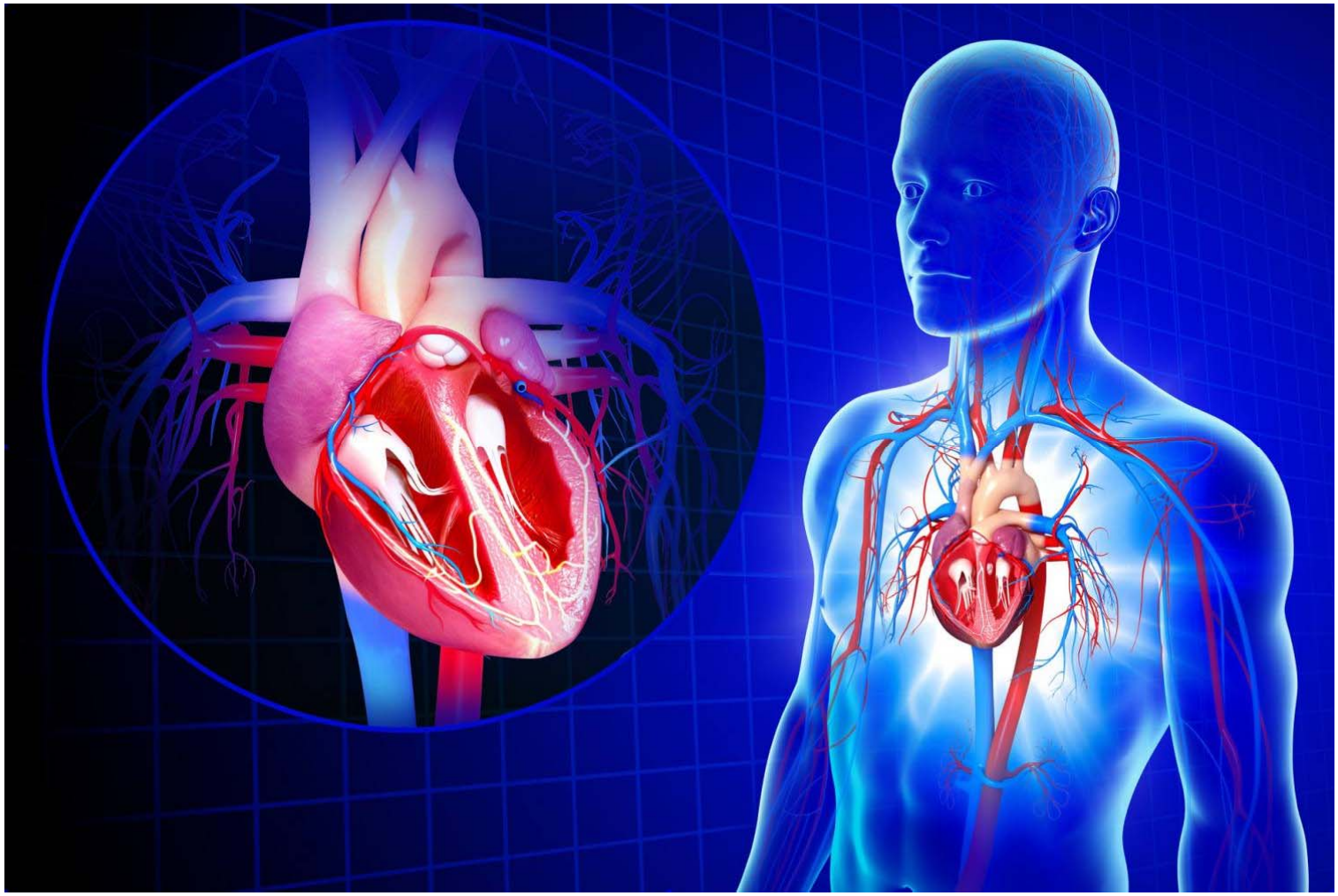


Assist. Lec.: Safa Jalil AL-Yassiri

Cardiovascular system (CVS)

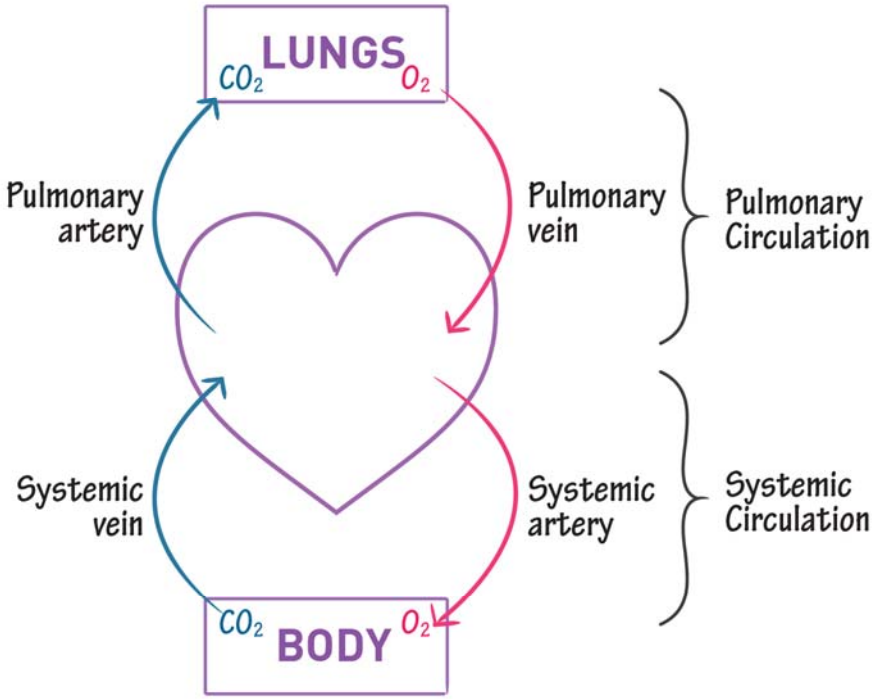
Cardiovascular system:

- The cardiovascular system consists of the heart, blood vessels and blood. Its primary function is to transport nutrients and oxygen-rich blood to all parts of the body and to carry deoxygenated blood back to the lungs.

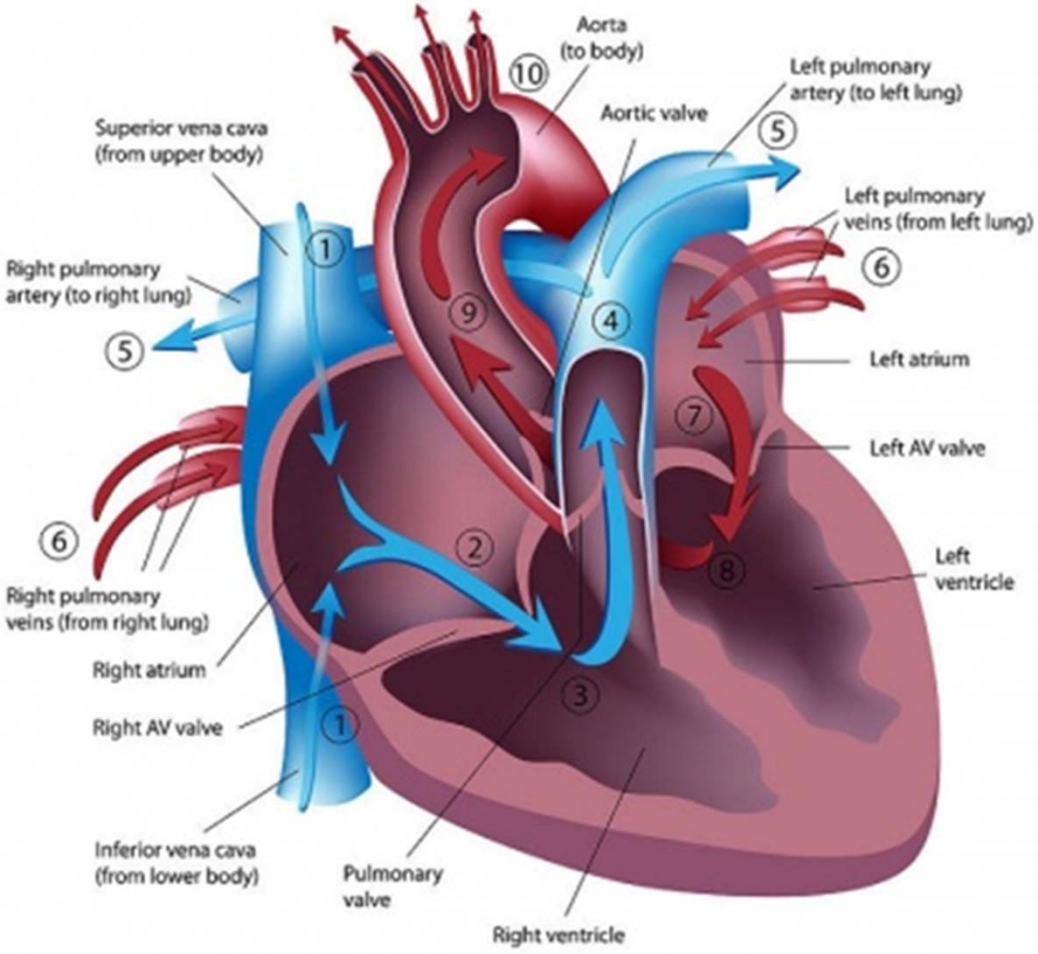
- There are two blood circulatory systems in the body.

  - **Systemic circulatory system:** This is the main blood circulatory system that transports blood to the organs, tissues, and cells throughout the body.

  - **Pulmonary circulatory system:** the blood moves between th heart and lungs. where oxygen enters the blood and carbon dioxide leaves.



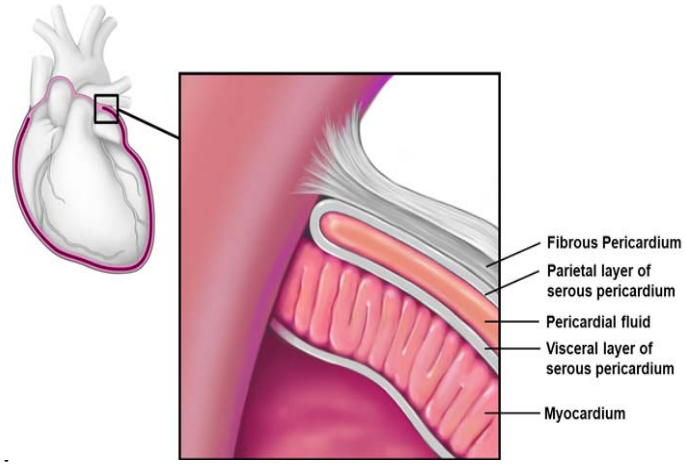
The pathway of blood flow through the heart



Anatomy:

- The heart is located in the thoracic cavity between the lungs. This area is called the mediastinum. The base of the cone-shaped heart is uppermost, behind the sternum, and the great vessels enter or leave here. The apex (tip) of the heart points downward and is just above the diaphragm to the left of the midline.

