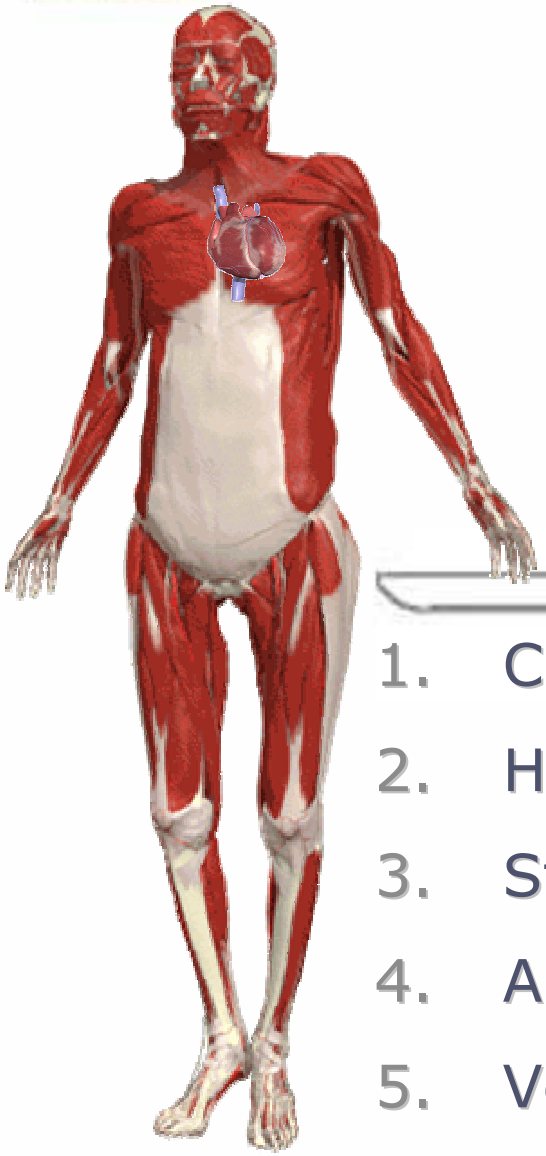
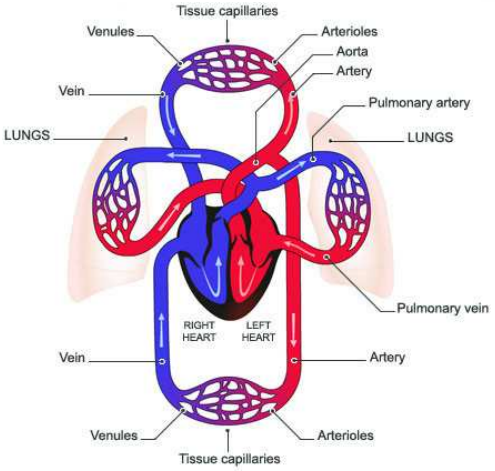


