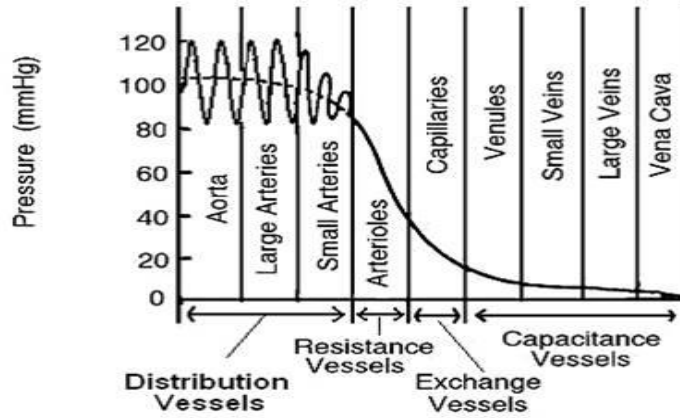


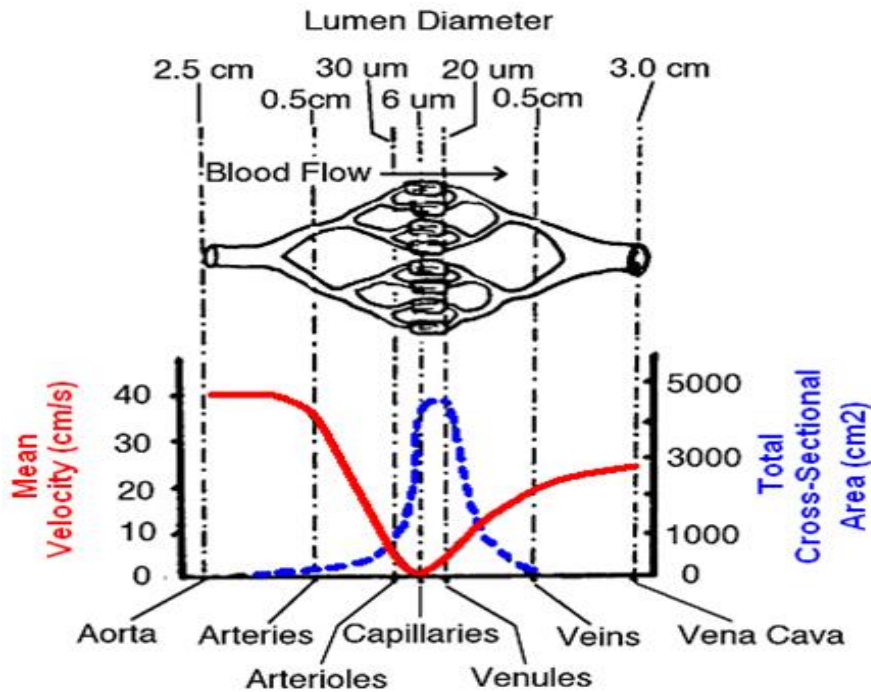
Circulatory System – Blood Vessels

- The special structural properties contribute to the characteristics seen throughout the circulation

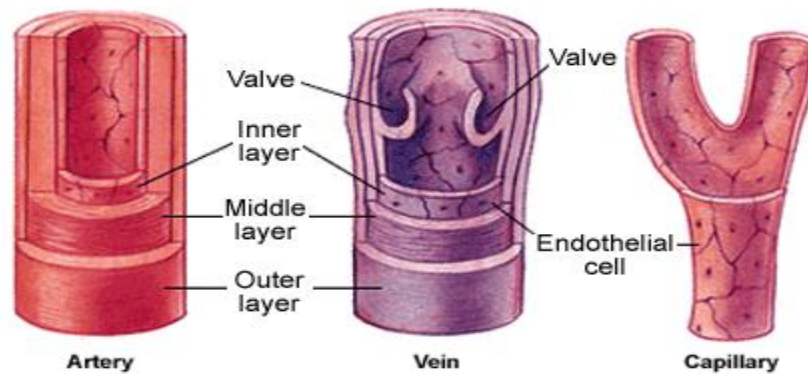


- Components of each vessel include elastic tissue, fibrous connective tissue and smooth muscle