The heart consist of:



- Pericardium: there are two layers:

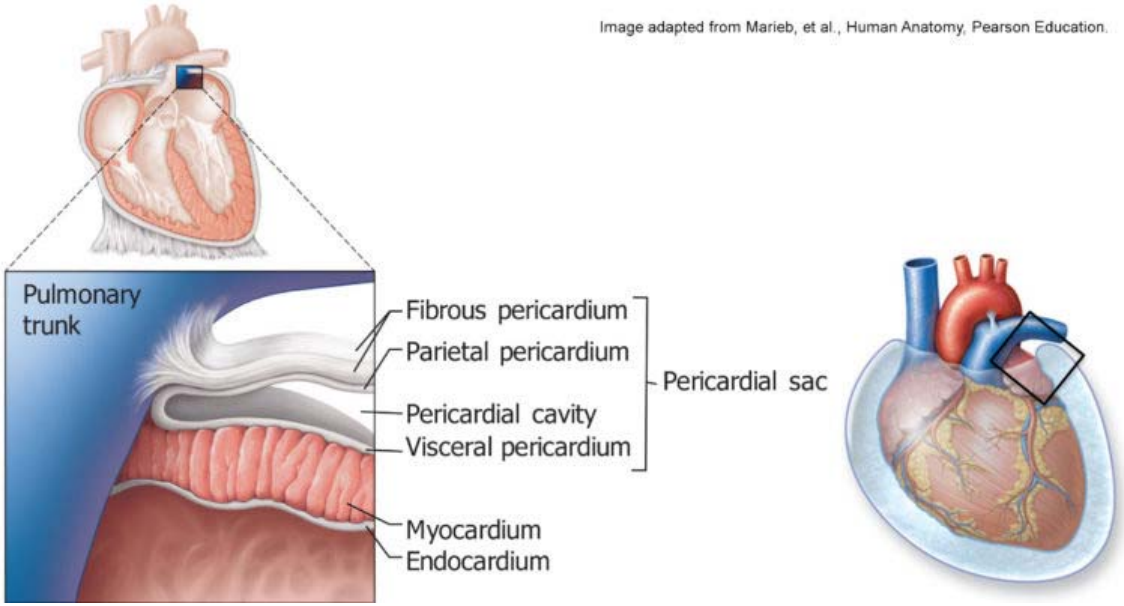
- **Fibrous pericardium:** a loose fitting sac of strong fibrous connective tissue.

- **Serous pericardium:** is a folded membrane; the fold gives it two layers:

  - Parietal pericardium : lining the fibrous pericardium.
  - Visceral pericardium :on the surface of the heart muscle often called the epicardium.

- Between the parietal and visceral pericardial membranes is serous fluid, which prevents friction as the heart beats. Called pericardial fluid.

- Myocardium (cardiac muscle).
- Endocardium is simple squamous epithelium that covers the champers and valves of the heart and continues into the vessels as their lining (endothelium) that is very smooth and prevents abnormal clotting.



Champers of the heart: the heart are consist of four champers:

- **Right Atrium:**

1. Receives blood from the upper body by way of the superior vena cava and receives blood from the lower body by way of the inferior vena cava.
2. The tricuspid (right atrioventricular valve) prevents backflow of blood from the right ventricle to the right atrium when the right ventricle contracts.

- **Left Atrium:**

1. Receives blood from the lungs by way of four pulmonary veins.
2. The mitral (left atrioventricular or bicuspid valve) prevents backflow of blood from the left ventricle to the left atrium when the left ventricle contracts.

