Circulatory system

Premedical

Questions

- Are humans exothermic or endothermic organism?
- How does every cell of our body receive nutrients and oxygen?

Endothermic way of life require 10x more energy than exothermic.

Cells of body require nutrients, oxygen and exclude carbon dioxide and wastes.

Cardiovascular system:

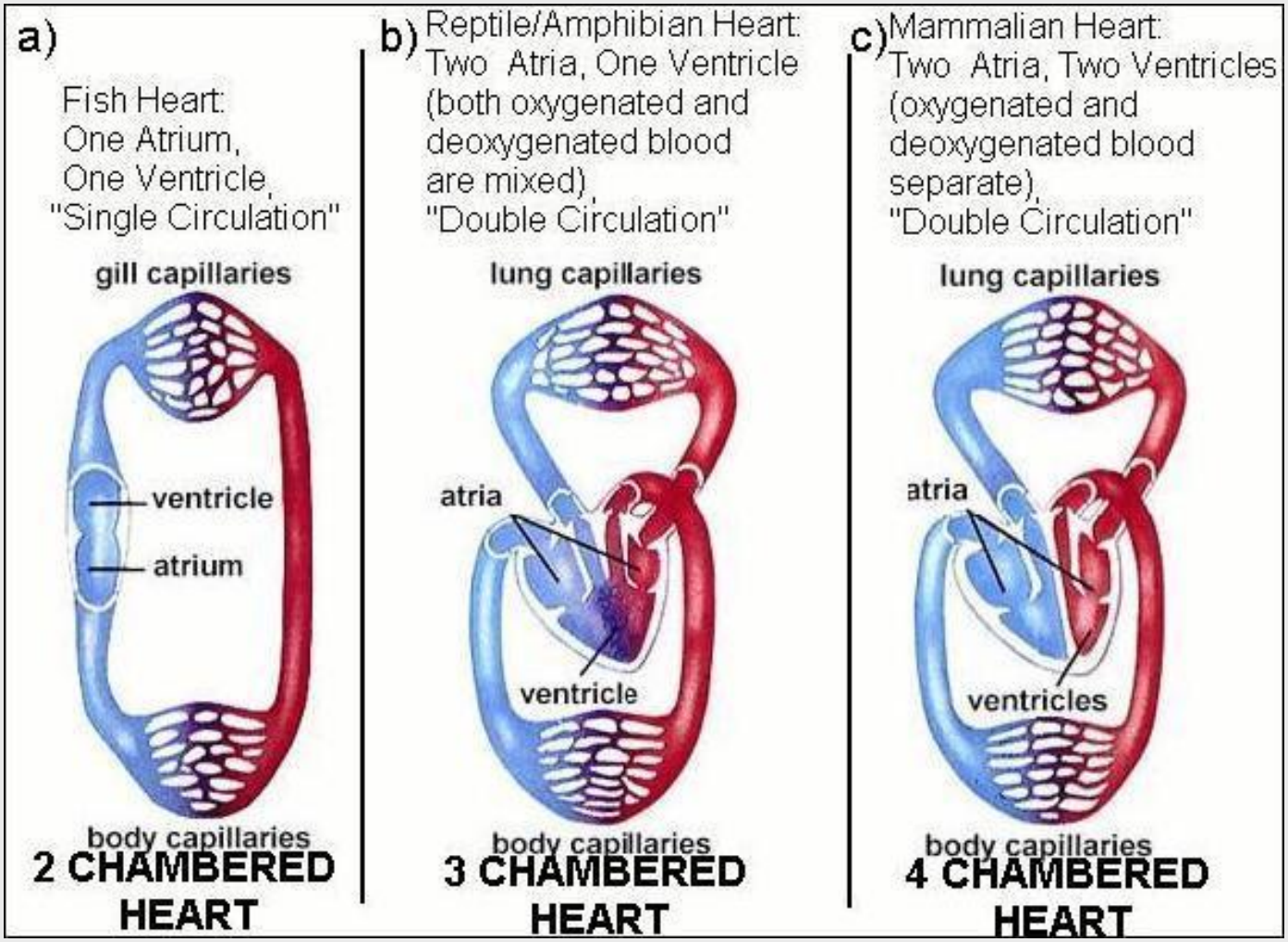
- **Blood - blood cells and plasma**
- **Vessels – arteries, veins, capillaries, arterioles, venules, capillary bed**
- **Heart – atria and ventricles**

Blood pressure

Questions

- How many chambers does a human heart have ?
  - Are they separated or not?

- Double circulation: independent body system and lung system supported by
- **Heart** with two separated **pumps: right heart and left heart, consisting of 4 chamberes**



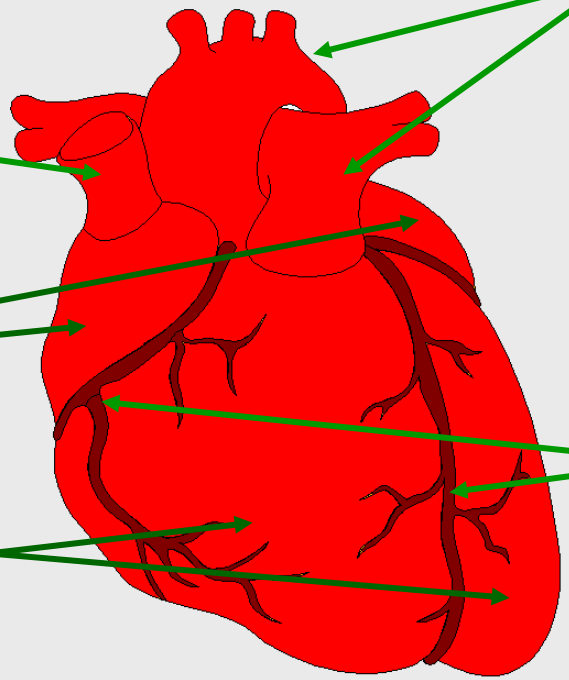
Questions

- Describe the main parts of a human heart.

The Heart

This is a **vein**. It brings blood from the body, except the lungs.

These are **arteries**. They carry blood away from the heart.



