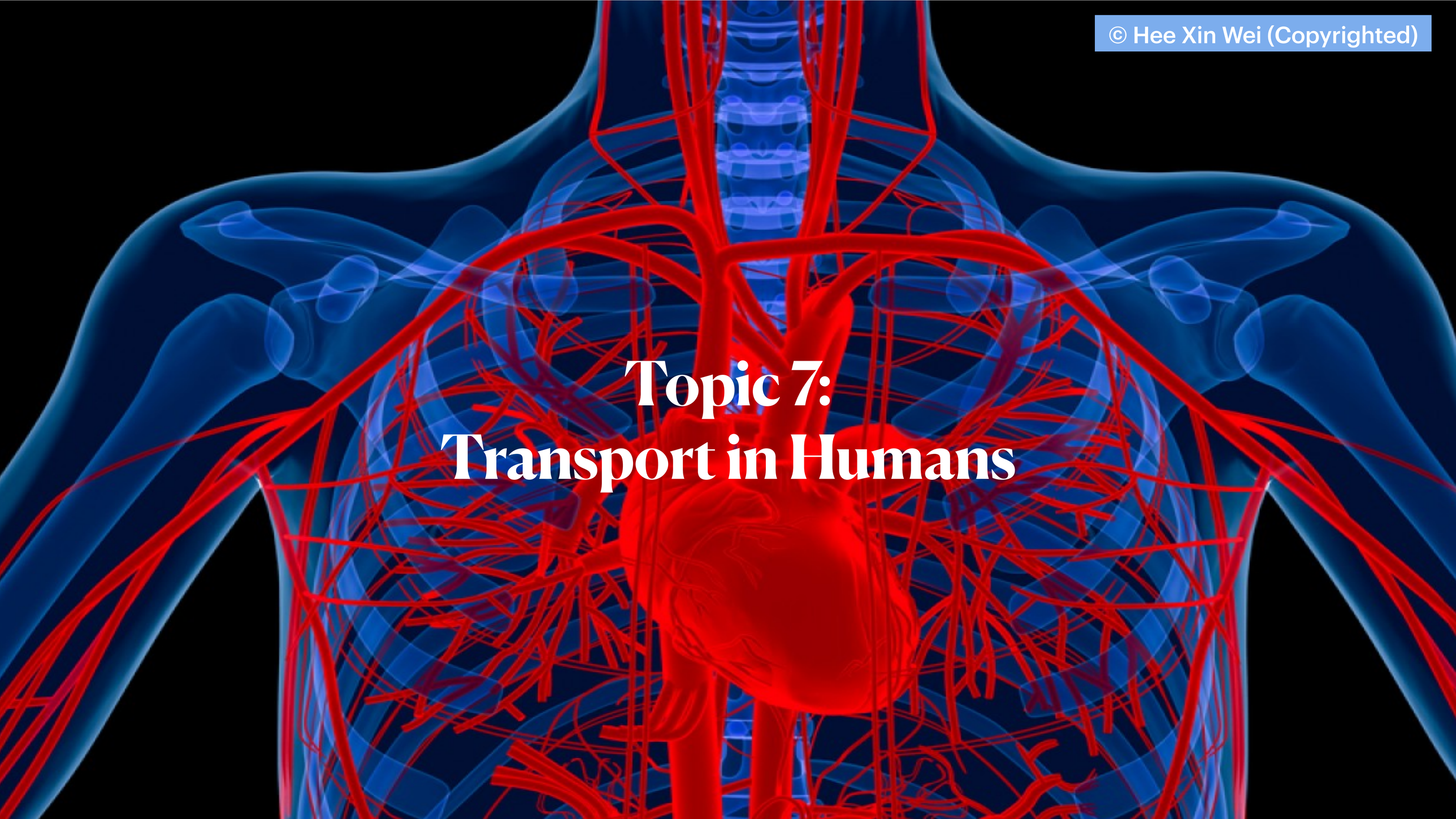
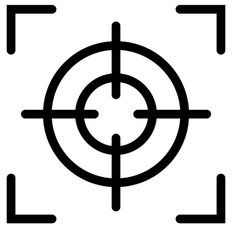


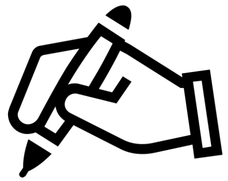
Topic 7:
Transport in Humans

Chapter Analysis



FOCUS

- Heavy content
- Knowledge on circulation system is linked to other chapters



EXAM

- commonly tested in both MCQ and structured
- tested every year in the past 5 years

