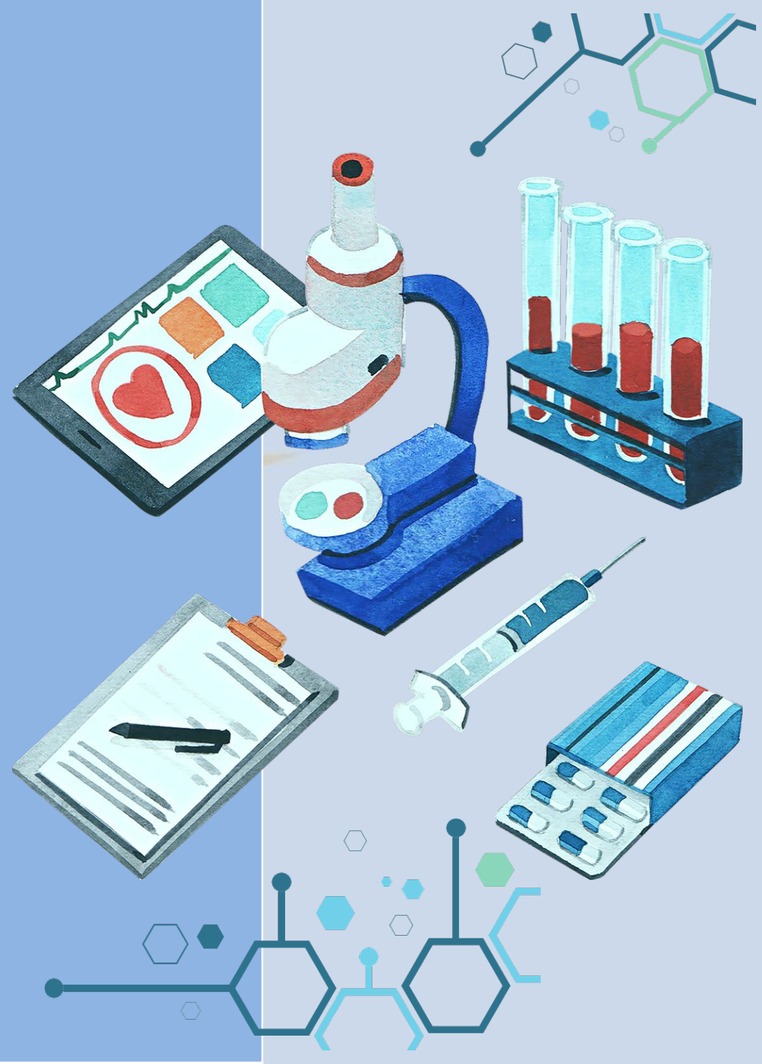
Tishk International University

## Faculty of Applied Science

## Department of Anesthesia

# The Cardiovascular System



Fall Semester

Course Name : Biophysics

Stage : First

Prof. Dr. Fatiheea F Hassan

2026

**Primary function of the cardiovascular system is :-**

To supply body cells with O2 and nutrients and carry away CO2 and waste products.

