Academic year 2021-2022

2nd year S-3

Cardiovascular Module

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Lecture 1: Introduction to the Cardiovascular system

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Learning Outcomes of the CVS module

1. The anatomy: to know the structure and relations of the heart and major blood vessels of the body and relate their structure to function in the circulation

2. The physiology: to know the the heart as a pump, including the function of the heart valves.

3. Embryology: to know the development of the heart, some common congenital defects, and the pathology of valvular problems.

4. Blood flow, vascular resistance and the special features of the pulmonary, cerebral, coronary, skin and skeletal muscle circulations

5. Autonomic nervous system in the control of cardiovascular function, including the concepts of local and central control

Learning Outcomes

6. Mechanisms controlling cardiac output

7. Cardiac cycle and the categories of drugs used for common cardiac conditions

8. The normal electrocardiogram and their relationship to electrical events

9. The coronary circulation and ischaemic heart disease

10. Acute chest pain

11. Heart failure

12. Shock

Introduction to the Cardiovascular system
Learning Outcomes

To describe:

1. The factors influencing the exchange of substances between the blood in capillaries and the surrounding tissues

2. The critical importance of adequate blood flow for the maintenance of capillary exchange

3. The rate of typical blood flows in ml/min/g tissue and ml/min/organ for major organs of the body, including the brain, kidneys, heart muscle, gut, skeletal muscle and skin

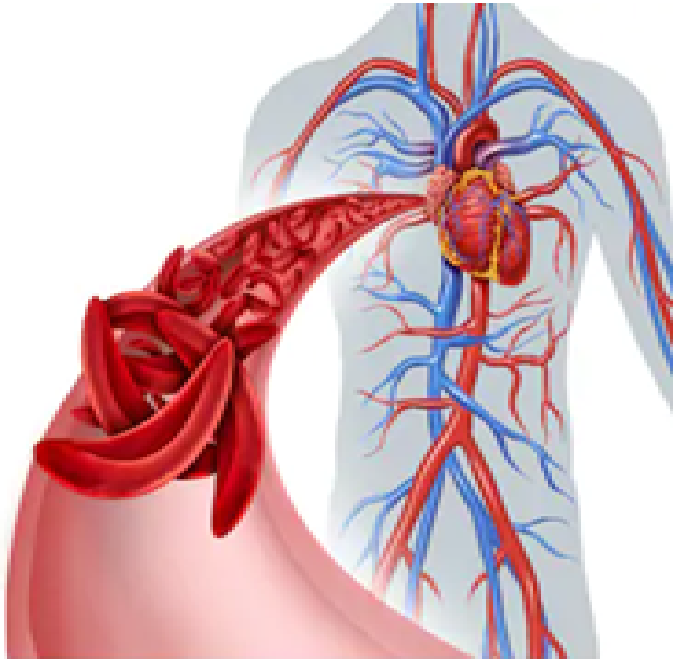
4. The distribution of cardiac output over major organs of the body

5. The major functional components of the circulation

6. The distribution of blood volume over the major parts of the circulation

LO1

- The cardiovascular system serves to supply cells in the body with their metabolic needs, which requires a system of distribution of materials and exchange with the tissues.
- Exchange with the tissues occurs at the capillaries, which are vessels lined with a single layer of endothelial cells surrounded by basal laminathrough which many substances may diffuse easily.
- 98% of exchange is by diffusion.



LO1

Diffusion is affected by :

1-The area available for exchange.