2 atria

2 ventricles

Coronary arteries supply the heart with blood

first branches

The heart has four chambers

External Heart Anatomy

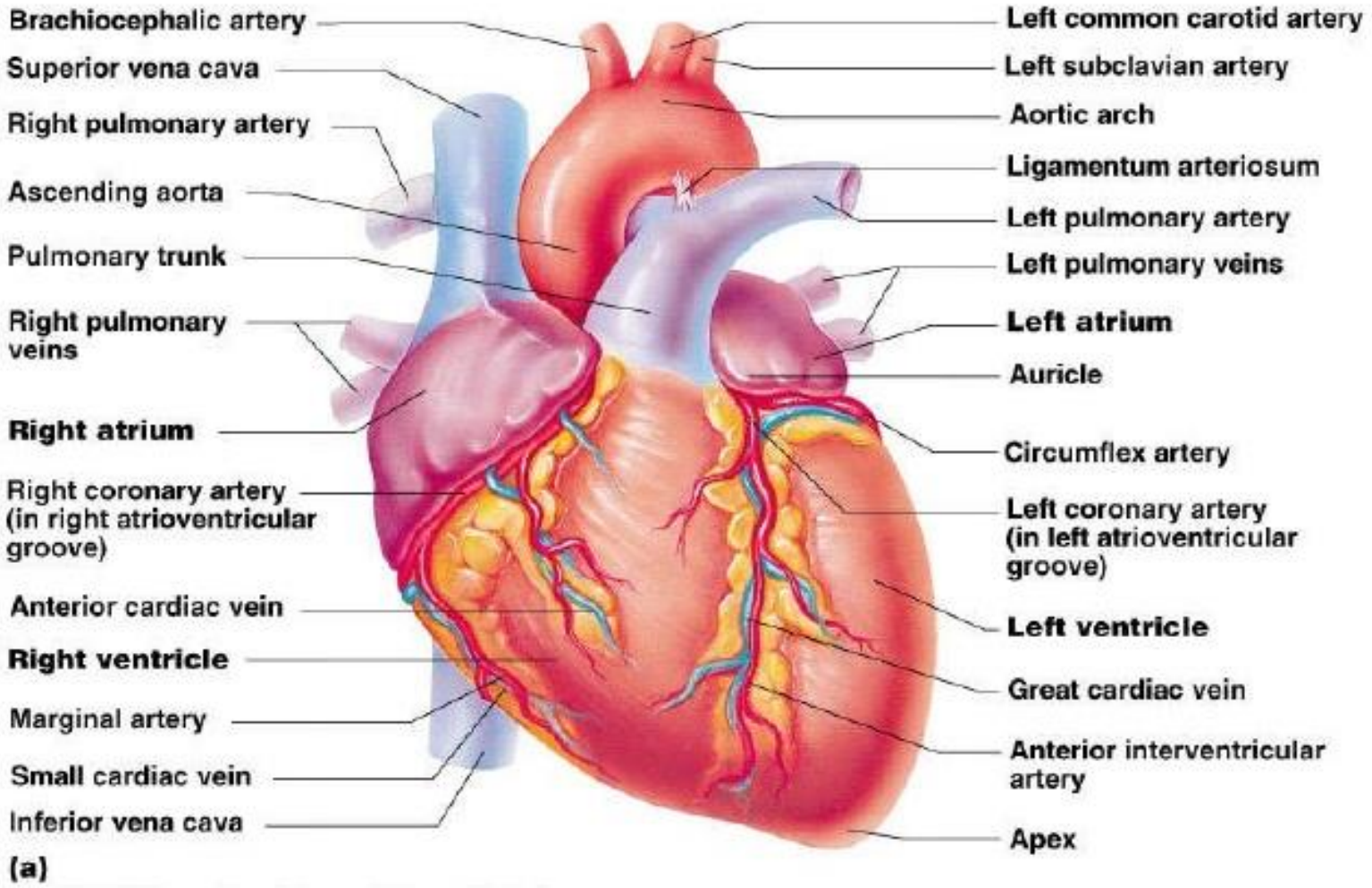


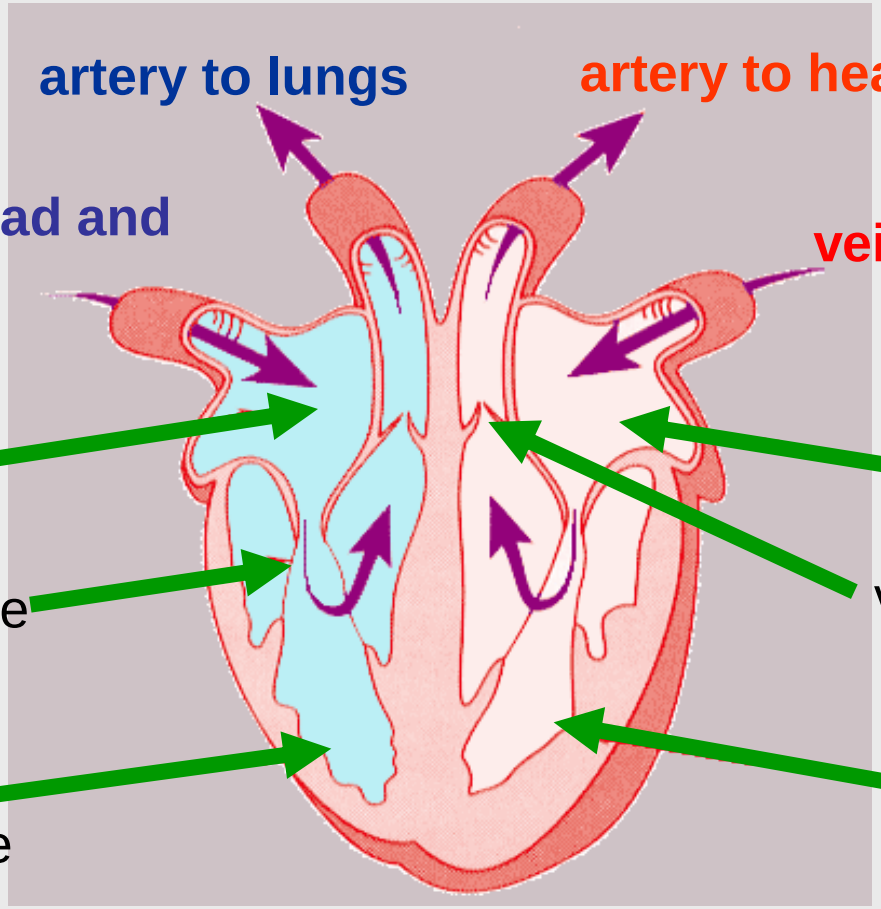
Figure 11.2a

Questions

- Which heart (ventricle) does pump a blood to lung circulation?
- Which heart (ventricle) does pump a blood to body circulation?

The Heart

Heart atrias help to fulfill heart ventricles and these ventricles comprise the major source of power to transport the blood to the pulmonary circulation thanks to the right ventricle or to peripheral circulation thanks to the function of the left ventricle.



Questions

- What layers can we recognize in the heart wall?
- What is a composition of middle layer?
- What tissue can we observe in the layers of the heart‘s wall?

The wall

The heart lies in an serosal cavity = in **pericard**

The heart wall consists of

- **Epicardium** – outer layer = visceral pericardium

- **Myocardium** = cardiac muscle tissue. We divide **cardiomyocytes** to working and conducting ones. Their contraction is very similar to contraction of striated muscle cells, but differs in a duration, which is much longer.

- **Endocardium** – inner layer that consists of **endothelial cells**, which line the heart, covers the heart valves.

