

Circulatory Physiology

- The primary function of the components of cardiovascular system is to maintain adequate blood flow into the capillaries and into all the tissues of the body.

Hemodynamic

- **Hemodynamic** is a study of blood flow in various segments of the vascular system.
- Factors affecting blood flow
- Types of blood flow
- Regulation of blood flow in different situation.

Factors that affecting blood flow

1. Pressure gradient (ΔP)

2. Resistance (R)

$$\text{Flow (Q)} = \Delta P / R$$

3. Preload

4. After load

1. Pressure gradient:

- Fluid always flows from **an area of higher pressure to an area of lower pressure**. The largest pressure difference or pressure gradient is found in systemic circulation where the blood leaves the left ventricle.

Circulatory pressure is divided into 3 components:

- Arterial pressure / blood pressure
- Capillary pressure
- Venous pressure

2-Resistance

- **Any force opposes movement of the blood.**
- It depends on the:

- **Viscosity of the blood:** increase in blood viscosity leads to increase the resistance. Thus, increase in viscosity leads to decrease blood flow and vice versa. i.e. **the thicker the blood the more resistance there is.**
- **Length of blood vessel:** the blood flow is inversely proportional to the length of the vessel because the resistance in the long vessel is higher than in the short blood vessel.
- **Radius of blood vessel:** is very important in the blood flow. If the radius is decrease the resistance increases so, the blood flow decrease. i.e **the large radius the less resistance.**
- $R = L \times V \times 8 / r^4 \times \pi$

3. Preload:

Amount of the blood volume returning to the heart and waiting to be ejected. •

- Reload depends on:

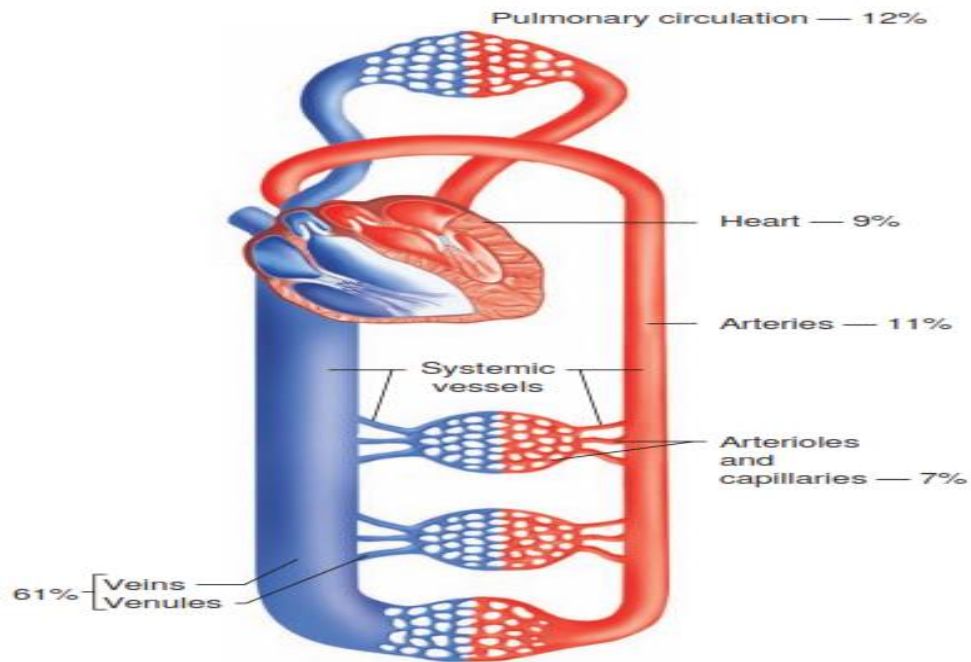
1. Diastolic venous return (total volume in the venous bed).

Venous return depends on:

a). Filling pressure (depends on the blood volume and vasomotor tone).

b). Filling time (when heart rate increase filling time decrease).

2. Systolic ejection..... starling's law (the more heart muscle stretches during diastole the more forcefully the contraction during systole).



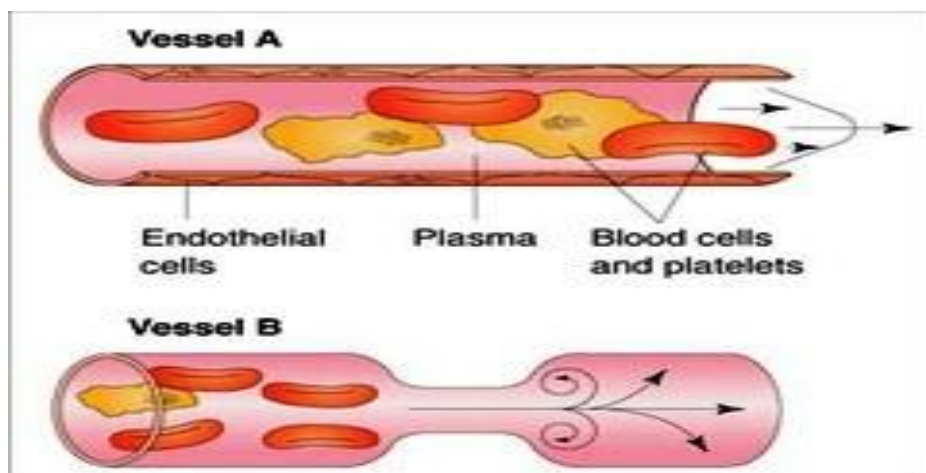
4. Afterload

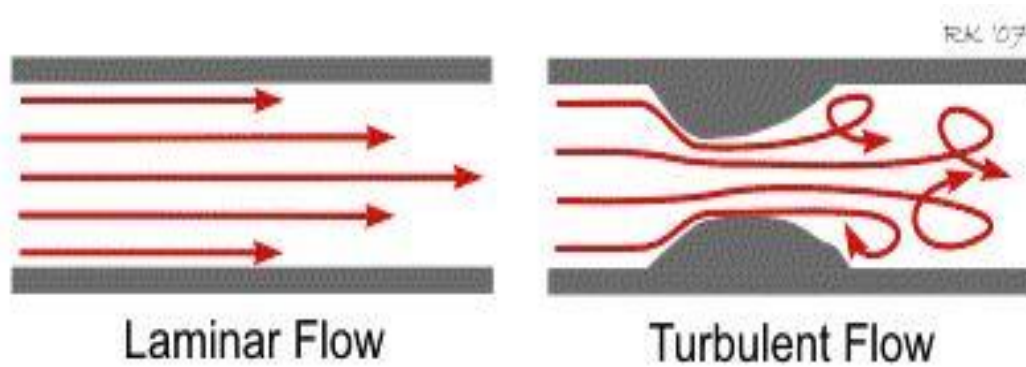
- Is the pressure (resistance) the ventricle must work against to push blood out to the body. i.e. **resistance to ejection**.

Afterload depends on: vessel status (in the absence of aortic stenosis)

Types of blood flow:

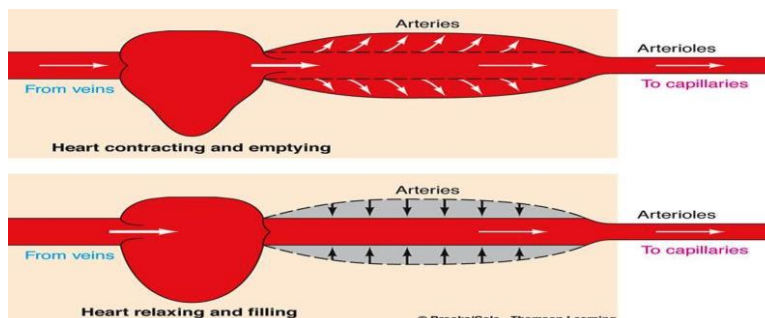
- **Laminar blood flow:** Blood flow in the blood vessels is normally streamline.
- **Turbulent blood flow:** The blood moves in irregular varying paths continuously mixing the vessel and colliding with vessel wall.

