Circulatory system

1st lecture

Prof.Dr.Rashad Fadhil

- Circulation systems

move gasses (and other essential resources such as nutrients, hormones, etc) throughout the animal's body

Most animals have a circulatory system

- It transports O_2 and nutrients to cells
- It takes away CO_2 and other wastes

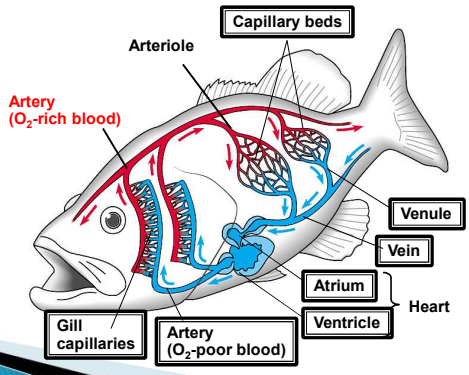
True Circulatory Systems

- 3 main components in a true circulatory system:
  1. Circulatory fluid (blood)
  2. Muscular pump (heart)
  3. Tubes to transport fluid (blood vessels)

True Circulatory Systems

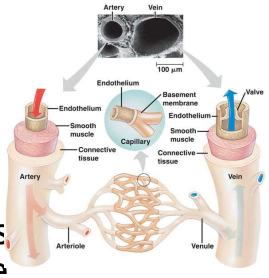
- In general, higher metabolism means a more complex circulatory system
- An animal either has an open or a closed circulatory system
  - Open: fluid is circulated through an open body chamber.
  - Closed: fluid is circulated through blood vessels.

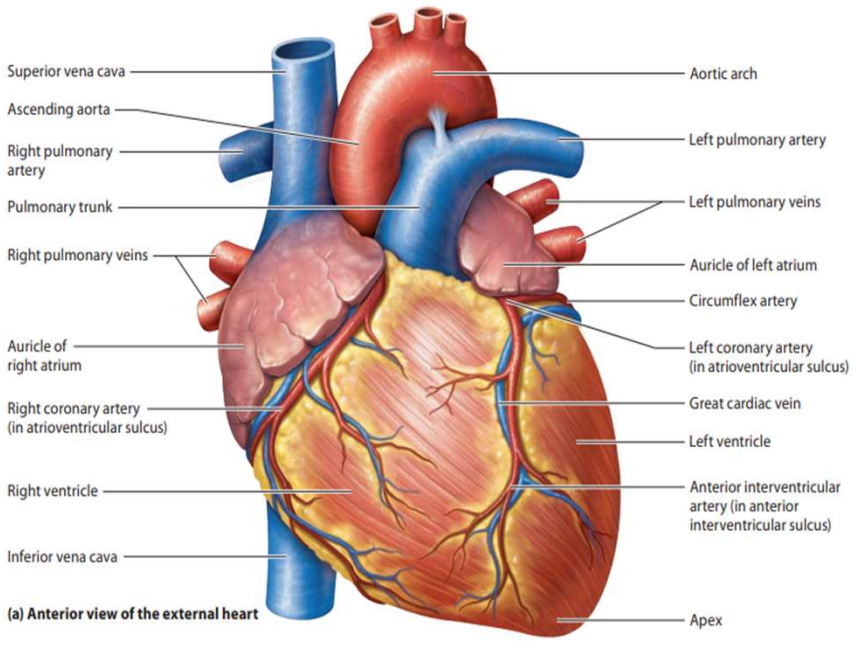
- Closed systems
  - A heart pumps blood through arteries and capillary beds
  - The blood returns to the heart via veins



Closed Circulatory System

- Complex system of tubes
- **arteries** = vessels that carry blood from heart to capillaries (throughout body)
- **veins** = vessels that carry blood from capillaries to heart (in general)
- **capillaries** = tiny, porous vessels through which molecules diffuse in / out (throughout body)





(a) Anterior view of the external heart

The Heart

- heart is a pump that contracts rhythmically to deliver blood to the body. But the heart actually consists of two pumps that propel blood to two different destinations.
- the heart is a muscular organ that pumps blood through the body. The blood is contained within the heart's hollow spaces, its lumen. Like all organs, the heart is composed of different tissue layers that work together to ensure its proper functioning

Functions of the Heart

- The primary function of the heart—to pump blood
- the heart pumps blood through two different sets of vessels, or circuits.
- The heart has other functions besides pumping blood. One of the most important is to help maintain the homeostasis of the pressure that blood exerts on the blood vessels, also known as blood pressure.