WEIGHTAGE

- Constitute to around 9% in Paper 2 in the past 5 years

Key Concept

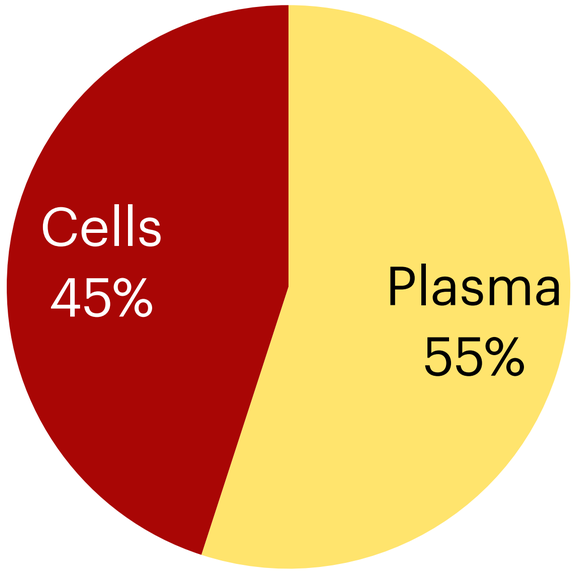
Components of blood

Blood group

components and roles of blood

(1) role of blood in transport

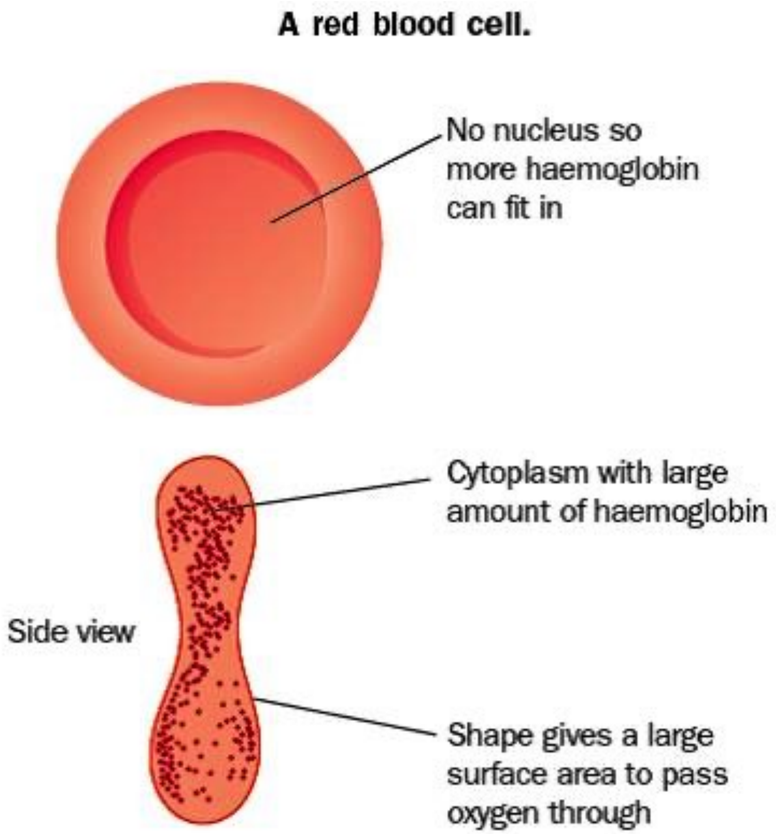
- red blood cells
- white blood cells
- platelets



1. **90% water:** essential in **transporting blood cells** and **dissolved substances**
2. **10%** a mixture of dissolved substances:
   - **Soluble plasma proteins** such as fibrinogen, prothrombin and antibodies. Fibrinogen and prothrombin play an important part in the clotting of blood. These proteins are made in the lever. Antibodies help to fight diseases.
   - Dissolved **mineral salts**, for example, hydrogencarbonates, chlorides, sulfates and phosphates of calcium, sodium and potassium. All these occur as ions in the plasma. Calcium is essential for blood clotting.
   - **Food substances**, for example, glucose, amino acids, fats and vitamins.
   - **Excretory products**, for example, urea, uric acid and creatinine. Carbon dioxide is present as hydrogencarbonate ions.
   - **Hormones,** for example, insulin.
   - **Vitamins**

red blood cells

(2) role of blood in transporting oxygen



1. The oxygen diffuse from the lung into the blood and bind reversibly with **haemoglobin in red blood cells** to form **oxyhaemoglobin**.
2. When blood is transported to oxygen-poor respiring tissues, oxyhaemoglobin releases its oxygen which then diffuses into tissue cells.

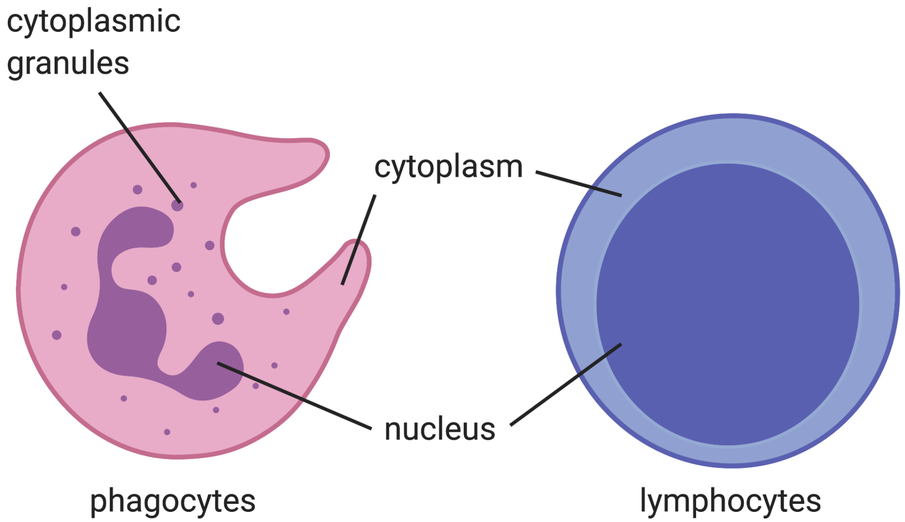
(more will be discussed in the respiration chapter)

Adaptation of RBC to its function:

- Contains **haemoglobin**, an iron-containing protein which is able to **bind reversibly with oxygen**, which enables red blood cells to **transport oxygen** from the lungs to other body parts
- Mature red blood cells **do not possess a nucleus**, enabling it to carry more haemoglobin and thus more oxygen.
- **Flattened, biconcave shape** which increasing the **surface area to volume ratio** for faster diffusion of oxygen
- Flexibility to turn **bell-shaped** in order to pass through the narrow lumen of the capillaries

white blood cells

(3) role of blood in immune function and (4) tissue rejection



IMMUNE FUNCTIONS

(i) **Phagocytes** have lobed nuclei and granular cytoplasm. They **engulf and digest foreign particles** such as bacteria (phagocytosis)