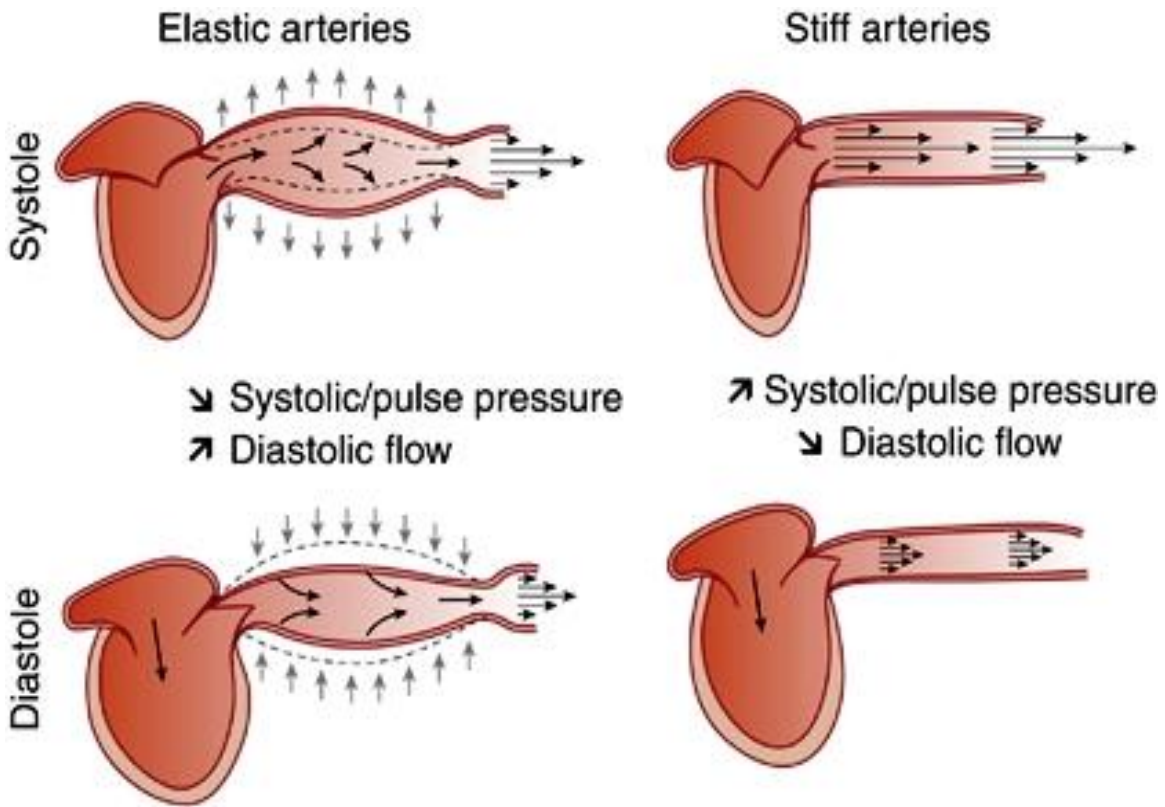


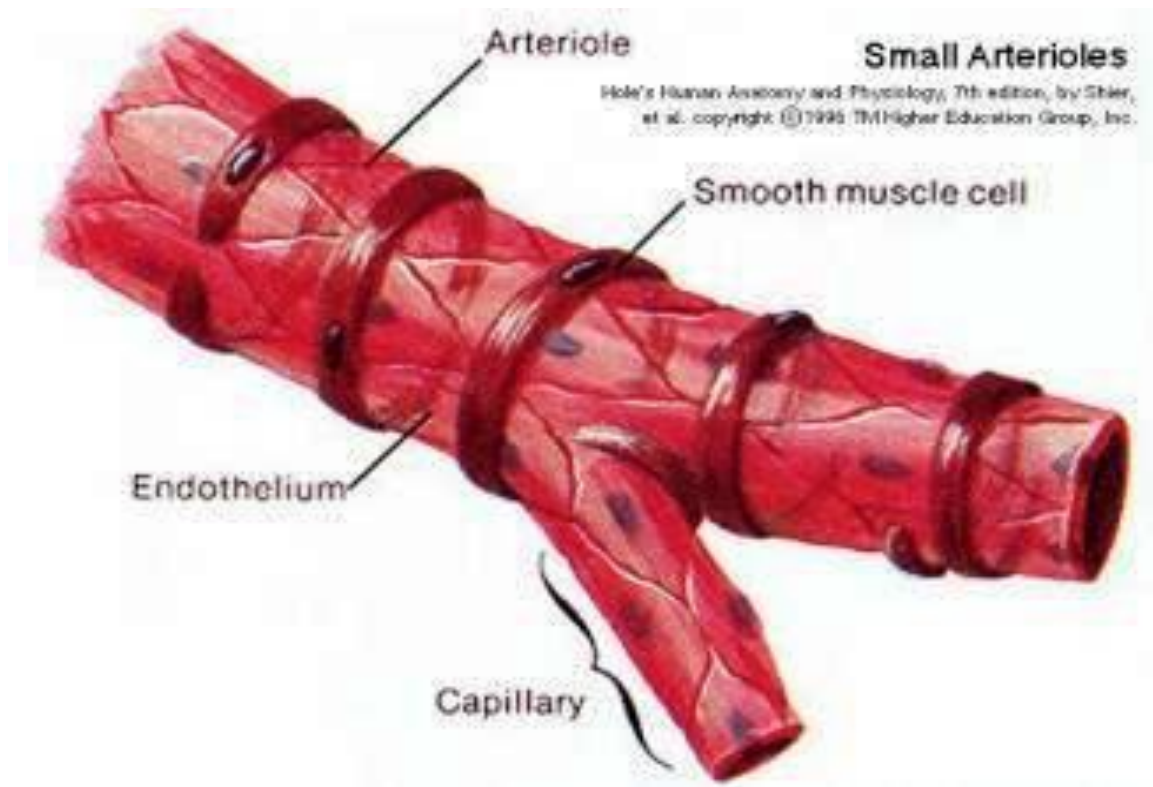


Velocity and blood flow

- The main velocity of the blood in the proximal portion of the aorta is 40 cm/sec.
- The flow is biphasic
- The velocity is much greater in the systole than it is in the diastole (in the distal portions of the aorta and in large arteries).
- **Distensibility** and **elastic recoil** properties of the elastic blood vessels leads to reduce velocity during systole and to blood flow during diastole.
- The arterioles play a major role in the control of the blood flow to organs and tissues (act as valves of circulation).
- Arterioles along with elastic vessels convert pulsatile flow in the arteries to a steady flow in the capillaries.