**Mean Blood Velocity & Total Cross Sectional Area**



- Blood velocity is NOT the same as blood flow
- Blood velocity is the speed at which the blood is moving through a particular blood vessel
  - o Measured in cm/sec
- Blood flow is the volume of blood moving through a set of vessels
  - o Measured in L/min
- Mean blood velocity is higher in aorta than vena cava, where blood flow is the same in both
  - o Because the aorta has a smaller diameter = blood needs to move faster to be at same speed as vessel with greater diameter (vena cava)



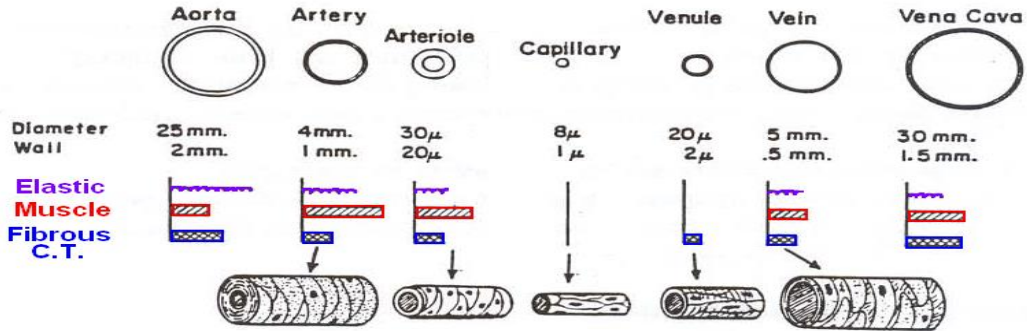
Arteries and Veins contain 3 layers in their walls:

1. Outer layer (tunica externa)
  - Composed mostly of fibrous connective tissue
2. Middle layer (tunica media)
  - Consists of smooth and elastic tissue
3. Inner layer (tunica interna)
  - Composed of endothelial cells

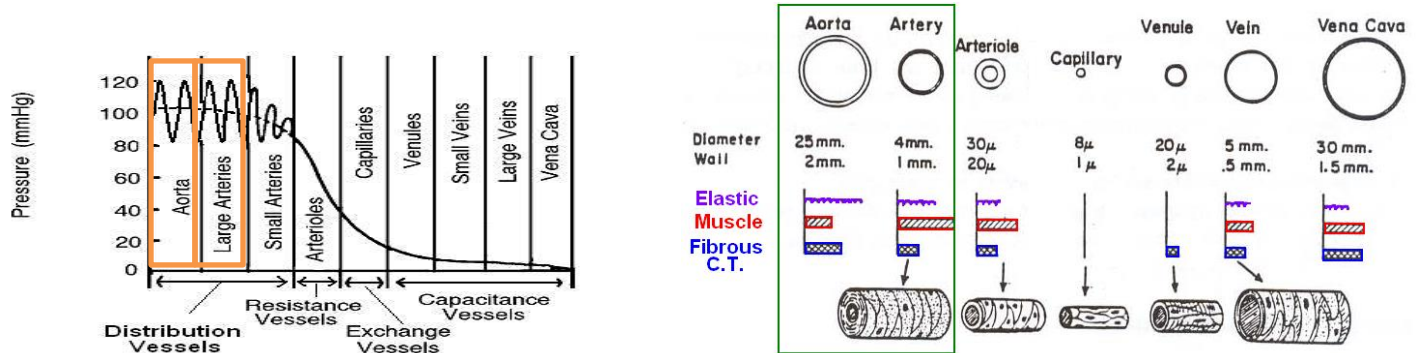
Along with these 3 layers, veins also contain valves to ensure blood flow in one direction – to the heart

*Capillaries* are composed entirely of a single layer of endothelial cells. These thin walls permit the diffusion of substances into and out of the blood

Relative Amount of elastic, smooth and fibrous connective tissue:



### Aorta & Large Arteries



### Blood characteristics

- Very high blood pressure – pulsates 120/80 mmHg
- High blood velocity

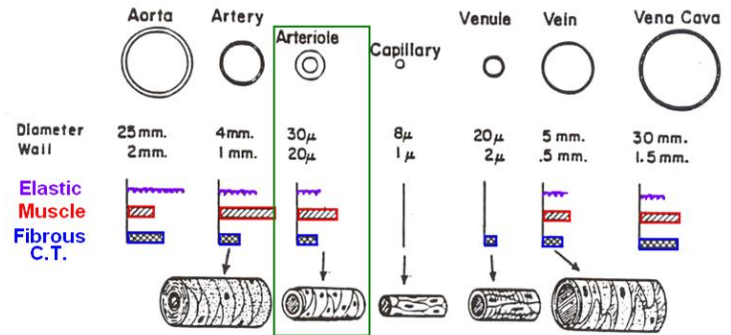
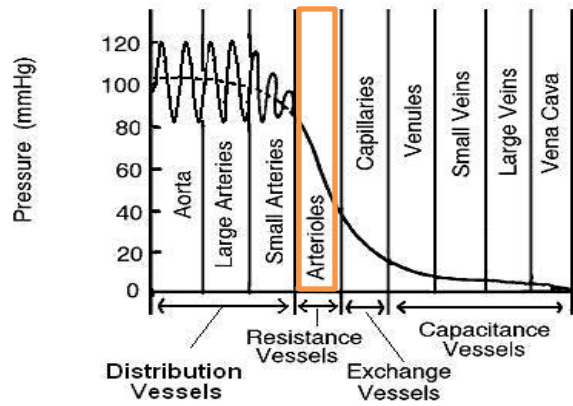
### Structure

- Large diameter
- Lots of elastic tissue
- Relative thin walls
  - o Easily distended
  - o Low resistance to blood flow
  - o Small drop in blood pressure

### Purpose

- “shock absorbers”
- Distribute the blood

## Arterioles



## Blood Characteristics

- Large drop in blood pressure
- Lower blood velocity

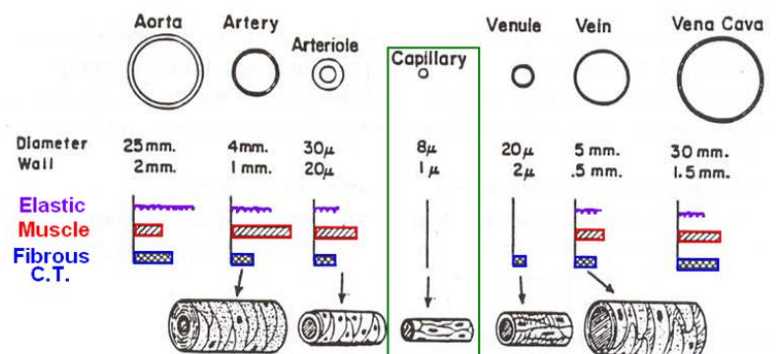
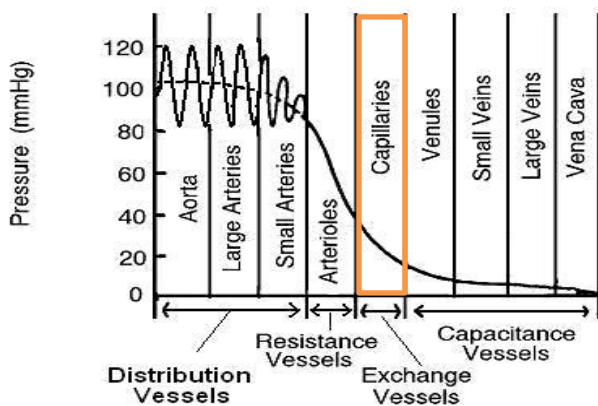
## Structure

- Small diameter
- Very thick walls
- Large smooth muscle content innervated by ANS
  - o Causes vasoconstriction and vasodilation
  - o Controls blood flow\*

## Purpose

- Resistance vessels
- Control blood flow to organs\*

## Capillaries



### Blood Characteristics

- Low blood pressure
- Very low blood velocity (1-2 cm/sec)

### Structure

- Only one endothelial cell thick (no elastic or muscle)
- Extremely large TOTAL cross sectional area
- Very large surface area for diffusion
  - o Gas, nutrients, waste