**Cardiovascular system is a closed-circuit system, composed:**

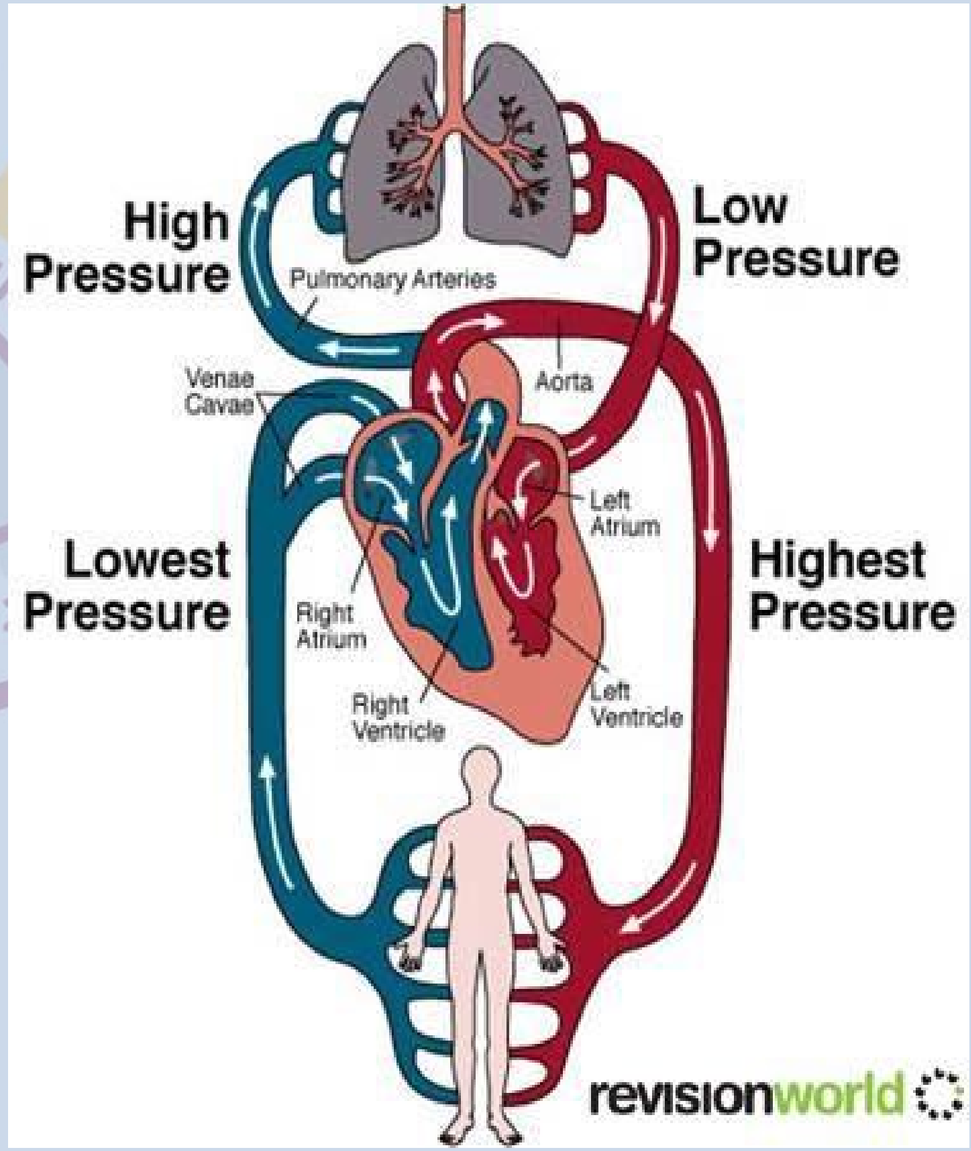
**- Heart**

**- Arteries**

**- Capillaries**

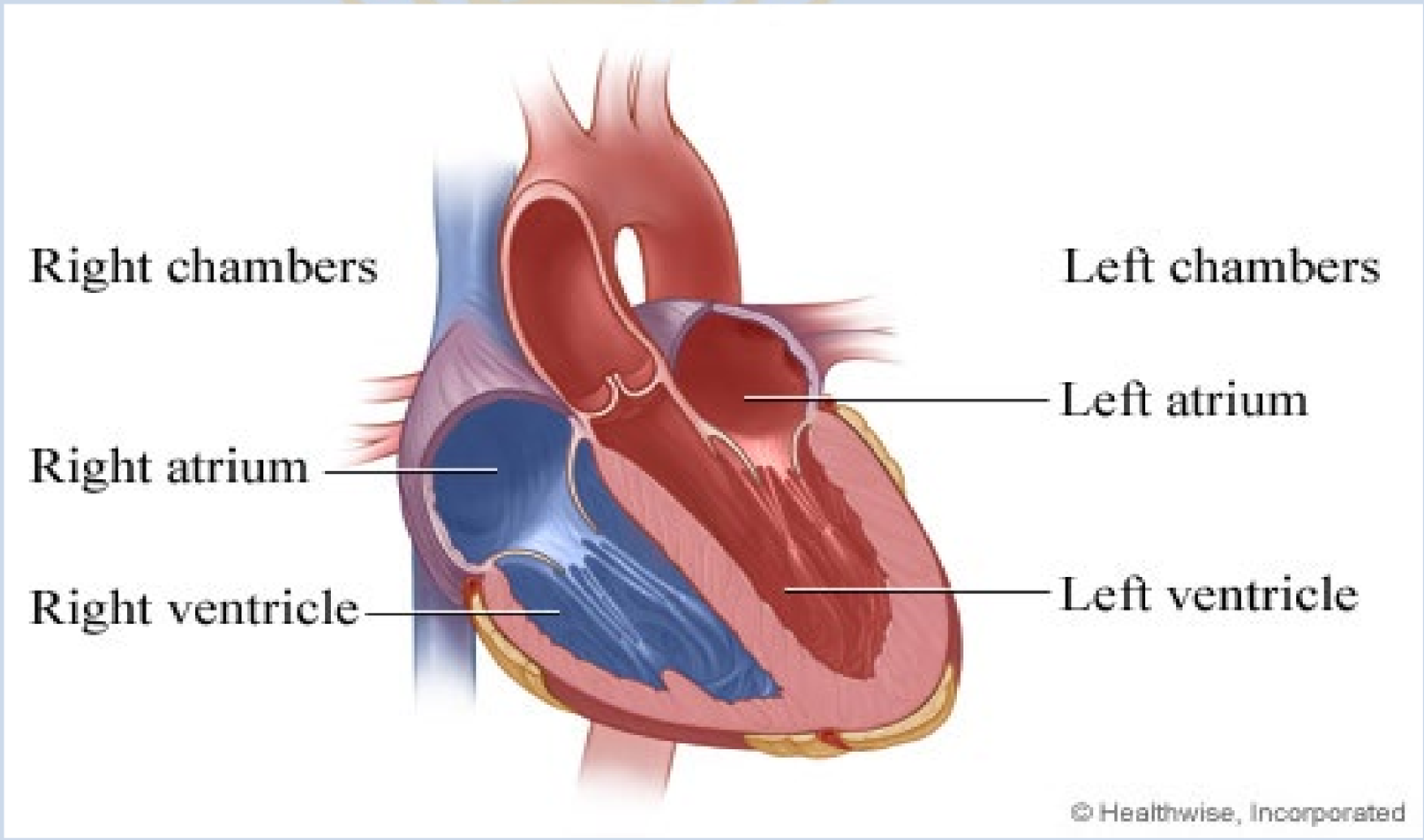
**- Veins**

**- Blood**

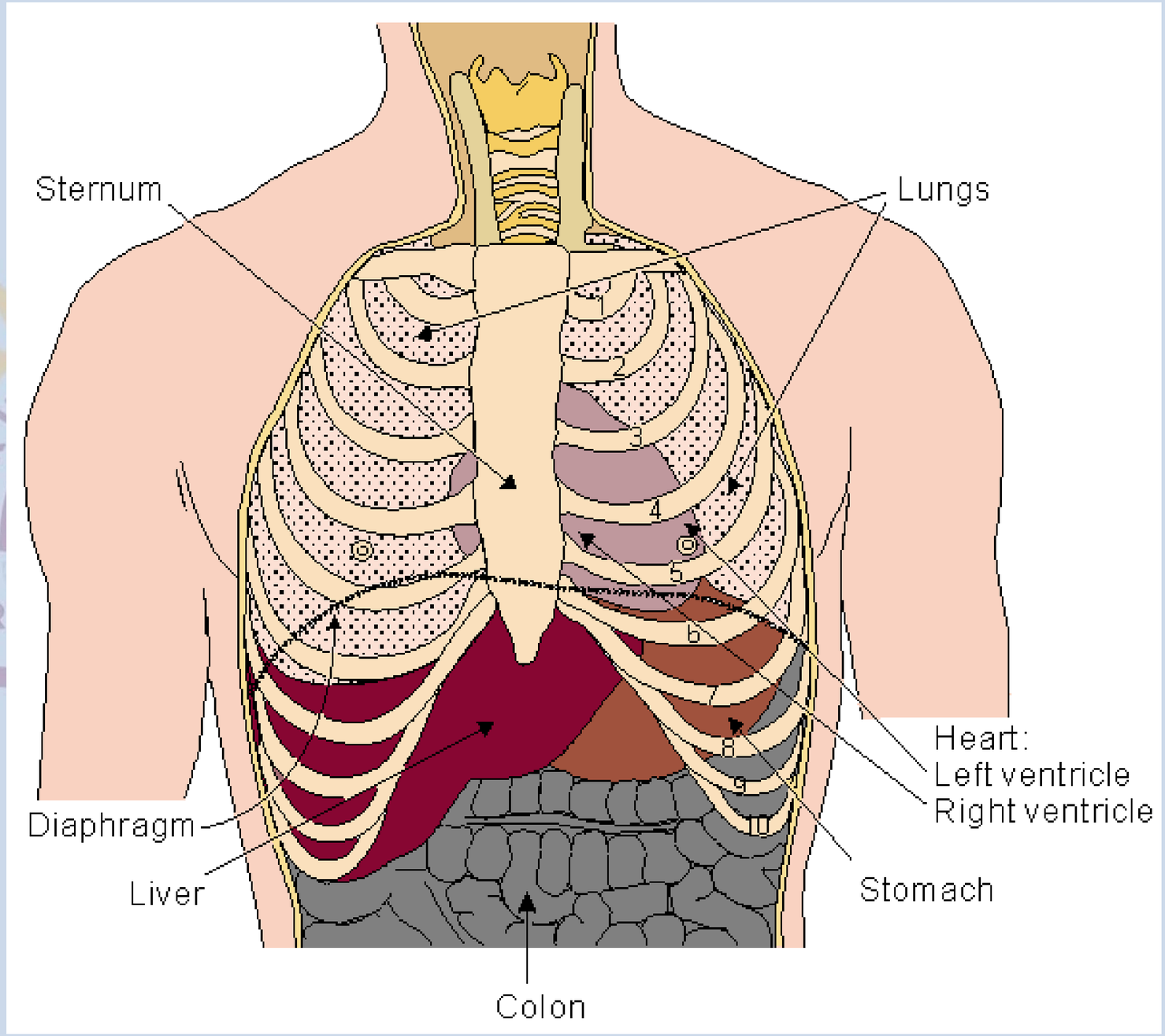


# HEART

**Heart is a four chambered, hollow muscular organ approximately the size of your fist**



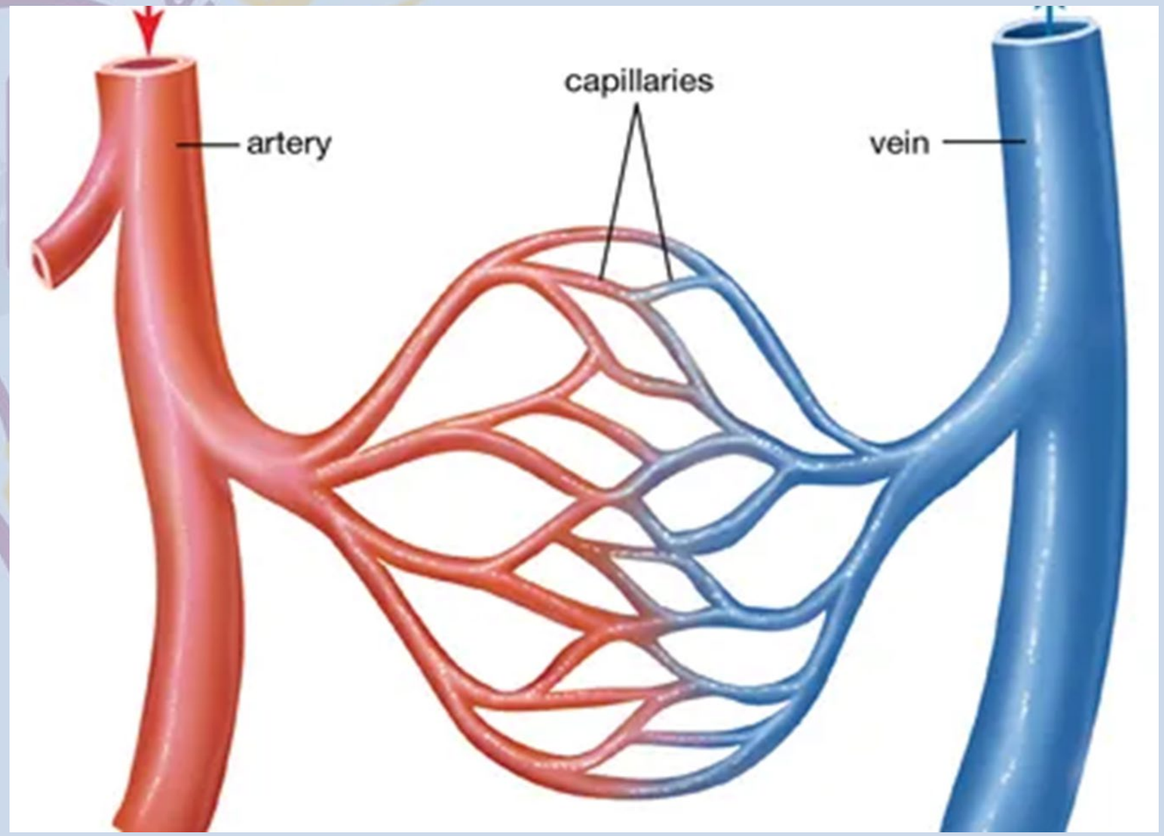
- **Location:**
  - **Superior surface of diaphragm**
  - **Left of the midline**
  - **Anterior to the vertebral column**
  - **posterior to the sternum**