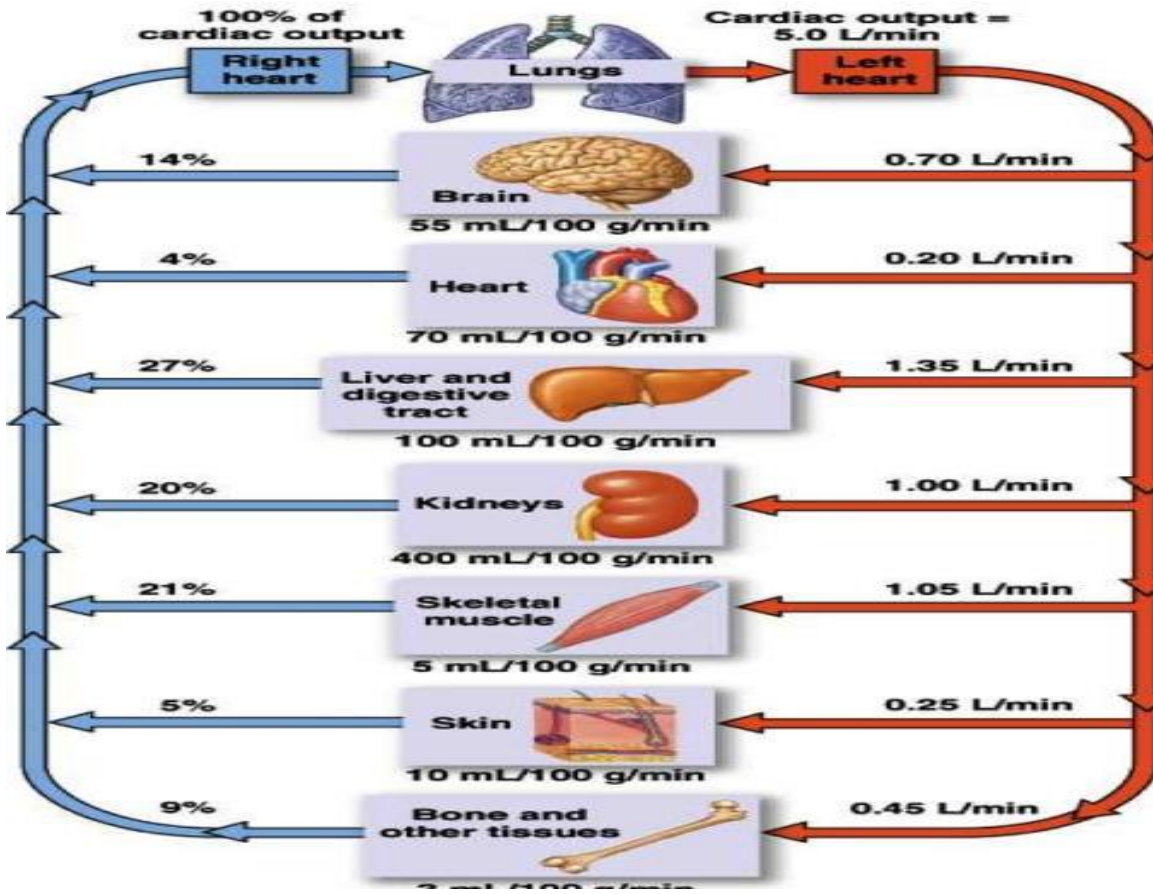


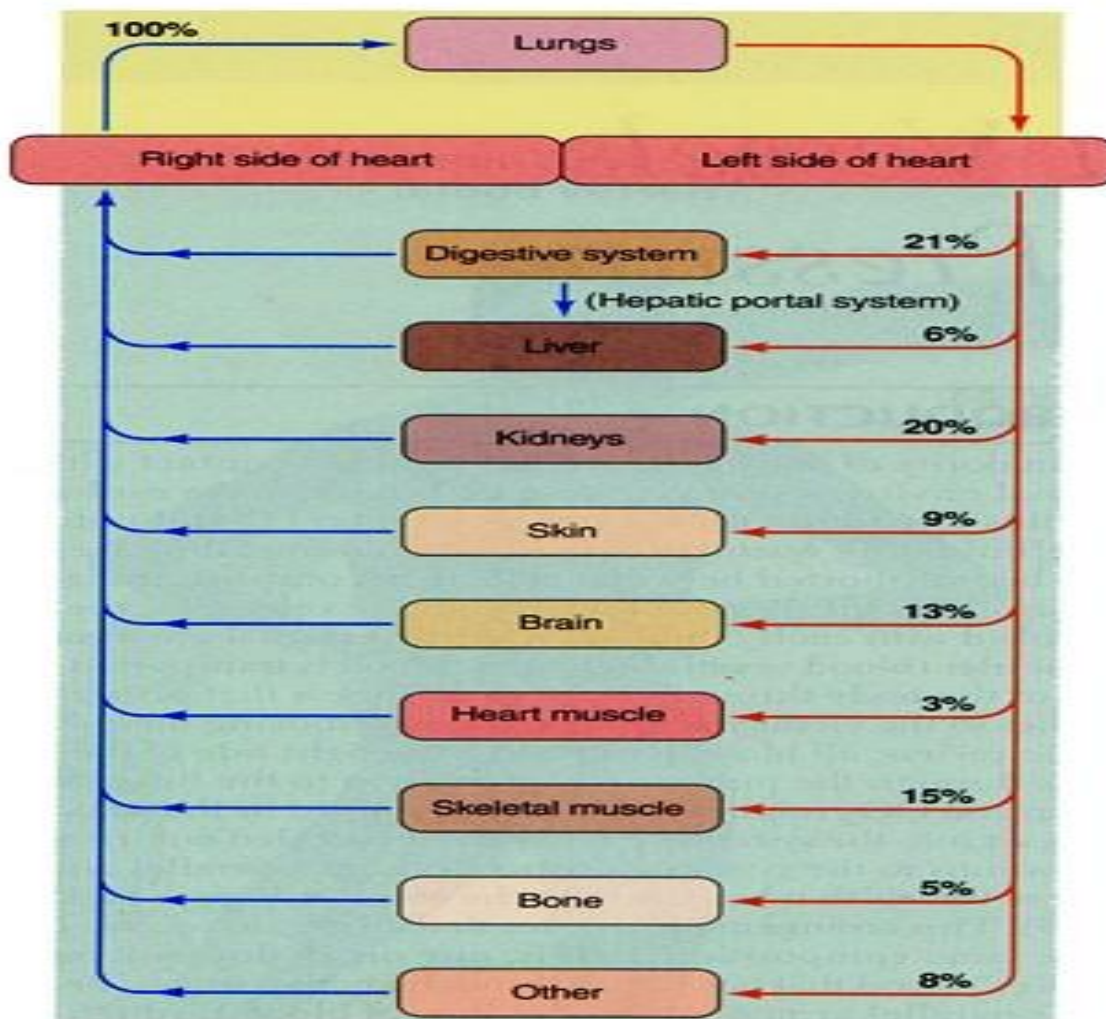


- **Distribution of blood flow to various regions of the body**
- At rest 5 liters of blood enters aorta per minute. Blood flow to the liver brain heart and kidney is very high.

DISTRIBUTION OF BLOOD IN THE BODY AT REST

Blood flow to the major organs is represented in three ways: as a percentage of total flow, as volume per 100 grams of tissue per minute, and as an absolute rate of flow (in L/min).