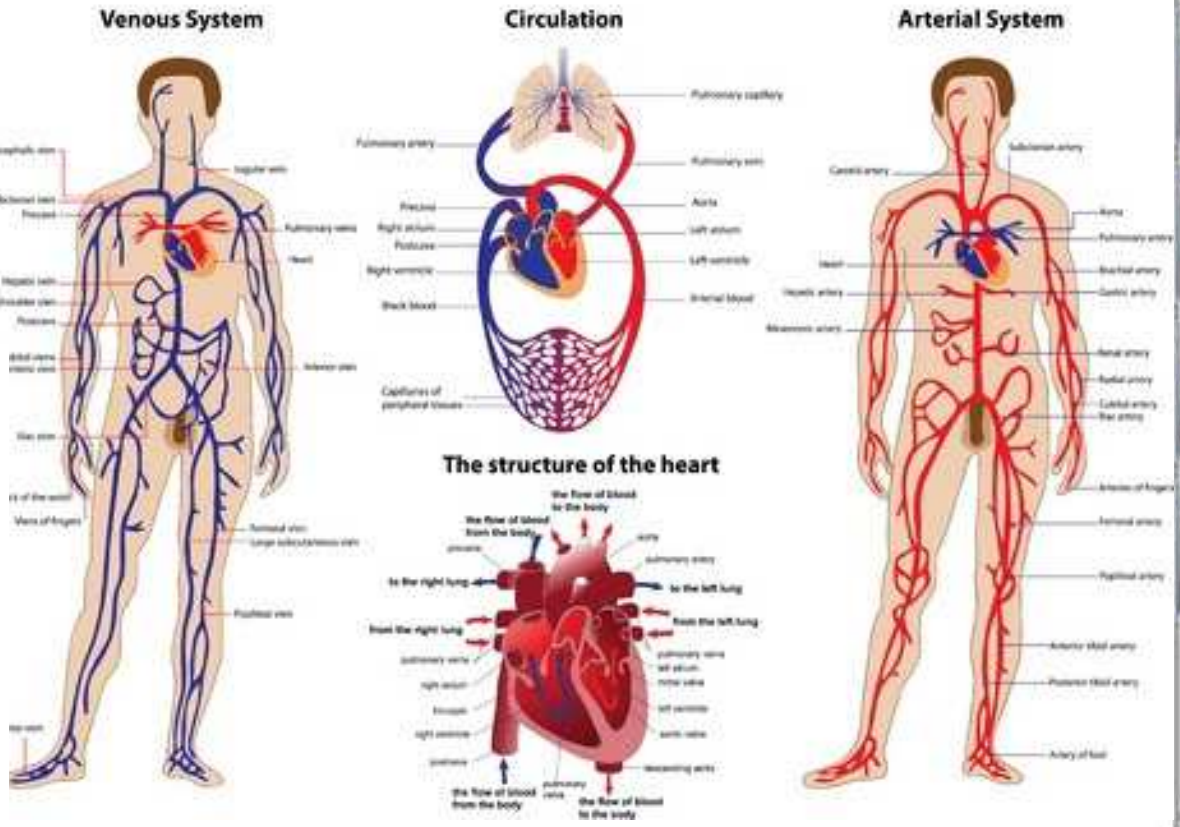
Cardiovascular system

1. Cardiovascular system – general overview
2. Heart – structure, innervation and blood supply
3. Structure of the blood vessels
4. Arteries of the human body
5. Veins of the human body
6. Lymphatic system

Cardiovascular system

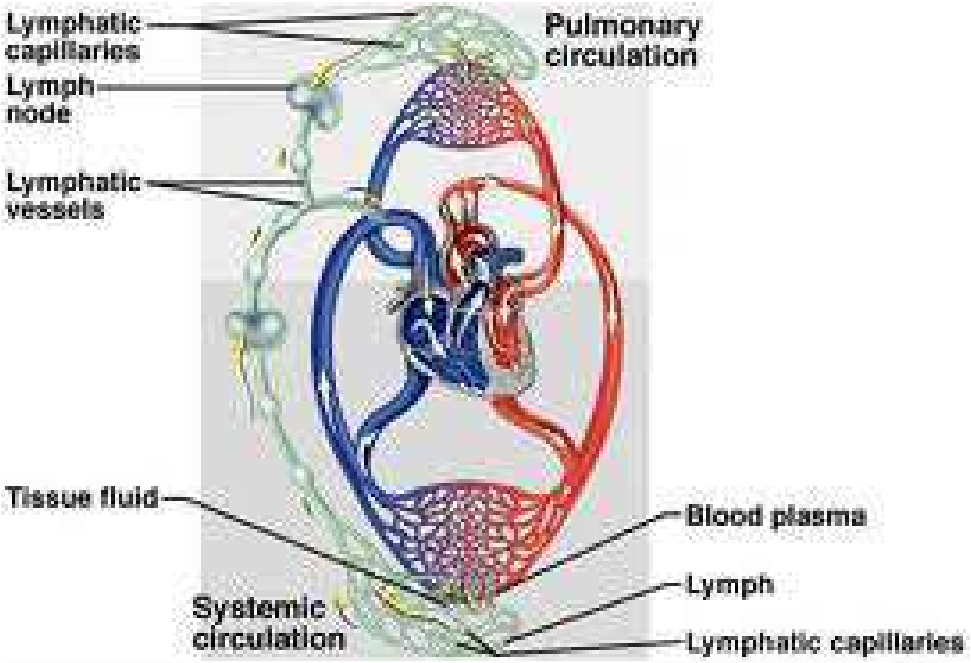
- Angiology (Gr. ἀγγεῖον, *angeīon*, „vessel"; и -λογία, *-logia*) = vascular medicine
- Cardiovascular system:
  - ✓ central organ – heart
  - ✓ blood vessels
    - ➢ arteries
    - ➢ capillaries
    - ➢ veins