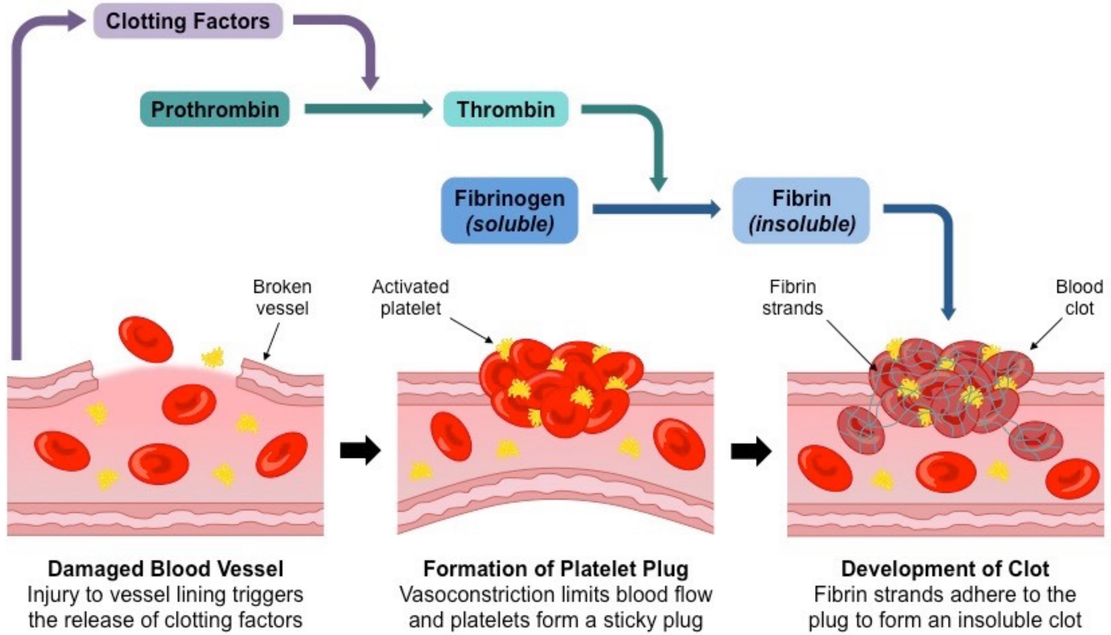
(ii) **Lymphocytes** have a large rounded nucleus and a small amount of cytoplasm. They **produce antibodies** to protect the body from pathogens.

TISSUE REJECTIONS

1. Tissue rejection occurs when the transplanted tissue is not accepted by the body of the transplant recipient.
2. This because the tissues of the transplanted organ are **treated as foreign bodies by the recipient's immune system** and are **attacked by phagocytes**.
3. Prevention of tissue rejection:
   (a) Required tissue can be transplanted from **genetically-similar donors** (family members)
   (b) Tissue can be transplanted from **one part of the body to another**, e.g. skin grafting, as the tissue will be recognised as the recipient's own tissue.
   (c) **Immunosuppressive drugs** can be taken to **suppress the immune system** of the recipient.
   - However, this means that patients will suffer from **lowered resistance to infection** and they have to continue taking the drugs for their entire lifespan

platelets

(5) role of blood in blood clotting



- **Blood platelets** or **thrombocytes** are not true cells. They have no nucleus and they are membrane-bound cell fragments
- They play a part in the **blood clotting**

1. Where there is an injury such as a cut, blood vessels are damaged and **platelets** are **activated**, releasing clotting factors like **thrombokinase**.
2. Thrombokinase converts plasma protein, **prothrombin**, into **thrombin** in the presence of **calcium** and **vitamin K**.
3. Thrombin converts soluble **fibrinogen** to insoluble **fibrin**
4. Fibrin forms a **mesh** across the damaged surface and **traps red blood cells**, forming a **clot.**
5. The clot prevents further blood loss, and also restricts the entry of pathogens into the blood.

ABO blood groups

Blood Group	Antigen on red blood cells	Antibody in blood plasma
A	Antigen A	Antibody B
B	Antigen B	Antibody A
O	No antigen	Antibody A and Antibody B
AB	Antigen A & Antigen B	No antibodies

Donor	Receipient			
	A	B	O	AB
A	✓	✘	✘	✓
B	✘	✓	✘	✓
O	✓	✓	✓	✓
AB	✘	✘	✘	✓

✓ - blood transfusion is accepted
✘ - blood transfusion is rejected

- Blood group classification is based on the **antigens present** on the cell surface membrane of red blood cells
- Blood plasma contains **antibodies** which can **recognise the antigens** as either foreign or self
- An immune response will occur where **antibodies** in the blood plasma of **recipient** would react with the **antigens** of red blood cells of **donor**, causing **agglutination or clumping of red blood cells**
- The clumps may block up small blood vessels and prevent the flow of blood, which is very dangerous.

- **Blood group O** is known as the **universal donor** as there are no antigens on the donor's red blood cells and thus will not react with the recipient's antibodies thus no agglutination will occur
- **Blood group AB** is known as the **universal acceptor** as there are no antibodies in the plasma of the recipient, thus will not react with donor's red blood cells antigens thus no agglutination will occur

Key Concept

artery, veins, capillaries
tissue fluid

Blood Capillaries

artery and veins

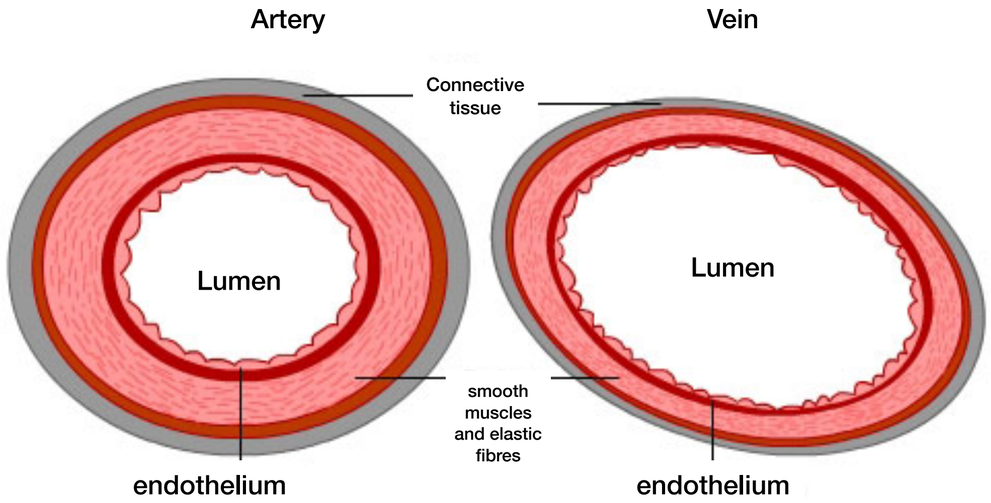
ARTERY

Function:

- Arteries are blood vessels which carry blood away from the heart, thus need to **withstand the high pressure** of blood pumped out of the heart.
- All arteries carry **oxygenated blood** with the exception of the pulmonary arteries.