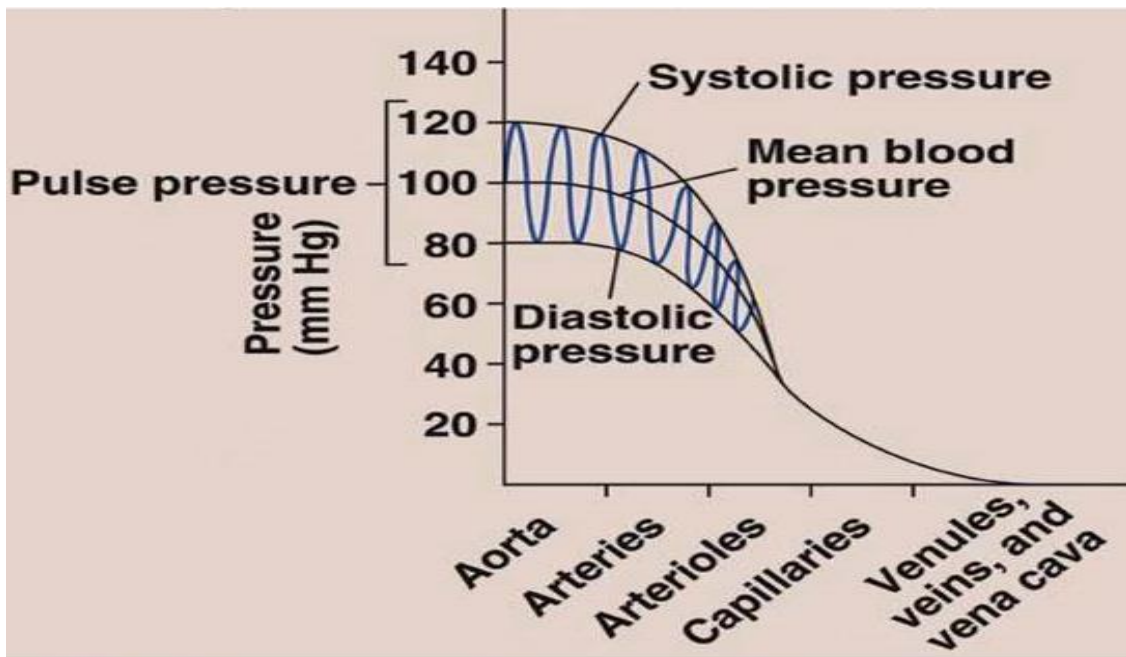


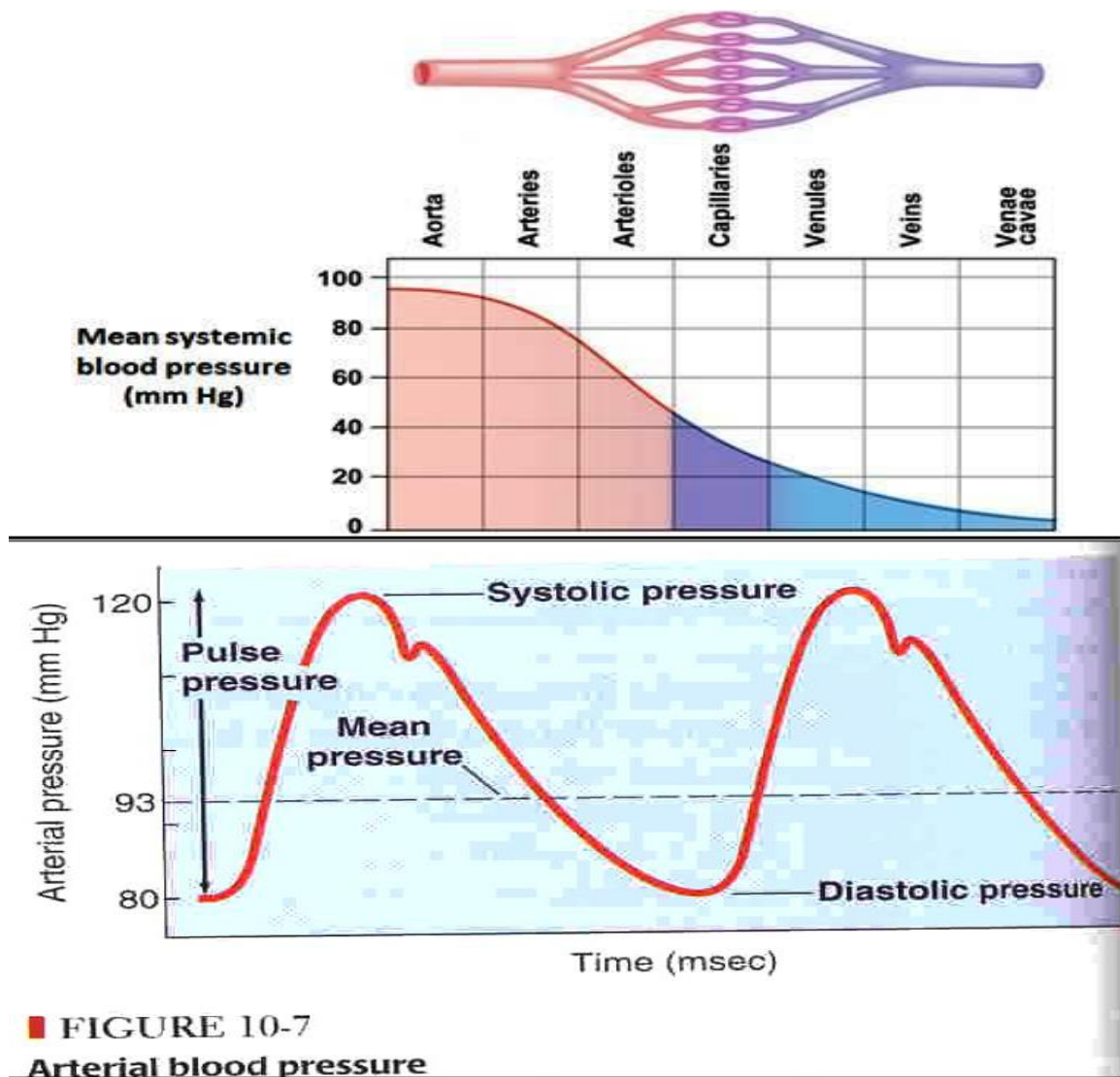


Arterial Blood Pressure

- Means the pressure or force exerted by column of blood on the walls of arteries.
- **Systolic blood pressure:** the maximum pressure in the aorta and large arteries produced by blood during the systolic phase of cardiac cycle is **120 mmHg**.
- **Diastolic blood pressure:** the minimum pressure in the aorta and large arteries produced by blood during diastolic phase of cardiac cycle is **70-80 mmHg**.
- Pulse pressure is the difference between systolic pressure and diastolic pressure (40 -50 mmHg).

- **Mean arterial pressure** is the average pressure produced by blood during the cardiac cycle. Because the systole is shorter than diastole
- $MAP = \text{diastolic pressure} + 1/3 \text{ pulse pressure}$.
- **MAP is responsible to keep the blood flow to the tissues.**
- The main pressure at the end of arterioles is **30 – 38 mmHg**.





Mean systemic pressure (MSP):

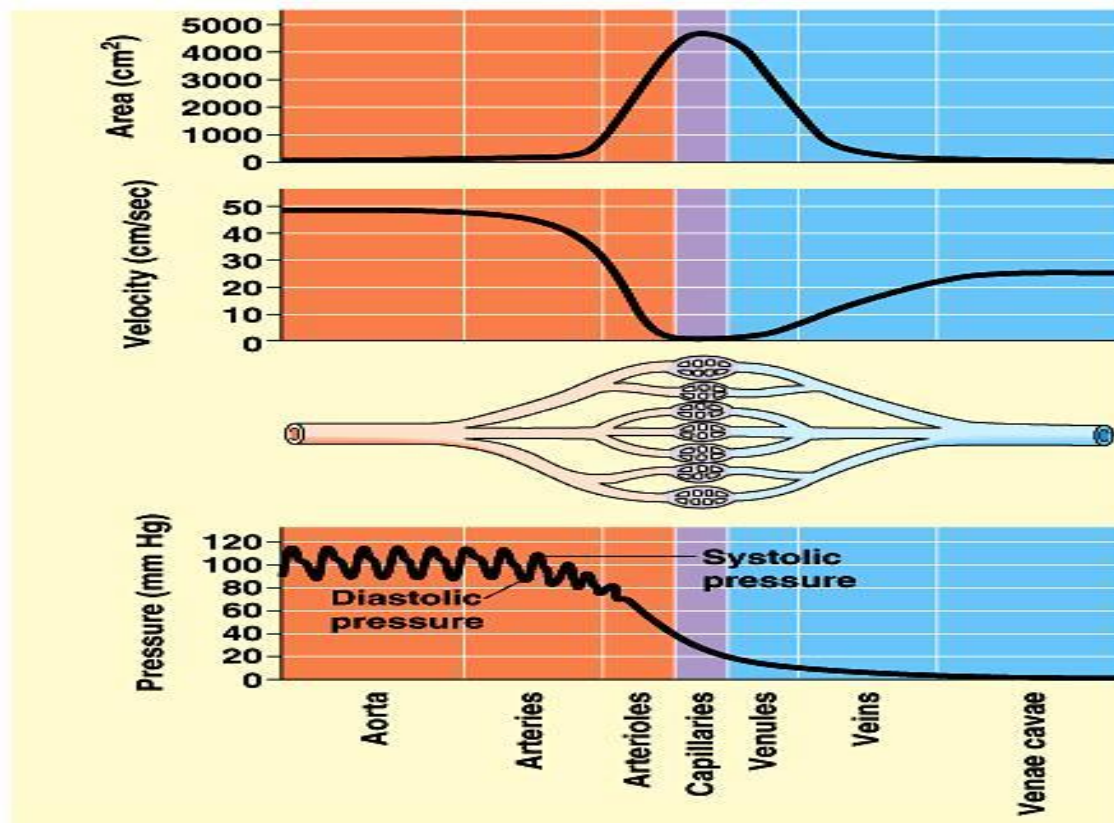
means the

pressure in the **arteries** + pressure in the **capillaries** + pressure in the **veins**.

MSP maintains venous returns from tissues to the heart (6.5 mmHg)