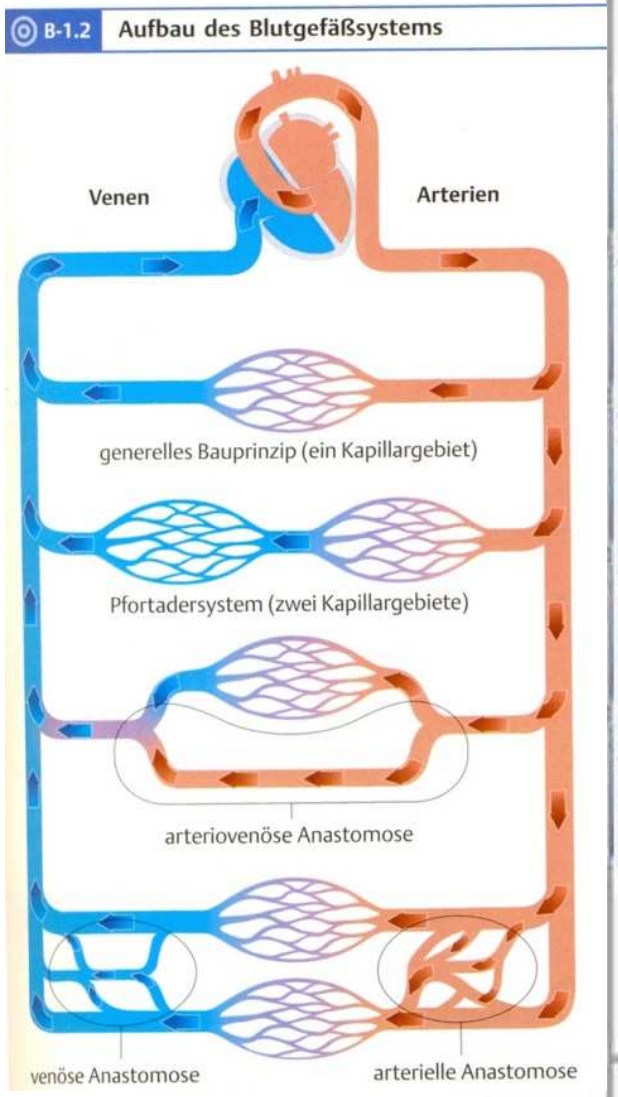




Circulatory system

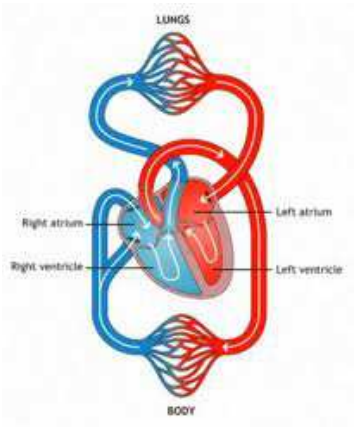
- Two parts (systems):
  - ✓ blood-vascular system
    - ➢ arterial system
    - ➢ venous system
  - ✓ lymphatic system