Structure and adaptations:

- Thick, muscular and elastic walls
- Thick walls allow arteries to withstand immense pressure of blood that was just pumped out of the heart
- Elasticity of wall allows arteries to stretch and recoil under high pressure and push blood along arteries



VEINS

Function:

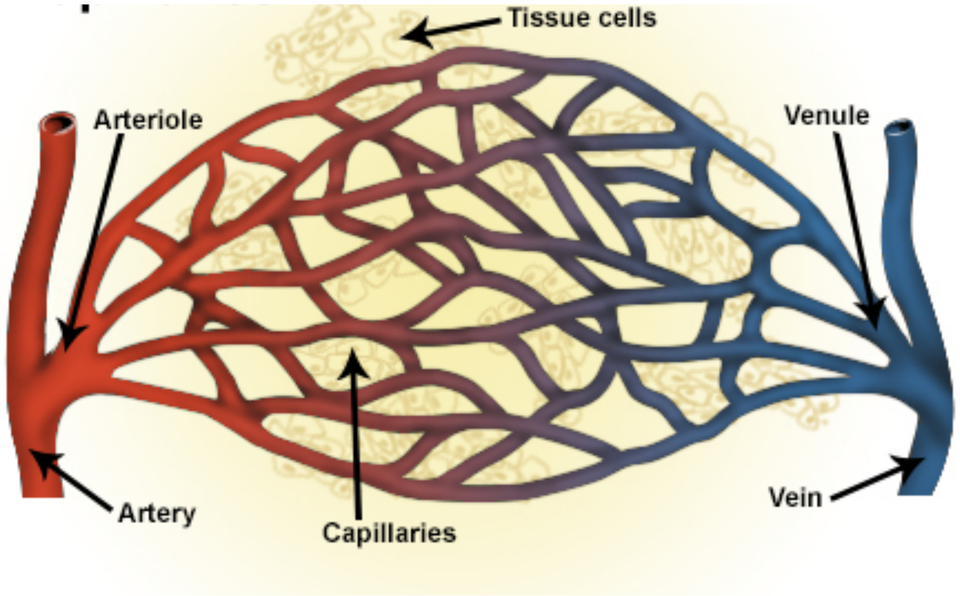
- Veins transport blood back to the heart
- All veins carry **deoxygenated blood** with the exception of the pulmonary veins.

Structure and adaptations:

- Middle wall contains much less smooth muscle and elastic fibres. Hence they are **not as thick, muscular or elastic as arteries** as the **blood pressure is lower**
- Large lumen offer low resistance to blood flow, blood can flow smoothly back to the heart
- **Semi lunar vales** are present which will close to **prevent backflow of blood** to ensure flow of blood in one direction.

Blood vessels

Capillaries



Blood flows from artery —> arteriole —> **capillaries** —> venule —> vein

Function:

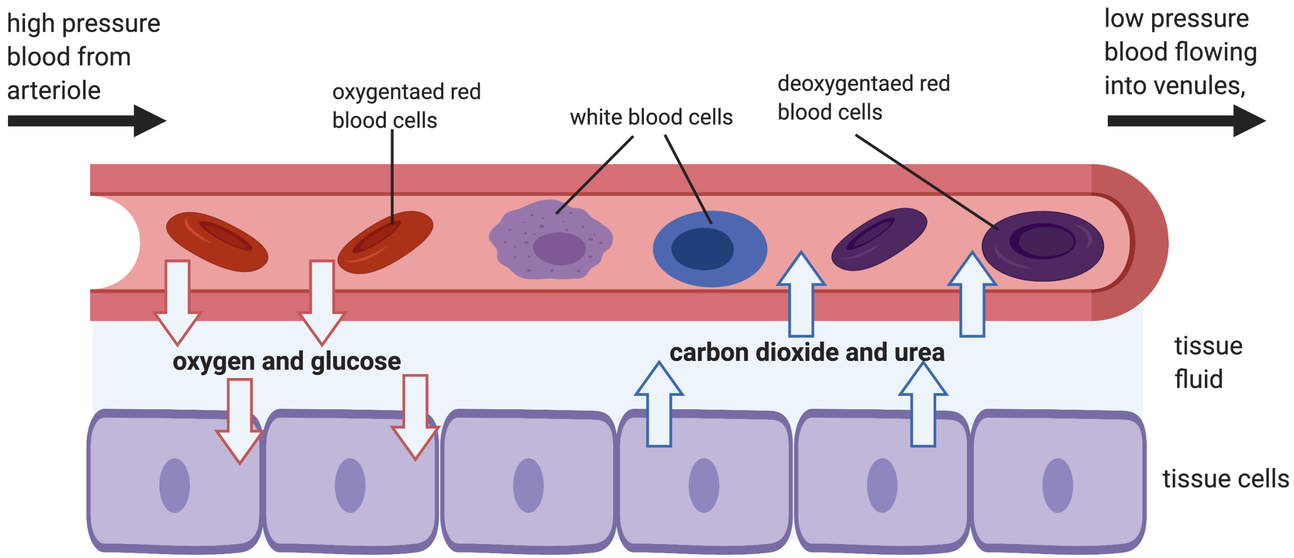
- Allow exchange of nutrients and waste materials between blood and tissue fluid
- gaseous exchange

Structure and Adaptations:

- The wall of capillary is single layer of endothelial cells. **One cell thick wall** allows **shorter distance** for oxygen and food substances to **diffuse** from and waste products to diffuse from
- **Extensive network** of blood capillaries surrounding the cells maintains **steep concentration gradient** to ensure efficient exchange of materials with tissue cells
- The **extensive branching** increases the total **cross-sectional area** of the vessels, **lowering the blood pressure** in the capillaries and hence **slowing down blood flow**, giving more time for the **exchange of substances.**