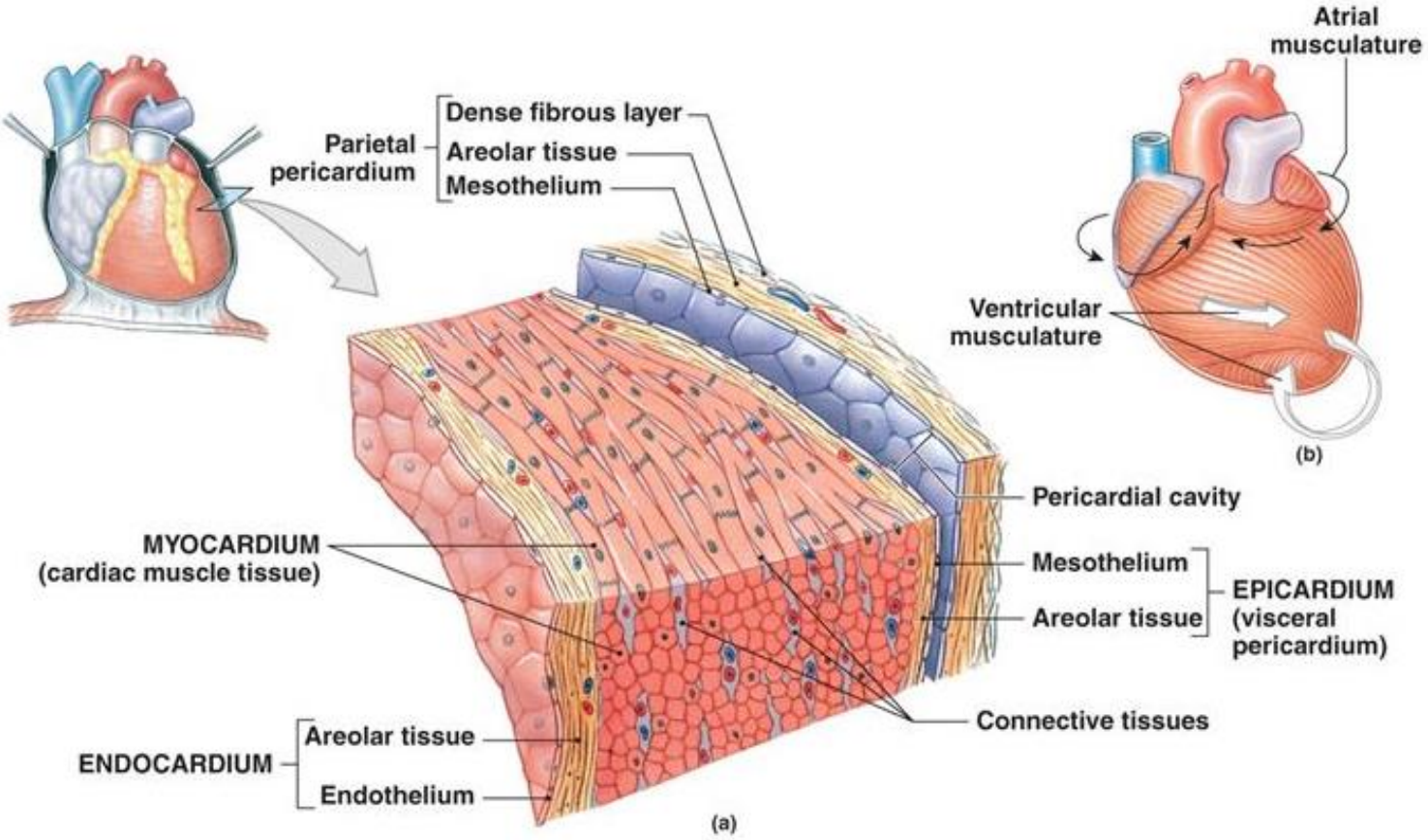


Figure 20–4 The Heart Wall

Questions

- Where do impulses for cardiac contraction arise and how do they spread??
- What is a primary heart pacemaker?
- How can we get an information about heart rhythm, action, frequency and about the position of the heart?

Formation, conduction of cardiac action potentials

- The stimulus for contraction originates in the conductive system comprising **sinoatrial (SA) node**, atrial internodal pathways, **atrioventricular (AV) node**, bundle of His fibers and its branching to left and right bundle and following system of Purkinje fibres.
- The highest frequency of the excitatory stimulus is created by **SA node** and so we call it as **primary heart pacemaker.** Pacemaker cells are spontaneously depolarizing cells.
- All myocardial cells are able to create the excitatory impulse – the heart automacy (autonomy). In physiological state is this impulse generated only by pacemaker cells.
- Changes in voltage which can be recorded by the electrocardiography. Electrocardiogram informs us about the heart rhythm, action, frequency and about the position of the hear.

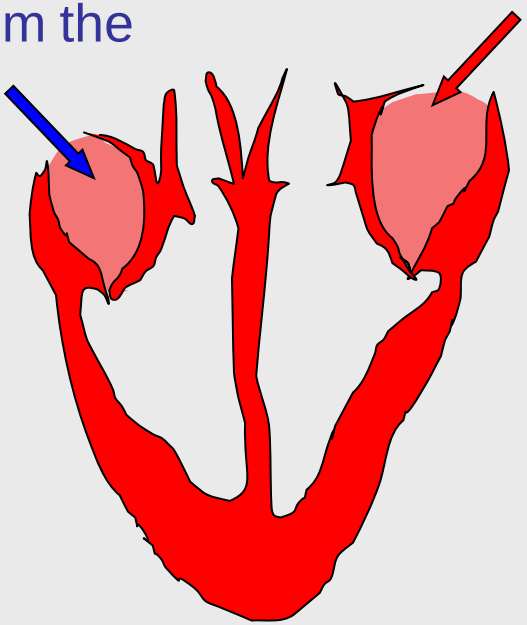
Questions

- What is a cardiac cycle look like?
- Where do impulses for cardiac contraction arise?
- What is the function of the valves?

Cardiac cycle

Heartbeat: STEP ONE

blood from the body



blood from the lungs

Every part of heart relaxes during diastole.

Heart muscles **relax** and blood flows into the atria.

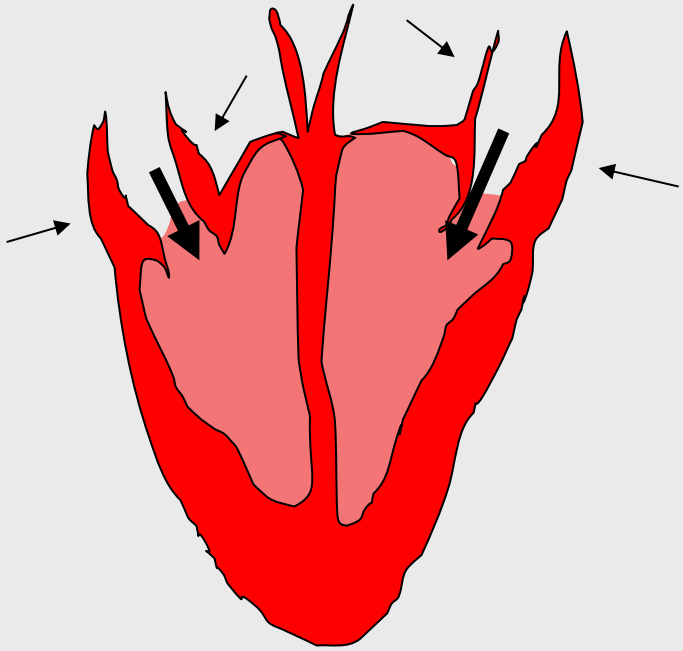
Cardiac cycle

STEP TWO

Cycle starts by spontaneous generation of the action potential in sinoatrial node and spreading of the depolarization across atrias to the AV node.

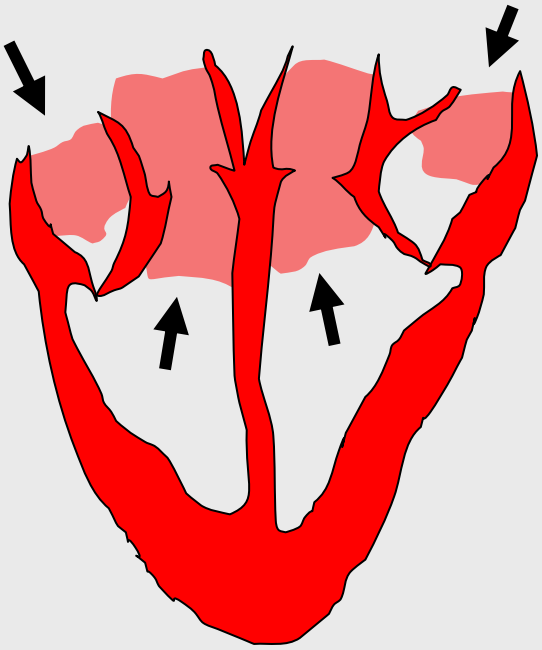
The atria then **contract** and the **open** valves allow blood flow into the ventricles.

Here is spreading of action potential slow and causes delay of 0,1s before going to ventricles.



Cardiac cycle

STEP THREE



The valves **close** to stop blood flowing backwards.

The ventricles **contract** forcing the blood to leave the heart.

At the same time, the atria are being relaxed and once again being filled with blood.

The heartbeat – the cycle repeats itself.

Valves

The AV valve on the right side of the heart is called the **tricuspid** valve, because it has three leaflets (cusps).

The AV valve on the left side of the heart is called the **bicuspid** valve or **mitral valve**, because it has two leaflets.

