# CIRCULATORY SYSTEM
- Heart
- Vessels
    - Arteries
    - Veins
    - Capillaries

# BLOOD VESSELS
- 3 layers
    - Tunica intima
    - Tunica media
    - Tunica adventitia

## Tunica intima
- innermost layer (direct contact with blood)
- Composed of
    - ==Single layer of squamous endothelial cells== arranged in longitudinal direction with basal lamina
    - Subendothelial layer : loose collagenous connective tissue + smooth muscle cells + elastic and reticular fibres
- function of endothelium :
    - Nonthrombogenic surface
        - Blood will not clot
        - Secretes agents that will control local blood clot formation
    - vascular tone and blood flow
        - Stimulate smooth muscle contraction
    - inflammation and local immune response
        - Can induce WBC to stop and undergo transendothelial migration to sites of injury or infection ( mainly in post capillary venules )
    - secrete growth factors
        - Stimulate formation of vascular system

## Tunica media
- middle layer
- Composed of
    - Concentric layers of smooth muscle cells
    - Elastic, collagen and reticular fibres
    - Elements of ground substance (produced by smooth muscle cells )
- according to amount of and content of tunica media we can distinguish different types of vessels

## Tunica adventitia
- Outer layer
- Composed of
    - Longitudinally arranged collagen and elastic fibres
    - Adipose cells
    - Smooth muscle cells (veins)

## Vasa vasorum
- smaller vessels present within adventitia of vessels
- Nourish the vessels
- Present more in veins that arteries
    - Veins carry deoxygenated blood which doesn't contain adequate nourishment for the walls of

the veins

## ARTERIES VS VEINS

1. **Presence or absence of internal / external elastic membrane**
   ○ Only present in arteries

   **Internal elastic lamina**
   ‣ layer of elastic fibres at the border between tunica intima and tunica media
   ‣ (Part of tunica intima)

   **External elastic lamina**
   ‣ layer of elastic fibres at the border between tunica media and tunica adventitia

2. **Lumen shape**
   ○ Arteries : regular lumen
   ○ Veins : irregular lumen

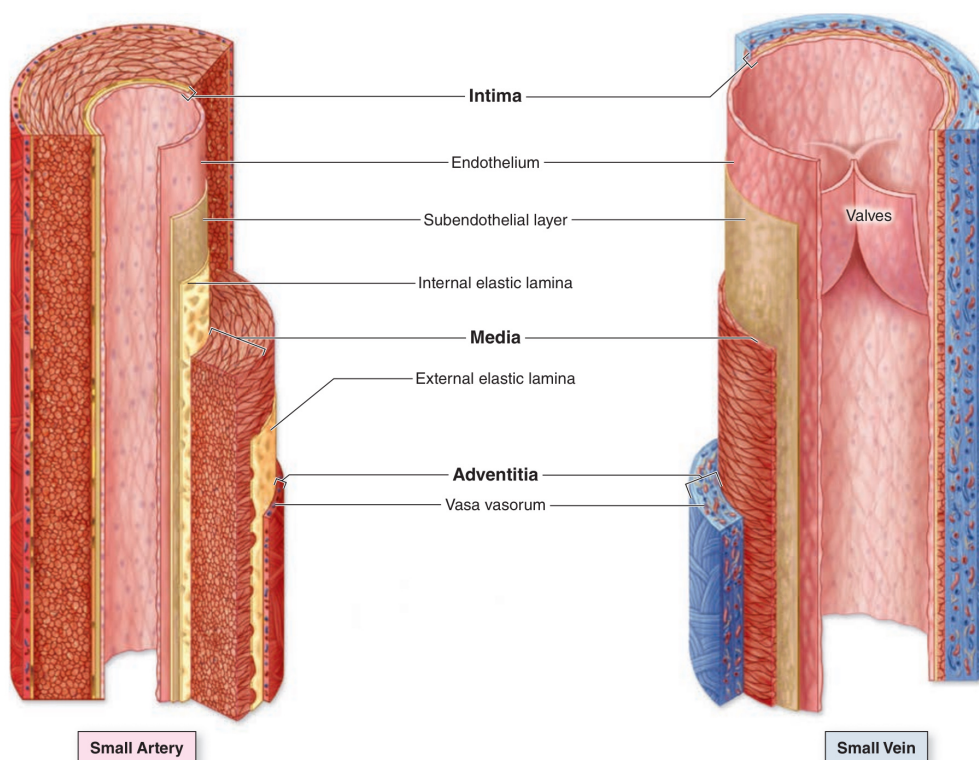3. **Thickest layer**
   ○ Arteries : tunica media
   ○ Veins : tunica adventitia