Circulation of Blood through the Pulmonary and Systemic Circuits

- The heart is divided functionally into right and left sides.
- The right side of the heart pumps blood to the lungs, whereas the left side of the heart pumps blood to the rest of the body.
- The right side of the heart, shaded blue is sometimes called the pulmonary pump
- because it pumps blood into a series of blood vessels leading to and within the lungs, collectively called the pulmonary circuit.
- The pulmonary arteries of the pulmonary circuit deliver oxygenpoor and carbon dioxide–rich, or deoxygenated blood to the lungs

The Great Vessels, Chambers, and Valves of the Heart

- the heart consists of four chambers:
- two atria
- two ventricles.
- The atria receive blood from veins, and pump blood into the ventricles through structures called valves. These valves have flaps that close when the ventricles contract, keeping the blood from moving backward. The contracting ventricles then eject blood into arteries, which carry the blood through either the systemic or pulmonary circuit.

The Great Vessels

- The vessels that bring blood to and away from the heart, the great vessels, are the largest ones in the body.
- There are four main great vessels
- Major systemic veins

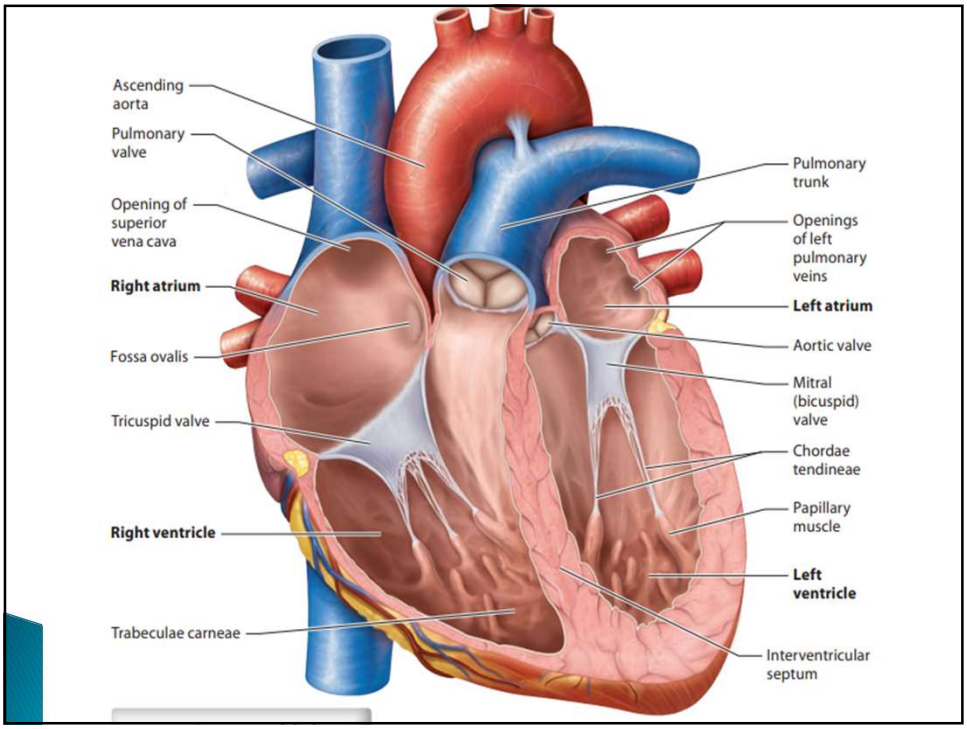
1- superior vena cava

2- inferior vena cava.

