antibodies** that fight specific pathogen - **LYMPHOCYTES**
 - **Antibodies destroy the bacteria**
 - by causing their surface membrane to rupture;
 - causing them to **clump together** or agglutinate so that they can be **easily ingested by phagocytes**;
 - Antibodies neutralise harmful toxins produced by bacteria.
e.g.



The BLOOD - PLATELETS

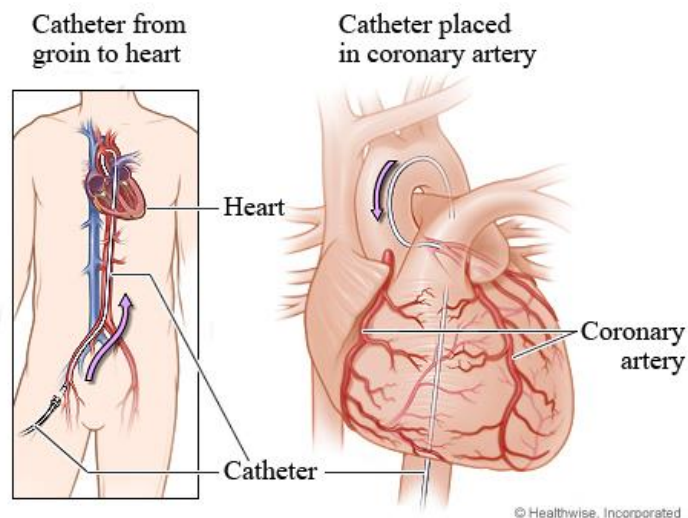
- Also known as thrombocytes
- They are not true cells. They are a membrane bound fragments of cytoplasm from bone marrow cells.
- They play a part in **blood clotting**.
- Blood clotting process;



CORONARY HEART DISEASE

- The most common heart disease.
- It is a disease affecting the coronary arteries which supply blood to the heart muscle.
- Blood supply to the heart muscles can be greatly reduced and this can lead to a **HEART ATTACK**.

- Greatly reduced blood flow to a certain part of the heart muscle.
- Heart muscles do not receive sufficient **oxygen** and nutrient such as **glucose**.
- The region of the heart muscle dies.



<https://www.webmd.com/heart-disease/guide/cardiac-catheterization1#1>

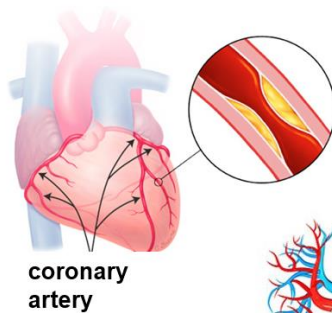
- Causes of Coronary Heart Disease
 - A high-fat diet rich in cholesterol and saturated animal fats
 - Emotional stress
 - Smoking
 - Sedentary lifestyle

Commented [PLX7]: <https://www.youtube.com/watch?v=H8okcrdD-IQ>

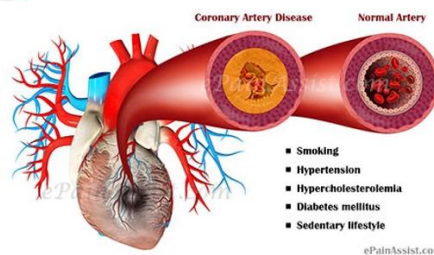
CORONARY Heart Disease



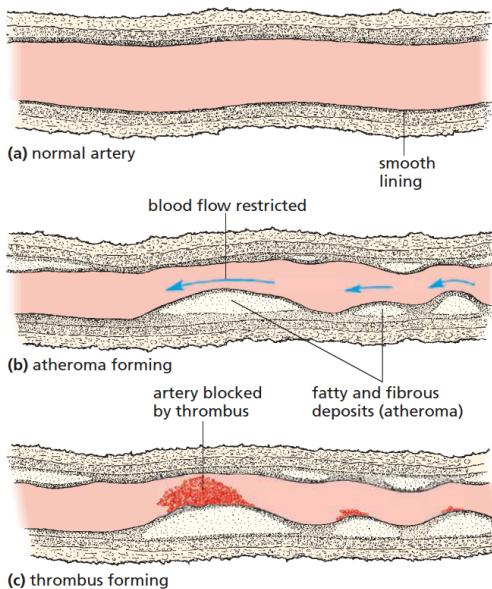
- The tissues of the heart are supplied by the **coronary arteries**.



Fatty deposit in the coronary artery.
Supply of oxygen to the heart muscle is reduced.
May lead to heart attack.



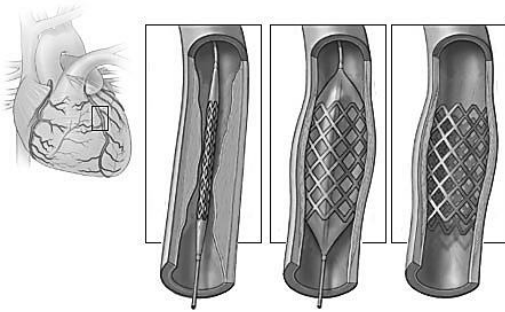
ePainAssist.com



- In a normal artery, blood is able to flow through smoothly.
- Fatty substances such as **cholesterol** and **saturated fats** may be deposited on the **inner walls** of the coronary arteries.
- Lumen of these arteries are narrowed. Reduced blood flow.
- A rough inner surface is developed. Fibrinogen in the plasma deposits fibrin on it, **causing a thrombus (blood clot) to form**.
- Heart muscles receive insufficient oxygen and glucose.
- CHEST PAIN / HEART ATTACK!

Extension:

Figure below shows a Stent Heart Surgery that will be done in patients. Do you think this is effective in preventing future occurrence of coronary heart disease? Discuss with your partner.



© Healthwise, Incorporated

<https://www.michaelwest.com.au/inside-the-stent-investigating-the-boom-in-cardiac-surgery/>

ANSWER

By inflating the balloon, the lumen of the affected section in the coronary artery can be widened, resulting in increased blood flow to the heart muscles.

The metal stent ensures that the lumen of the coronary artery remains wide in the long term, so that there is a consistent supply of blood to the heart muscles.

Discussion: Preventive measures against Coronary Heart Disease

The End