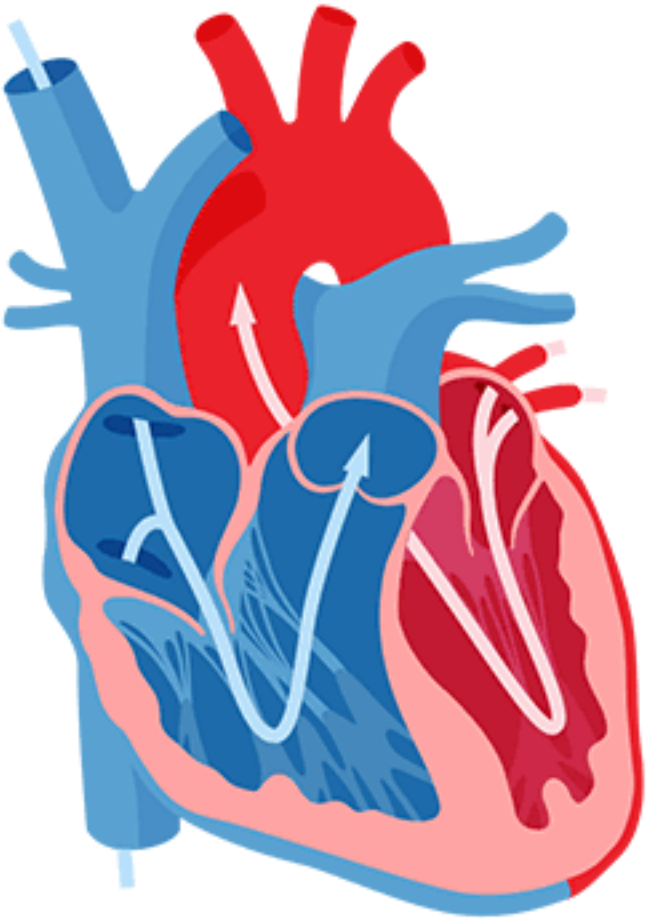
Physiology of Heart



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PHYSIOLOGICAL ANATOMY of the HEART

The HEART is the great central pump of the CVS. It lies in the left side of the thoracic cavity partly behind the sternum and between the right and left lungs. It is covered by a fibrous sac called the pericardium.

GENERAL STRUCTURE OF THE HEART

- The heart is a hollow muscular organ. Its walls are composed of a muscle called the cardiac muscle or the myocardium