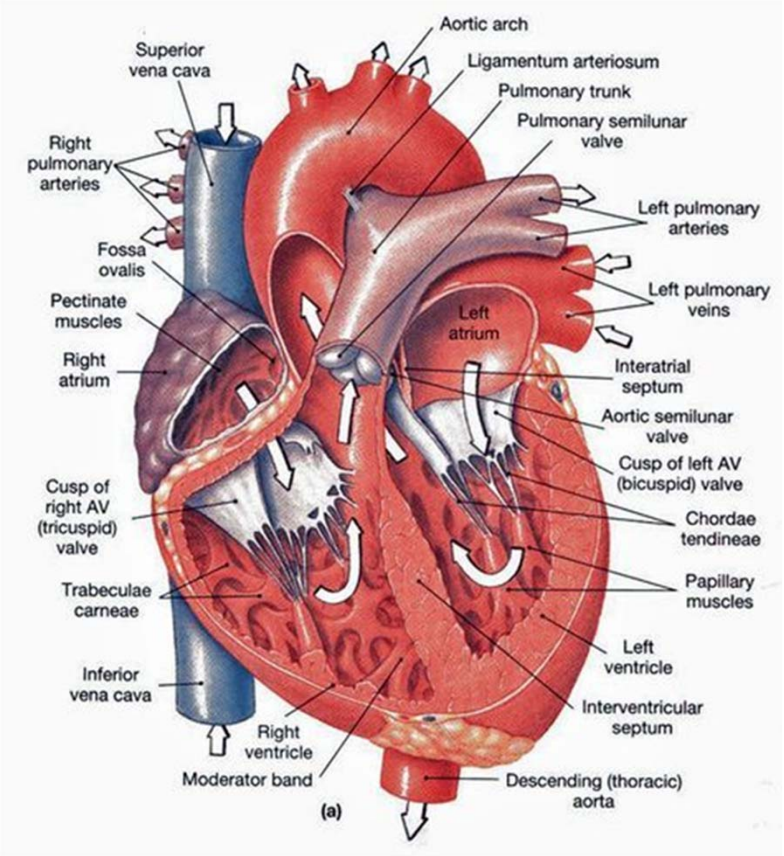
- Another function of the atria is the production of a hormone involved in blood pressure maintenance. When the walls of the atria are stretched by increased blood volume or blood pressure, the cells produce atrial natriuretic peptide (ANP), also called atrial natriuretic hormone (ANH). ANP decreases the reabsorption of sodium ions by the kidneys, so that more sodium ions are excreted in urine, which in turn increases the elimination of water. The loss of water lowers blood volume and blood pressure.

- **Right Ventricle:** has relatively thin walls

1. Pumps blood to the lungs through the pulmonary artery.

2. The pulmonary semilunar valve prevents backflow of blood from the pulmonary artery to the right ventricle when the right ventricle relaxes.

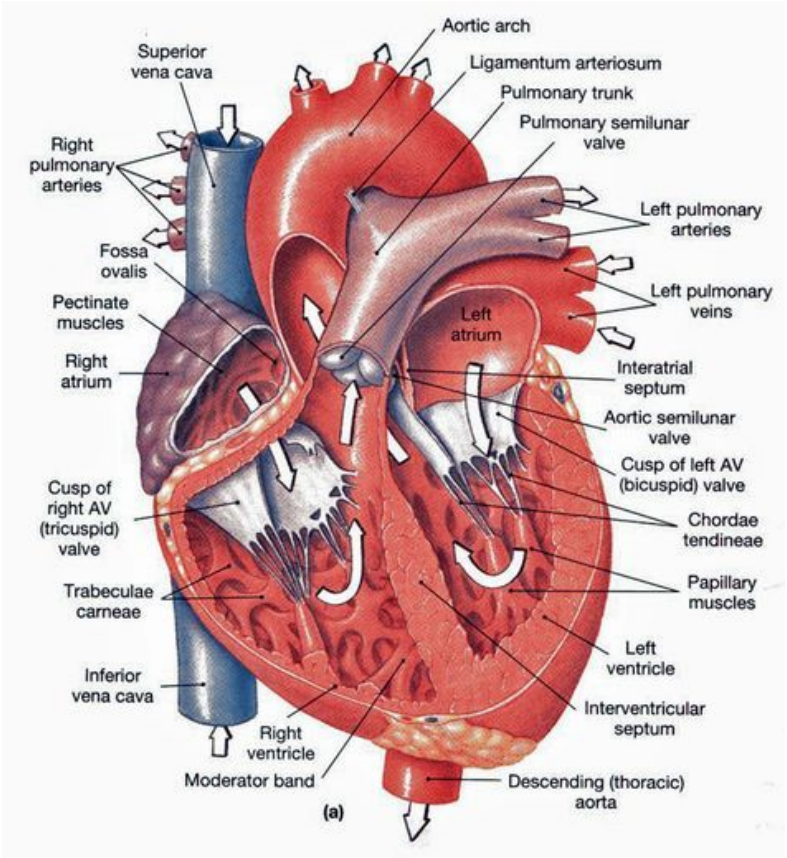
3. Papillary muscles (Projecting into the lower part of the right ventricle are columns of myocardium) and chordae tendineae (Strands of fibrous connective tissue, the chordae tendineae extend from the papillary muscles to the flaps of the tricuspid valve prevent inversion of the right AV valve when the right ventricle contracts.



Left Ventricle: has thicker walls than does the right ventricle

- Pumps blood to the body through the aorta.
- The aortic semilunar valve prevents backflow of blood from the aorta to the left ventricle when the left ventricle relaxes (diastole).
- Papillary muscles and chordae tendineae prevent inversion of the left AV valve when the left ventricle contracts (systole).

❖ The heart is a double pump: The right side of the heart receives deoxygenated blood from the body and pumps it to the lungs; the left side of the heart receives oxygenated blood from the lungs and pumps it to the body. Both sides of the heart work simultaneously.