4. **Presence or absence of valves**
   ○ Arteries : no valves
   ○ Veins : valves - foldings of tunica intima

5. **Vasa vasorum**
   ○ More in veins than arteries ( deoxygenated blood )



Intima
Endothelium
Subendothelial layer
Internal elastic lamina
Media
External elastic lamina
Adventitia
Vasa vasorum
Valves

Small Artery

Small Vein

# ARTERIES

- arteries can be divided according to the size and characteristics of **tunica media**

## Elastic arteries (large)
- aorta / pulmonary arteries and their largest branches
- Carry blood to smaller arteries
- Features :
    - Tunica intima
        - Subendothelial layer : large amount of smooth muscle cells
        - Internal elastic membrane : not defined

    - Tunica media
        - Thickest layer
        - Large amount of elastic fibres forming <mark>fenestrated membrane</mark>
            - Creation of diastolic pressure
        - Smooth muscle cells : capable of producing substances that fibroblast would usually produce
        - Ground substance
        - External elastic membrane : not well defined

    - Tunica adventitia
        - Thinner than tunica media
        - Vasa + nervi vasorum

## Muscular arteries (medium)
- Most named arteries in body
- Distribute blood to organs
- Features :
    - Tunica intima
        - Internal elastic membrane : well defined
        - Subendothelial layer : thick

    - Tunica media
        - Many concentric layers of smooth muscle cells with much less elastic fibres
        - External elastic membrane : developed only in larger muscular arteries

    - Tunica adventitia
        - Thinner than tunica media
        - Vasa + nervi vasorum

## Small arteries
- same as muscular arteries but tunica media has thinner layer of smooth muscle cells
- No vasa vasorum
- No external elastic membrane

## Arterioles :

- smallest arteries branches
- Non collapsed lumen
  - Tunica intima
    - Endothelium : touches muscle cells of tunica media in some places ( penetrated through basal lamina)
    - Subendothelial layer : very thin
  - Tunica media
    - Internal elastic membrane : only in larger arterioles
    - Smooth muscle layer : 1-5 layers thick ( only one layer in small arterioles )
    - External elastic membrane : absent
  - tunica adventitia
    - Very thin

## Metarteriole / precapillary

- terminal branches of arterioles
- Non collapsed lumen
  - Tunica intima
    - Endothelium
  - tunica media
    - Few smooth muscle cells
    - Multiplication of smooth muscle cells present in the **pre capillary sphincter ( regulates blood flow into the capillary )**
  - tunica adventitia
    - Very thin

## CAPILLARIES

- Thinnest section of the blood stream
- Facilitate substance exchange between blood and tissues
- function in groups called capillary beds
  - Size and shape depends on the metabolic activity of the tissue
- Consist of
  - **Endothelium ( no Subendothelial layer )**
  - **Basal lamina**
  - **Pericytes**
    - elongated cells with many protrusions around the vessel
    - Contractile ability due to presence of actin and myosin
    - Line the capillaries and correspond to smooth muscle in the media of larger vessels