The superior vena cava (SVC) drains deoxygenated blood from veins superior to the diaphragm,

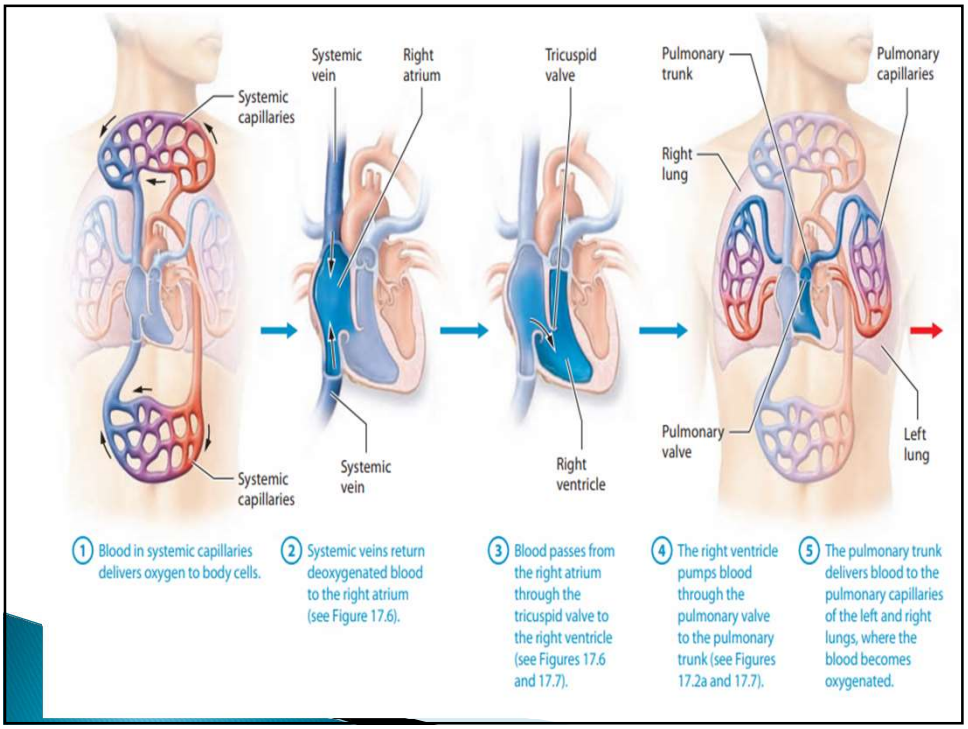
The inferior vena cava (IVC) drains deoxygenated blood from veins inferior to the diaphragm

- **Pulmonary trunk.**
- The large pulmonary trunk receives deoxygenated blood pumped from the right ventricle. The pulmonary trunk is the largest vessel of the pulmonary circuit.
- **Pulmonary veins.**
- Once the blood is oxygenated in the pulmonary capillaries, it returns to the heart via a set of pulmonary veins.
- Most people have four pulmonary veins—two from each lung—that drain oxygenated blood into the posterior part of the left atrium.
- **● Aorta.**
- The aorta supplies the entire systemic circuit with oxygenated blood. The aorta is the largest and thickest artery in the systemic circuit and, in fact, in the entire body.
- The aorta stems from the left ventricle as the ascending aorta, after which it curves to the left and makes a U-turn as the aortic arch. (Notice that the pulmonary trunk splits into the two pulmonary arteries just underneath the aortic arch.)



pulmonary circuit

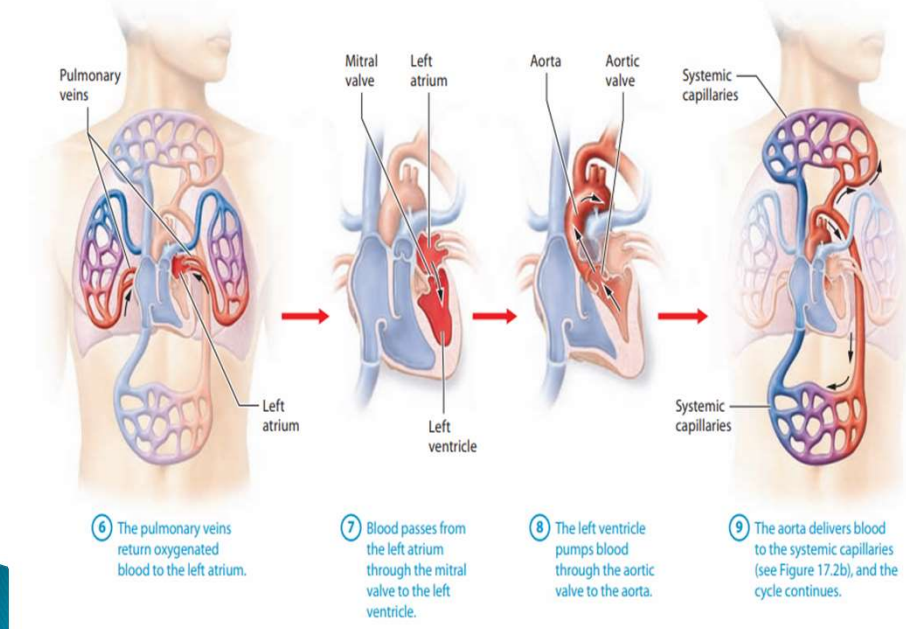
- The pulmonary arteries of the pulmonary circuit deliver oxygen poor and carbon dioxide–rich, or deoxygenated blood to the lungs.
- A process called gas exchange takes place between the tiny air sacs in the lung, called alveoli and the smallest vessels of the pulmonary circuit, called the pulmonary capillaries
- During gas exchange, oxygen diffuses from the air in the alveoli into the blood in the pulmonary capillaries, and carbon dioxide diffuses from the blood in the pulmonary capillaries to the air in the alveoli, to be expired.
- The veins of the pulmonary circuit then deliver this oxygen-rich, or oxygenated, blood to the left side of the heart. Vessels and organs that transport oxygenated blood.