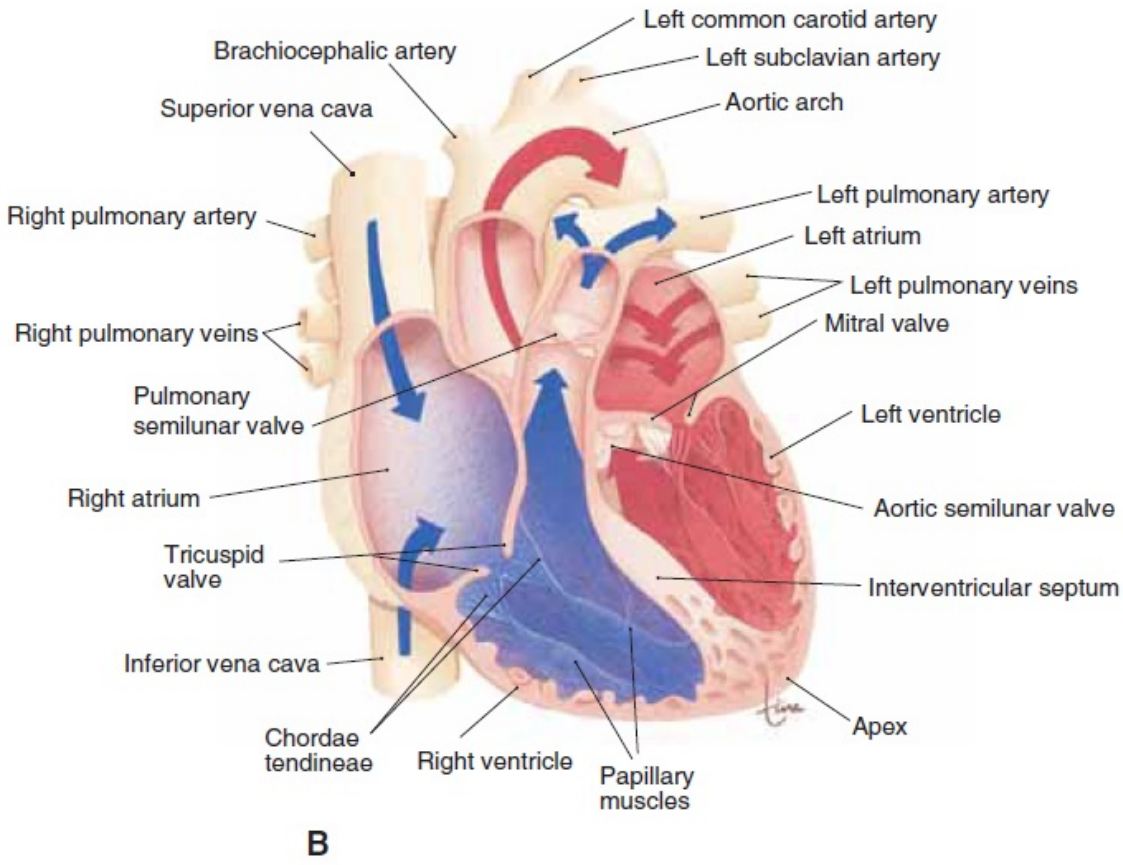


Figure 12–2. (**A**) Anterior view of the heart and major blood vessels. (**B**) Frontal section of the heart in anterior view, showing internal structures.
QUESTION: In part B, in the right atrium, what do the blue arrows represent?

Heart sounds:

When listening to a normal heart with a stethoscope, one hears a sound usually described as “lub, dub, lub, dub.”

- ❑ The “lub” is associated with closure of the atrioventricular (A-V) valves at the beginning of systole.
- ❑ The “dub” is associated with closure of the semilunar (aortic and pulmonary) valves at the end of systole.
- ❑ The “lub” sound is called the first heart sound, and the “dub” is called the second heart sound, because the normal pumping cycle of the heart is considered to start when the A-V valves close at the onset of ventricular systole.
- ❑ If any of the valves do not close properly, an extra sound called a heart murmur may be heard.

Heart rate:

- A healthy adult has a resting heart rate (pulse) of 60 to 80 beats per minute. A rate less than 60 (except for athletes) is called bradycardia; a prolonged or consistent rate greater than 100 beats per minute is called tachycardia.

- A child's normal heart rate may be as high as 100 beats per minute, that of an infant as high as 120, and that of a near-term fetus as high as 140 beats per minute.

- These higher rates are not related to age, but rather to size: the smaller the individual, the higher the metabolic rate and the faster the heart rate.

Cardiac output: is the amount of blood pumped by **a ventricle in 1 minute**. A certain level of cardiac output is needed at all times to transport oxygen to tissues and to remove waste products. During exercise, cardiac output must increase to meet the body's need for more oxygen.