Semiluminar: the **pulmonary** valve

the **aortic valve**

Atrioventricular (A-V) valves (tricuspid and mitral) prevent retrograde flowing of the blood from ventricles to atrias during the systole.

Semilunar valves (pulmonary and aortic) prevent retrograde flow from aorta and pulmonary artery back to the ventricle during the diastole.

Questions

- What is a systole?
- What is diastole?
- What is a pulls?
- What is the cardiac minute output?
- What does determine a blood pressure?

Cardiovascular terms

Systole is a the phase where the myocardium is contracted in a coordinated manner in response to an endogenous stimulus

Diastole is the period of time when the heart fills with blood after systole.

Pulls - The rhythmical throbbing of arteries produced by the regular contractions of the heart, especially as palpated at the wrist or in the neck. Normal is 70 - 75/minute/man

Cardiac output is the volume of blood being pumped by the heart, in the time interval of one minute

Heart murmur – defect of valve

Blood pressure – hydrostatic pressure

- **is a force exerted by circulating blood on the walls of blood vessels.**
- **Cardiac output and blood vessel resistance is decisive.**
- During each heartbeat, BP varies between a maximum **(systolic)** and a minimum **(diastolic)** pressure.

Peptides released by the heart muscle

We know about several natriuretic peptides bud major are two – ANP (atrial natriuretic peptide) and BNP (brain natriuretic peptide). Both have important vasodilatory effect.

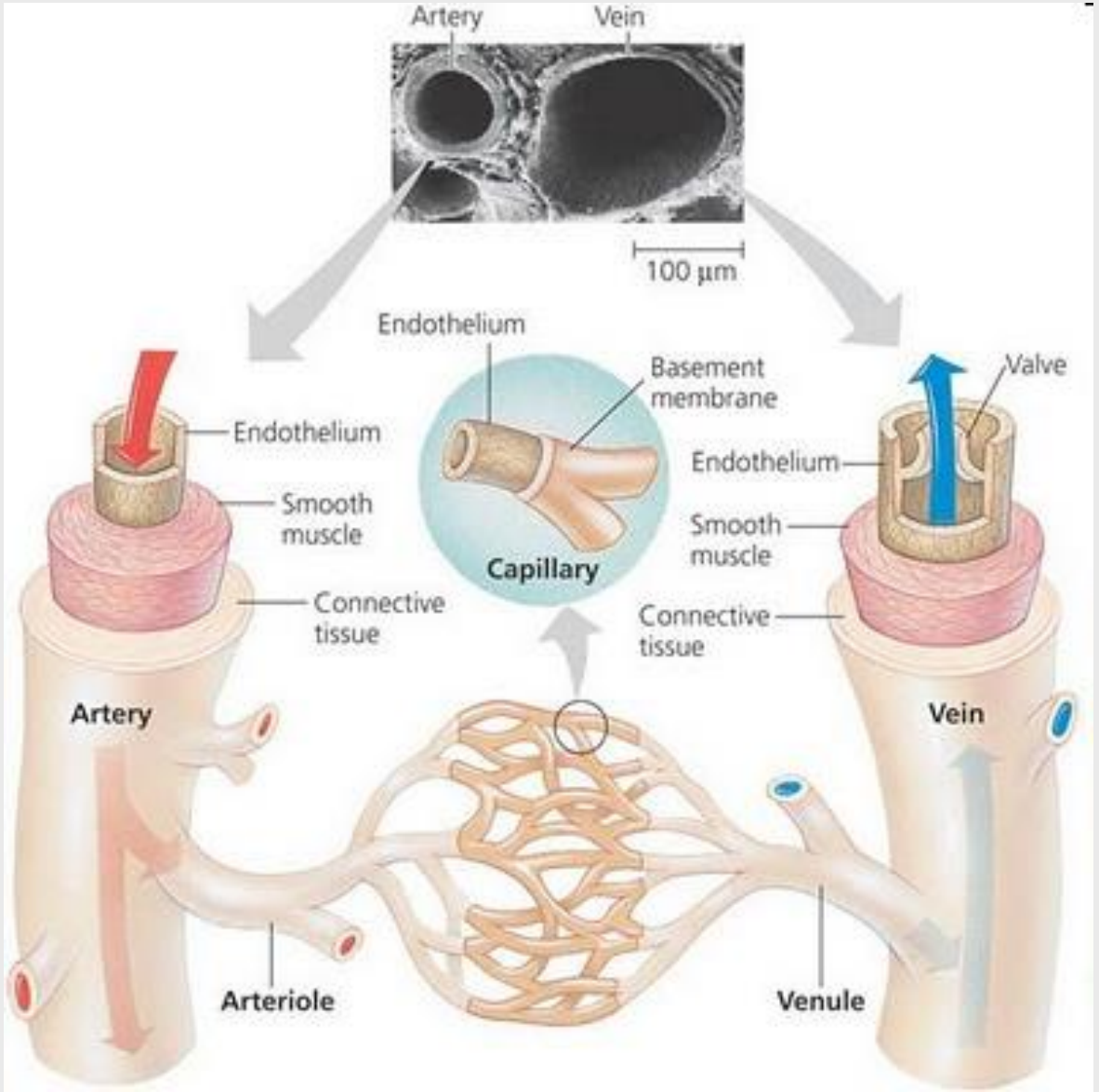
Questions

- What are the types of blood vessels?
- What is the difference in the structure of artery, vein and capillary?

The vascular system

System of 5 types of blood vessels

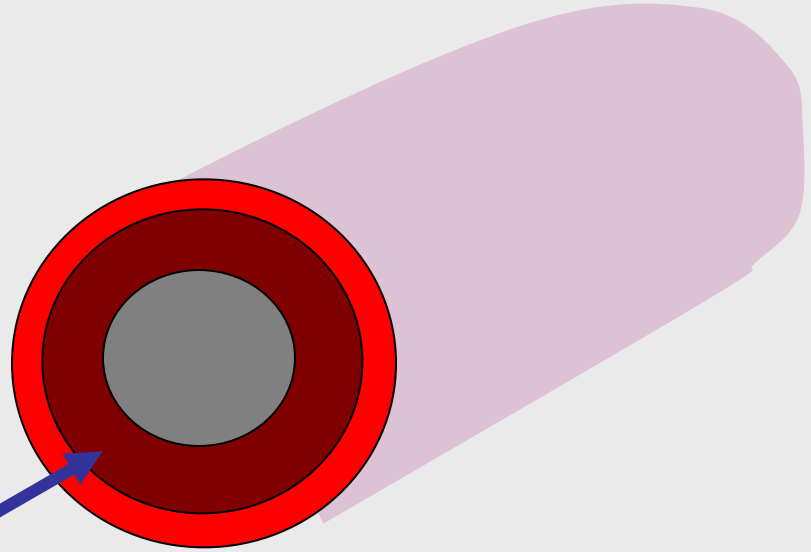
a. **ARTERY**
b. **Arteriole**
c. **CAPILLARY**
d. **Venule**
e. **VEIN**



The ARTERY

Arteries distribute blood under a high pressure throughout the entire body. They are morphologically adapted to suit this purpose. Arteries have thick muscle-rich walls.

Elastic fibres allow the artery to maintain a blood pressure



thick muscle with elastic fibres

The thick smooth muscle can contract to ***push*** the blood along.

Arterioles

Arterioles are the smallest branches of the arteries. They role consist in controlling the flow of blood into the capillary system. This is achieved by an action of muscle cells in their walls.