# BLOOD VESSELS

- Blood Vessels -A closed network of tubes

- These includes:
  - Arteries
  - Capillaries
  - Veins

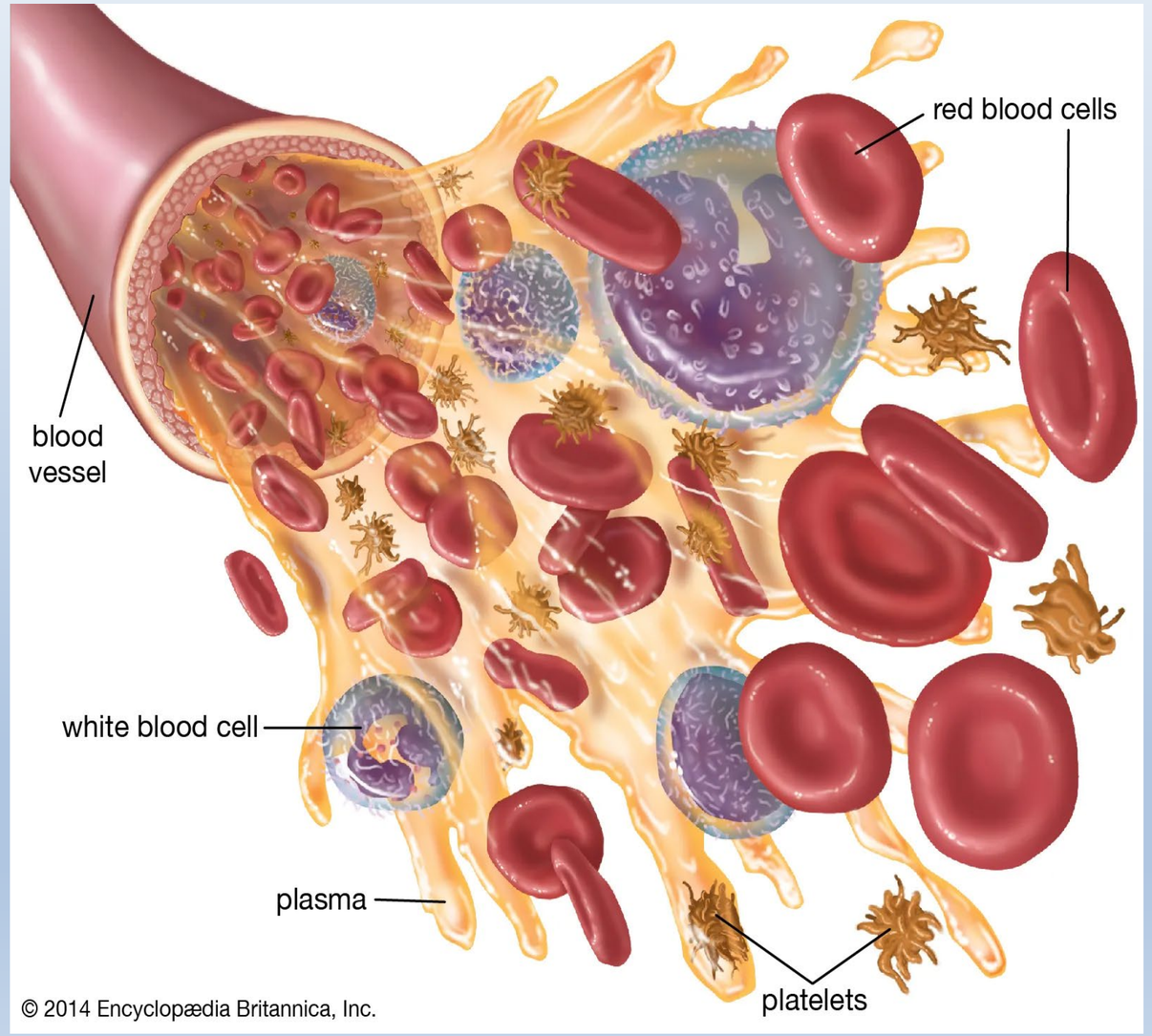


# BLOOD

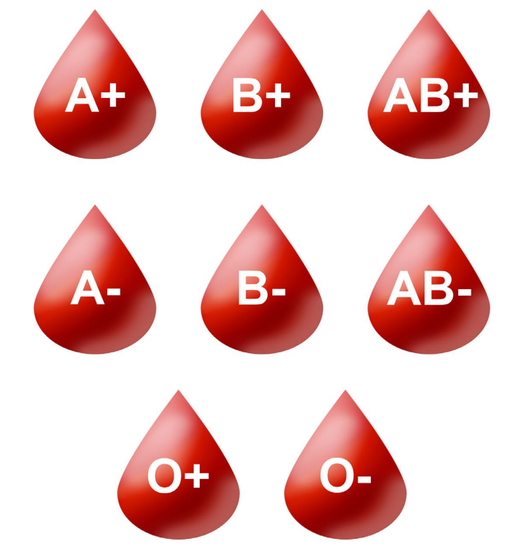
## The Blood compose from  Blood cells & Plasma

- **Blood cells:-**
  1- Erythrocytes - Red Blood Cells
  2- Leucocytes- White Blood Cells
  3- Thrombocytes- Platelet

- **Plasma is fluid portion**

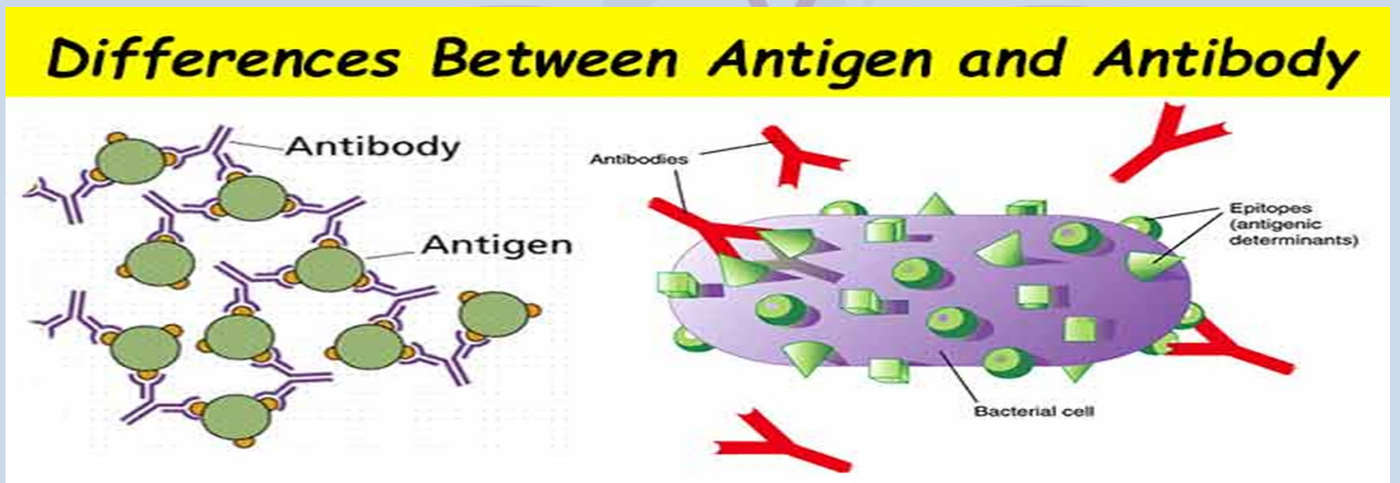


# Types of Blood




**The blood group is identified by antibodies and antigens in the blood. Antibodies are proteins found in plasma. They're part of the body's natural defenses. They recognize foreign substances, such as germs, and alert the immune system, which destroys them.**
**Antigens are protein molecules found on the surface of red blood cells.**

**In addition to the A and B antigens, there is a protein called the Rh factor, which can be either present (+) or absent (–), creating the 8 most common blood types (A+, A-, B+, B-, O+, O-, AB+, AB-)**



# What are the blood types?

## A+, A-, B+, B-, O+, O-, AB+, AB-

**O+** is the most frequently occurring blood type and is found in **38 percent** of the population. O positive red blood cells are **compatible to any red blood cells** that are positive (A+, B+, O+, AB+).

**A+ :-** This blood is the second most frequently occurring blood type. Thirty-four of every 100 people have A+ (**about 34%).**

**A-, B+, B- :-** These are rare blood types and less than **10 percent** of the population have this blood type.

**O-** is found in **seven percent** of the population.

**AB+:-** less than **four percent** have this type of blood.

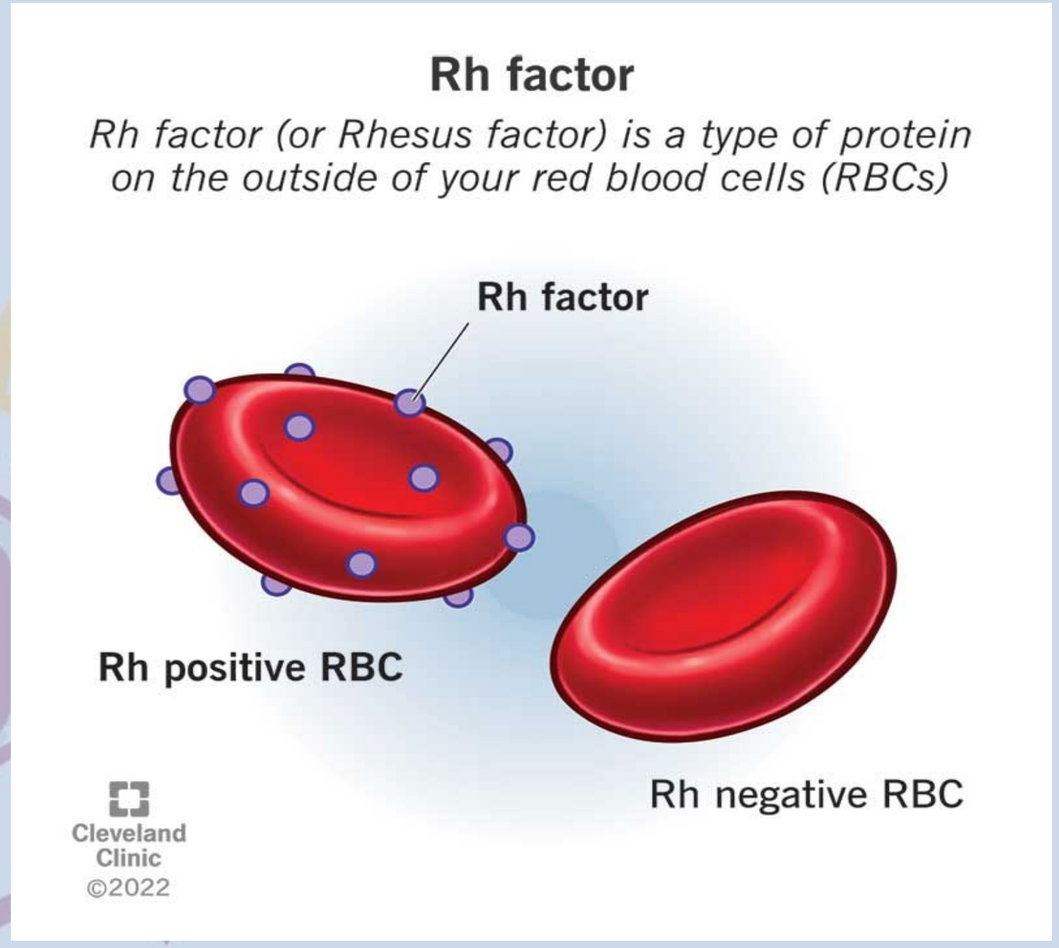
**AB-:-** This is the least common blood type, less than **1%** of the population