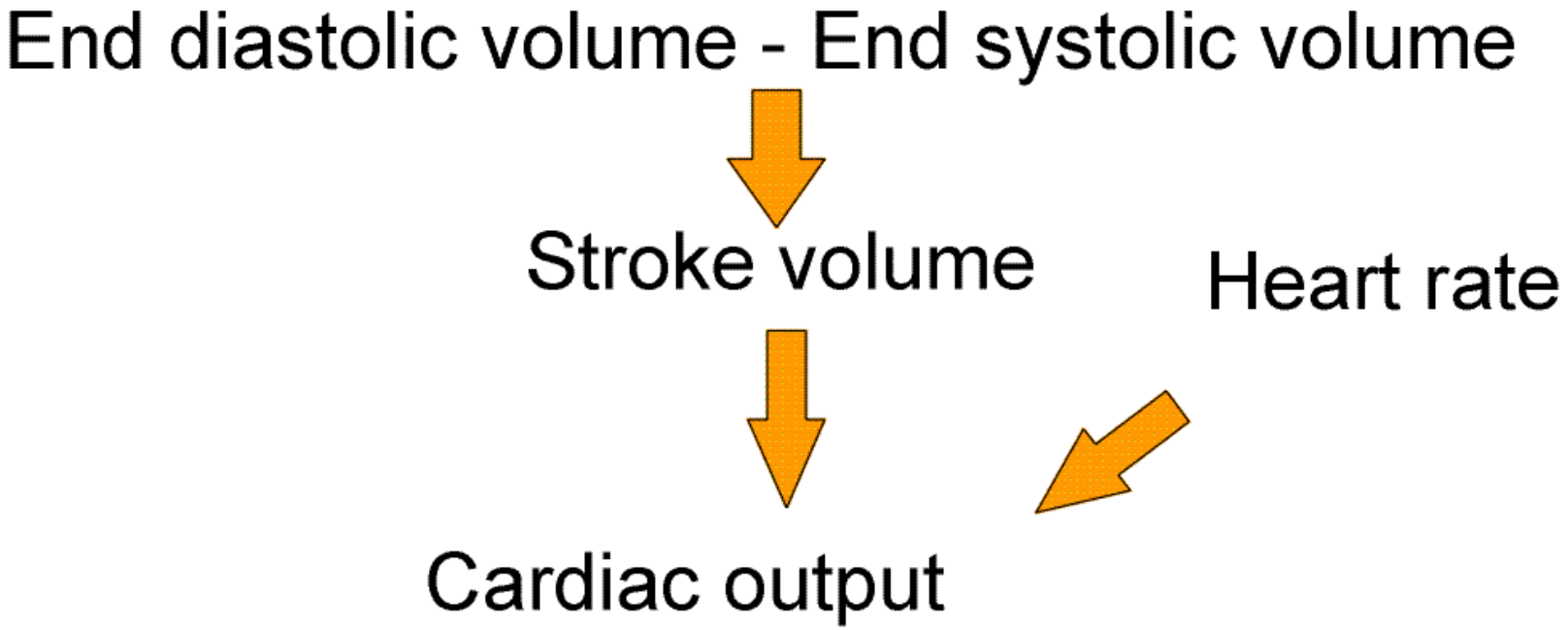
Stroke volume: is the term for the amount of blood pumped by **a ventricle per beat**.

- During diastole (relaxed) , normal filling of the ventricles increases the volume of each ventricle to about 110 to 120 ml. This volume is called the end diastolic volume (EDV).
- The remaining volume in each ventricle, about 40 to 50 ml, is called the end-systolic volume (ESV).
- Then, as the ventricles empty during systole (contracted), the volume decreases by about 70 ml, which is called the stroke volume.

EDV-ESV=stroke volume

Cardiac output= stroke volume * pulse (heart rate)

Cardiac output = 70 mL * 70 bpm
Cardiac output 4900 mL per minute (approximately 5 liters)


End diastolic volume - End systolic volume
Stroke volume
Heart rate
Cardiac output

- The fraction of the end-diastolic volume that is ejected is called **the ejection fraction**, usually equal to about (60%). The ejection fraction percentage is often used clinically to assess cardiac systolic (pumping) capability. A lower percentage would indicate that the ventricle is weakening.

Heart rate (pulse) increases during exercise, and so does stroke volume. The increase in stroke volume is the result of

Starling's law of the heart: which states that the more the cardiac muscle fibers are stretched, the more forcefully they contract. During exercise, more blood returns to the heart; this is called venous return. Increased venous return stretches the myocardium of the ventricles, which contract more forcefully and pump more blood, thereby increasing stroke volume.

The Vascular System:

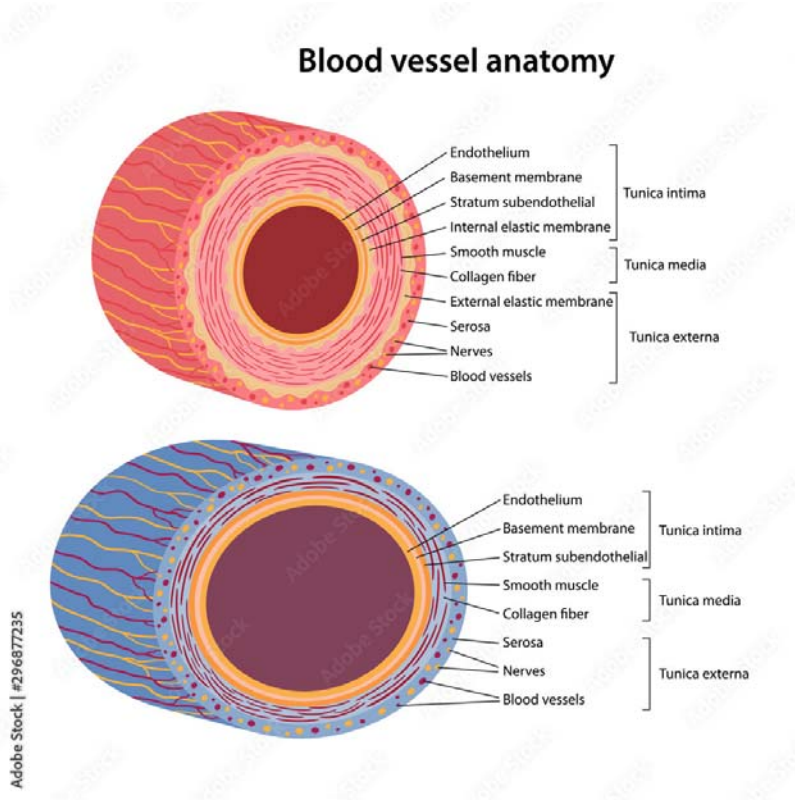
The vascular system consists of the arteries, capillaries, and veins through which the heart pumps blood throughout the body.