### Purpose

- Exchange vessels

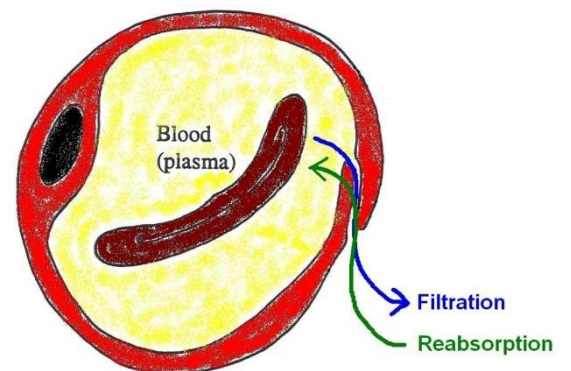
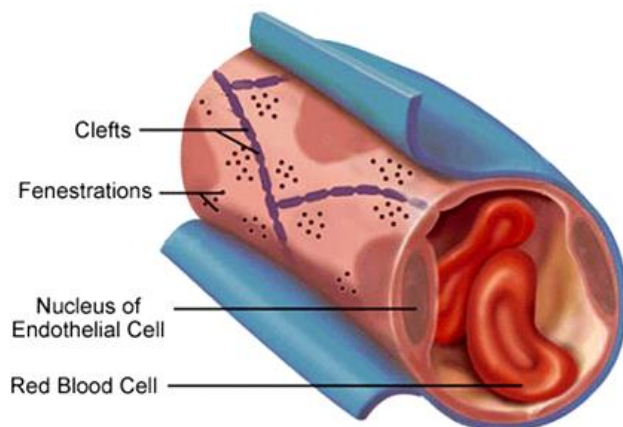
### Exchange in Capillaries

#### 1. Diffusion

- Substances moving down their concentration gradients
- Oxygen and CO<sub>2</sub>

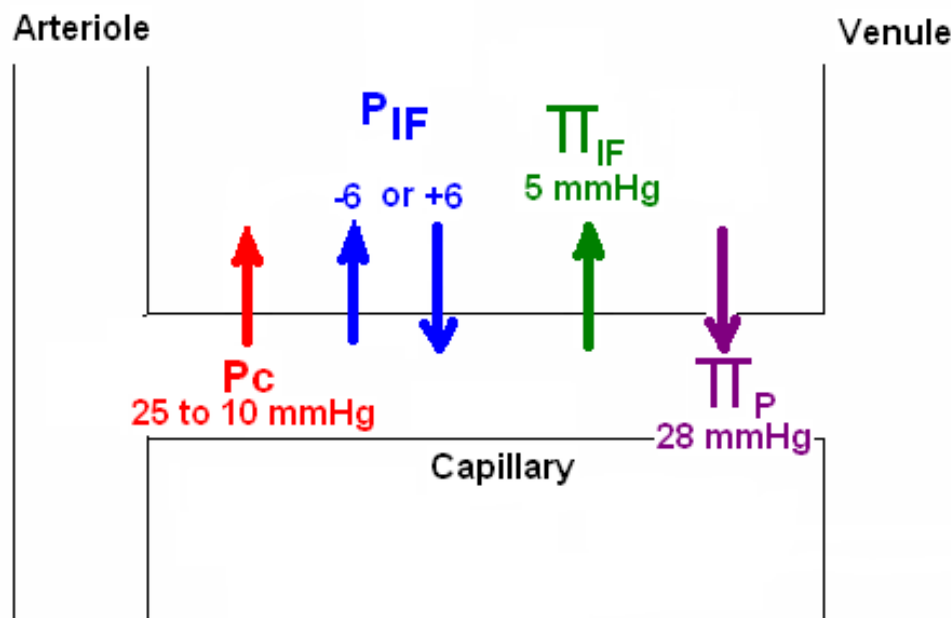
#### 2. Filtration & Reabsorption

- Movement of fluid across capillary depends upon a balance of 4 forces called Starling Forces