capillaries and tissue fluid

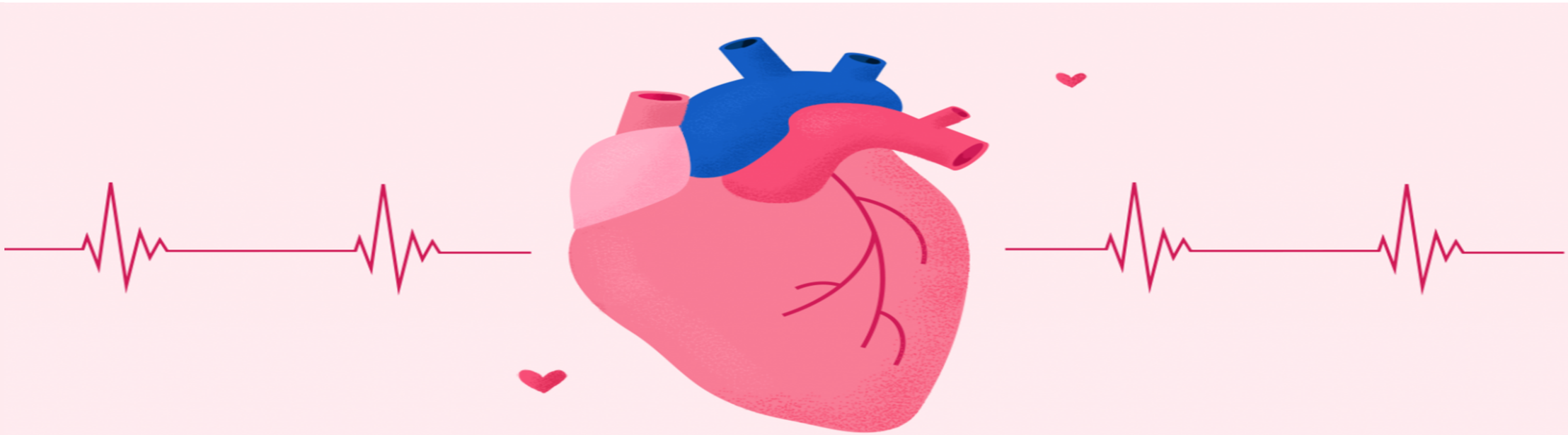
exchange of materials



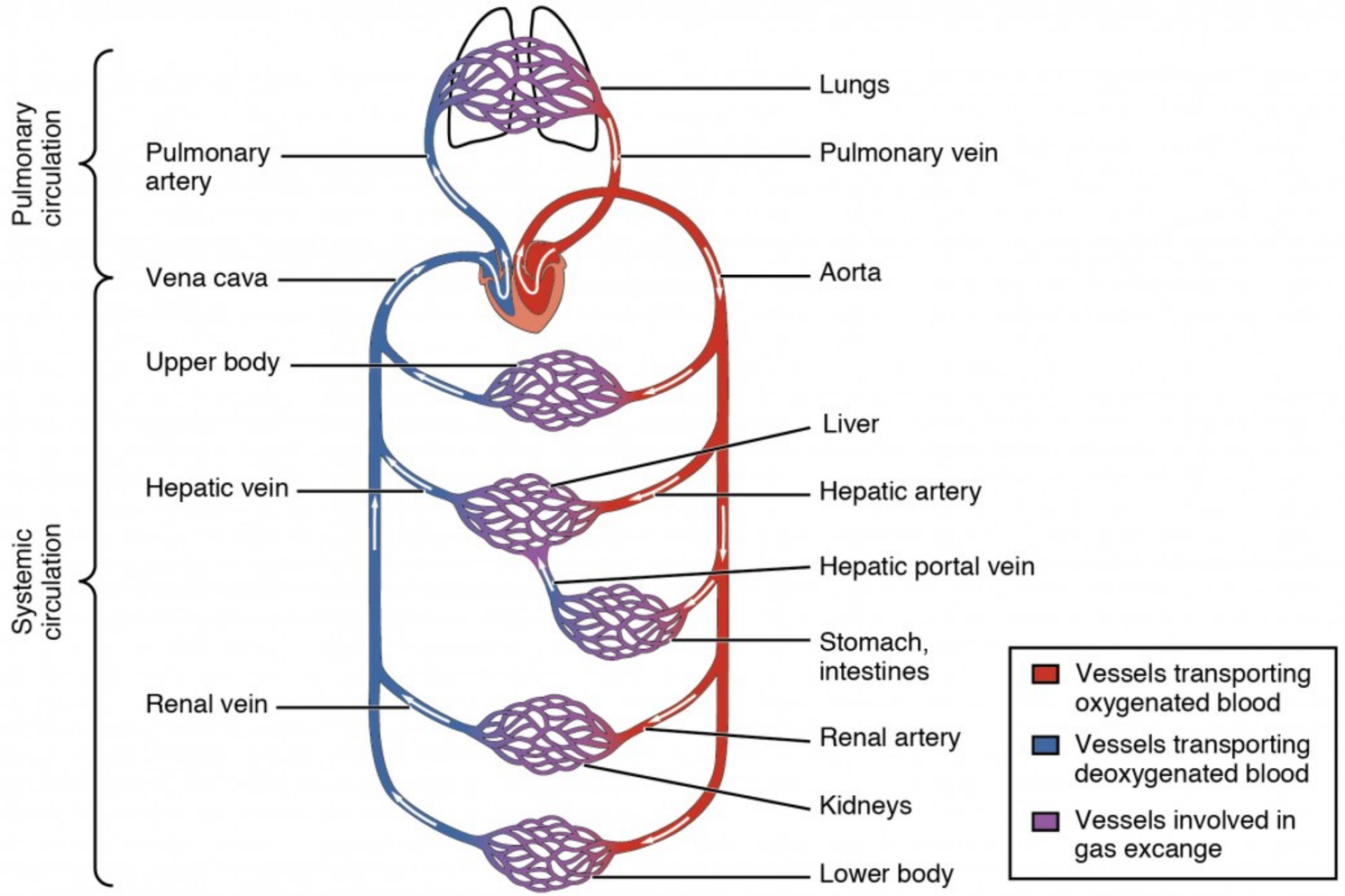
- The solution bathing tissue cells becomes known as **tissue fluid**
- Dissolved **food substances and oxygen** diffuse from the blood in the blood capillaries into the tissue fluid and then into the cells
- ***Metabolic waste products*** such as **urea and carbon dioxide** diffuse from the cells into the tissue fluid and then through the blood capillary walls into the blood, which are transported to excretory organs for removal