❑ Arteries:

- Blood is pumped from the ventricles into large elastic arteries that branch repeatedly into smaller arteries called arterioles. The arterioles play a key role in regulating blood flow into the tissue capillaries

- In cross-section, we find three layers (or tunics) of tissues, each with different functions.

- ➢ Inner layer (tunica intima): simple squamous epithelial tissue (endothelium), very smooth to prevent abnormal blood clotting; secretes nitric oxide (NO), a vasodilator.
- ➢ Middle layer (tunica media): smooth muscle and elastic connective tissue; contributes to maintenance of diastolic blood pressure (BP).
- ➢ Outer layer (tunica externa): fibrous connective tissue to prevent rupture under the high pressure.



Types of Blood Vessels

Heart

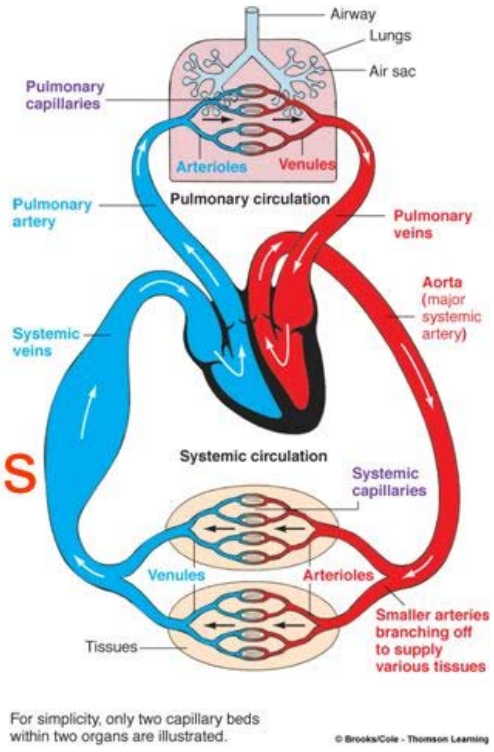
Arteries

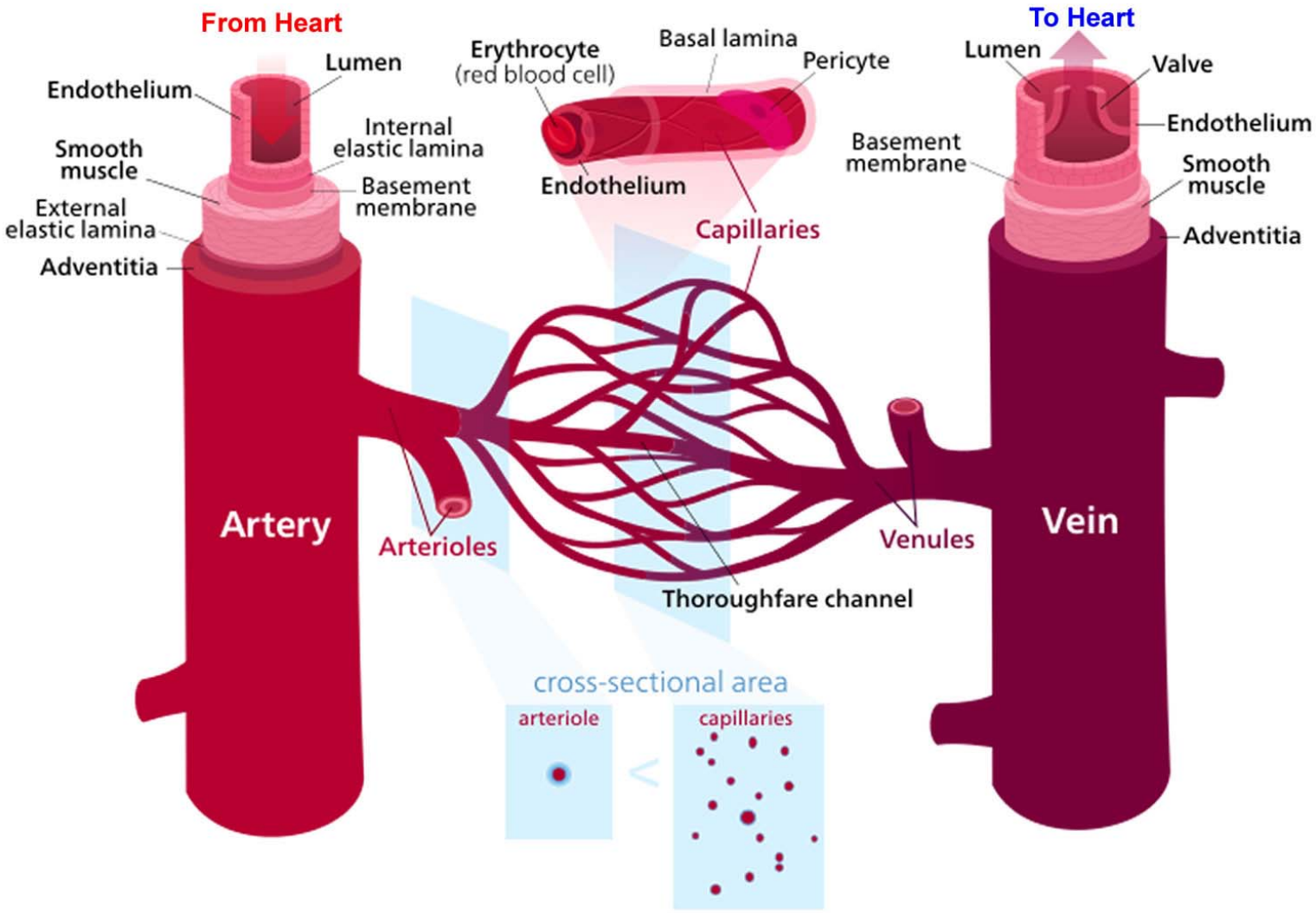
Arterioles

Capillary Beds

Venules

Veins




From Heart
To Heart
Lumen
Endothelium
Internal elastic lamina
Smooth muscle
Basement membrane
External elastic lamina
Adventitia
Erythrocyte (red blood cell)
Basal lamina
Pericyte
Endothelium
Capillaries
Lumen
Valve
Endothelium
Basement membrane
Smooth muscle
Adventitia
Artery
Arterioles
Venules
Vein
Thoroughfare channel
cross-sectional area
arteriole
<
capillaries

Veins:

- Veins carry blood toward the heart. After blood passes through the capillaries, it enters the smallest veins, called venules. From the venules, it flows into progressively larger and larger veins until it reaches the heart.

- In the pulmonary circuit, the pulmonary veins transport blood from the lungs to the left atrium of the heart. This blood has a high oxygen content because it has just been oxygenated in the lungs.

- Systemic veins transport blood from the body tissue to the right atrium of the heart. This blood has a reduced oxygen content because the oxygen has been used for metabolic activities in the tissue cells.

- The walls of veins have the same three layers as the arteries but, is less smooth muscle and connective tissue. This makes the walls of veins thinner than those of arteries, which is related to the fact that blood in the veins has less pressure than in the arteries.

- **Medium and large veins have venous valves**, similar to the semilunar valves associated with the heart, that help keep the blood flowing toward the heart. Venous valves are especially important in the arms and legs, where they prevent the backflow of blood in response to the pull of gravity.

Capillaries:

- capillaries are actually the extension of the endothelium, the simple squamous lining, of arteries and veins. Carry blood from arterioles to venules.

- Some tissues do not have capillaries; these are the epidermis, cartilage, and the lens and cornea of the eye.

- Walls are one cell thick (simple squamous epithelial tissue) to permit exchanges between blood and tissue fluid.

- Precapillary sphincters found at the beginning of each network. are constrict or dilate depending on the needs of the tissues. Because there is not enough blood in the body to fill all of the capillaries at once, precapillary sphincters are usually slightly constricted. In an active tissue that requires more oxygen, such as exercising muscle, the precapillary sphincters dilate to increase blood flow.

- Some organs have another type of capillary called sinusoids are very permeable capillaries found in the liver, spleen, pituitary gland, and red bone marrow to permit proteins and blood cells to enter or leave the blood.

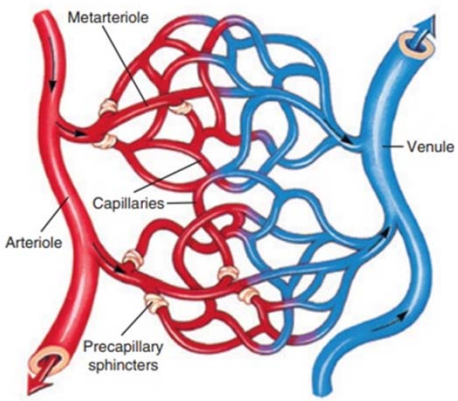


FIGURE 19-4 Just as we travel on different types of roads, our vasculature consists of several different types of vessels.

- Capillaries are the sites of exchanges of materials between the blood and the tissue fluid surrounding cells, some of these substances move from the blood to tissue fluid, and others move from tissue fluid to the blood.

- Blood pressure here is about 30 to 35 mmHg, and the pressure of the surrounding tissue fluid is much lower, about 2 mmHg. Because the capillary blood pressure is higher, the process of filtration occurs, which forces plasma and dissolved nutrients out of the capillaries and into tissue fluid. This is how nutrients such as glucose, amino acids, and vitamins are brought to cells.

- Gases move by diffusion, that is, from their area of greater concentration to their area of lesser concentration. Oxygen, therefore, diffuses from the blood in systemic capillaries to the tissue fluid, and carbon dioxide diffuses from tissue fluid to the blood to be brought to the lungs and exhaled.

- Albumin contributes to the colloid osmotic pressure (COP) of blood; this is an “attracting” pressure, a “pulling” rather than a “pushing” pressure. At the venous end of capillaries, the presence of albumin in the blood pulls tissue fluid into the capillaries, which also brings into the blood the waste products produced by cells. The tissue fluid that returns to the blood also helps maintain normal blood volume and blood pressure.