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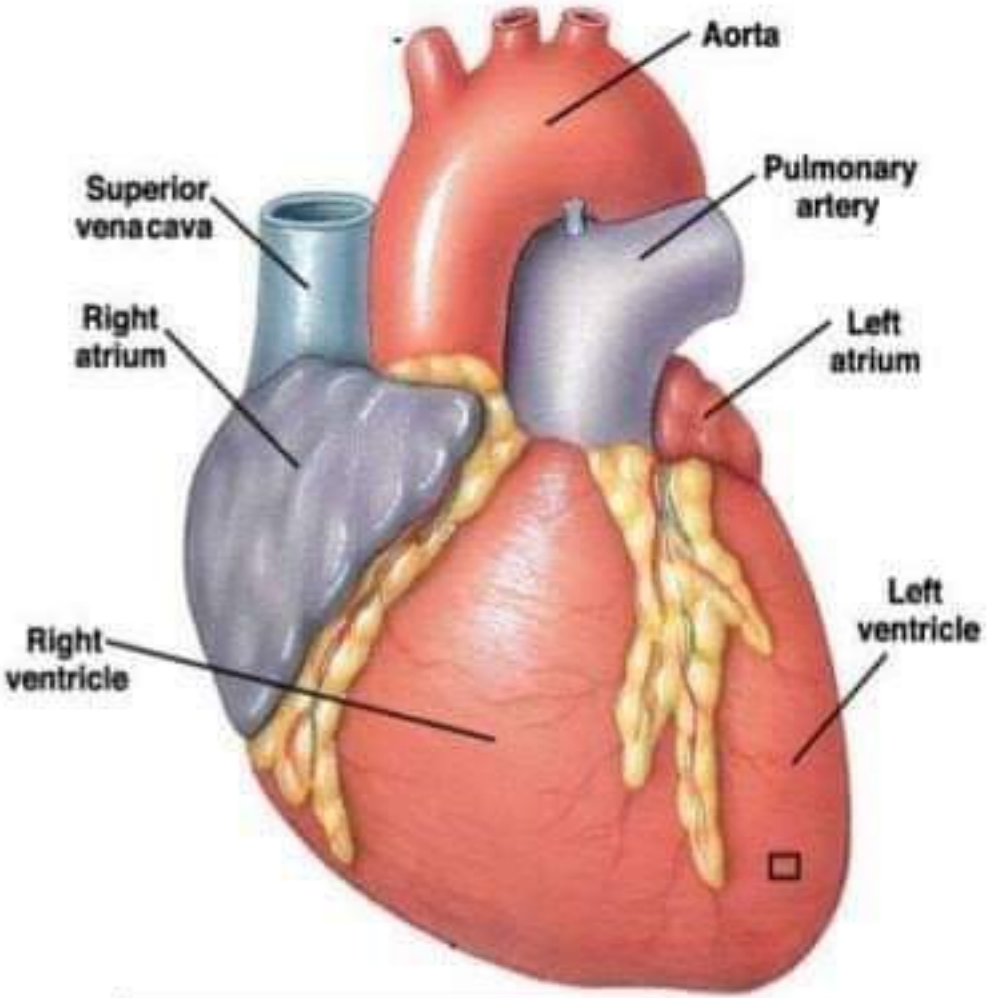
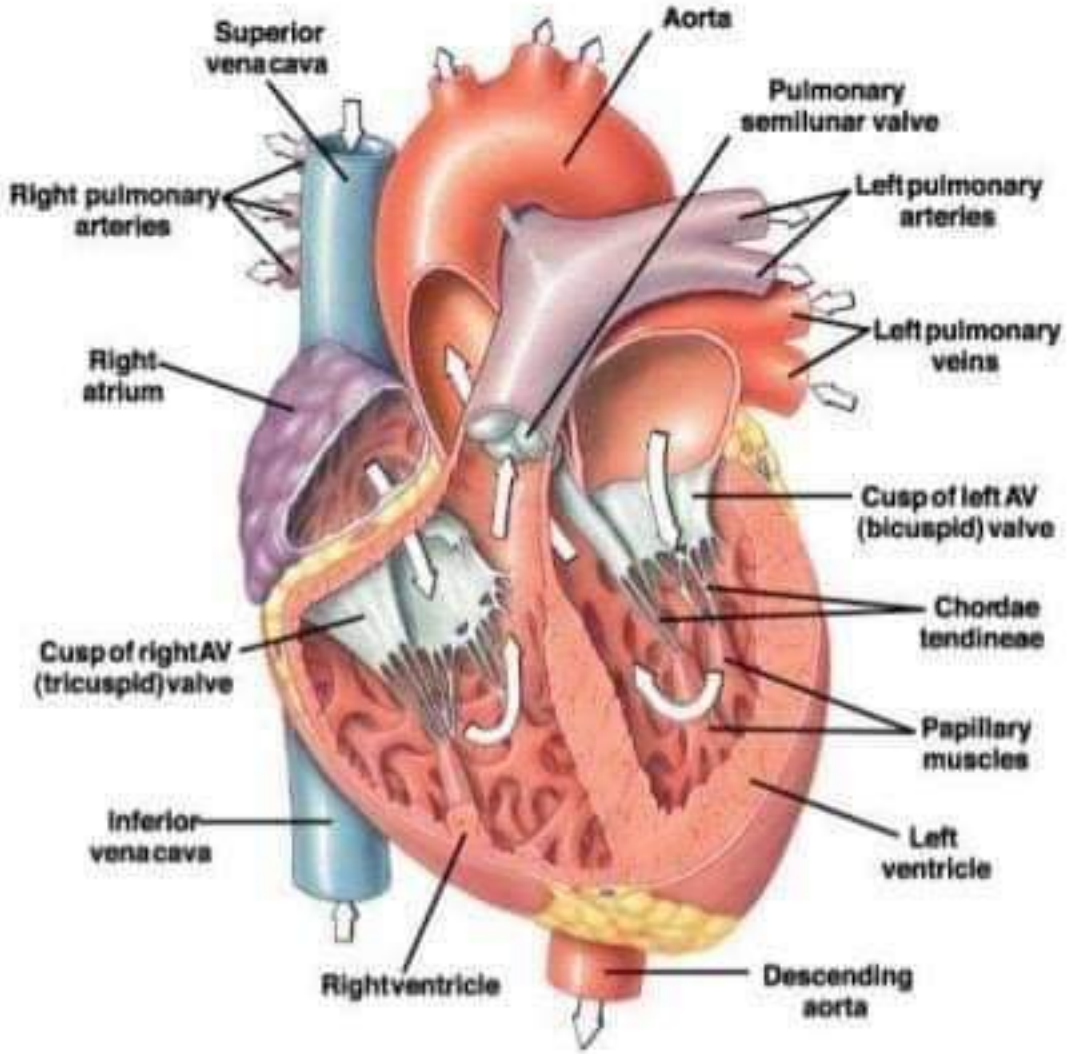


The ventricles occupy the bulk of the heart. The arteries and veins all attach to the base of the heart.