Key Concept

Double circulation
Structure of heart
Cardiac cycle
Coronary heart disease



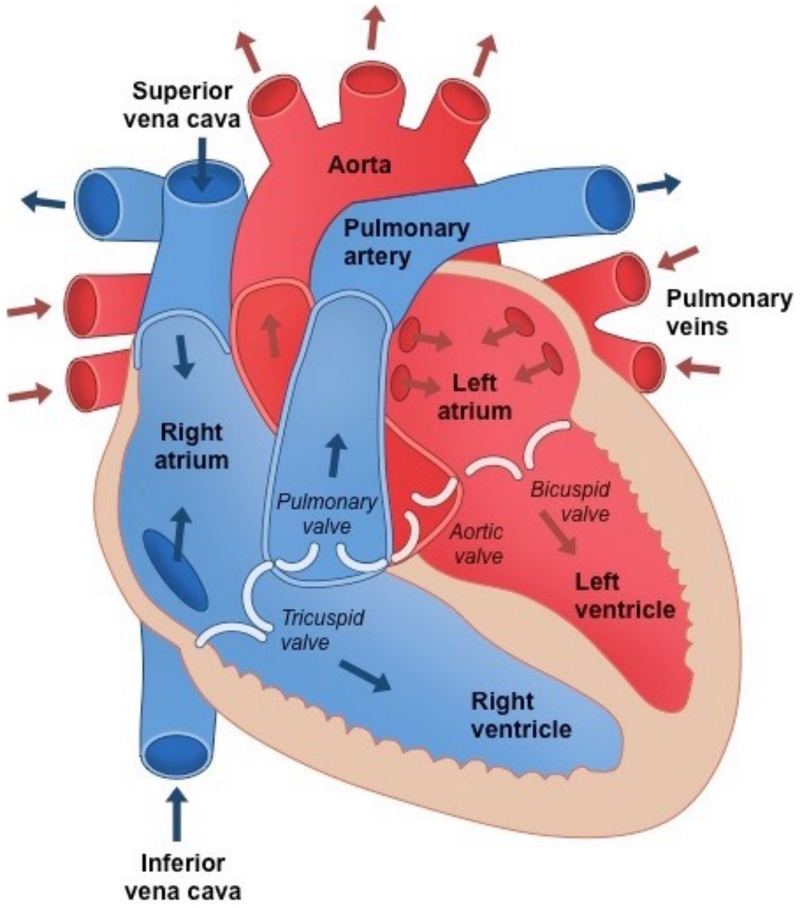
Double circulation



(a) Systemic circulation – Carries oxygenated blood (oxygen-rich) from the heart to all body organs and returns oxygen-poor blood to the heart

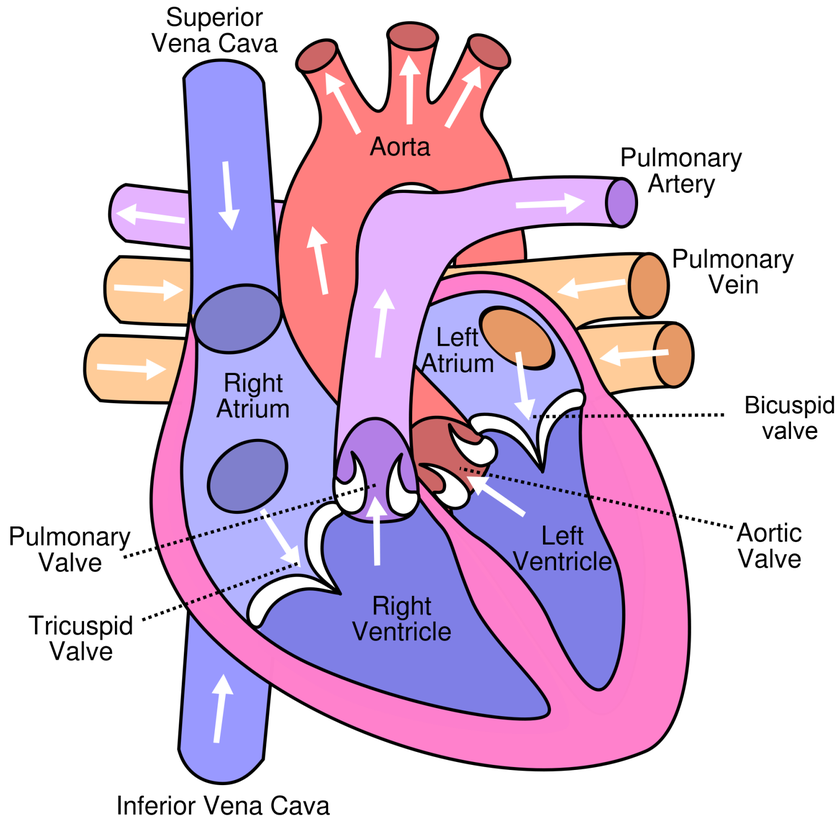
(b) Pulmonary circulation – Carries deoxygenated blood (oxygen-poor) from the heart to the lungs for gaseous exchange before returning blood to the heart for transport to the body organs via systemic circulation

structure of heart



atrium	• upper chambers of the heart, with relatively thin walls. They collect blood returning to the heart and pump it into the ventricles.
ventricle	• lower chambers of the heart • The ventricles have thick, muscular walls compared to atrium. • The **left ventricle has thicker walls** than the right ventricle, as it has to pump blood to the rest of the body, while right ventricle pumps blood to the lung
median septum	• muscular wall that separates right and left sides of the heart • The median septum **prevents the mixing of deoxygenated blood** in the right side with the **oxygenated blood** in the left side to ensure **maximum amount of oxygen** is transported to the body • Mixing will reduce the amount of oxygen carried to the tissue cells.
atrioventricular valves	• Between the right atrium and ventricle is the **tricuspid valve** which consists of three flaps attached to the walls of the right ventricle by cord-like tendons called cordae tendineae. • Between the left atrium and left ventricle is the **bicuspid valve** which consists of two flaps, also attached by cordae tendineae. • **Prevent back flow of blood** from ventricles to atrium
semi lunar valves	• **Aortic valve** on left side, **pulmonary valve** on right side of the heart • Located at the start of the aorta and pulmonary arteries • **Prevent back flow of blood** from arteries back to ventricles