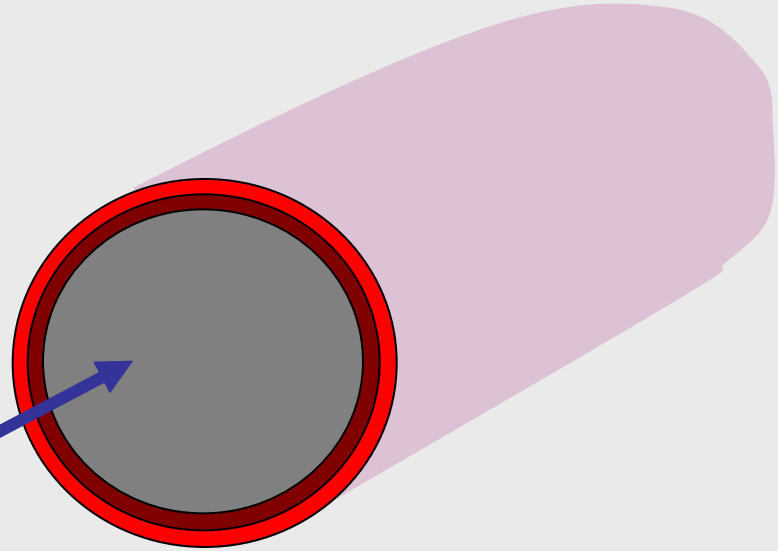
Arterioles and small arteries are known as resistance vessels, because they form a main portion of a peripheral resistance value.

Venules

Venules collect the blood from capillaries and then merge into large veins.

The VEIN

System of veins is often called a low pressure system due to its function as a blood reservoir. Apart from its blood reservoir function, blood flows back to the heart through veins.



Veins have valves, which prevent a backward blood flow

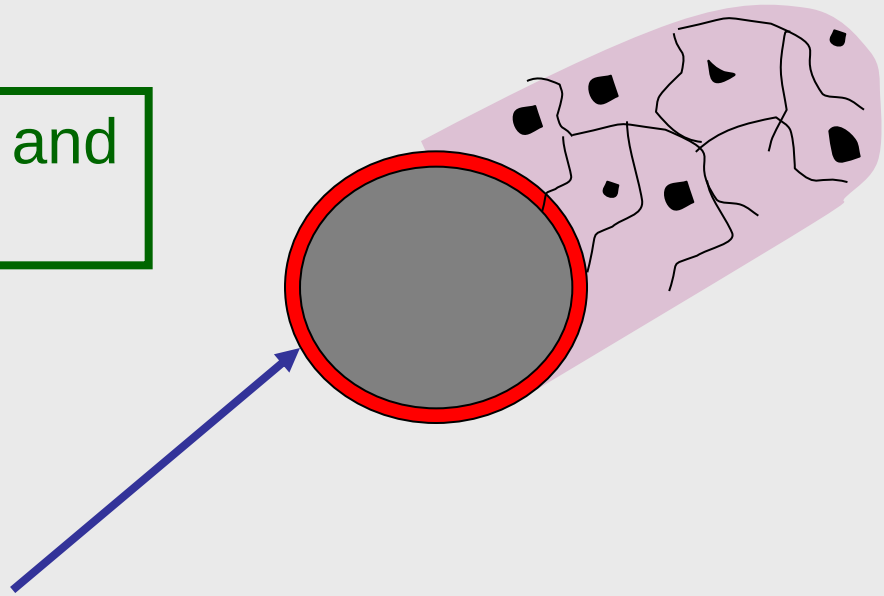
thin muscle and elastic fibres

Body muscles surround the veins, so that when they contract, they move body, they also squeeze the veins and push the blood along the vessels.

The CAPILLARY

Exchange of nutrients, electrolytes and respiratory gases takes place in the capillaries. There is only a 7 % of total blood volume in capillaries, but this portion is sufficient enough to provide nutrition to an entire organism.

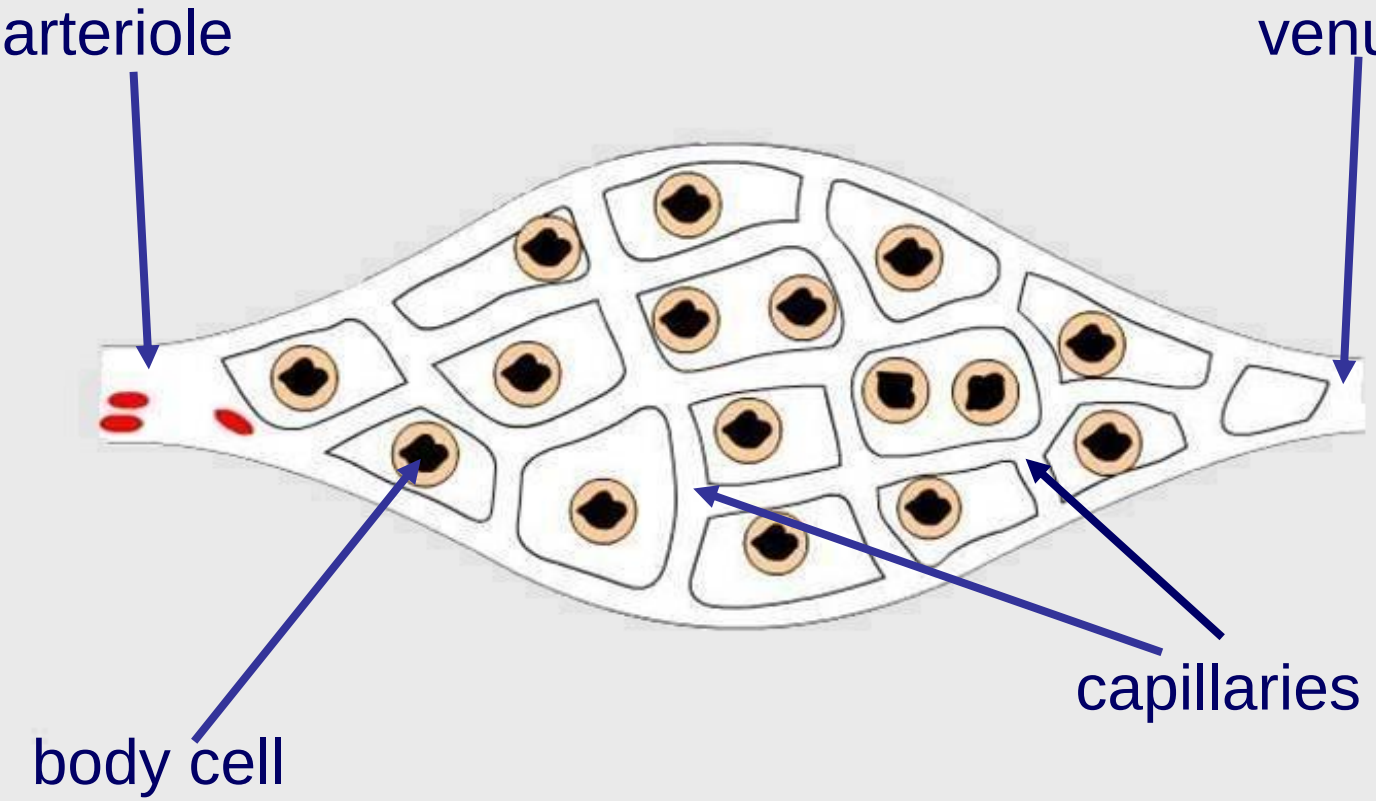
Basement membrane and endothel



the wall of a capillary is only one cell thick

The CAPILLARY

A collection of capillaries is known as a **capillary bed**.



Filtration rate is determined:

1) Difference between capillary hydrostatic pressure and the interstitial hydrostatic pressure determines the hydrostatic pressure gradient.

2) Difference between capillary oncotic pressure and interstitial oncotic pressure determines the osmotic pressure gradient.

Questions

- What are the main processes of vascular circulation at the capillary bed?

Processes at the capillary bed

Exchange of nutrients, respiratory gases and fluid

The semi-permeable membrane (basement membrane) of capillary walls allows:

- **nutrients**, **oxygen**, and **water** to diffuse from the blood to the tissues.
- **waste** products, like **carbon dioxide**, diffuse from the tissues into the blood.