One-way flow through the heart is ensured by two sets of valves.

Cardiac Chambers & their functions

The human HEART is consist of four chambers:

- Two atria (right and left) which are separated from each other by the interatrial septum.

- Two ventricles (right and left) which are separated from each other by the interventricular septum.

- The wall of the left ventricle is about 3 times thicker than the wall of the right ventricle.

- The ventricular myocardium (wall) is much thicker and stronger than the atrial myocardium (wall). The atrial muscle (of both atria) is completely separated from the ventricular muscle (of both ventricles) by a fibrous ring called AV ring (atrioventricular ring).

- The atria have 2 main functions:
  1) They act as blood reservoir for the blood returning back to the heart.
  2) They act as pumps (primer pumps). Atrial contraction pushes about 25% of the blood filling the ventricles during ventricular diastole and about 75% of the blood that ventricles during their diastole pass passively i.e. by its own weight.

- The ventricles, on the other hand , are the powerful cardiac pumps filling the arteries with blood. The right ventricle (pulmonary pumps) pushes blood into the pulmonary arteries and the left ventricle (systemic pump) pushes blood into the aorta during ventricular systole.

Cardiac Valves and their functions

The human heart contains four valves

- Two atrioventricular valves (AV valves) between the atria and the ventricles:
  - Tricuspid valve between the right atrium and the right ventricle.
  - Mitral or tricuspid valve between the left atrium and there left ventricle.

- Two semi lunar valves:
  - Aortic valve between the left ventricle and the aorta.
  - Pulmonary valve between the right ventricle and the pulmonary trunk.

Functions of the cardiac valves

The cardiac valves allow for the blood to pass only in one direction i.e.

- The AV valves allow for the blood to pass from the atria into the ventricles during ventricular diastole. During ventricular systole, the AV valves close to prevent back flow of blood from the ventricles into the atria.
- The semi lunar valves allow for the blood to pass from the ventricles into the arteries during ventricular systole. During ventricular diastole, these valves prevent back flow of blood from the arteries into the ventricles (as these valves become closed during ventricular diastole).

- It should be noted that:
  a) The valves open or close depending upon the pressure gradient of the blood on both sides of the valves e.g.
- The AV valves:
  - Open when the atrial pressure becomes higher than the ventricular pressure or
  - Close when the ventricular pressure becomes higher that the atrial pressure.
- The semi lunar valves:
  - Open when the ventricular pressure becomes higher than the arterial pressure and
  - Close when the arterial pressure becomes higher than the ventricular pressure.

The right ventricle

- The right ventricle pumps relatively large volumes of blood at a low pressure through the pulmonary circulation (the right ventricle is essentially flow generator).
- The normal cross-section of the right ventricle is crescent-shaped.
- If the right ventricle must eject blood against a high pressure for prolonged periods (as seen in certain pulmonary diseases), it assumes a much more cylindrical appearance and there is a thickening of the right ventricular free wall (right ventricular hypertrophy).

The left ventricle

- The left ventricle pumps blood through the systemic circulation.
- It is cylindrical in shape and normally has a thicker wall than does the right ventricle.
- The left ventricle works much harder than the right ventricle because of the higher pressure in the systemic circulation (the left ventricle is essentially pressure generator).
- Consequently, the left ventricle is more commonly affected by disease processes than is the right ventricle.