Facts About Blood

The Rh factor is a protein that can be found on the surface of red blood cells.

If the blood cells have this protein, then the blood is Rh positive.

If the blood cells do not have this protein, then the blood is Rh negative.

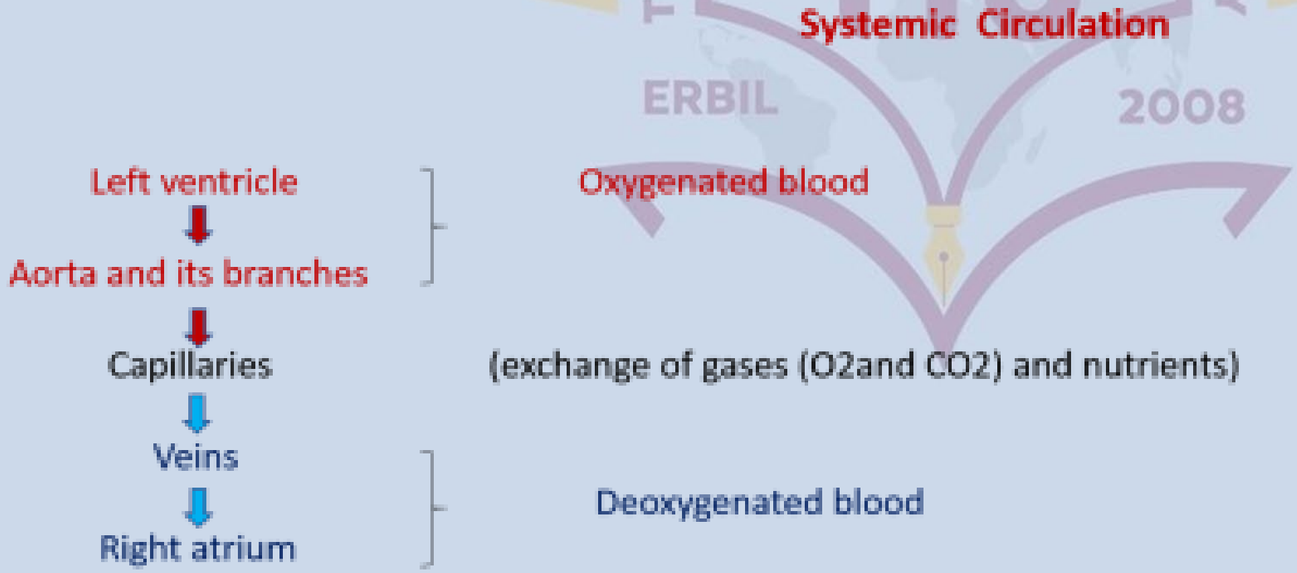


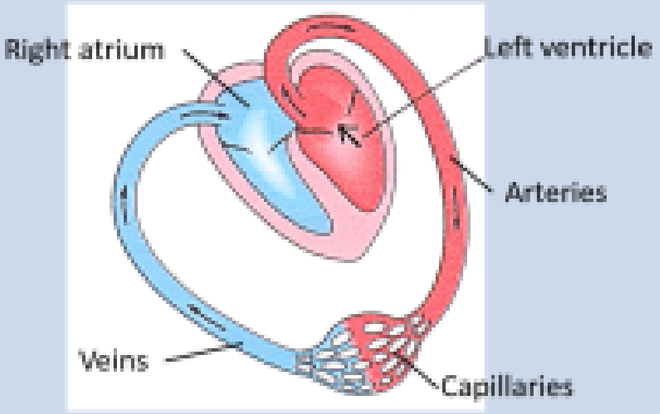

The "positive" or "negative" part of the blood type, such as O positive or A negative, refers to the Rh status

# Major components of the cardiovascular system

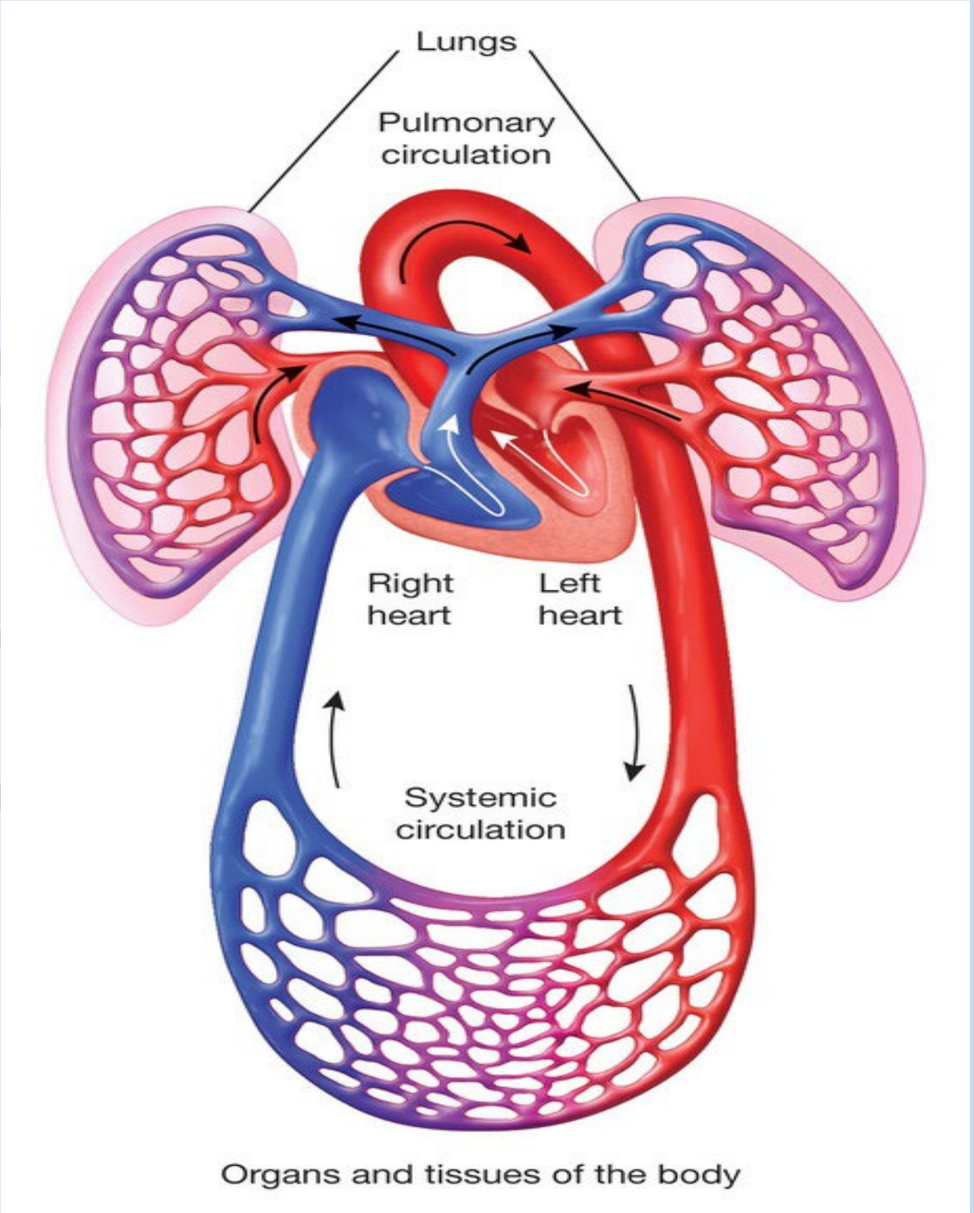
## 1-Systtemic circulation in the rest of the body

The blood is pumped by the contraction of the heart muscles from the left ventricle at a pressure of about 125mmHg into a system of arteries that subdivided into smaller arteries (arterioles) and to capillary bed. During the a few seconds it is in the capillary bed the blood supplies O2 to the cells and picks up CO2 from the cells.