- The left side of the heart, often called the systemic pump and shaded red receives oxygenated blood from the pulmonary veins and pumps it into the blood vessels that serve

systemic circuit.

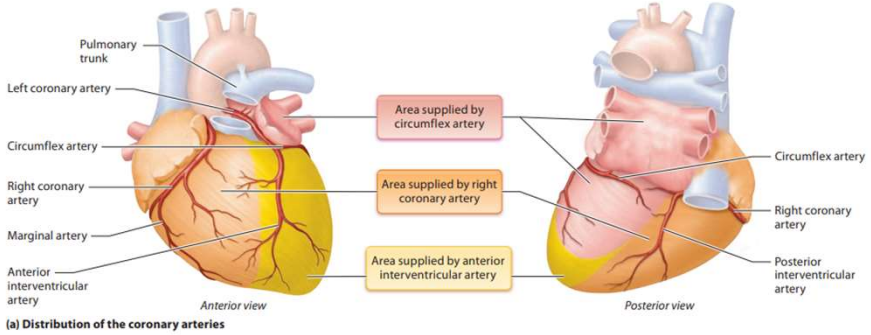
- In the systemic circuit, arteries deliver oxygenated blood to the smallest blood vessels, the systemic capillaries.
- Here gas exchange occurs again, except in reverse: Oxygen diffuses from the blood into the tissues, and carbon dioxide diffuses from the tissues into the blood. In addition to delivering oxygen,
- blood also delivers nutrients, picks up wastes to be excreted, and distributes hormones to their target cells throughout the body.
- As a result of gas exchange in the tissues, the blood is deoxygenated and the veins of the systemic circuit then deliver it back to the right side of the heart, to be pumped into the pulmonary circuit. The pulm



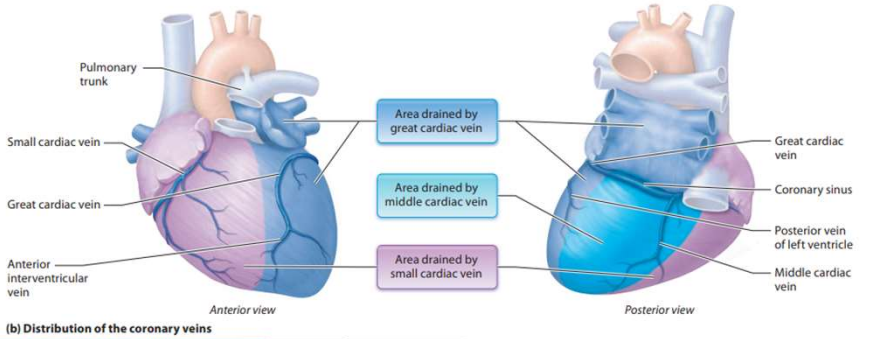
- The pulmonary circuit is a low-pressure circuit because it delivers blood to the lungs, whereas the systemic circuit is a highpressure circuit because it has to deliver blood to the entire rest of the body.
- Keep in mind that both sides of the heart function at the same time to keep blood moving through these circuits.