Cross–section through a capillary

Capillary with a pericyte
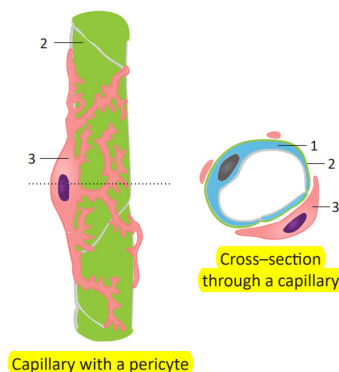
- based on the structural differences of capillaries we distinguish 4 types
    - Structural differences is the basis of the permeability differences
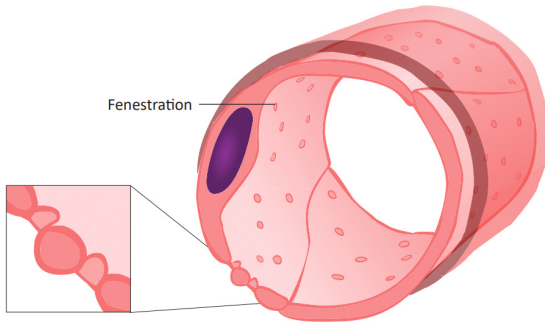
## Continuous / somatic capillaries
- continuous endothelium
    - No fenestrations or pores
- basal lamina is continuous
- Brain / skeletal muscle / lungs
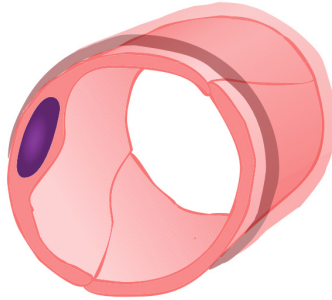
Continuous capillary

## Fenestrated capillaries
- endothelial cells with fenestrations
    - Fenestrations covered by a membrane : diaphragm
- Basal lamina is continuous
- Organs with quick substance exchange : endocrine glands / intestines

Fenestration

Fenestrated capillary

## Capillary with pores
- endothelial cells with fenestrations and no diaphragm
- True pores
- Basal lamina is continuous
- Only in renal glomeruli
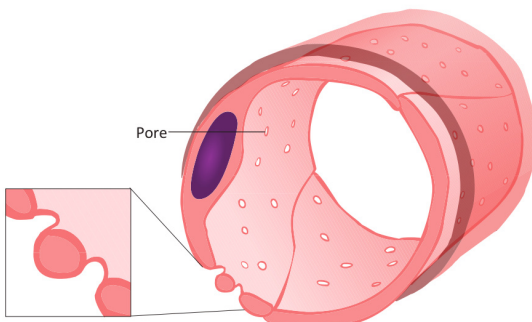
Pore

Capillary with pores

## Sinusoidal capillaries
- larger perforations without diaphragm
- **Discontinuous basal lamina**
- Much larger diameter
    - ○ **Slows down blood flow allowing for maximal exchange between blood and tissue**
- liver / spleen / bone marrow

Pores

Fenestration

Sinusoid capillaries
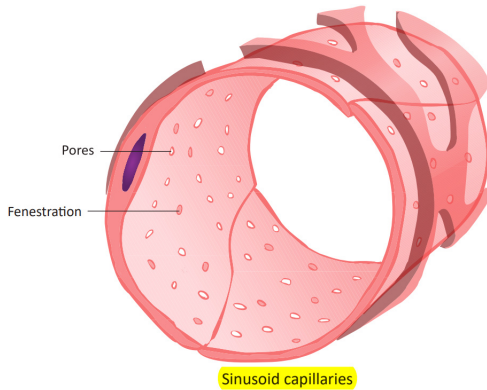
## VEINS
- low pressure system
- Contain valves
- Wall consists of same 3 layers but **tunica adventitia is most predominant**

## Post capillary and collecting venules
- same as capillary but wider lumen and more pericytes

## muscular venules
- Tunica intima
    - ○ Endothelial cells
    - ○ Pericytes
    - ○ No Subendothelial layer

- tunica media
    - ○ 1-2 layers of smooth muscle cells

- tunica adventitia
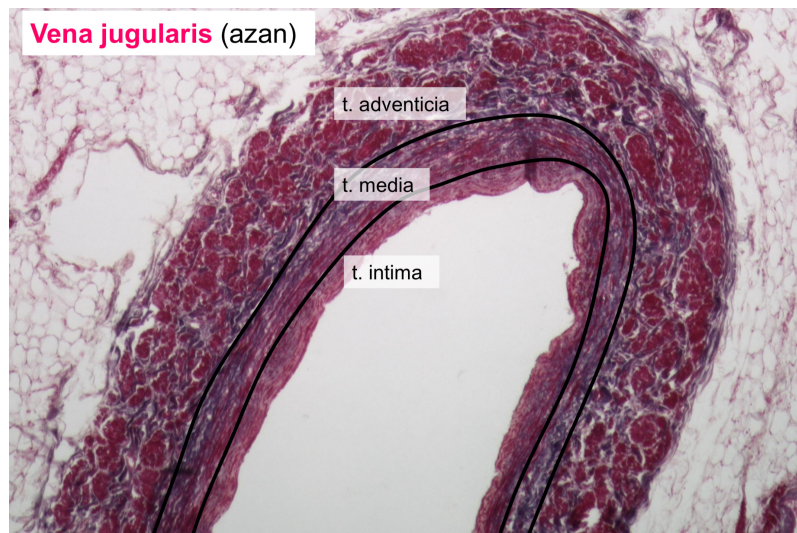    - ○ Loose connective tissue