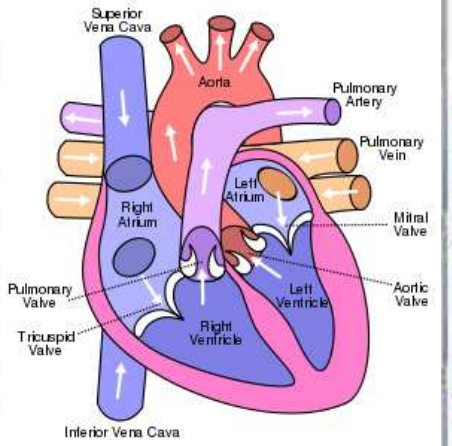


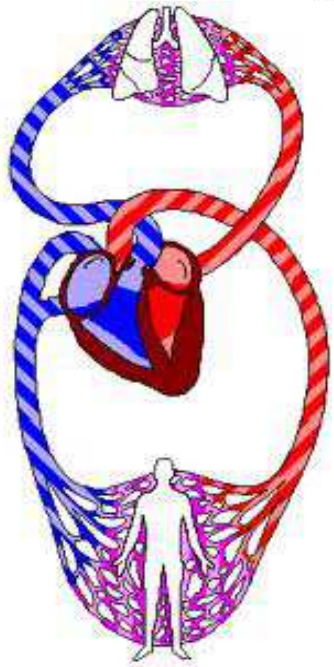


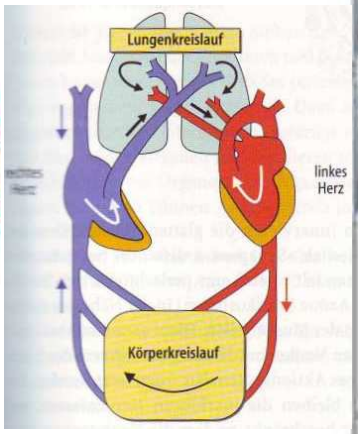
Central organ

- Heart – *cor*, (Gr. *cardia*):
  - ✓ 'left (arterial)' heart
  - ✓ 'right (venous)' heart
- Functional compartments:
  - ✓ atria – left and right
  - ✓ chambers – left and right
- Blood circulation:
  - ✓ systemic circuit
    - ➢ portal circulation
  - ✓ pulmonary circuit



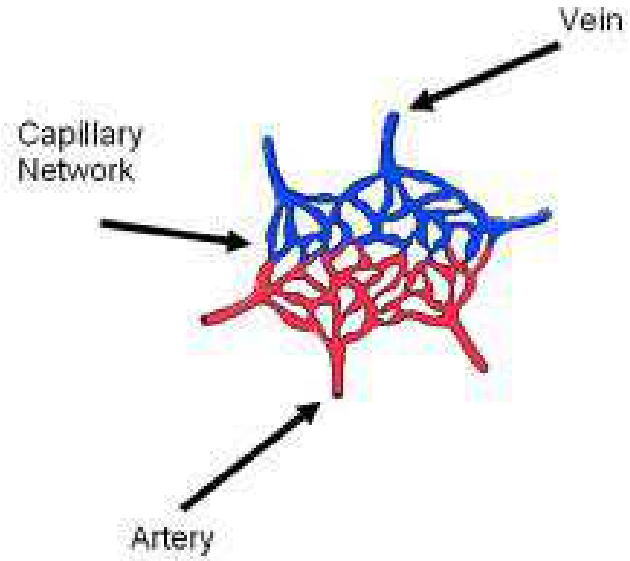


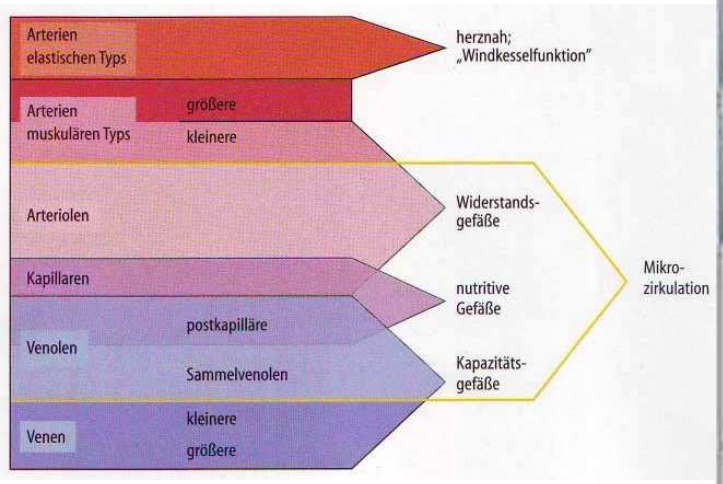




Circulatory system

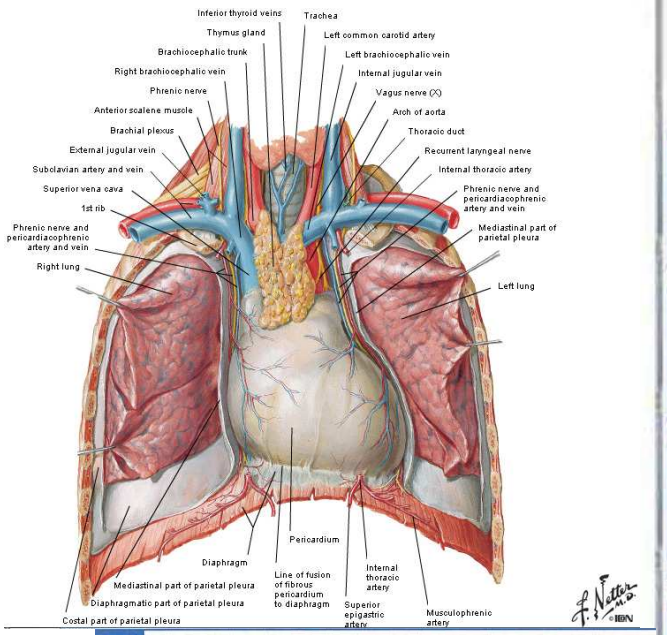
- Blood flow (circulation)
- Blood vessels, *vasa sanguinea*
  - ✓ arteries, *arteriae*
    - ➢ arterial system
  - ✓ capillaries
    - ➢ microcirculatory compartment
  - ✓ veins, *venae*
    - ➢ venous system
- Collateral circulation