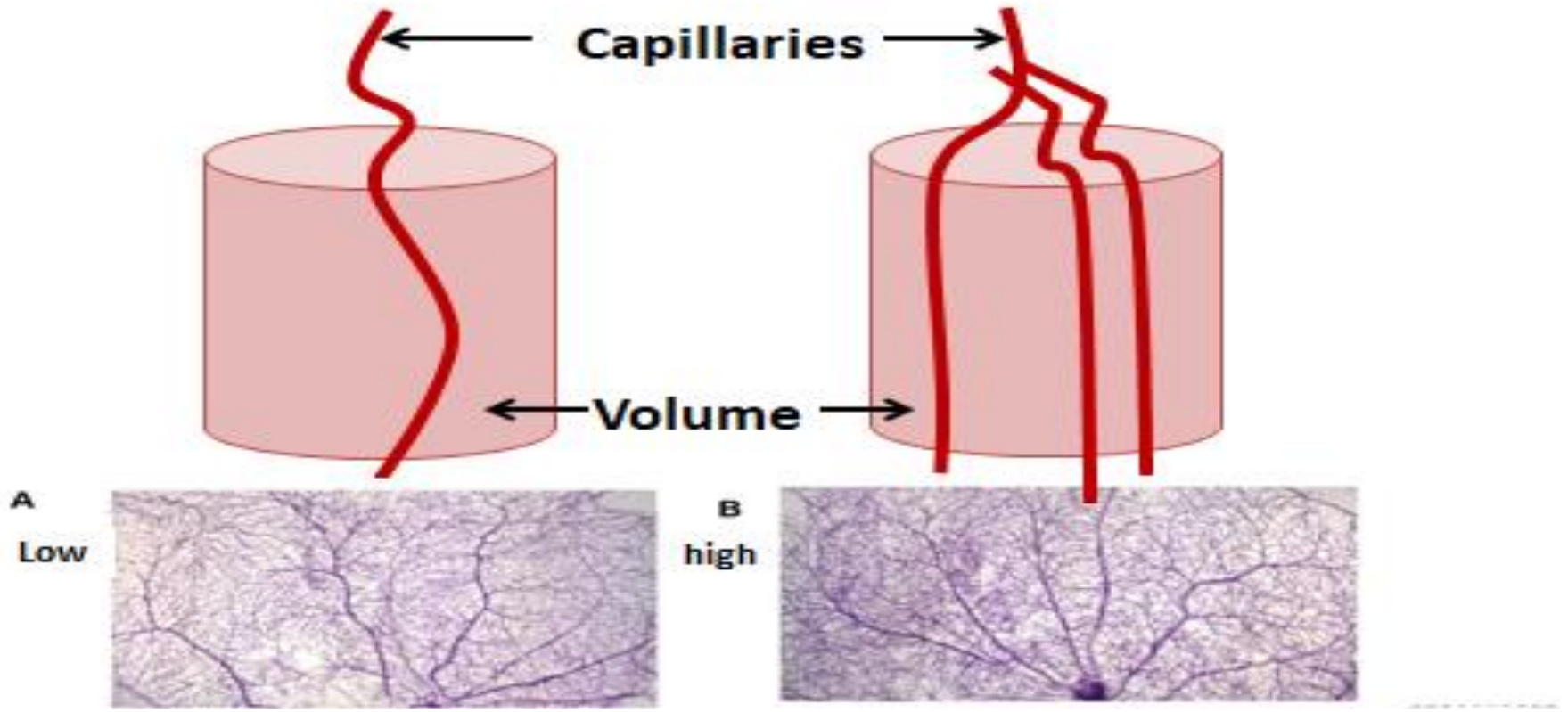
2-The difficulty of movement through the barrier ('diffusion resistance').

3-The concentration difference ('gradient').

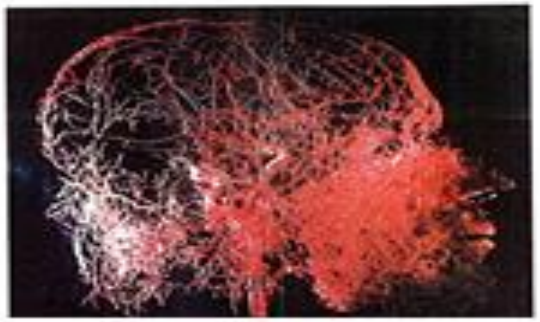
LO1

1-The area available for exchange in the tissue	•Is determined by how many capillaries there are per unit volume (the 'capillary density').
	•This varies from tissue to tissue
	•It is highest in the most metabolically active tissues .