Blood flow from the heart

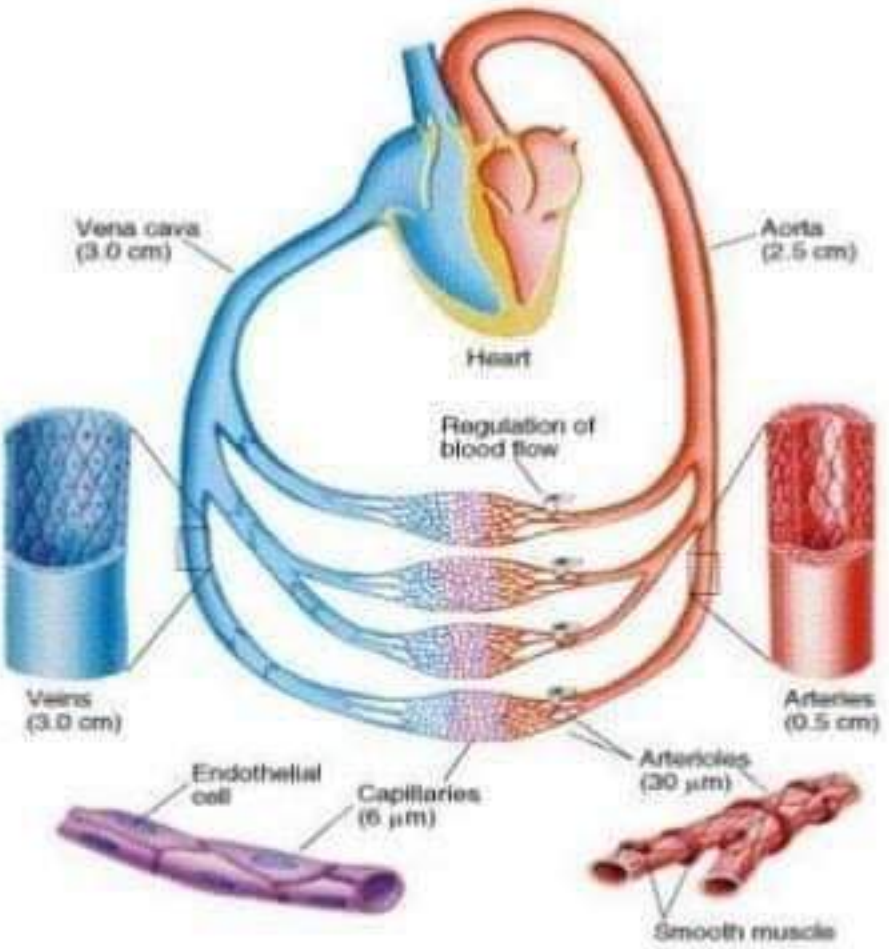
- During ventricular systole, blood is pumped into the circulation.
- During diastole, the pumping of blood stops and the ventricles get filled with blood.
- In this way, the flow of blood from the ventricles into the systemic and pulmonary circulations is an intermittent pulsatile flow.

❖The heart rate is under neural control. Cardiac sympathetic efferent activity increases the heart rate, whereas parasympathetic (vagal) efferent impulses decreases heart rate.

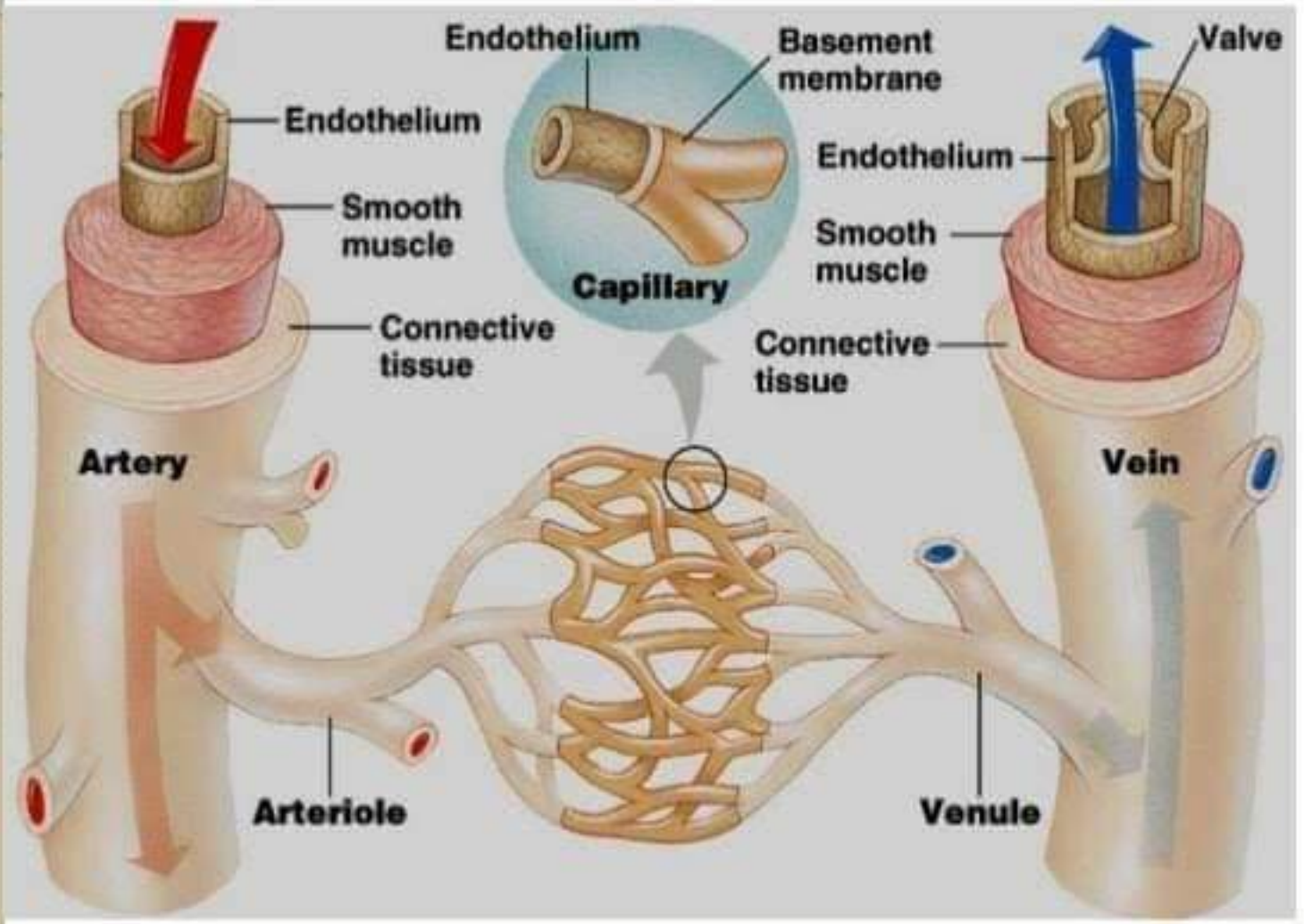
❖The heart of a normal adult male beats automatically and regularly at a rate of 75 beats/minute during rest. The normal range of heart rate is between 60 – 100.