Blood cells and proteins are big enough, so they stay in capillaries. Blood loose a water, but 85% is coming back to venules according to osmotic gradient. 15% of water is running to lymph vessels.

The main transport process in capillaries is a simple diffusion. Oxygen and carbon dioxide pass directly through the capillary wall, while ions, glucose and water pass through its pores.

The main factor that determines the capillary blood flow is a value of pO2, which controls a tone of precapillary sphincter.

Questions

- What is the main largest artery in the human body?
- What are large arteries and veins in the human body?

Subclavian vein

Superior vena cava

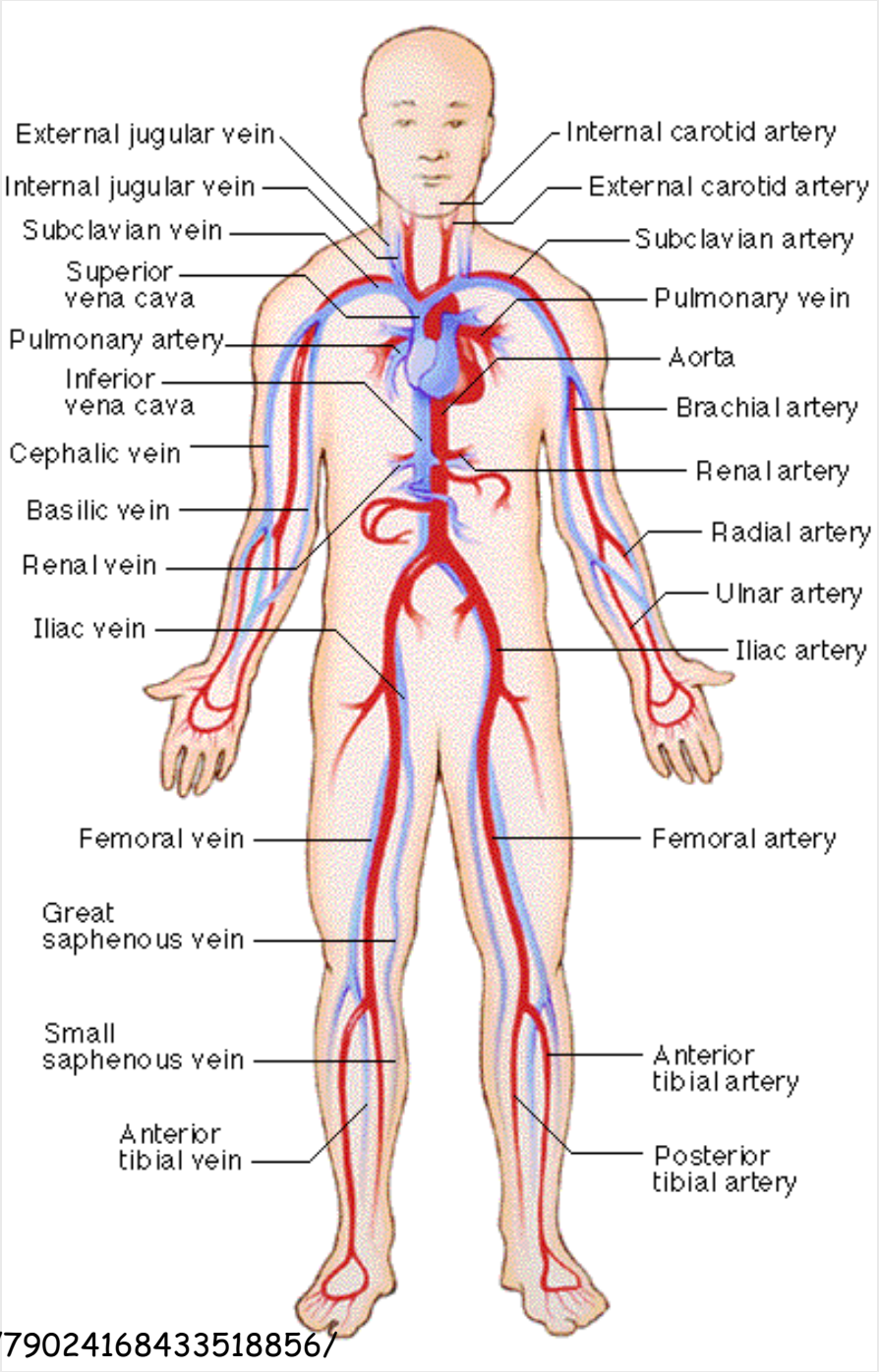
Pulmonary artery

Inferior vena cava

Renal vein

Iliac vein

Femoral vein



The aorta is the largest artery in the body

Carotid arteries

Subclavian artery

Pulmonary vein

Aorta

Renal artery

Iliac artery

Femoral artery

https://www.pinterest.com/pin/790241684335188856/

Questions

- What is it portal circulation?
- What is the renal blood circulation?

Nutritive circulation of liver - hepatic artery

Hepatic portal system = Functional circulation of liver

Is a portion of the systemic circulation

The **gastric vein** (stomach), **splenic vein** (spleen), **pancreatic vein** (pancreas), and **mesenteric veins** (small intestines) empty into the **portal vein** that carries the blood to the liver.

The **hepatic vein** carries blood to the inferior (caudal) vena cava.

Blood flow from the abdominal organs that passes through the portal vein, the sinusoids of the liver, and into the hepatic vein before returning to the heart from the inferior vena cava.

This pathway permits the liver to process and to detoxify substances entering the body from the gastrointestinal tract.