LO1



LO1



The vascular network in human head

Renal vascular network

The nail bed capillaries

LO1

2-The difficulty of movement through the barrier ('diffusion resistance')

resistance to diffusion depends on:

-nature of the molecule

eg lipophilic or hydrophilic, size .

-nature of the barrier

eg pore size and number of pores for hydrophilic substances

-path length

depends on capillary density

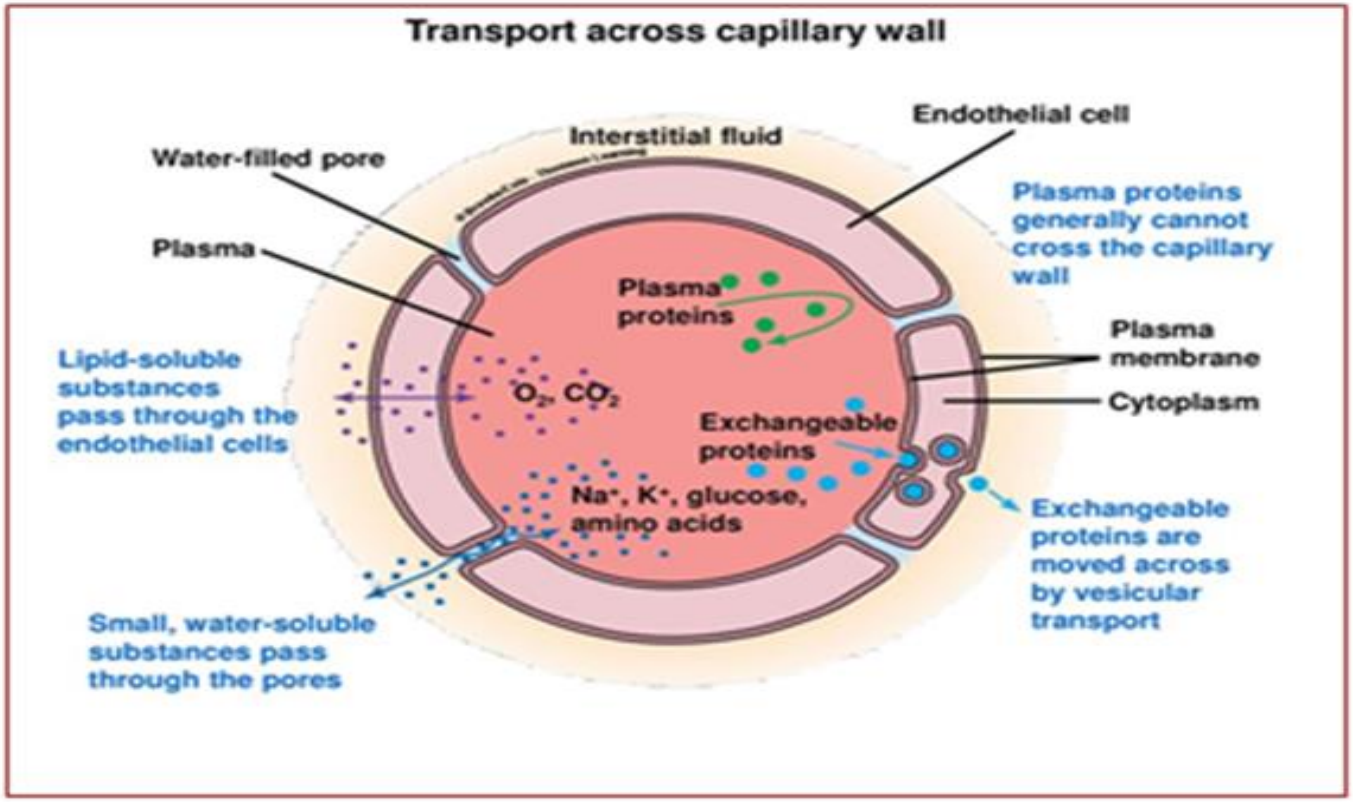
path is shortest in the most active tissues