The Coronary Circulation

- Although the heart's chambers are filled with blood, the myocardium is too thick for oxygen and nutrients to diffuse from inside the chambers to all of the organ's cells. For this reason, the heart is supplied by a set of blood vessels collectively called the coronary circulation
- The Coronary Vessels The coronary arteries deliver oxygenated blood to the coronary capillary beds, where gas and nutrient exchange takes place within the myocardium. Then the deoxygenated blood drains from capillaries into a series of coronary veins

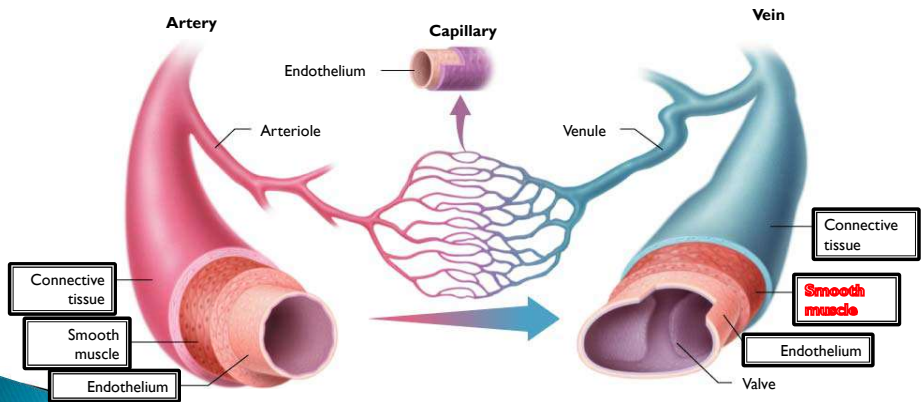


(a) Distribution of the coronary arteries



(b) Distribution of the coronary veins

Mammalian Blood Vessels



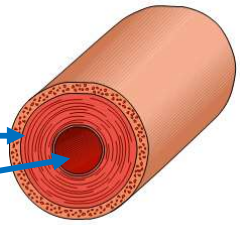
Main parts Circulation System

1. Heart
2. Blood Vessels
3. Blood

- *Arteries*
- *Arterioles*
- *Veins*
- *Venules*
- *Capillaries*

Main Blood Vessels

Arterie

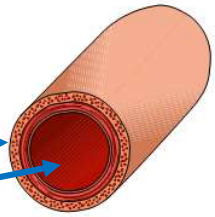


Carry blood under high pressure

Thick elastic wall

Narrow lumen

Veins



Carry blood under low pressure

Carry blood towards the heart

Have valves to prevent backflow

Thin wall

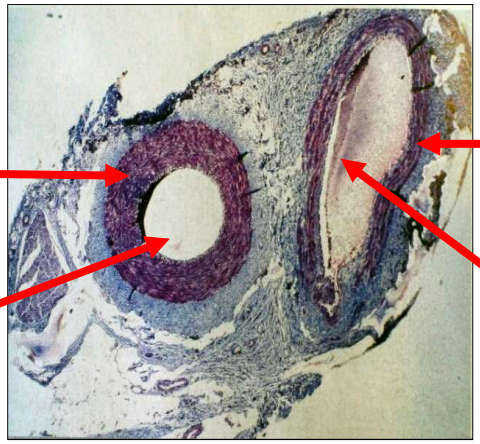
Wide lumen

Blood vessels under the microscope

Arteries

Thick Wall

Narrow lumen



Veins

Thin Wall

Wide lumen

Have valves to prevent backflow

Blood Vessels - Wall Structure

Blood vessels are hollow and tubular

Lumen = hollow area

Composed of up to 3 Layers:

- Tunica Intima
- Tunica Media
- Tunica Externa

Blood Vessels - Wall Structure

Tunica Intima – inner-most layer

- Inner lining called the *vascular endothelium*

Tunica Media – middle layer

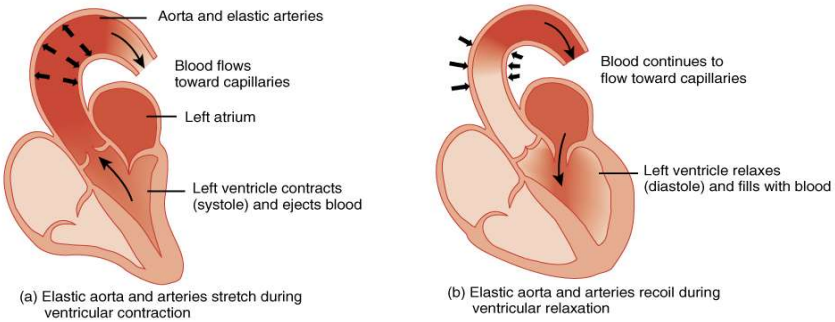
- Composed of smooth muscle and elastin
- Vasodilatation and vasoconstriction