## Small and medium veins
- tunica intima
    - ○ One layer endothelial cells
    - ○ very thin Subendothelial layer

- tunica media
    - ○ **Circularly** arranged smooth muscle layer
    - ○ Collagen + elastic + reticular fibres
    - ○ IEL not developed

- tunica adventitia
    - Widest layer
    - **Longitudinally arranged smooth muscle layer**
    - EEL not developed
    - Vasa vasorum

- contain valves

## Large veins
- Tunica intima
    - One layer of endothelial cells
    - Subendothelial layer : wide with smooth muscle cells

- tunica media
    - Thin layer of circular smooth muscle cells

- tunica adventitia
    - Most developed
    - **Longitudinally arranged muscle bundles** ( more muscle than media )
    - Collagen + elastic + reticular fibres )
    - Vasa + nervi vasorum
- valves



Vena jugularis (azan)

t. adventicia

t. media

t. intima

## THE HEART
- Located in the pericardium - double layered sack
- Composed of 3 layers

## Endocardium
- one layer of endothelial cells
- Subendothelial layer : loose connective tissue, elastic, collagen, smooth muscle cells
- Subendocardial layer :
    - Closest to myocardium
    - Connective tissue
    - **Purkinje fibres : hearts conducting system**
        - Specialised cardiomyocytes
        - Larger than cardiomyocytes
        - Paler than cardiomyocytes due to higher amount of glycogen

**Heart – Purkinje fibres of the conducting system (TRICHROME)**

SUBENDOCARDIUM
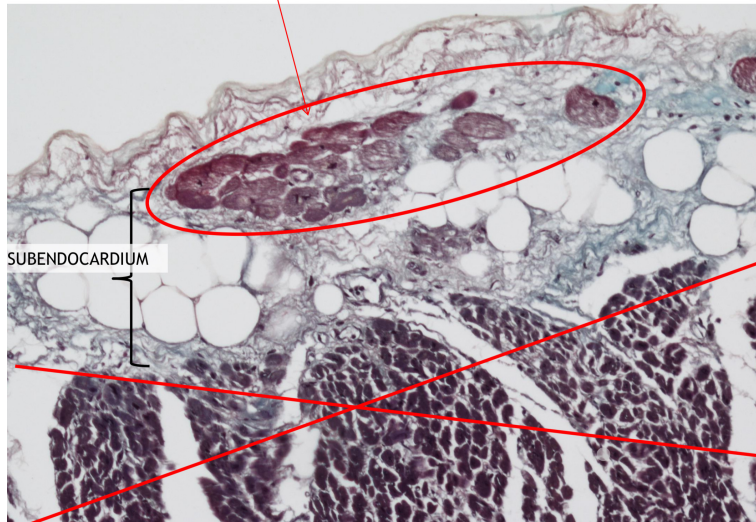
## Myocardium
- cardiomyocytes
- Thickest part of the heart wall
- Atria : 2 layers of heart muscle
- Ventricles : 3 layers of heart muscle
- Fibres arranged spirally around each heart chamber : pump blood
- Contain large amount of vessels

## Epicardium
- visceral layer of the serous part of the pericardium
- Subepicardial layer
  - Above myocardium
  - Thick layer of adipose tissue which cushions the heart
  - **Contains coronary arteries and veins**
- lamina propria
  - Thin layer of loose collagenous connective tissue
  - Contains nerves and capillaries
- mesothelium
  - Last layer
  - Simple squamous lining ( mesothelial lining )