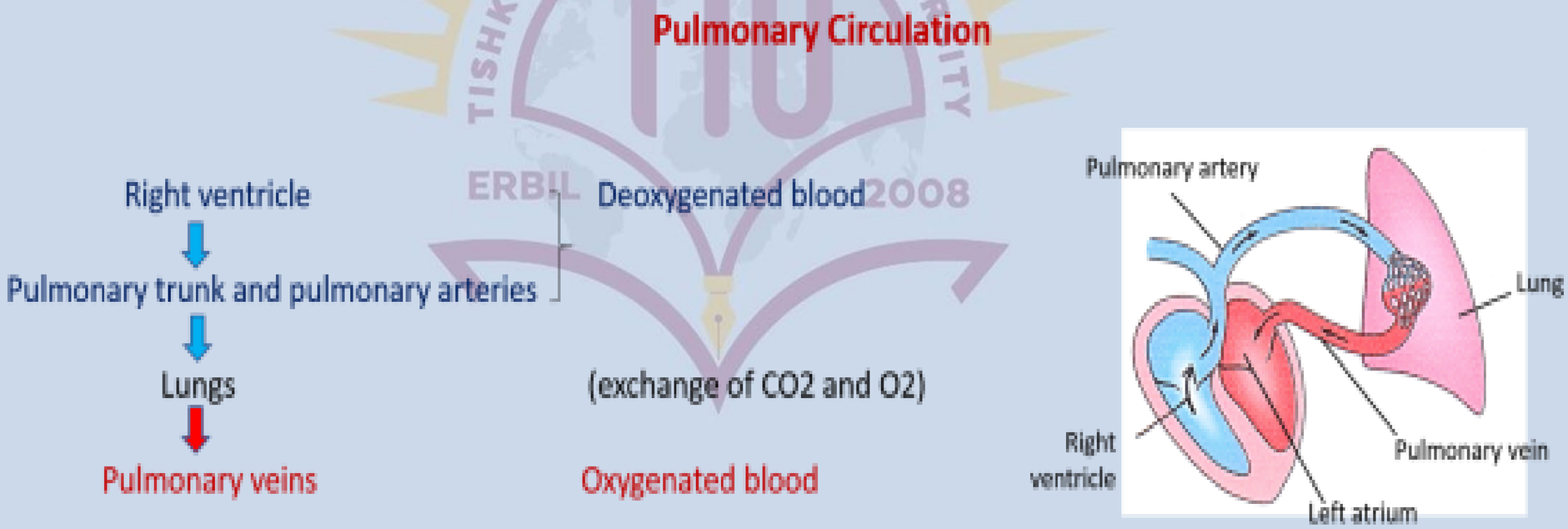



After passing through the capillary bed the blood collects in small veins that gradually combine into larger veins before inters the right side of the heart. The returning blood is momentarily stored in the reservoir (the right atrium), and during a weak contraction (5 to 6mmHg) the blood flows into right ventricle.



# 2-Pulmonary circulation

On the next ventricular contraction this blood is pumped at a pressure of about 25mmHg. Via the pulmonary arteries to the capillary system in the lungs, where it receives more O2 and where some of the CO2 diffuses into the air in the lungs to be exhaled. The freshly oxygenated left reservoir of the heart (left atrium) :during weak contraction (7 to 8mmHg), the blood flows into the left ventricle . On the next ventricular contraction this blood is again pumped from the left side of the heart into the general circulation.

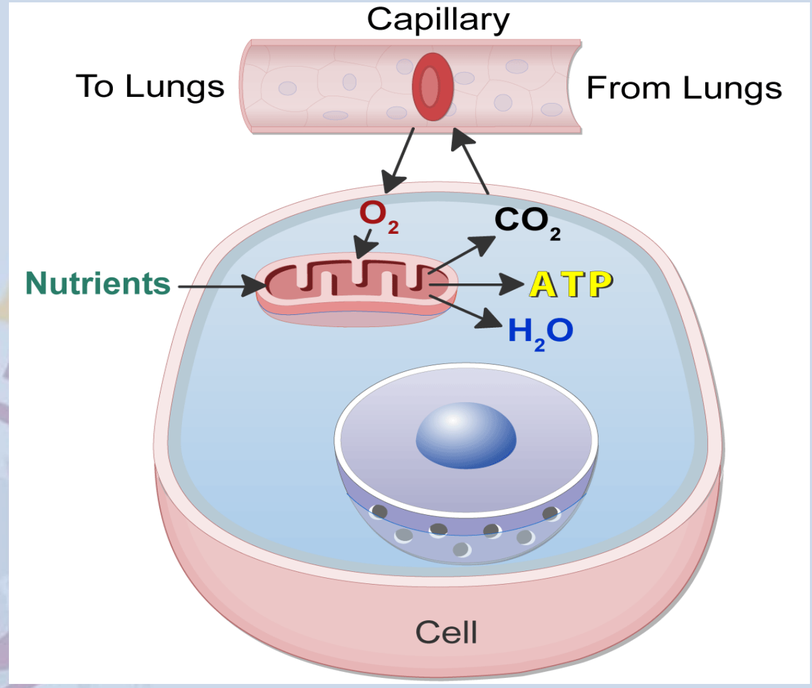


**Cellular Requirements for Energy**

Fuel: Cells obtain fuel from food to supply the energy necessary for biological processes.

**Oxygen ($O_2$):** Oxygen from the air combines with food molecules to release energy through a process often compared to combustion.

**Waste Disposal:** Cells must remove by-products of this energy production, which primarily include carbon dioxide ($CO_2$), water ($H_2O$), and heat.

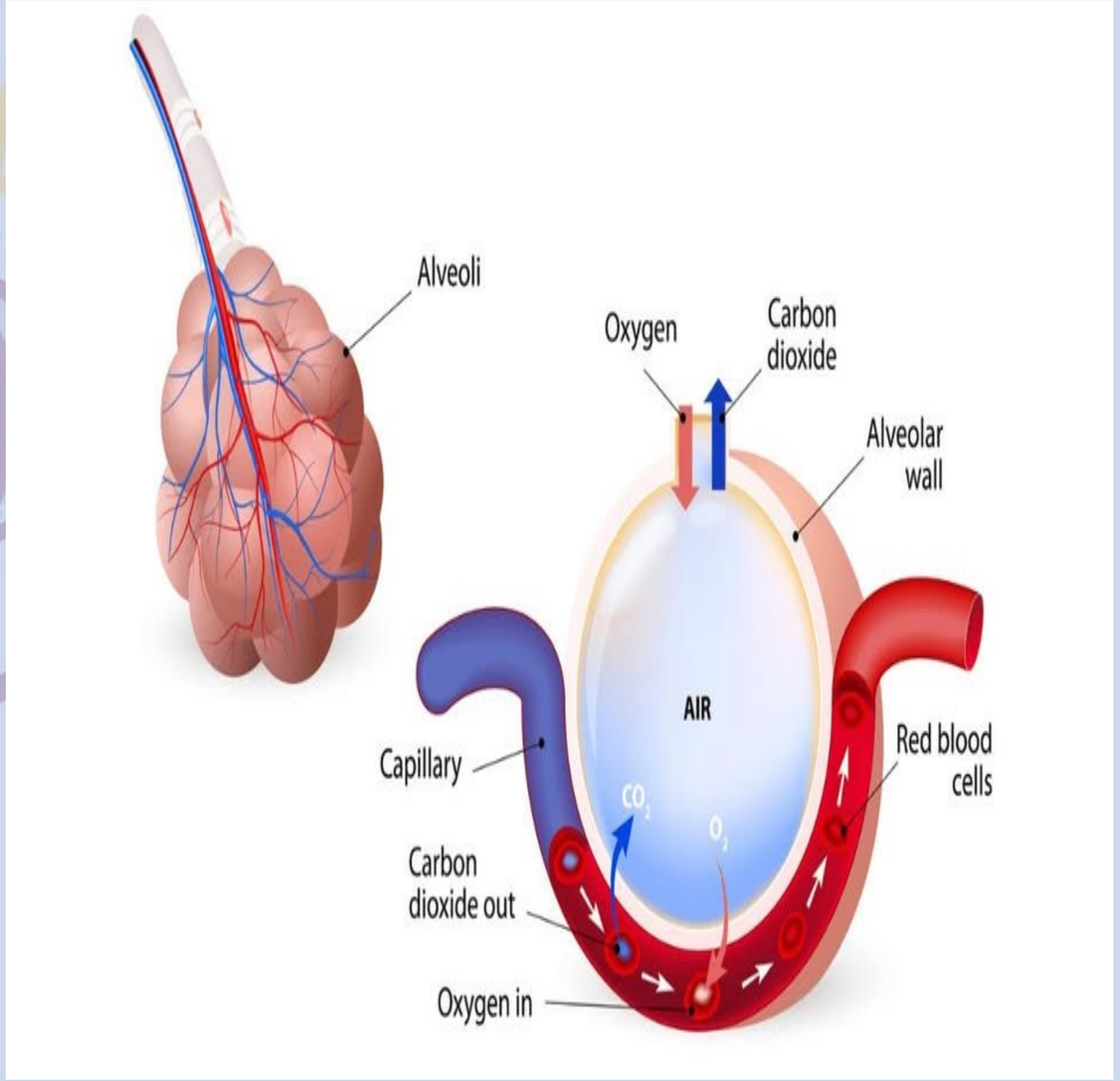


# O2 and CO2 exchange in the capillary system

Oxygen and carbon dioxide also diffuse through tissue. The most probable distance D that a molecule will travel after N collisions with other molecules with an average distance λ between collisions is: -

$$D = \lambda \sqrt{N}$$

**D** is the most probable diffusion distance
**N** is number of collisions
**λ** is the average of a molecule travel after N collisions



A typical value for λ in water, which can serve as a model for tissue, is about $10^{-11}$ m, and a molecule makes about $10^{12}$ collisions/sec. find the most probable diffusion distance after 1sec in water.