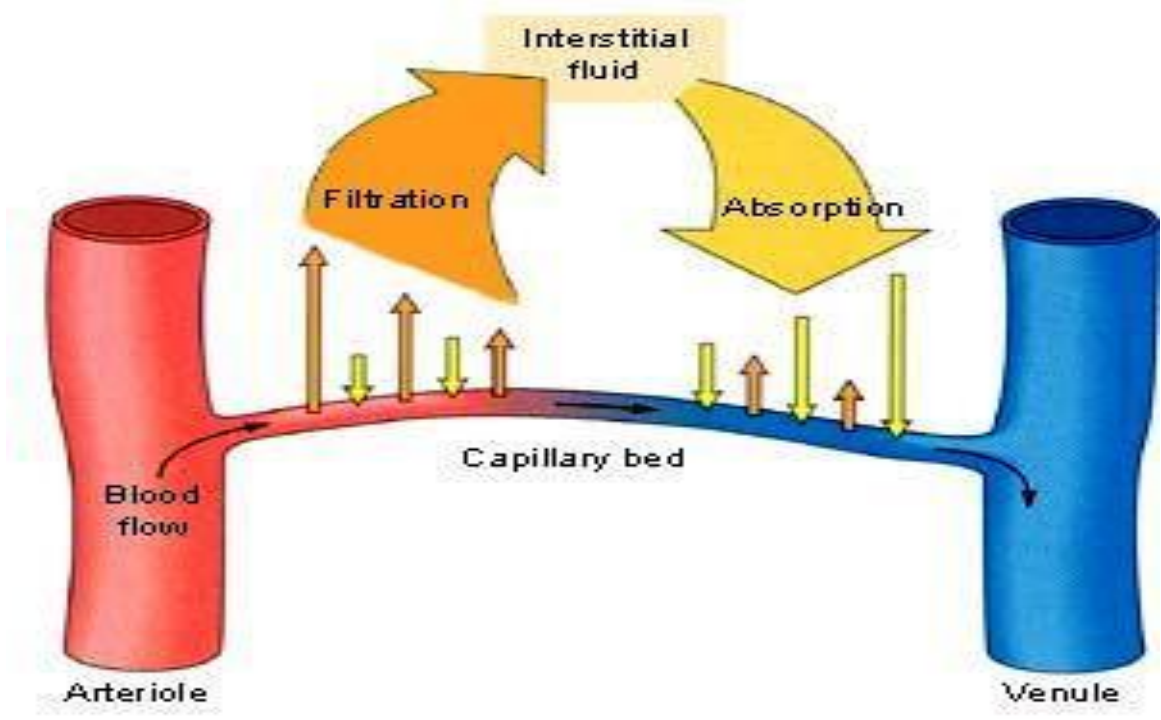
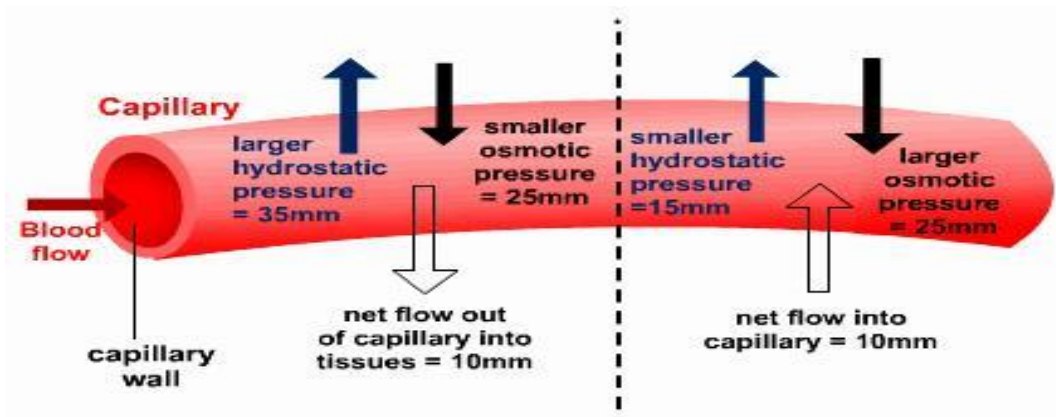
Capillary pressure and flow

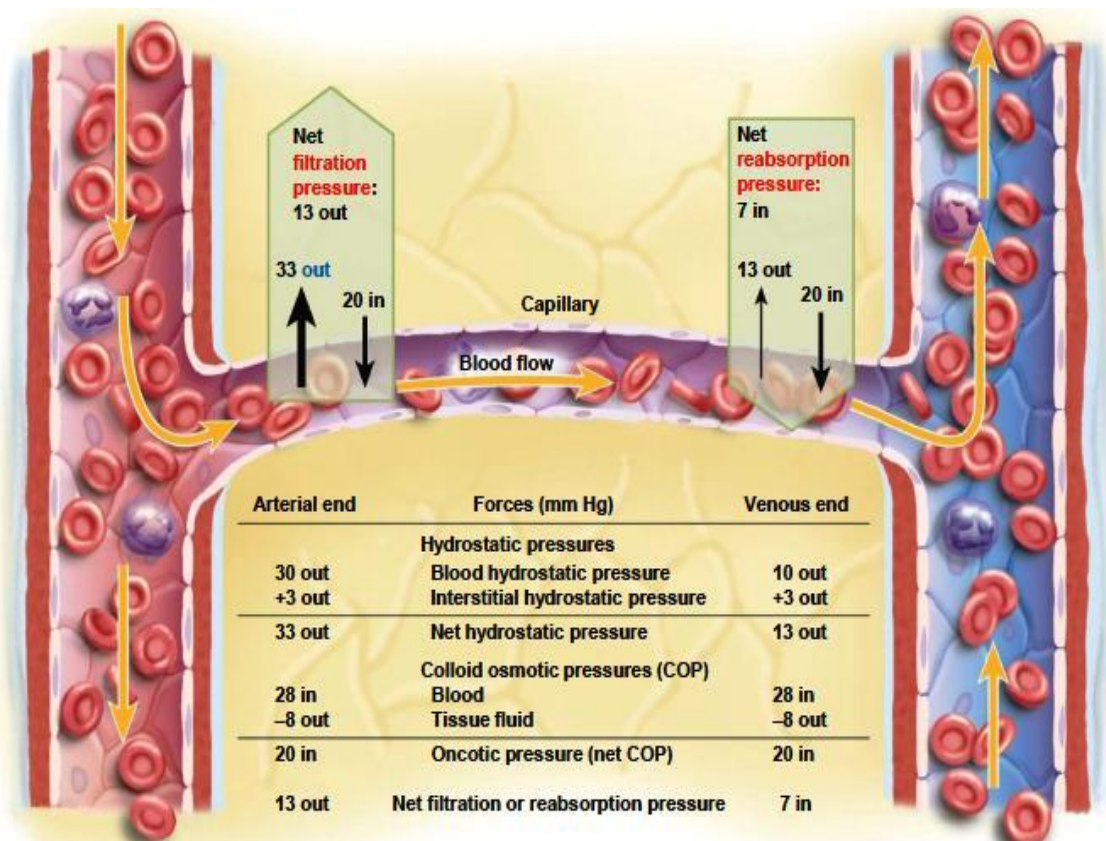
- Blood pressure in the capillary is about 32mmHg at the arteriolar end and 15 mmHg at venous end.
- The blood move slowly in the capillary 0.07/sec.



Transcapillary exchanges

1. Diffusion: O₂ and glucose transport from blood to the tissue and CO₂ and waste transport from tissue to the blood.
2. Filtration: it depends on
 - a). Hydrostatic pressure
 - b). Osmotic pressure