diffusion resistance is mostly low

LO1

- Some substances eg O_2 and CO_2 are lipophilic and diffuse through the lipid bilayer
- Others molecules such as glucose, amino acids and lactate are hydrophilic and diffuse through small pores in the capillaries, but prevent movement of molecules where molecular weight exceeds 60,000.
- All molecules will move down their concentration gradient.

LO1


Transport across capillary wall
Endothelial cell
Interstitial fluid
Water-filled pore
Plasma
Plasma proteins generally cannot cross the capillary wall
Plasma proteins
Plasma membrane
Cytoplasm
Lipid-soluble substances pass through the endothelial cells
O_2, CO_2
Exchangeable proteins
Na^+, K^+, glucose, amino acids
Exchangeable proteins are moved across by vesicular transport
Small, water-soluble substances pass through the pores

LO1

3-The concentration difference ('gradient')

- The relevant gradient is that between the capillary contents and the nearby cells.

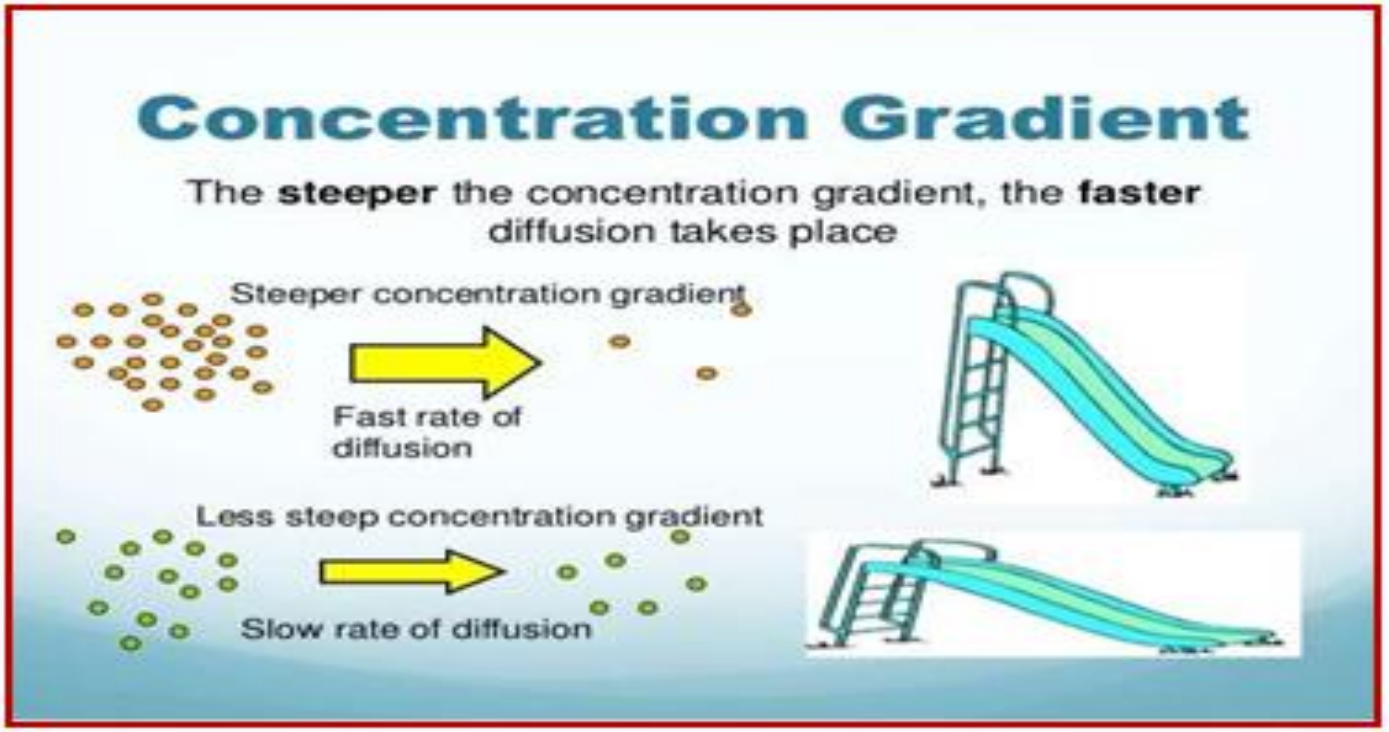
- It depends on:

1- The concentration of substances in the blood entering the tissue.

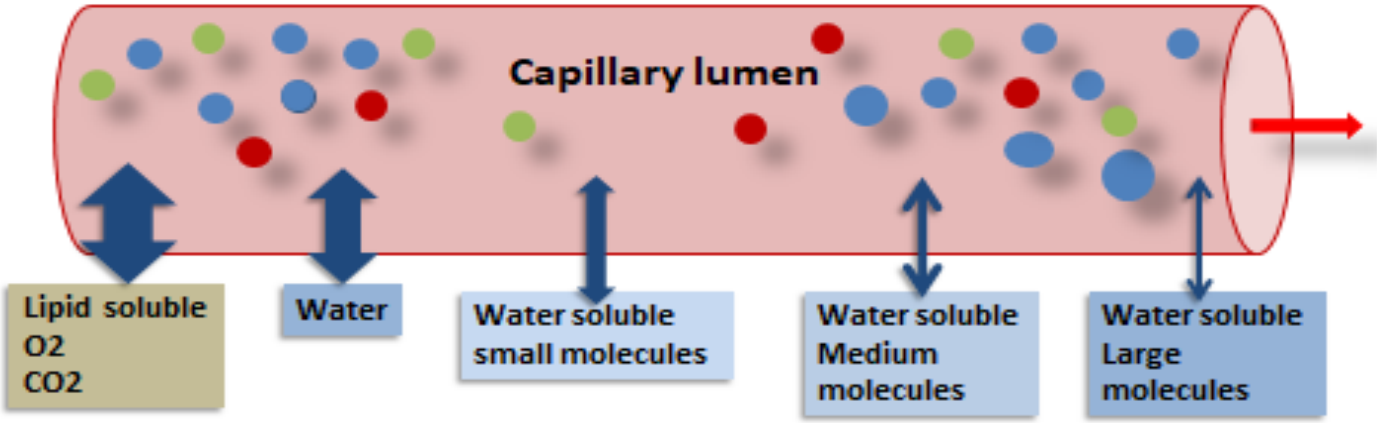
2-The more important variable is the flow of blood through the capillary.

- Unless blood is supplied at an appropriate rate, the gradients driving exchange will dissipate, and nutrients will not be supplied at the right rate.

LO1


Concentration Gradient
The steeper the concentration gradient, the faster diffusion takes place
Steeper concentration gradient
Fast rate of diffusion
Less steep concentration gradient
Slow rate of diffusion