$D = \lambda \sqrt{N}$

$D = 10^{-11}$ m $\sqrt{}$ $10^{12}$ collisions/sec

D= about $10^{-5}$ m .

This very short diffusion distance is the primary reason that the capillaries in tissue must be very close together.

Not all capillaries are carrying blood at any one time. In resting muscle only 2 to 5% of the capillaries are functional

At rest, your muscles don’t need much oxygen or nutrients, so the body keeps most capillaries closed. Only about **2–5%** are open (functional). This is controlled by tiny muscle rings called **precapillary sphincters**, which act like valves at the entrance of capillaries. By closing many capillaries, the body conserves energy and avoids sending unnecessary blood to inactive muscle. When muscles become active (e.g., during exercise), their demand for oxygen and nutrients increases.

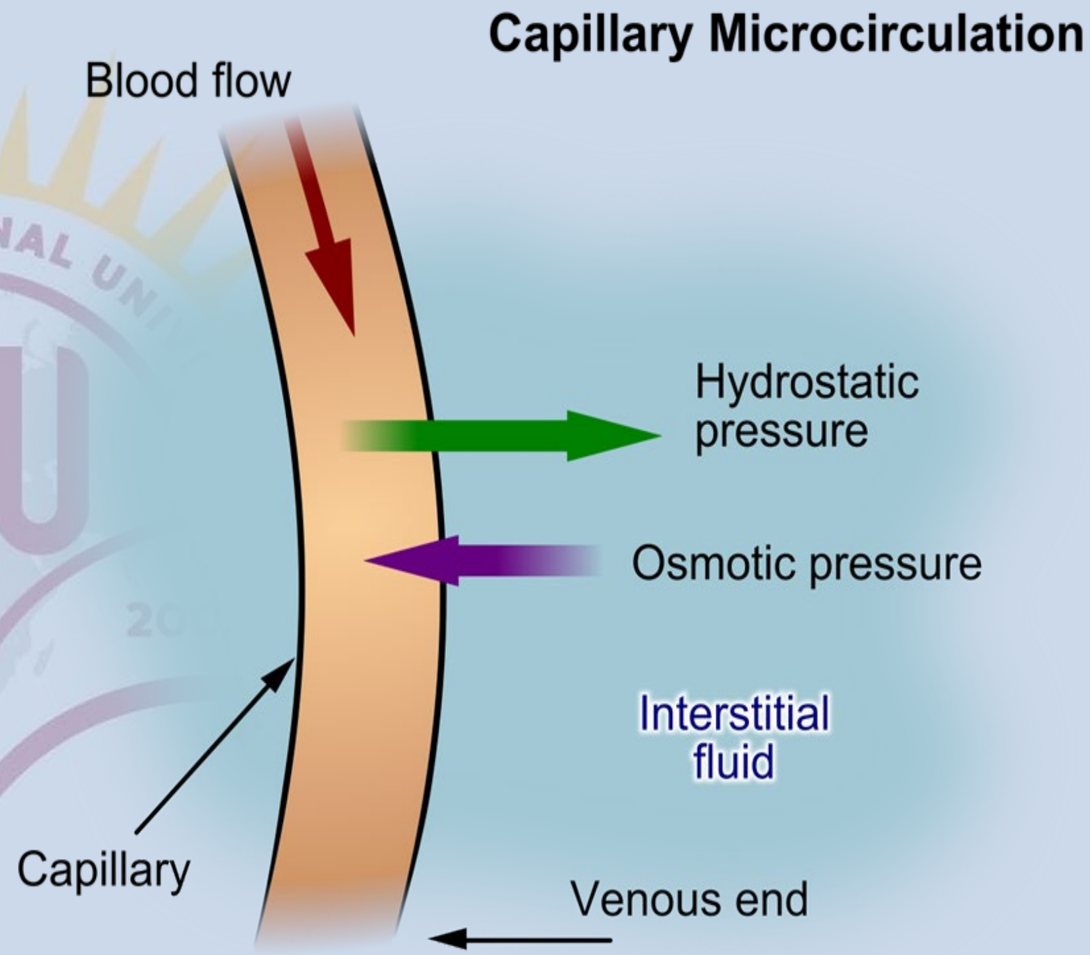
In response, these **precapillary sphincters** relax (open), allowing blood to flow into many more capillaries. This process is called increased perfusion. So, in simple terms: **At rest: Few capillaries open → low blood flow → energy conserved. During activity: Many capillaries open → high blood flow → more oxygen and nutrients delivered.** This system ensures that blood is directed where it’s needed most, rather than being evenly distributed all the time.

**Starling's law of capillary describes the flow of fluids into and out of the capillaries.**

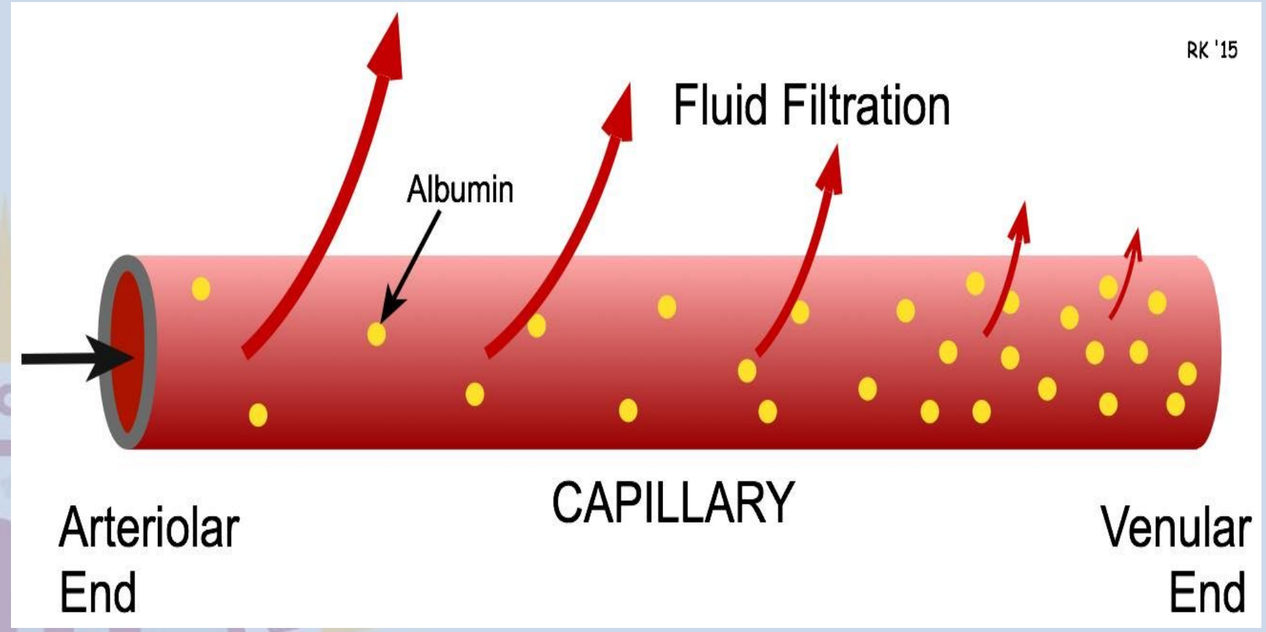
Fluid movement through the capillary wall is the result of two pressures: -

1- The hydrostatic pressure ρ across the capillary wall forcing fluids out of the capillary.

2- The osmotic pressure π bringing fluids in.



•Starling’s forces control the movement of fluid (Interstitial Fluid (water + dissolved substances)) in and out of capillaries, when it leaves the capillary.