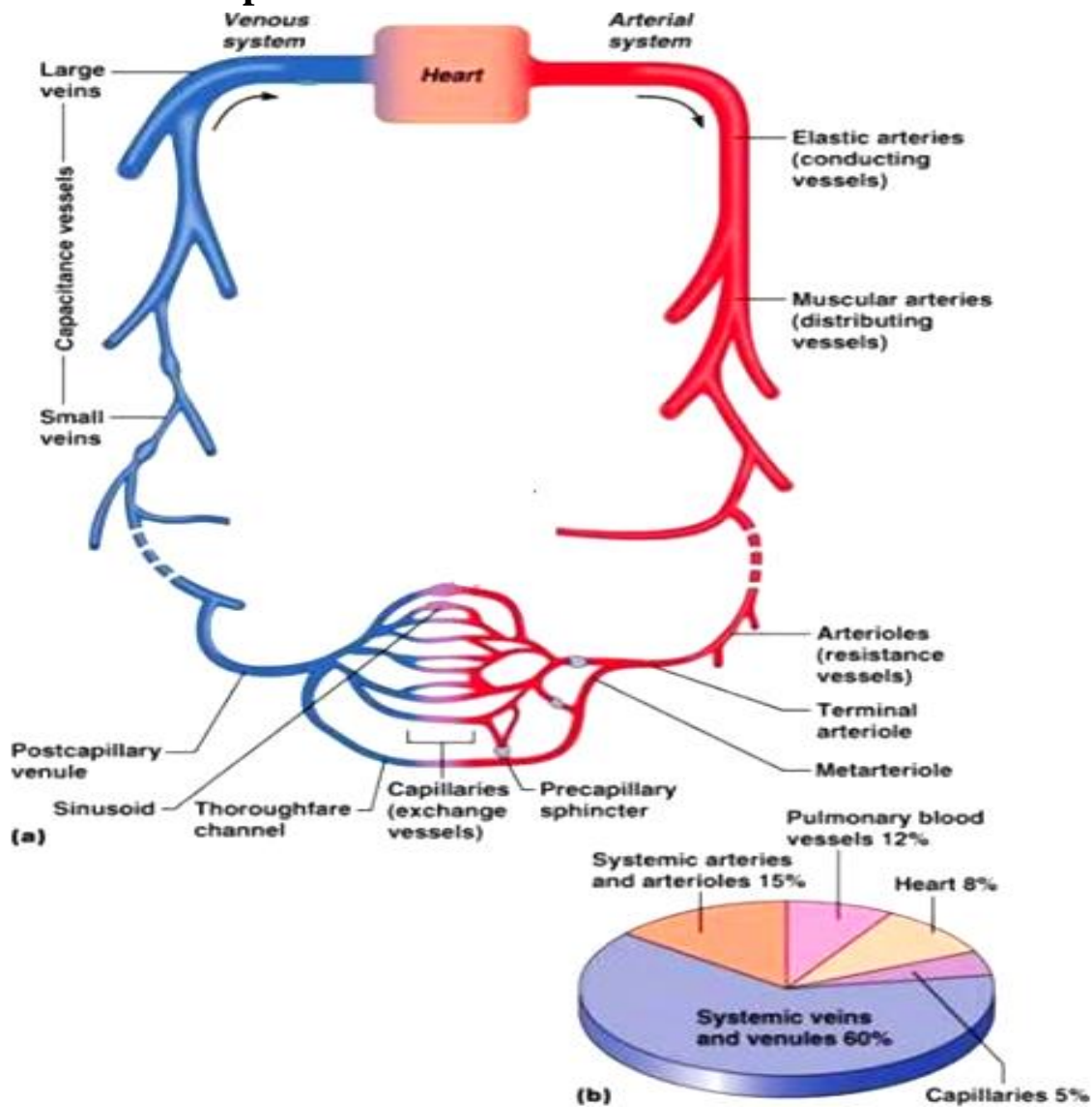
Venous pressure and flow

- Venules pressure 12- 18 mmHg
- large veins pressure 5.5 mmHg
- thoracic vena cava 4.6-2 mmHg.
- The velocity of blood in the great vein about 10 cm/ sec.

Functions of the veins:

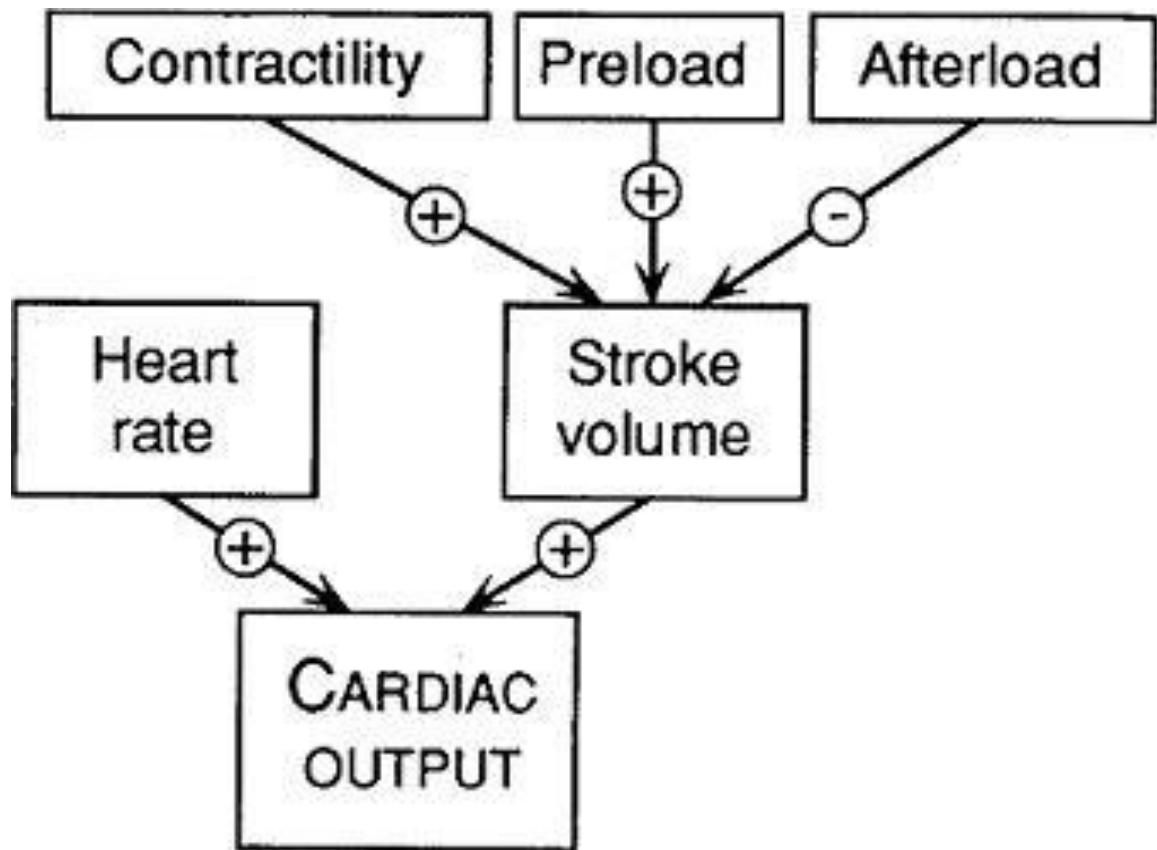
- Blood reservoirs
- Conduits
- Maintenance of cardiac output

Normal blood pressure

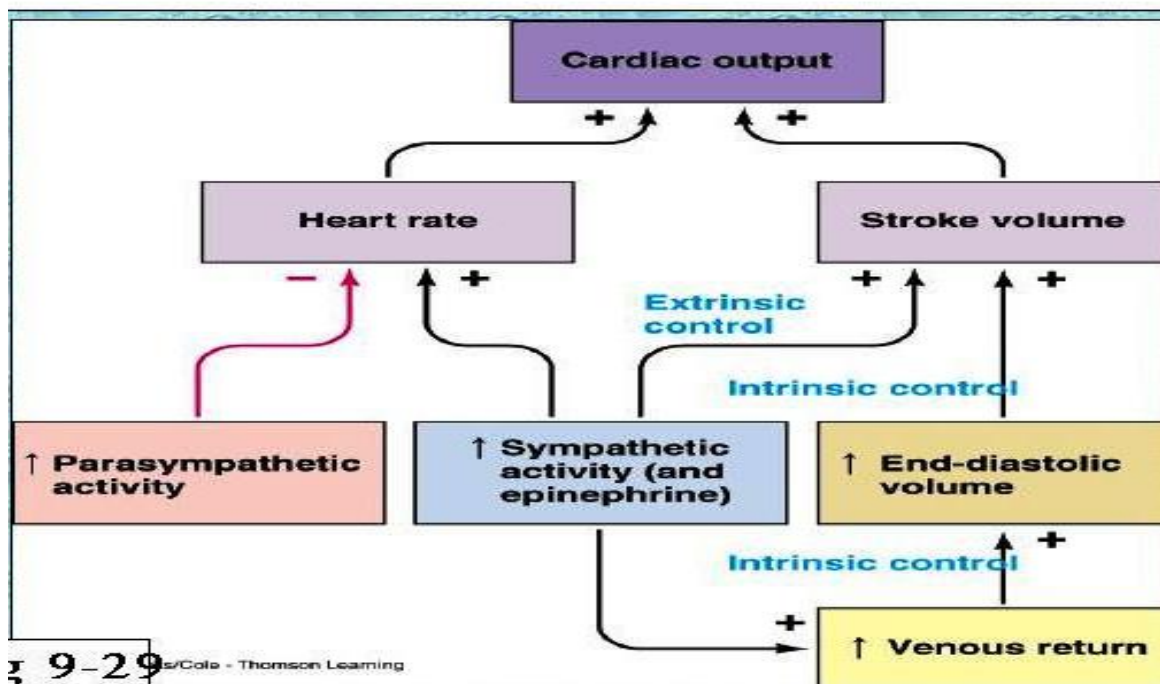


Normal blood pressure

- **Blood pressure =**
Cardiac output (CO) × Total peripheral resistance
- **CO = Stroke volume (SV) × Heart rate**
SV depends on:
 - Preload.
 - Contractility: force of ventricular contraction.
 - Afterload



Control of Cardiac Output



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Regulation of blood pressure

1. Neuronal

2. Hormonal

- **Neuronal**

1). Baroreceptors

- these receptors are located in the aortic arch and carotid sinus.
- Sensitive to changes in the blood pressure.