LO1

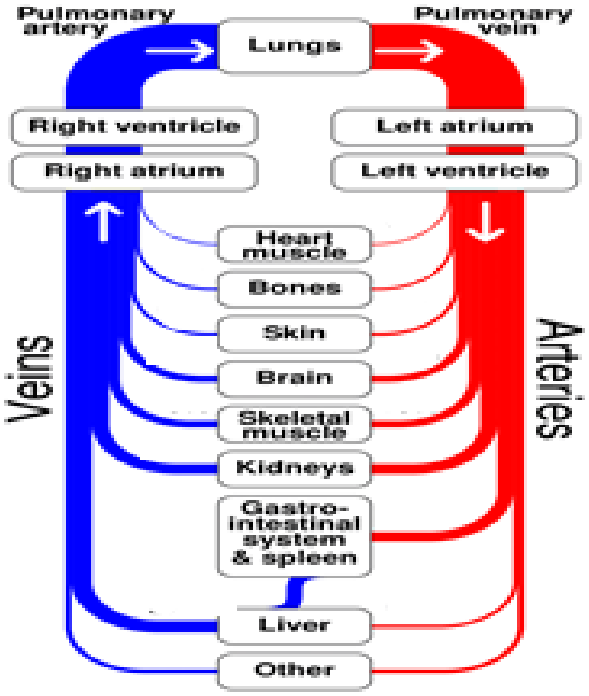


Diffusion according to the size and solubility of the molecules

LO2

- All other things being equal, then, the supply of nutrient to a tissue depends most critically on maintaining the right flow of blood for the prevailing level of metabolic activity.

- The cardiovascular system must maintain appropriate flows through all tissues.



LO3

Supply and Demand

blood flow must match the tissues' metabolic needs the higher the rate of metabolism the greater the demand for O_2 and nutrients increases in metabolism must be met by increases in blood flow the rate of blood flow is known as the perfusion rate.

LO3

Organs of the body	Min. Blood Flow (ml/min)	Max. Blood Flow (ml/min)
Brain	750	750
Heart	300	1200
Kidney	1200	1200
Gut(and liver)	1400	2400
Skeletal muscle	1000	16000
Skin	200	2500
Rest of the body	200	200
Total	5050	24250

LO4

The cardiovascular system as a whole must therefore:

- Deliver between 5 and 25 l.min-1 of blood to the body.
- Maintain a blood flow of 750 ml.min-1 to the brain at all times.
- Maintain blood flow to the heart muscles and kidneys at all times.