Veins of the Hepatic Portal System

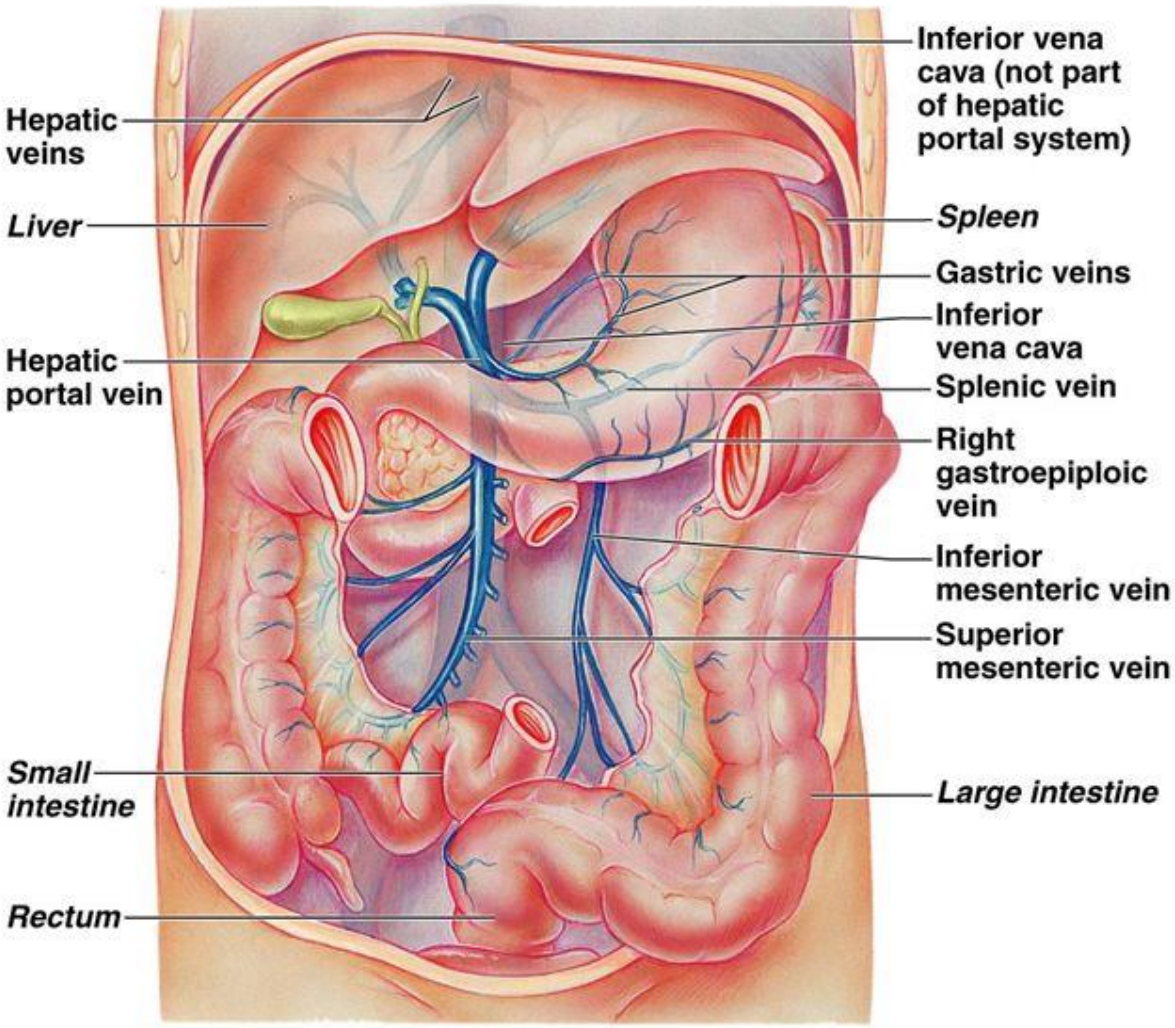


Figure 19.25

Renal blood circulation

Each kidney is supplied by **a renal artery**. This artery arises from the aorta. It divides into 2-3 branches before entering the renal cortex. One branch supplies the upper portion of a kidney, another the middle portion and the last one the lower portion.

Furthermore, these branches divides into the **interlobular arteries**, which give rise to an **afferent arterioles**. **Blood flows to glomerulus through the afferent arterioles**.

Blood is collected by interlobular veins, then passes to the arcuate veins, from those continue to **the interlobar veins**, which finally merge **into the renal vein**.

Questions

- What is lymphatic system and lymph?
- What is lymphatic tissue?
- What is the lymphatic circulation and lymphatic node?
- How is the lymphatic system connected to blood circulation?

The **lymphatic system**

is part of the immune system and acts as a secondary (accessory) **circulatory system**.

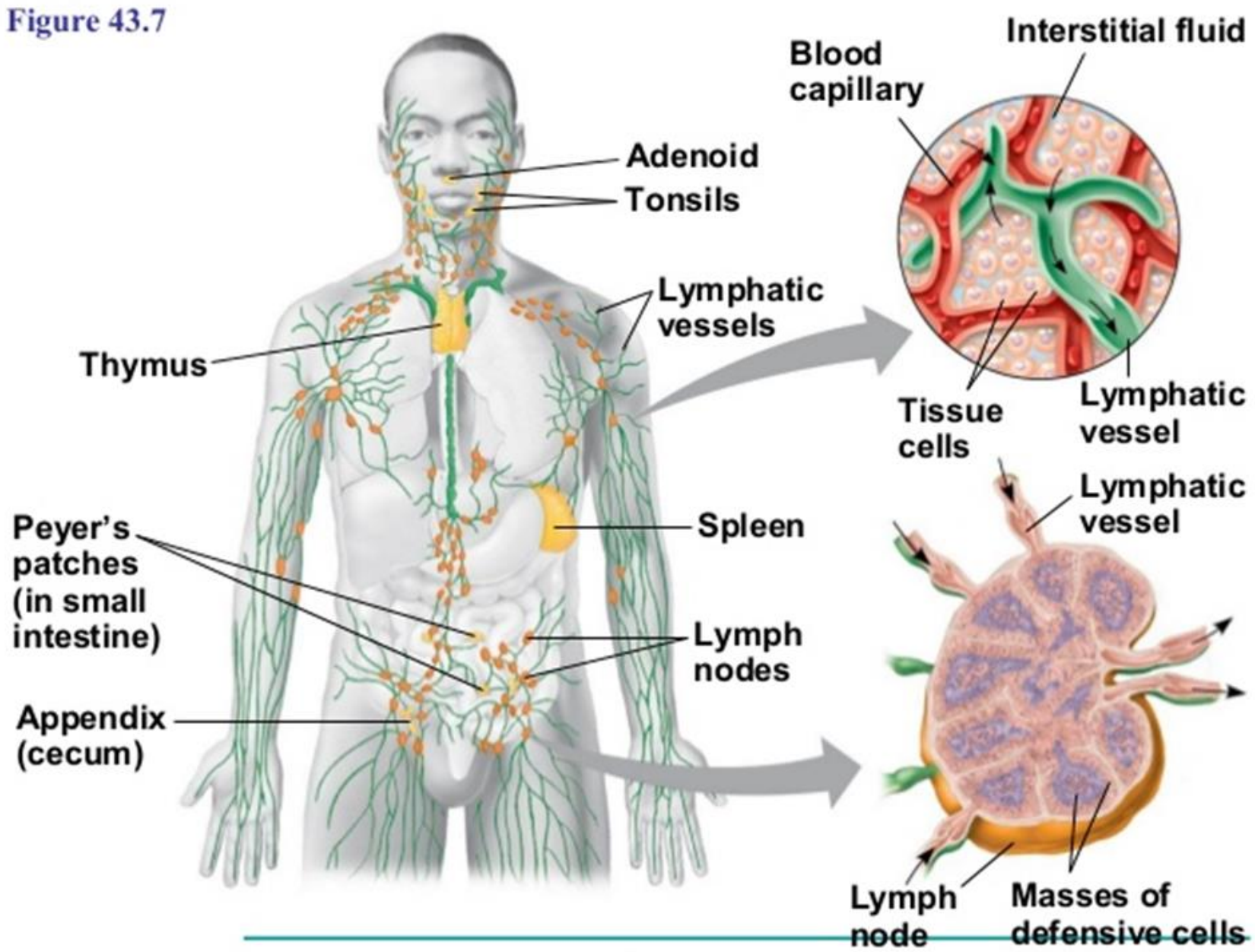
15% of fluid, the remainder filtered in the capillary wall, is drained off through the lymphatic vessels.

Lymph

It is about 95 per cent water; the remainder consists of plasma proteins and other chemical substances contained in the blood plasma, Its cellular component consists chiefly of lymphocytes.

- proteins (+ clotting factors)
- water and proteins, which returne to blood
- fats, fatty acid absorged from the gut and **transport** to circulatory system, and
- **immune cells** (lymphocytes, monocytes, and plasma cells)
- **remove** excess fluids from body tissues

Lymphatic tissue



Lymphatic circulation

As the collecting lymph vessel accumulates lymph from more and more lymph capillaries in its course, it becomes larger and is called the **afferent lymph vessel** as it enters a lymph node.