Send impulses to the cardiovascular center in the brain which lead to change in **peripheral resistant, heart rate, and stroke volume**

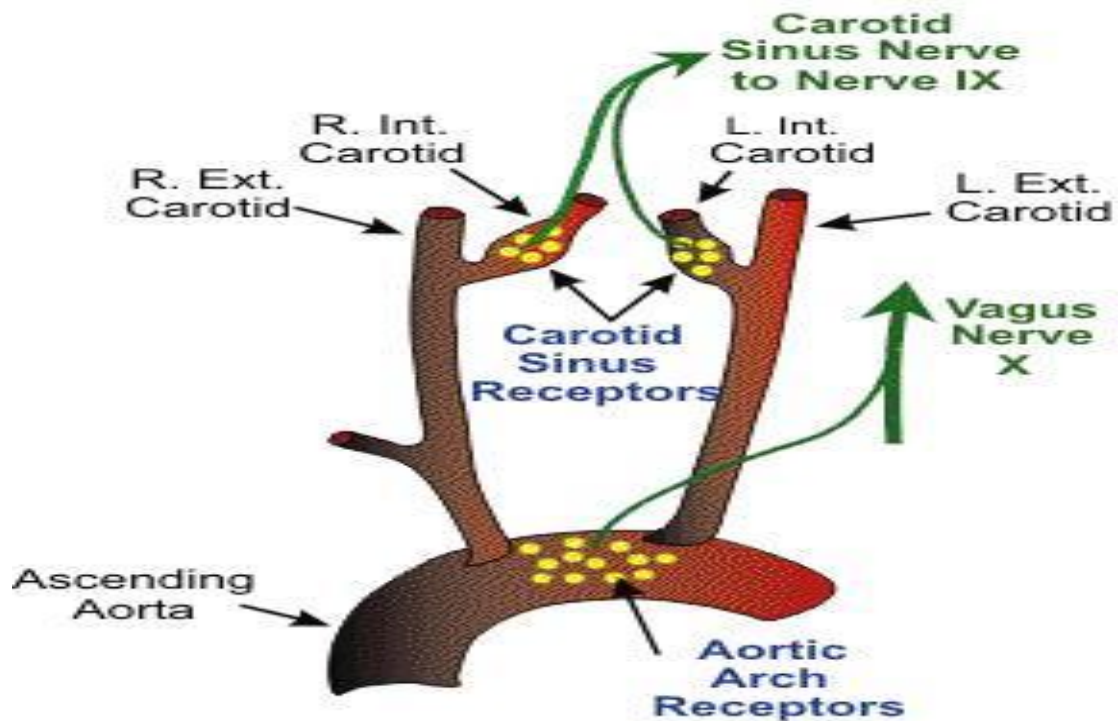
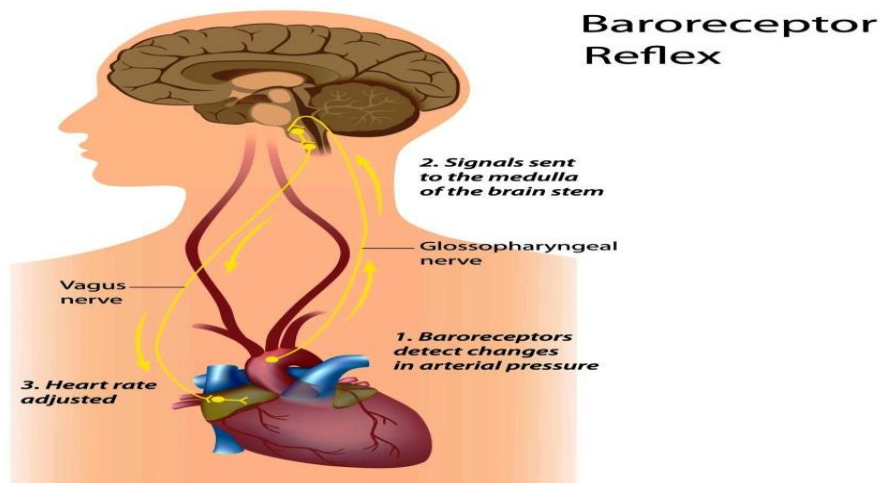
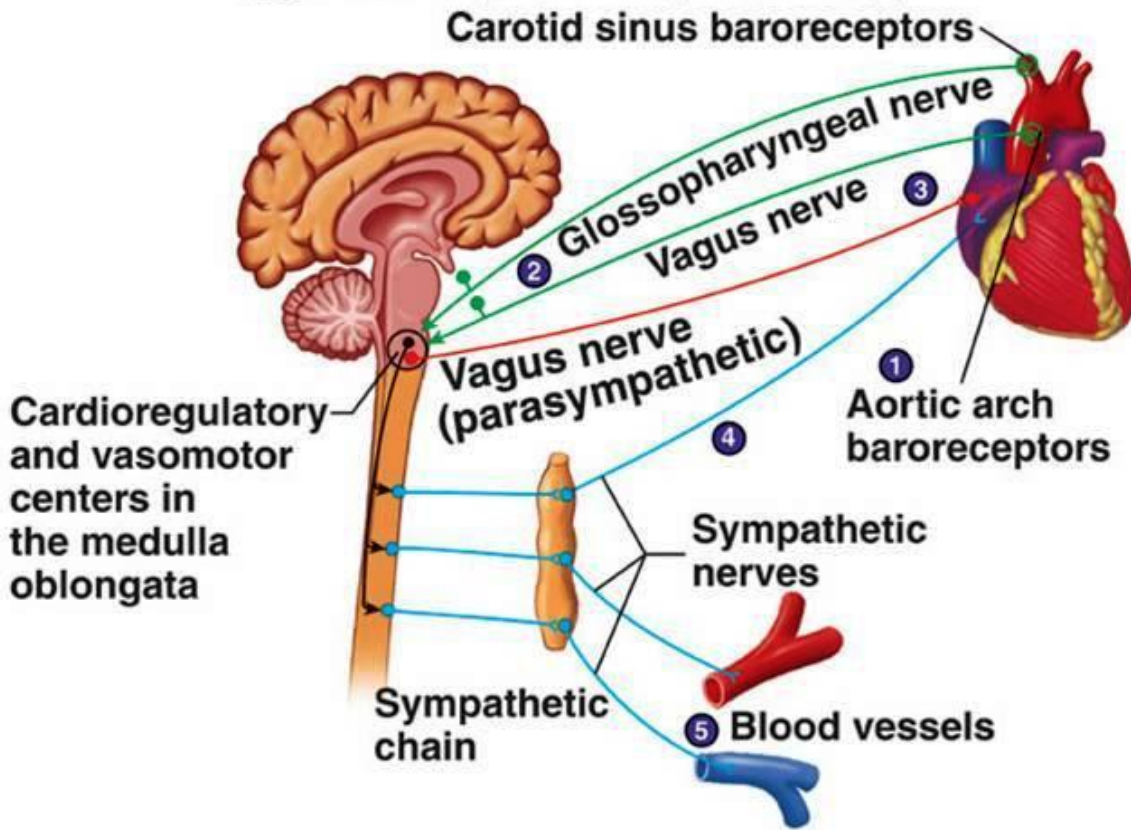
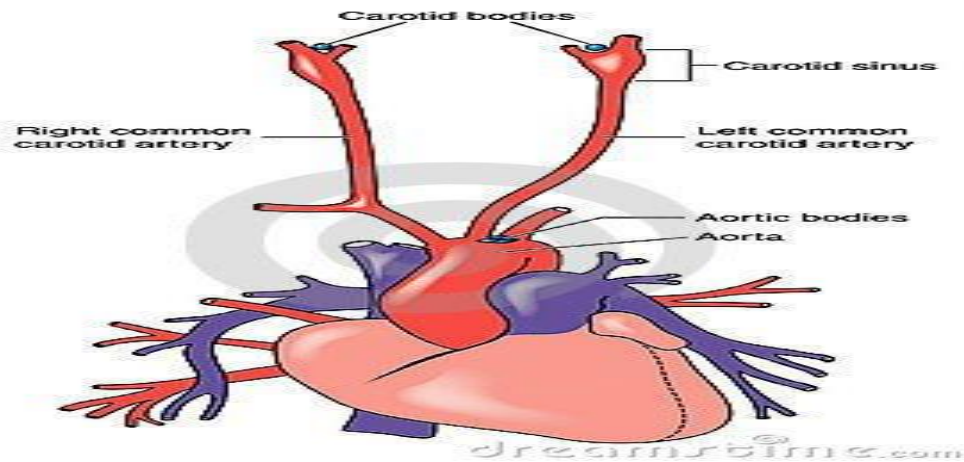