path of blood



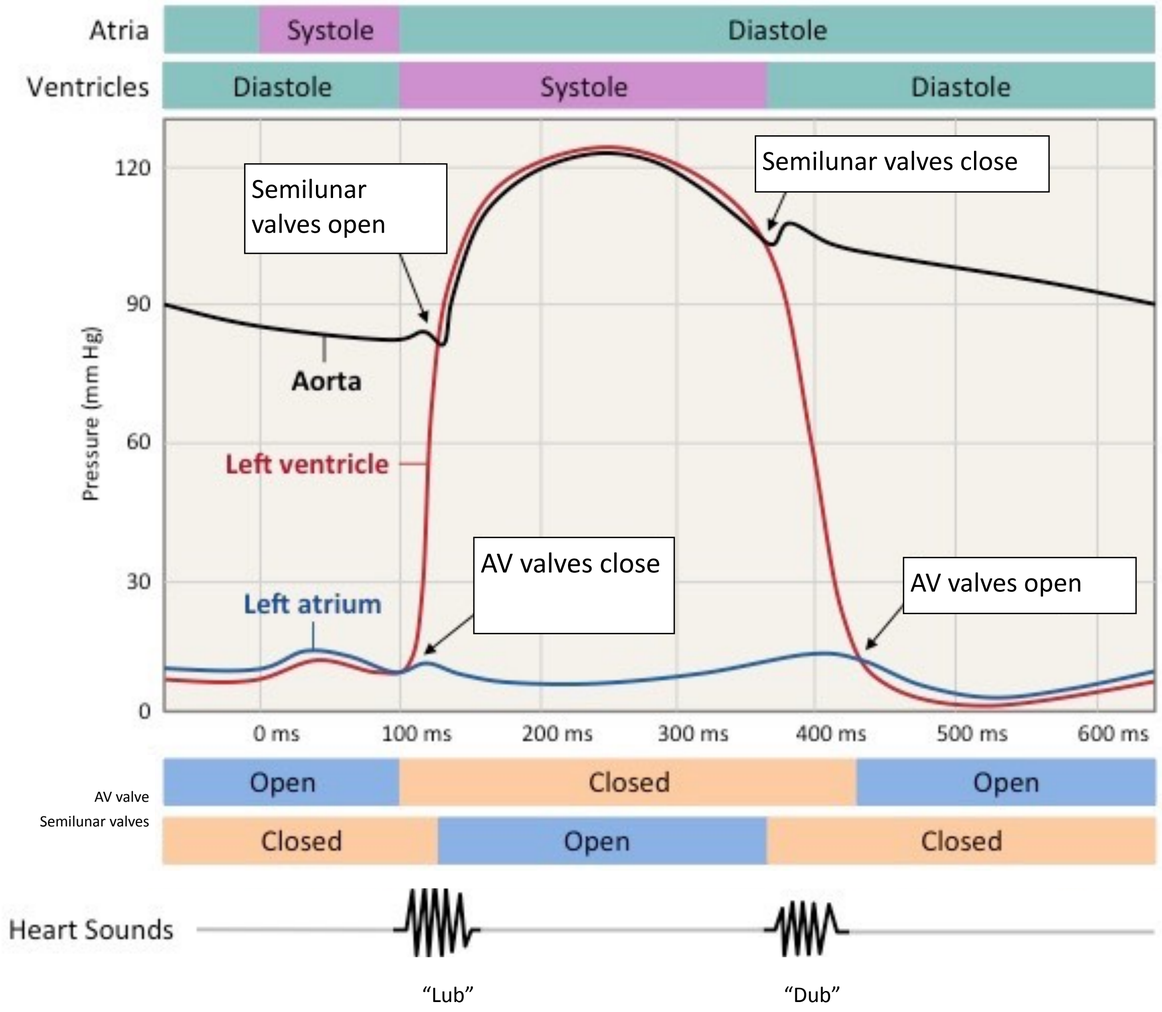
inferior/superior vena cava → right atrium → right ventricle → pulmonary artery → lung → pulmonary vein → left atrium → left ventricle → aorta → other parts of bodies

} deoxygenated blood

} oxygenated blood

→ : valves are present to prevent backflow of blood

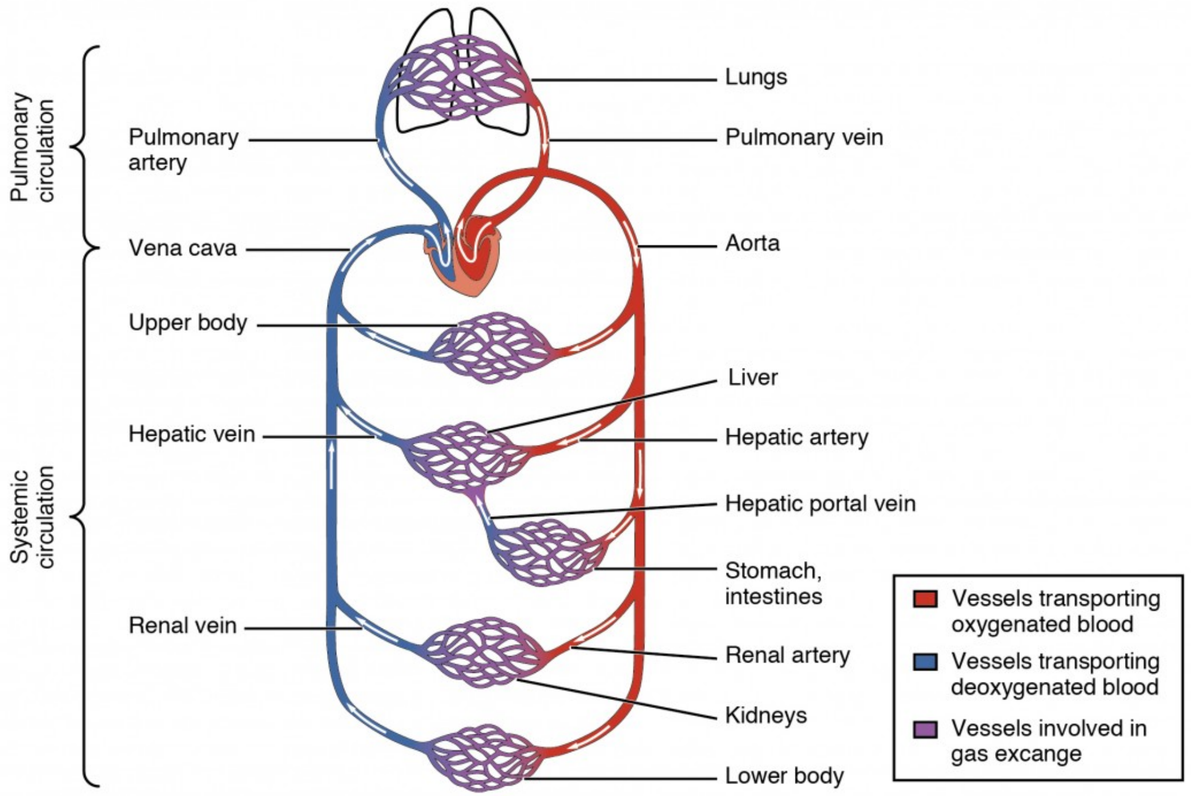
cardiac cycle



Cardiac cycle refers to the one complete sequence of relaxation phase is called **diastole** and contraction phase is called **systole**