Tunica Externa – outer-most layer

- Composed of collagen fibers (connective tissue)
- Support and reinforce blood vessel

Types of Arteries

- Elastic Arteries
  - Less muscle and more elastic tissue
  - Larger arteries such as aorta
  - Why do the larger arteries have more elastic tissue? What purpose do they



Types of Arteries

- Muscular Arteries

1. Less elastic tissue and more muscle
2. Medium size to smaller arteries
3. Capable of greater vasoconstriction and vasodilatation to adjust rate of flow

Smaller Vessels

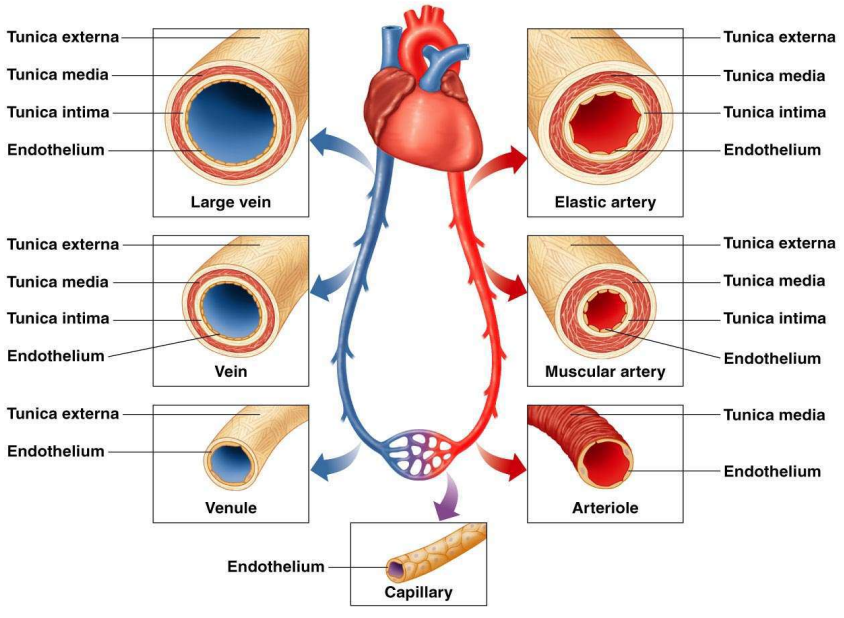
- Arterioles

–Smallest arteries

– Deliver blood to capillaries

– Smallest ones lose tunica externa

– Called resistance blood vessels because their vasoconstriction increases resistance, and their vasodilatation (relaxation) decreases resistance to blood flow



Capillaries – Tunica Intima

Continuous capillaries:

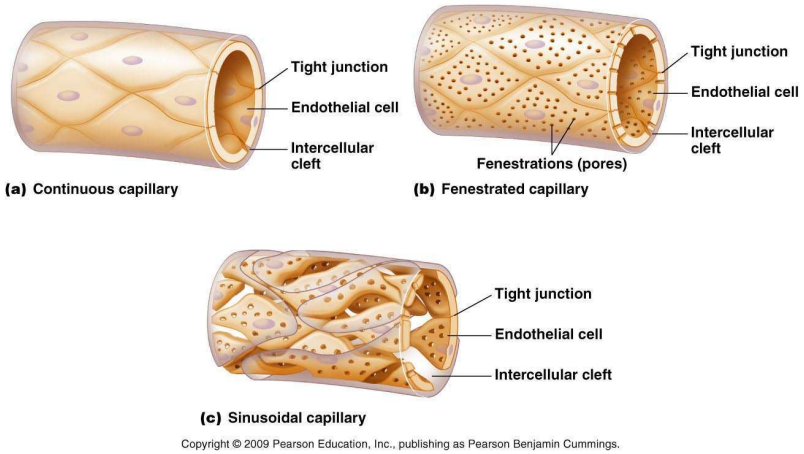
- seal between cells not usually complete allowing
- fluids and small molecules to pass.

Fenestrated capillaries:

- Cells of vascular endothelium have many pores.
- Passage of small molecules and fluids is easy.