#### 4 Starling Forces

1. Capillary Hydrostatic Pressure ( $P_c$ )
  - The pressure from the blood in the capillary
  - Blood pressure falls over length of capillary from the arterial end (15 mmHg) to the venous end (10 mmHg)
  - Tends to move fluid from plasma into interstitial space → **filtration**
2. Interstitial Fluid Hydrostatic Pressure ( $P_{IF}$ )
  - The pressure on the fluid in the interstitial space
  - Varies from organ to organ (-6 to +6)
  - When it is positive, it will cause **reabsorption** (brain, liver, kidney)
  - When it is negative, it will cause **filtration**
3. Interstitial Osmotic Pressure ( $\pi_{IF}$ )
  - Pressure caused by osmosis due to the few proteins in the interstitial fluid
  - Low pressure (5 mmHg)
  - Pressure tends to fluid into the interstitium → **filtration**
4. Plasma Osmotic Pressure ( $\pi_p$ )
  - Pressure is caused by osmosis due to proteins in the plasma
  - High pressure (28 mmHg)
  - Pressure moves fluid into the plasma → **reabsorption**



### Balance of Starling Forces; the Starling-Landis Equation

- Used to calculate the net fluid movement (NFM) across a capillary bend
- The balance of the Starling forces determines the net pressure for fluid movement and the direction of fluid movement across the capillary endothelium

$$\text{NFM} = K_f [ (P_C - P_{IF}) - (\pi_P - \pi_{IF}) ]$$

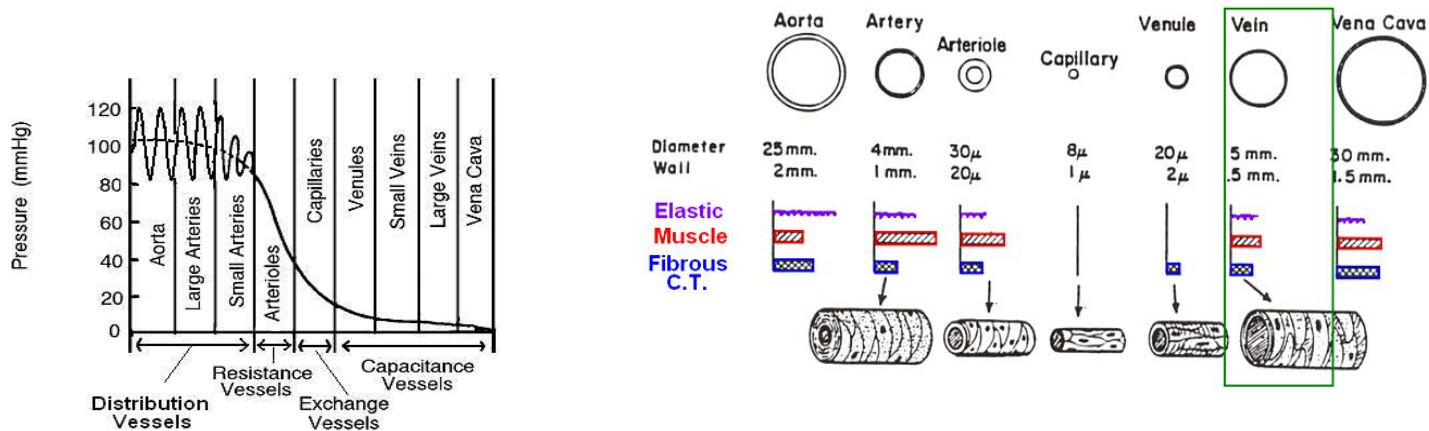
$K_f$

- The filtration coefficient and represents the permeability of the capillary
- Higher filtration coefficient = more "leaky" the capillary and more fluid can move across
- Unless otherwise stated, assume  $K_f = 1$

If NFM is negative, reabsorption back into capillary is happening

If NFM is positive, filtration out of capillary is happening

### Veins



### Blood Characteristics

- Very low blood pressure
- Low to medium blood velocity (5-10 cm/sec)

### Structure

- Very thin walls, large diameter
- Valves
- Some elastic tissue
- Some smooth muscle innervated by ANS (vasoconstriction or dilation (EDV))

### Purpose

- Capacitance vessels: 70% of total blood volume