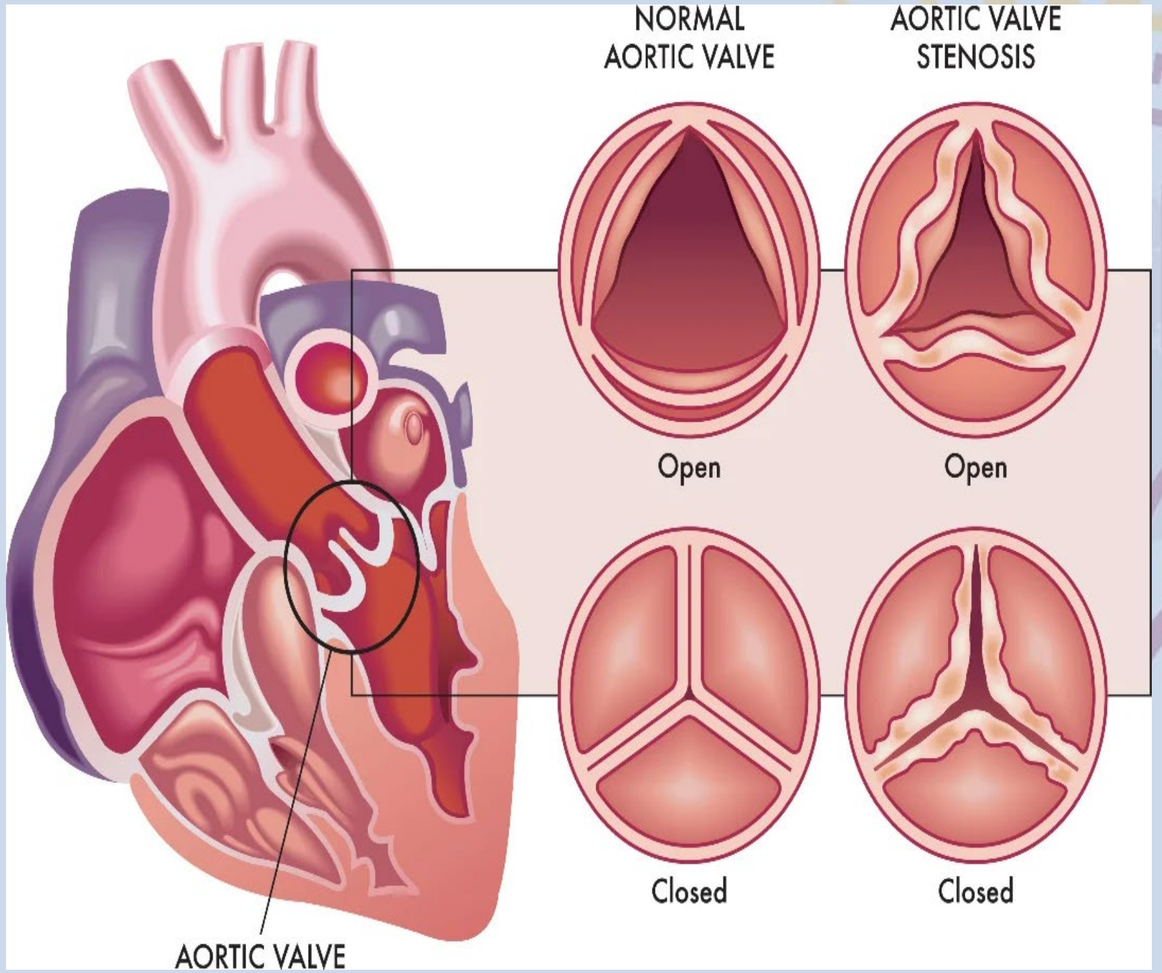


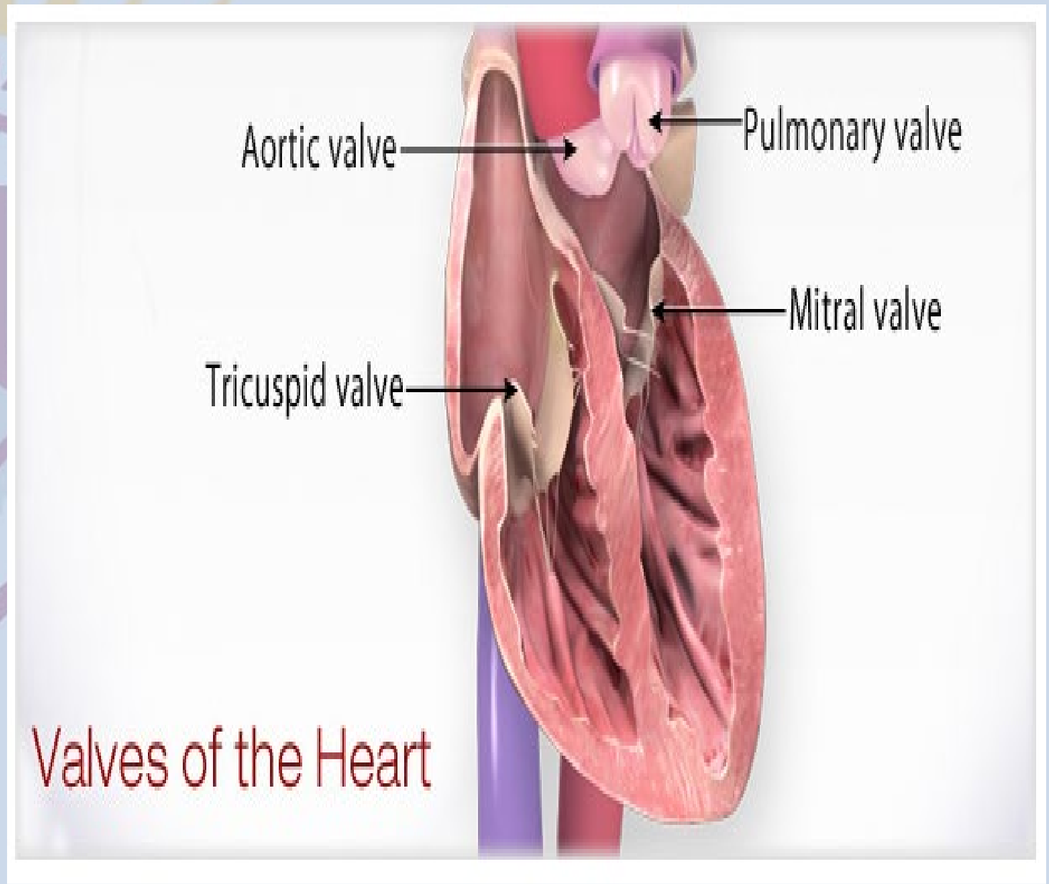

Moves OUT of capillary:
•Water
•Oxygen (dissolved)
•Glucose, ions, nutrients
•Small waste molecules

At arterial end (beginning of capillary)Hydrostatic pressure is high, the fluid is pushed out. This is called Filtration

At venous end (end of capillary)
•Osmotic pressure (due to proteins) is higher. Fluid is pulled back IN, waste and $CO_2$ return to blood

**The heart has a system of valves that**, if functioning properly, permit the blood to flow only in the correct direction. If these valves become diseased and do not open or close properly the pumping of the blood becomes inefficient.

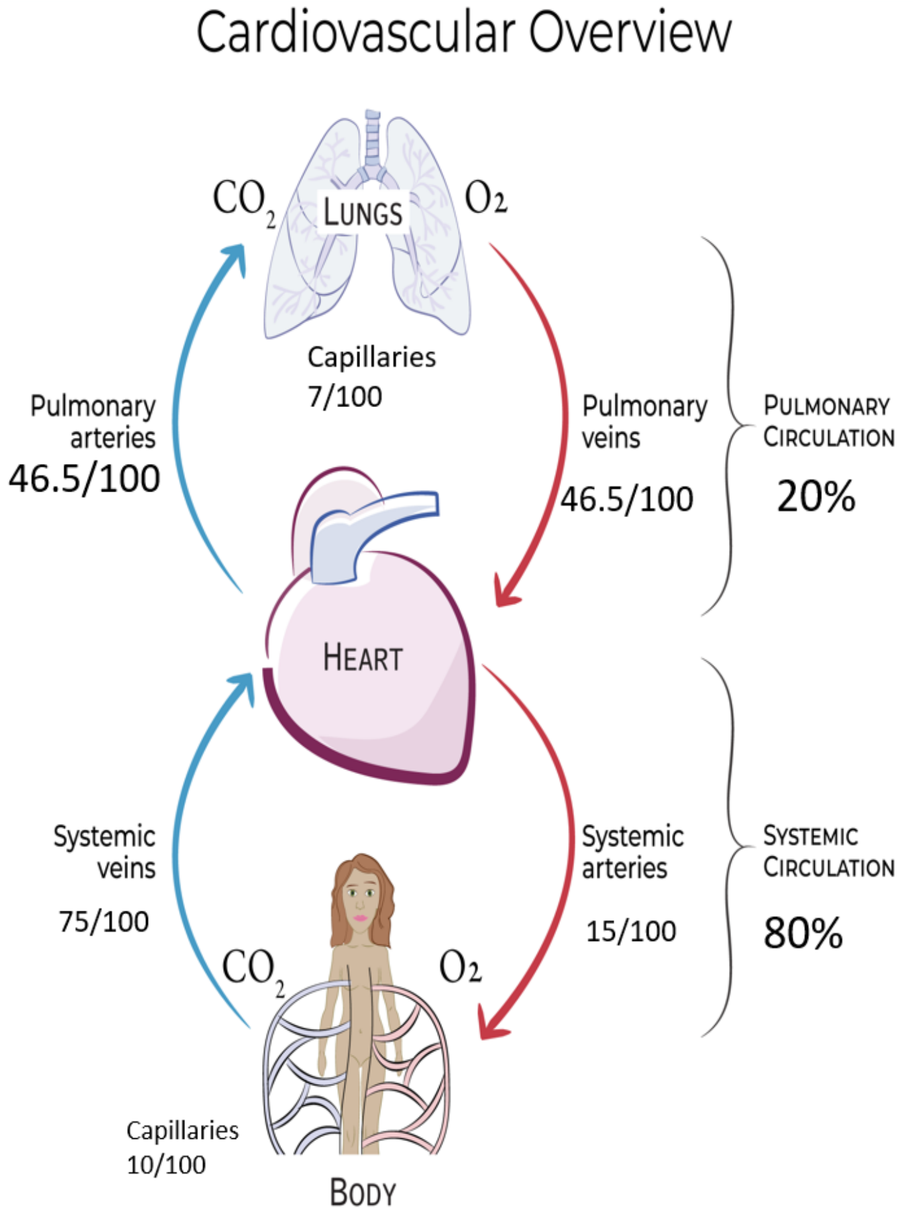


The blood volume is not uniformly divided between the pulmonary and systemic circulation, but it is primarily distributed with roughly 80% in the systemic circulation and only about 20% in the pulmonary circulation. The systemic side operates under high pressure, while the pulmonary side is a low-pressure, high-capacitance system