Sinusoidal capillaries:

- Most porous of all capillaries.
- Allows proteins to move across capillary wall.



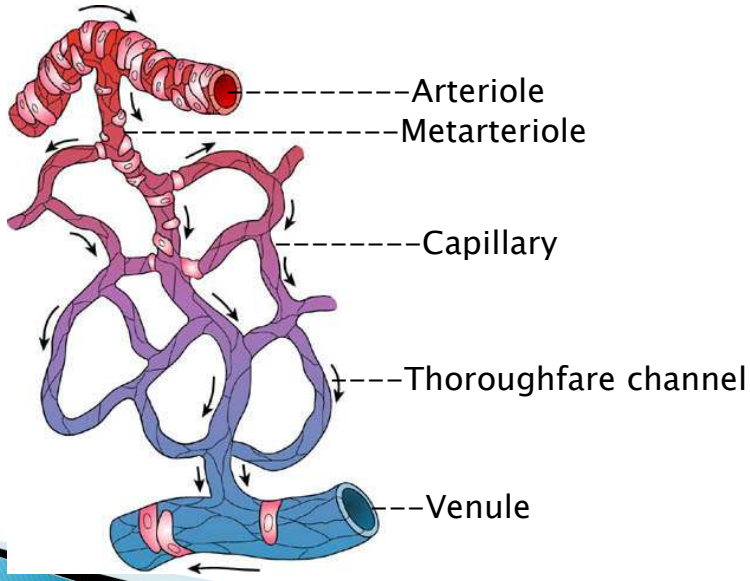
Capillaries

- Substances can move across walls by:
- Diffusion – lipid-soluble substances
- Vesicle transport – proteins
- **Paracellular pathway – small molecules like**
- water and ions can pass through pores
- between cells of the capillary walls.

Venules

- Small veins that collect blood from capillaries
- Tunica media contains only a few smooth muscle cells & scattered fibroblasts
- Rather porous endothelium

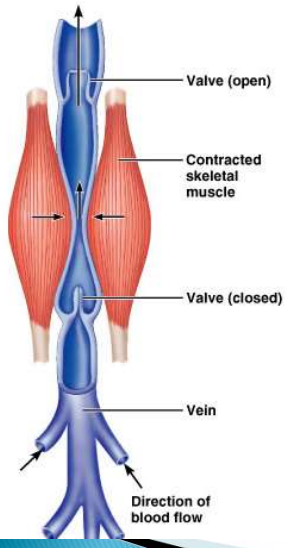
Microcirculation
Arterioles, Capillaries and Venules



Venous return – Volume of blood flowing back to heart through systemic veins (due to pressure generated by Left ventricle constriction)

- **Mechanisms of Venous Return:**
- **pressure gradient** – BP is the most important force in venous return
  - 7–13 mm Hg venous pressure towards heart
- venules (12–18 mm Hg) to central venous pressure – point where the venae cavae enter the heart (~5 mm Hg)
- **gravity** drains blood from head and neck
- **skeletal muscle pump** in the limbs
  - contracting muscle squeezed out of the compressed part of the vein
- **thoracic (respiratory) pump**
  - inhalation – thoracic cavity expands and thoracic pressure decreases, abdominal pressure increases forcing blood upward
  - CVP fluctuates : 2mm Hg– inhalation, 6mm Hg–exhalation
  - blood flows faster with inhalation
- **cardiac suction** of expanding atrial space

Special features of veins



Valves

- Prevent backflow
- Most abundant in legs (where blood has to travel *against* gravity)

Muscular contraction

- Aids the return of blood to heart in conjunction with valves

Mechanical issues…
(really good to know)

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- Three factors keep blood moving back to the heart
  - muscle contractions
  - breathing
  - one-way valves

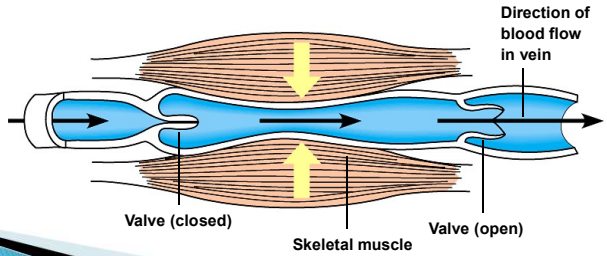

Figure 23.9B