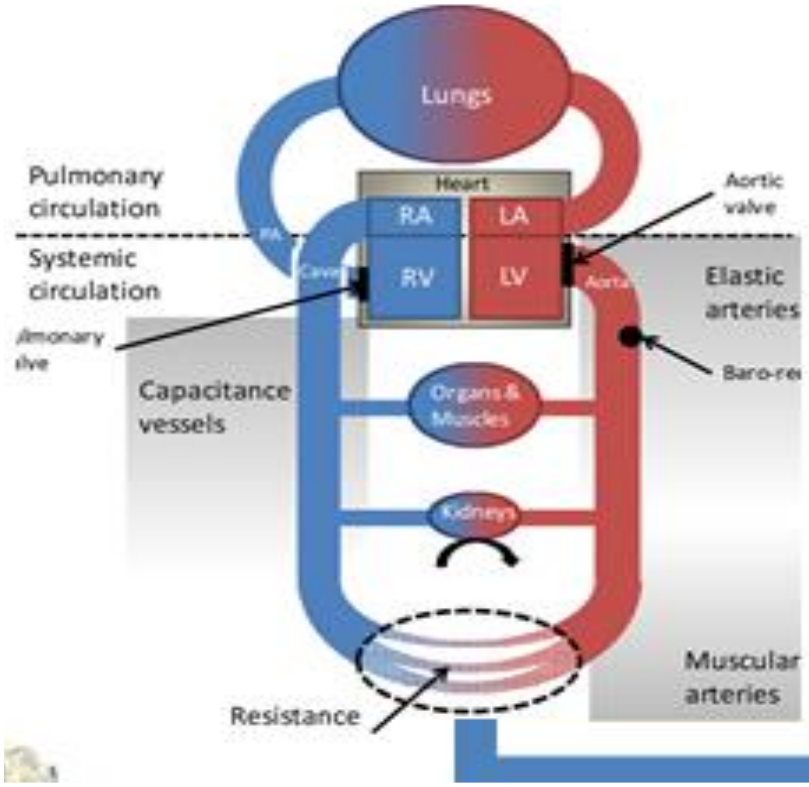
LO5

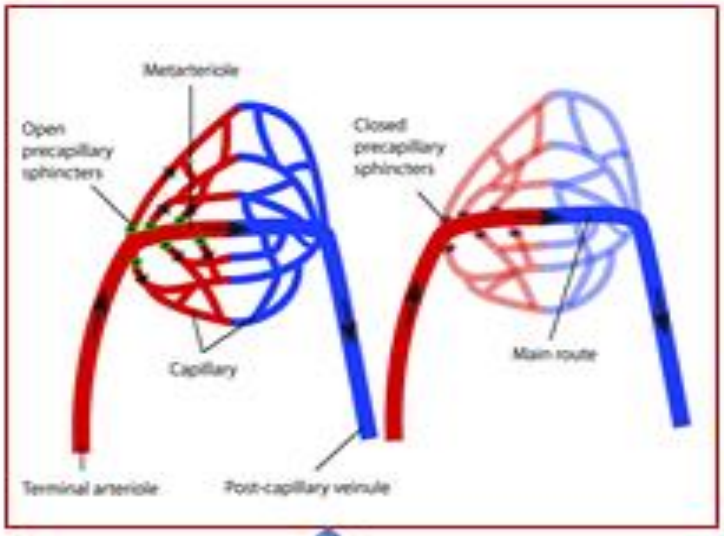
The major functional components of the circulation

- The pump - obviously the heart
- Distribution vessels – the arteries
- Resistance vessels - the arterioles and pre capillary sphincters
- Capacitance in the system - a 'store' of blood -Veins

LO5

The major functional components of the circulation

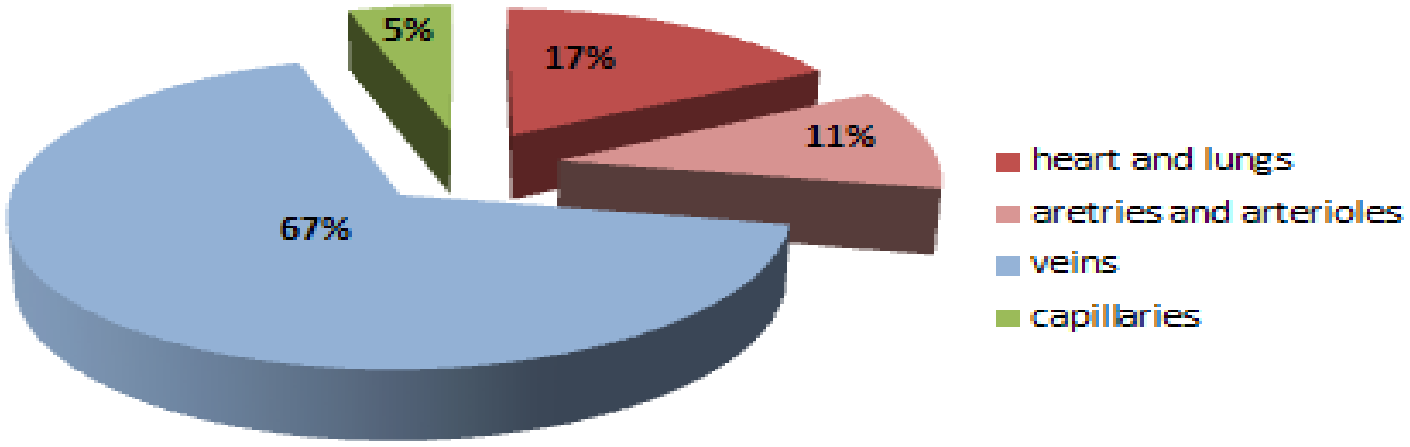




LO6

The distribution of blood volume over the major parts of the circulation

At rest, the blood volume of about 5liter is distributed as follows:



Thank you