1. Atrial systole: The **atria contract** causing a rapid but relatively small pressure increase, which **pumps blood** from the atria **to the ventricles**, through the open atrioventricular valves.
2. Ventricular Systole: The **ventricles contract** and the **atrioventricular valves close** to prevent backflow of the blood into the atria. This produces the **'lub' sound** of the heartbeat.
3. Atrial diastole: While the ventricles are contracting, the atria relax.
4. The pressure in the ventricles increases and becomes higher than that of aorta and pulmonary artery, causing the **semi-lunar valves to open**. Blood flows from the ventricles **into the arteries.**
5. Ventricular diastole: The **ventricles relax** causing drop in pressure, causing **semi-lunar valves to close** to prevent backflow of the blood into the ventricle. This produces the **'dub' sound** of the heartbeat.
6. Pressure in the ventricles eventually drops below the pressure in the atria so the **atrioventricular valves open**.
7. Pressure in the ventricles will increase again when blood from atria enters the ventricles, and the cycle repeats

Double circulation



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<u>Advantages of double circulation:</u>

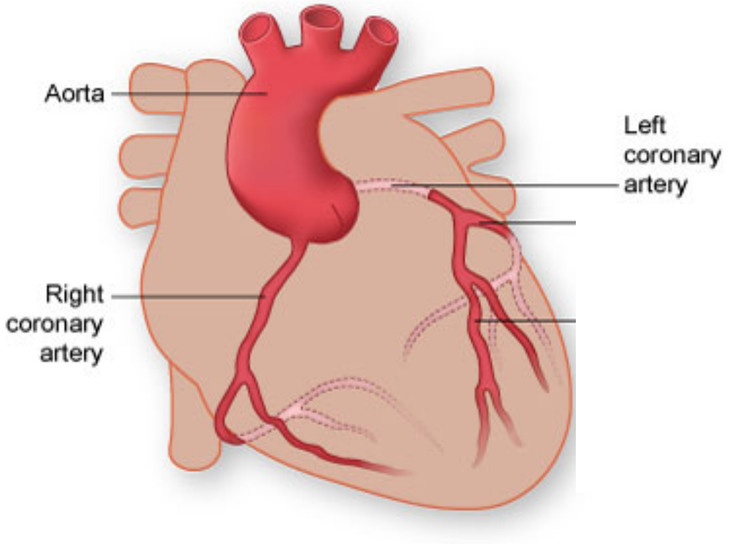
1. Complete **separation** of oxygenated and deoxygenated blood

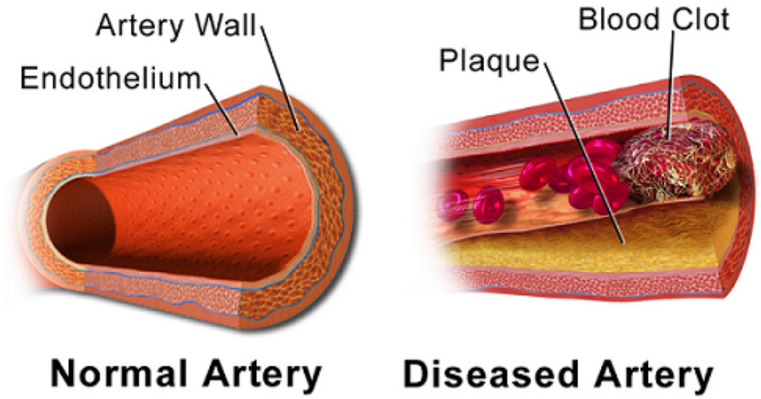
- Ensures only oxygenated blood can reach tissue cells.
- **Efficiency of transport** of oxygenated blood.

2. **Blood passes through the heart twice** in one complete circuit

- Blood **enters the lungs** is at a **lower pressure** compared to blood leaving the heart. This ensures that blood **flows more slowly** through the lungs, allowing sufficient time for the blood **to be well oxygenated** before it returns to the heart.
- Blood that leaves heart via aorta is at an extremely **high pressure**. Oxygenated blood is **distributed to the rest of the body tissues more quickly.** Helps to maintain the high metabolic rate in mammals.

coronary heart disease





The **coronary arteries** branch out from the **aorta** to provide **oxygen and nutrients** to the heart muscles

1. **Atherosclerosis** is the buildup of **cholesterol and fatty deposits** in the coronary artery wall

- the buildup of **cholesterol and fatty deposits** in the coronary artery wall
- The deposition of plaque causes **narrowing or occlusion of coronary artery**
- Narrow lumen causes **angina (chest pain)** or discomfort in the area of heart that **does not get sufficient blood**, hence **less oxygen and nutrients**
- The narrowing of the lumen of the arteries also causes an **increase in blood pressure**. This causes arteries to **develop rough linings**, which increases the likelihood of **formation of blood clots** inside the arteries. This is known as **thrombosis.**

2. **Blood clots complete block coronary artery**

- When the coronary arteries are completely blocked, **blood supply** to part of the heart muscle is **completely cut off**.
- Do not get **glucose and oxygen**
- The affected area of heart dies, affecting the heart's ability to **pump** and lead to **heart failure and heart attack**

coronary heart disease

Factors that contribute to atherosclerosis include:

(a) **High intake of cholesterol and saturated fats**: promote deposition of plaque along artery

(b) **Stress**: promote the buildup of plaque deposits in the arteries

(c) **Smoking:** Nicotine in cigarette increases blood pressure and carbon monoxide reduces oxygen carrying capacity of red blood cell

Preventive measures include:

(a) **Healthy diet**: Reduce cholesterol and saturated fats, substitute with polyunsaturated plant fats

(b) Not smoking

(c) **Exercising:** It strengthens the heart and maintains the elasticity of the arterial walls.

(d) **Stress management:** reduce high blood pressure

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