❖The stroke volume for each ventricle averages 70 ml of blood, and a normal heart rate is approximately 70-75 beats/minute; therefore, the cardiac output at rest is approximately 5 L/min.

Blood flow from the heart

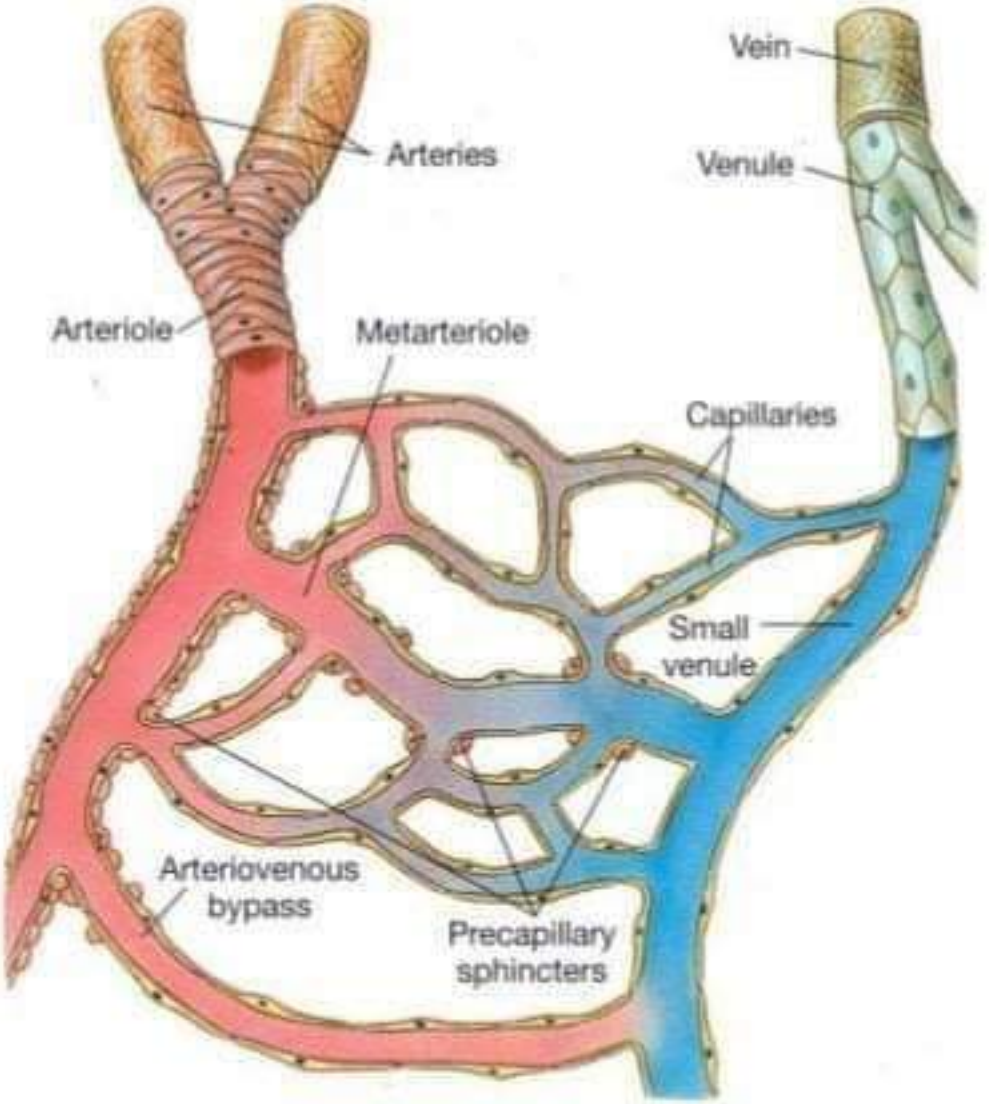


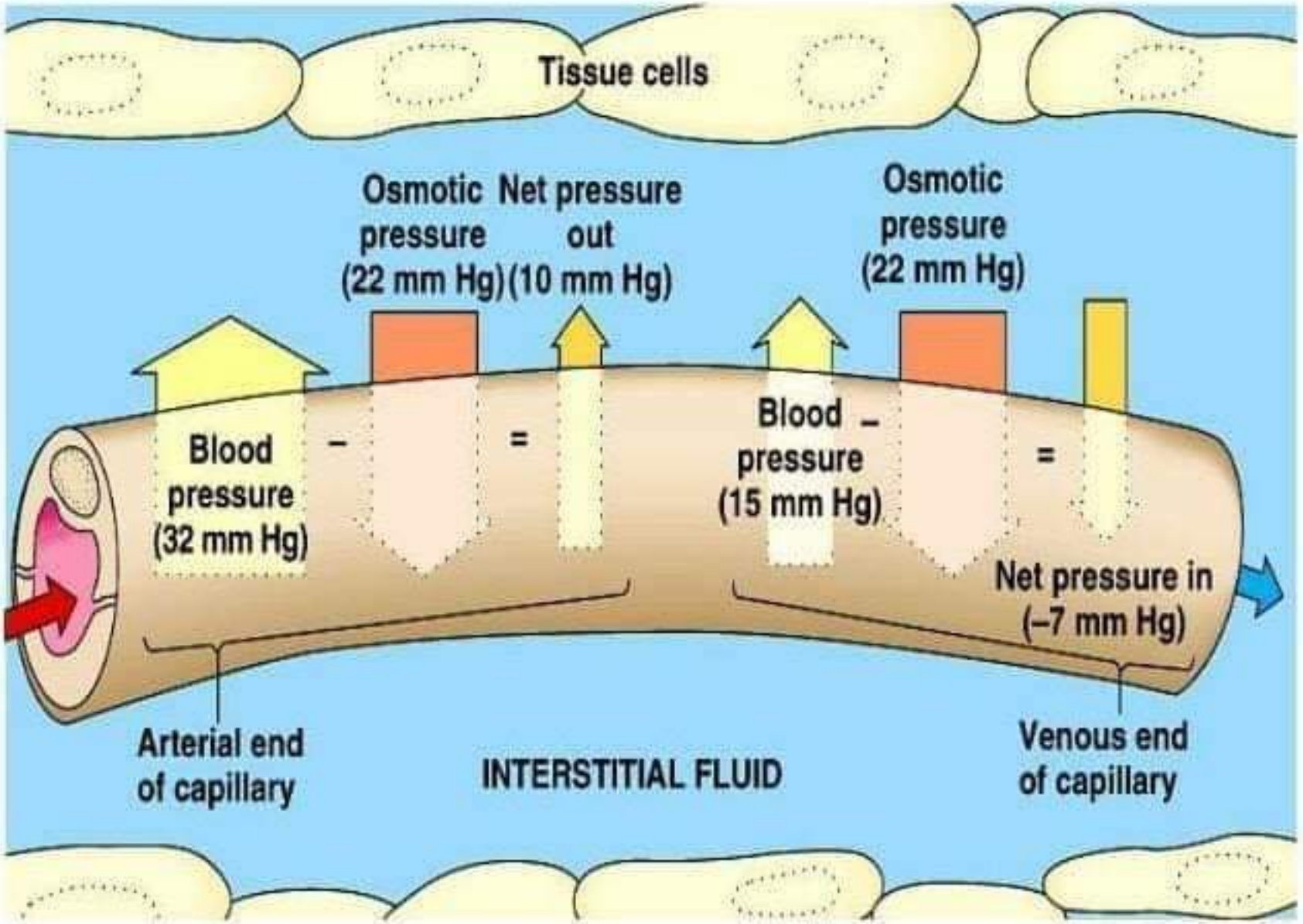
Blood vessels



Blood vessels

1. Elastic vessels.
2. Low-resistance vessels.
3. High-resistance vessels.
4. Exchange vessels.
5. Capacitance vessels.


Vein
Arteries
Venule
Arteriole
Metarteriole
Capillaries
Small
venule
Arteriovenous
bypass
Precapillary
sphincters