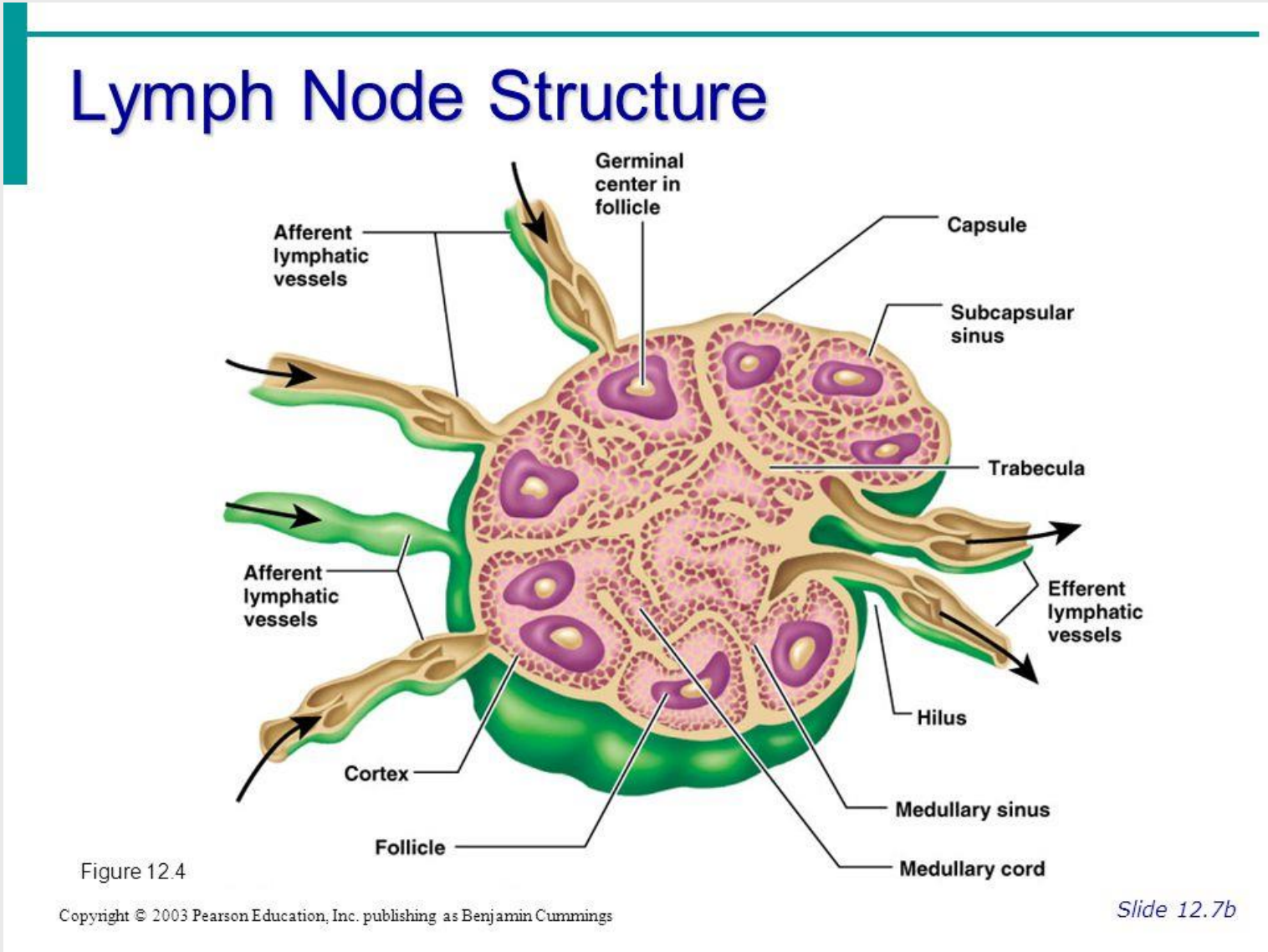
Lymphatic node

is accumulations of lymphoid tissue along the course of lymphatic vessels they consist of **an outer cortical and an inner medullary part.** Lymph nodes are the main source of **lymphocytes** of the peripheral blood and, as part of **the reticuloendothelial system**, serve as a defense mechanism by removing bacteria and toxins, and probably play a role in antibody formation.

There the lymph percolates through the lymph node tissue and is removed by the **efferent lymph vessel**. An efferent lymph vessel may directly drain into one of the **lymph ducts (the right lymphatic duct or the thoracic duct)**

Lymph node

has a fibrous outer covering (capsule), a cortex, and a medulla



An efferent lymph vessel may directly drain into one of the lymph ducts (the right lymphatic duct or the thoracic duct).

Both the **lymph ducts** return the lymph to the blood stream near **the subclavian veins**

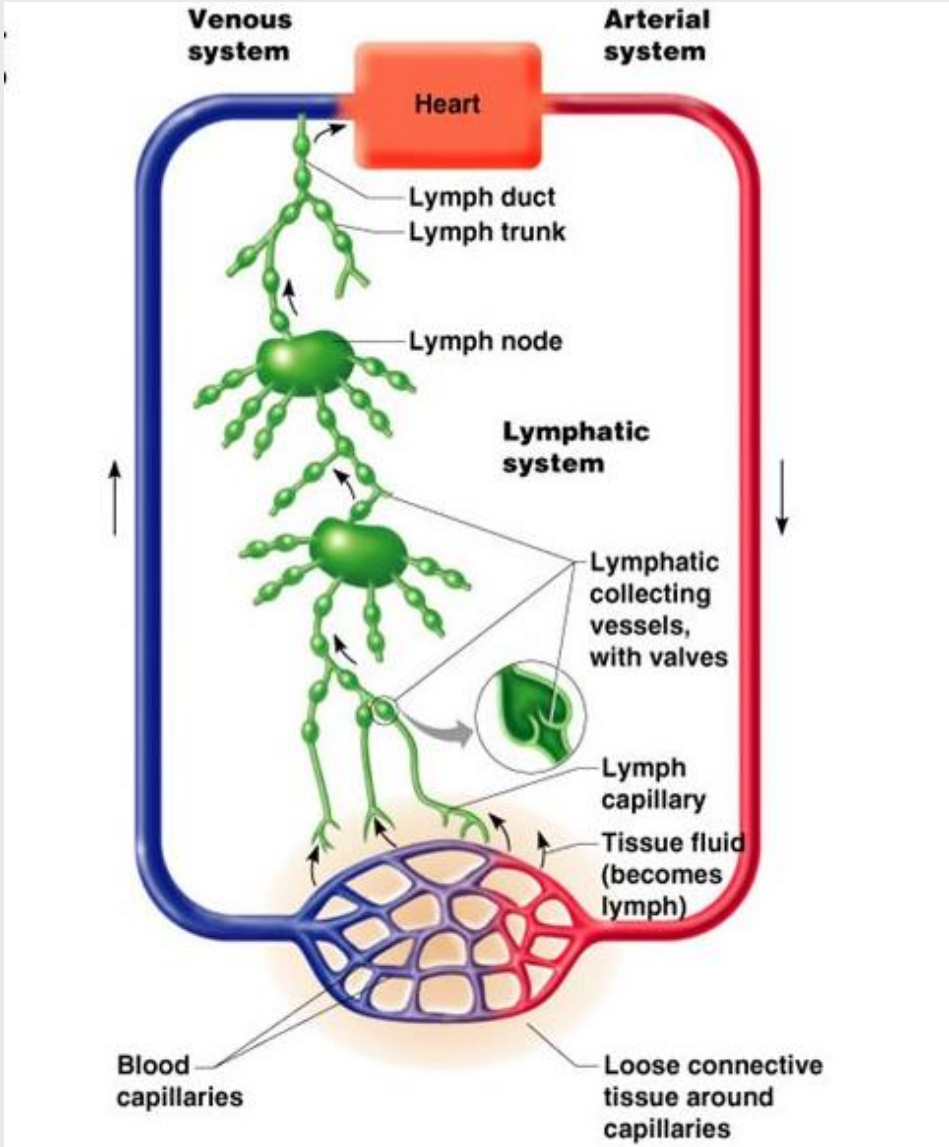


Figure 12.1

n Cummings

Thank you for your attention

Campbell, Neil A., Reece, Jane B., Cain Michael L., Jackson, Robert B., Minorsky, Peter V.**,** **Biology**, Benjamin-Cummings Publishing Company, 1996 – 2010. chapter 42

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