**Blood Circulation 100/100**

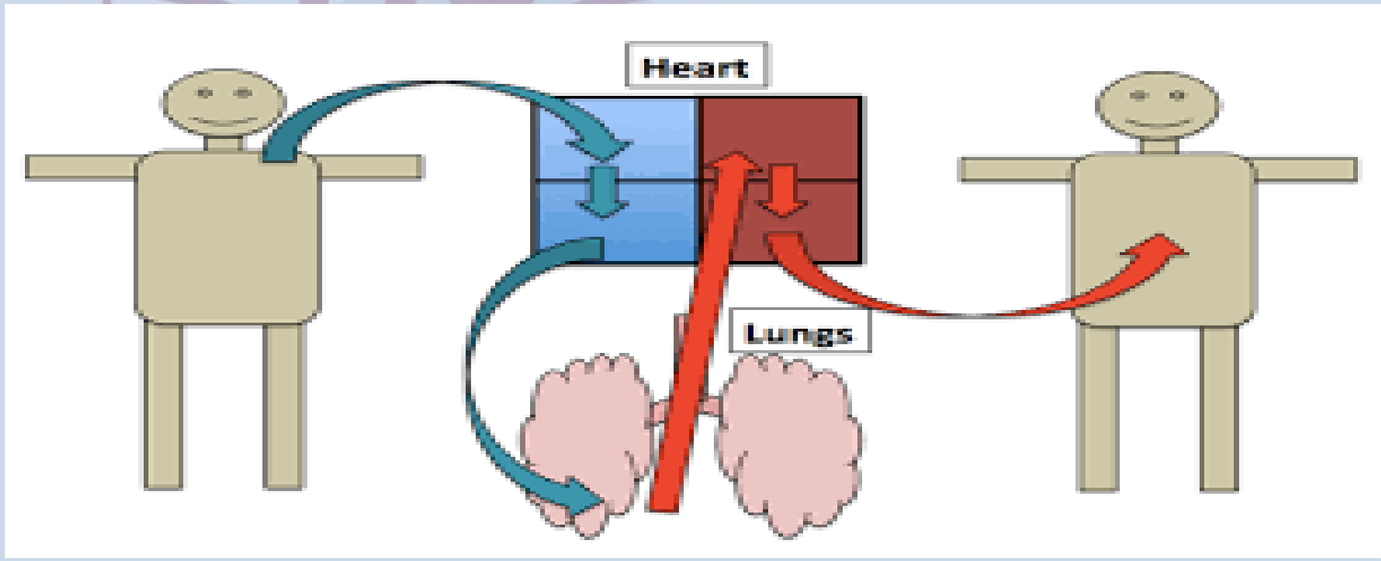
| **Systemic Circulation 80/100** | **Pulmonaire Circulation 20/100** |
|---|---|
| **Arteries** | **Arteries** |
| 15/100 | 46.5/100 |
| **Capillaries** | **Capillaries** |
| 10/10 | 7/100 |
| **Veins** | **Veins** |
| 75/100 | 46.5/100 |



**Work done by the heart**

In a typical adult each contraction of the heart muscles forces about **80ml** (about one-third of a cup) of blood through the lungs from the right ventricle and a similar volume to the systemic circulation from the left ventricle. In the process the heart does work.

The pressures in the two pumps of the heart are not the same. In the pulmonary system the pressure is quite low because of the low resistance of the blood vessels in the lungs.

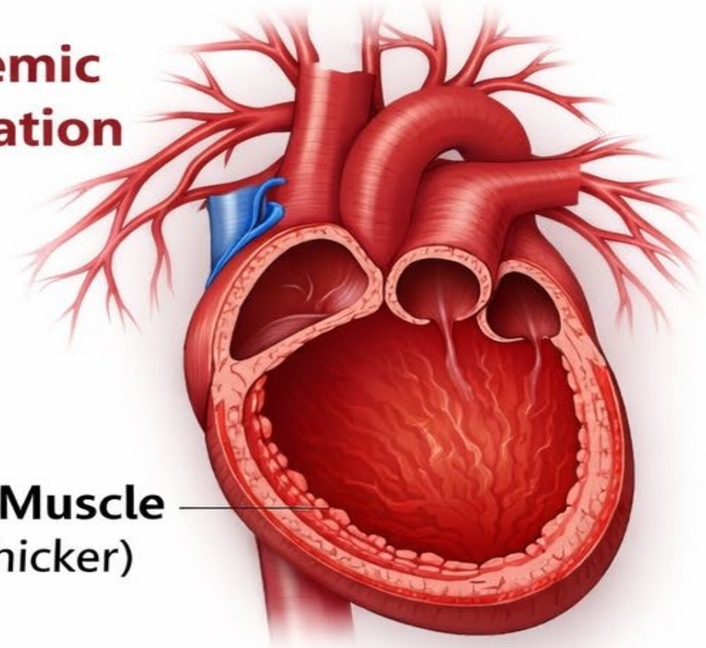


**The maximum pressure in the pulmonary circulation (systole)** is typically about **25 mmHg**, which is much lower than in the systemic circulation. To circulate blood through the larger systemic network, the left side of the heart generates pressures of about **120 mmHg during systole**. During the resting phase (diastole), the pressure is typically around **80 mmHg**.

The muscle of the left ventricle is about **three times thicker** than that of the right ventricle. Additionally, the **circular shape of the left ventricle** allows it to generate higher pressure more efficiently, whereas the **right ventricle has a crescent shape**, which is suited for pumping blood at lower pressure into the pulmonary circulation.

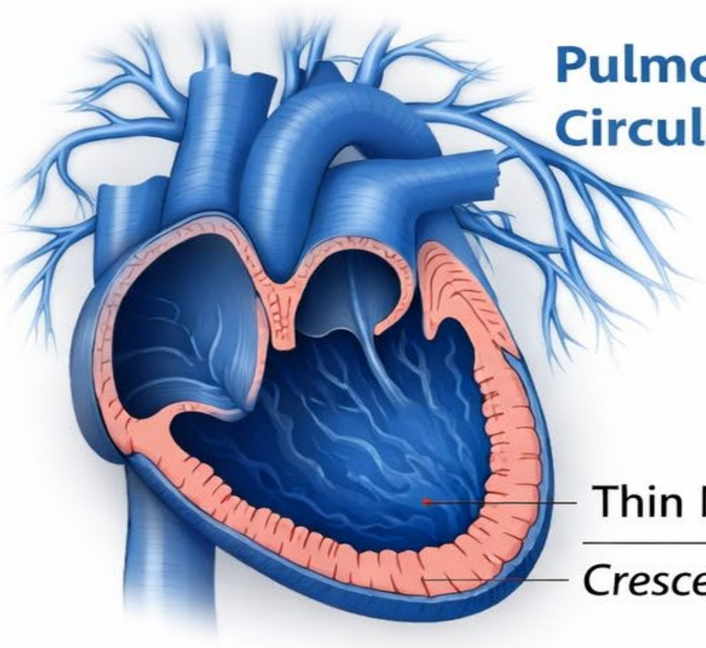
High Pressure → Low Pressure

**Systemic Circulation**



**Thick Muscle**
(3x thicker)

**Pulmonary Circulation**



Thin Muscle

*Crescent Shape*

| Systemic Pressures | |
|---|---|
| **Systolic:** | **120** mmHg |
| **Diastolic:** | **80** mmHg |

| Pulmonary Pressures | |
|---|---|
| **Systolic:** | **25** mmHg |
| **Diastolic:** | **8** mmHg |

The work done $W$ by a pump operating at a constant pressure $P$ is given by the product of pressure and the volume pumped $\Delta V$:

**W=PΔV.**

Similarly, the mechanical work performed by the heart can be estimated by multiplying the average blood pressure by the volume of blood ejected during each beat.

**The timing of the cardiac cycle for contraction and relax (one complete heartbeat)is:-**

- The heart contracts (systole) for less than **1/3** of the time
- The heart relaxes (diastole) for more than **2/3** of the time

**Example calculation:**

If the heart rate is 120 beats per minute:

$$120 \text{ beats/min} = \frac{120}{60} = 2 \text{ beats/sec}$$

$$\text{Time per beat} = \frac{1}{2} = 0.5 \text{ sec}$$

Since one cardiac cycle consists of:

- **1/3 contraction (systole)**
- **2/3 relaxation (diastole)**

$$\text{Contraction time} = 0.5 \times \frac{1}{3} \approx 0.17 \text{ sec}$$

$$\text{Relaxation time} = 0.5 \times \frac{2}{3} \approx 0.33 \text{ sec}$$

# Thank you