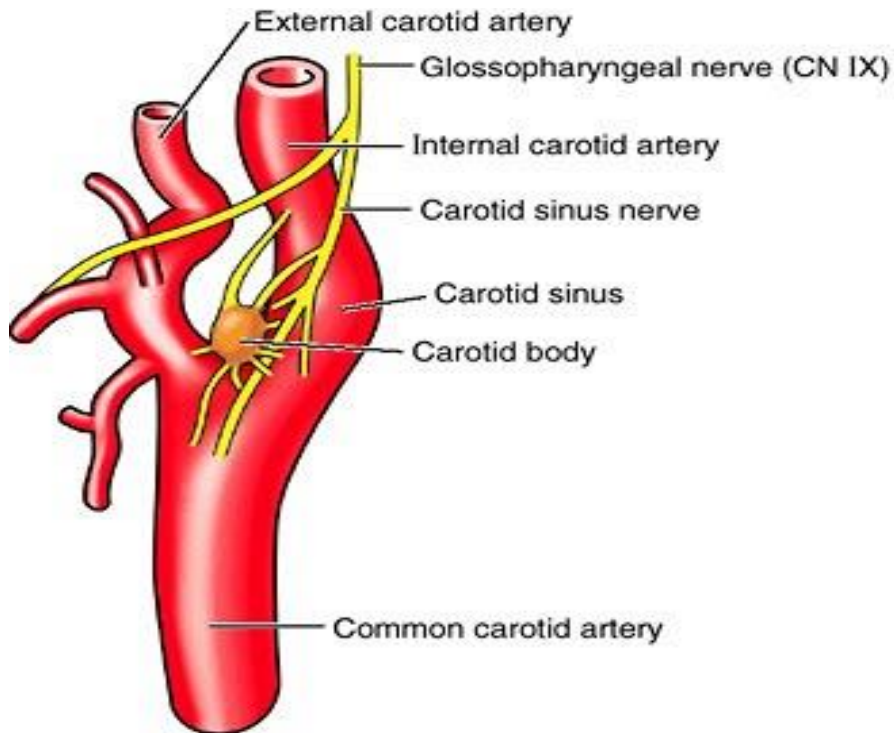
Figure 1. Location and innervation of arterial baroreceptors.





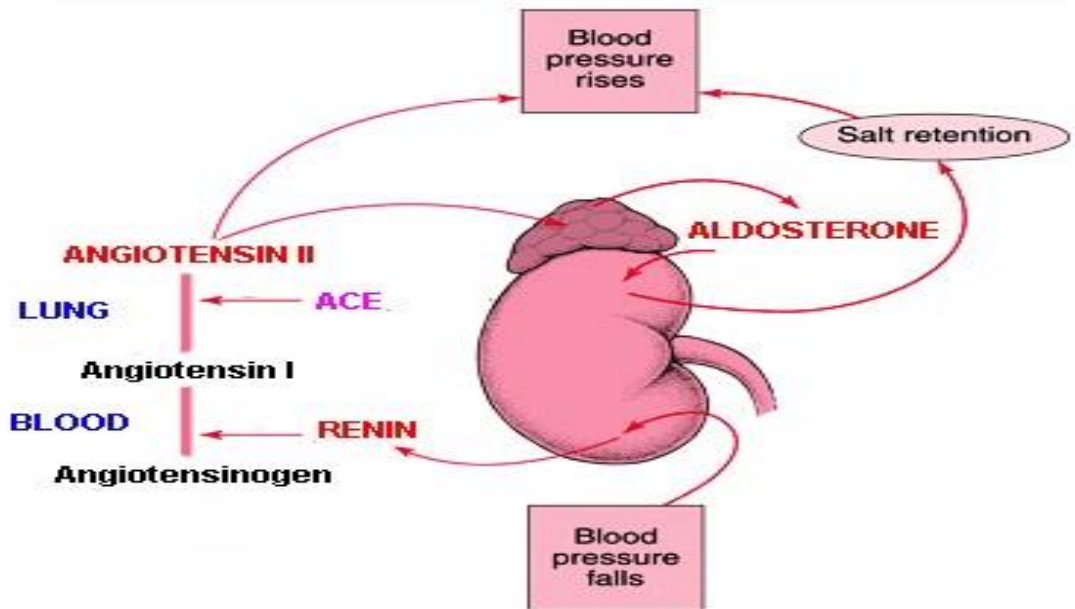
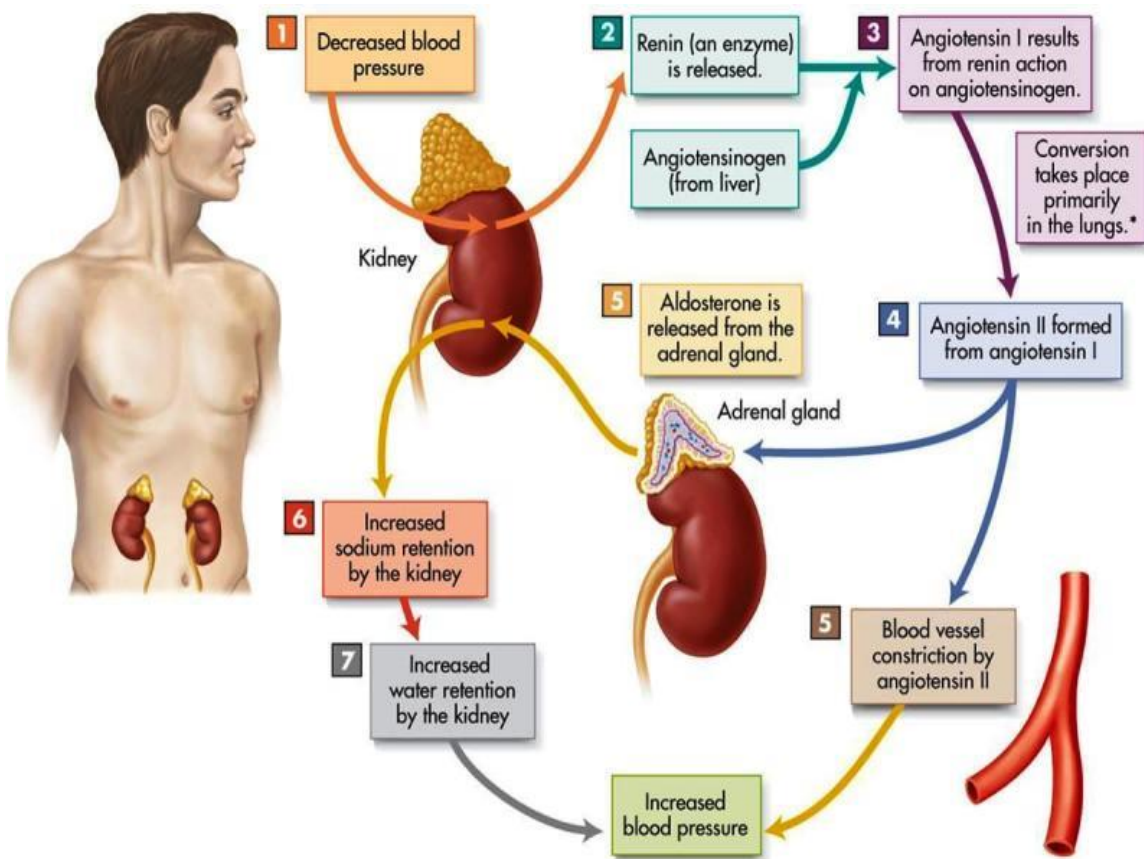
Chemoreceptors

- Present in the aortic and carotid body
- Sensitive to the O₂, CO₂, and pH level in the blood.



Hormonal

1. Renin- angiotensin -aldosterone mechanism



- epinephrine and norepinephrin increase blood pressure.
- Vasopressin (ADH) released by posterior lobe of pituitary gland leads to increase blood pressure.