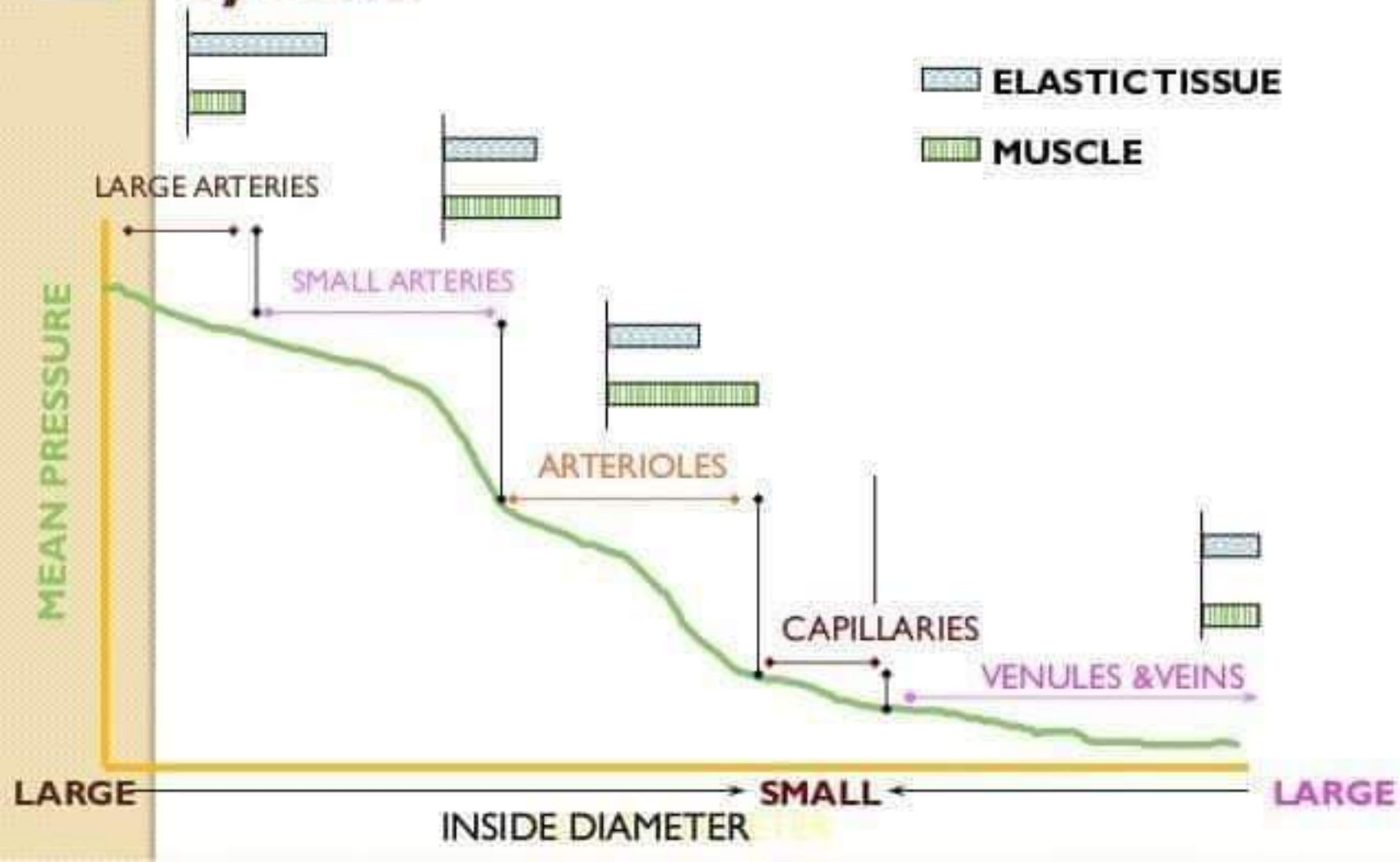


The peripheral resistance

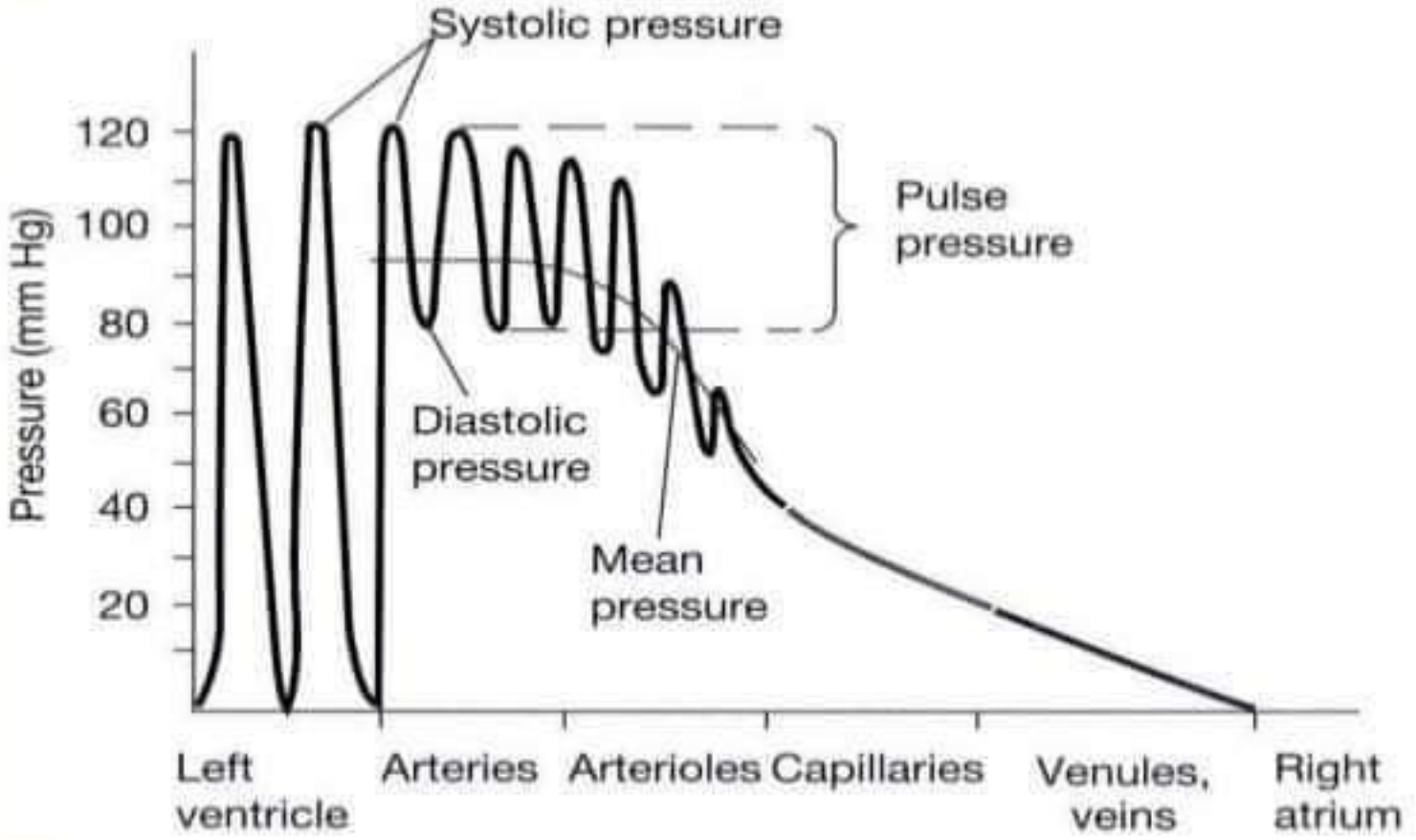
As the blood flows from the arterial to the venous side of the circulation, it meets resistance because of the smaller caliber of the vessels and the viscous nature of the blood. This is called the peripheral resistance.

It is an important factor in generating and maintaining the arterial blood pressure. Vasoconstriction of the small vessels increases the peripheral resistance, which in turn elevates the arterial blood pressure. Whilst vasodilatation decreases the resistance and lowers the pressure.

Pressure Drop in the Vascular System



Pressure Drop in the Vascular System



* The wall of the left ventricle is much thicker (15 mm) than the wall of the right ventricle (5 mm), yet the capacities and outputs of both ventricles are equal.

* The thickness of the ventricular wall reflects the pressure load on the ventricle. The pressure load on the left ventricle (the aortic pressure) is much higher than the pressure load on the right ventricle (the pulmonary arterial pressure).

Heart Sounds

- **Heart sounds** are the noises generated by the beating heart and the resultant flow of blood through it.
- Specifically, the sounds reflect the turbulence created when the heart valves snap shut.
- In cardiac auscultation, an examiner may use a stethoscope to listen for these unique and distinct sounds that provide important auditory data regarding the condition of the heart.
- In healthy adults, there are two normal heart sounds often described as a *lub* and a *dub* (or *dup*), that occur in sequence with each heartbeat.
- These are the **first heart sound** (S_1) and **second heart sound** (S_2), produced by the closing of the AV valves and semilunar valves, respectively.

Functions and Characteristics of the Blood

- Blood is the only liquid tissue in the body. It is a connective tissue.
- Consists of formed elements (cells and cell fragments) in a liquid intercellular matrix (plasma)
- Average adult blood volume is around 5 liters (8% of body weight)

Blood Functions

- Transportation: Blood transports oxygen and nutrients to cells, CO_2 and waste away from cells, hormones to target tissues
- Regulation: Helps maintain stable body temperature, pH, water and electrolyte levels
- Protection: Clotting prevents fluid loss, white blood cells protect body against disease