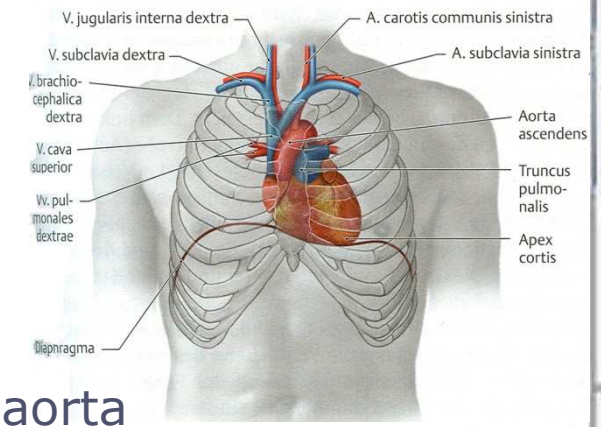


Heart – topography

- Location – asymmetric position
  - ✓ in middle mediastinum
  - ✓ upon *centrum tendineum*
- Somatotopy:
  - ✓ lateral – pericardium and mediastinal pleura
  - ✓ at the front – sternum and IV-VIth rib cartilage
  - ✓ at the back – esophagus and thoracic aorta

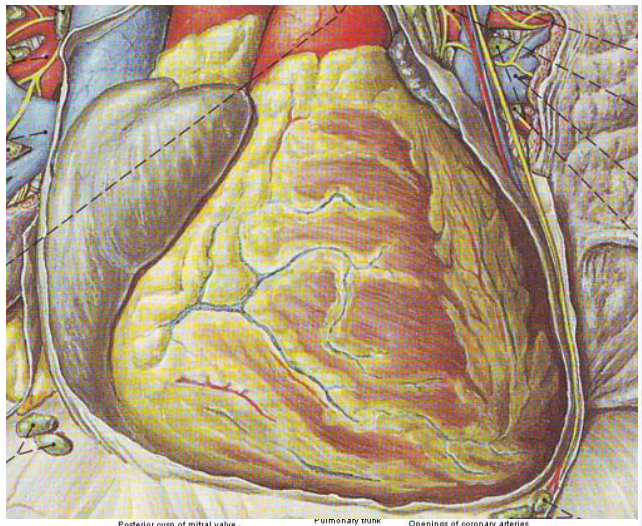


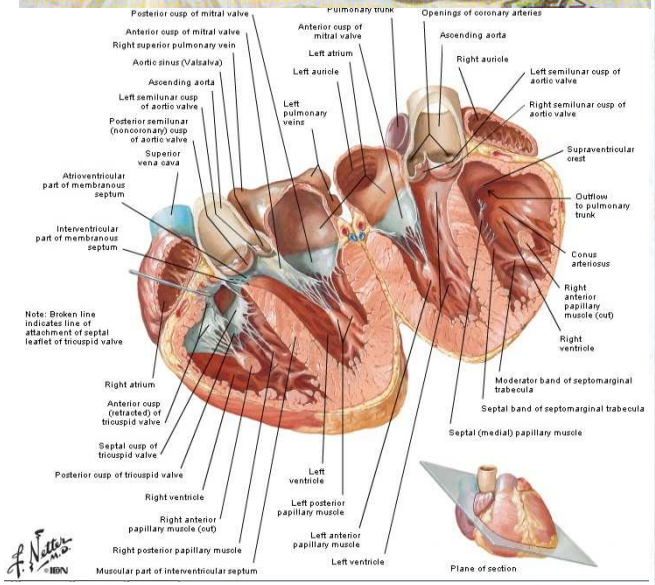
G-3.1 Lage von Herz und großen Gefäßen in der Brusthöhle



Heart – external surface

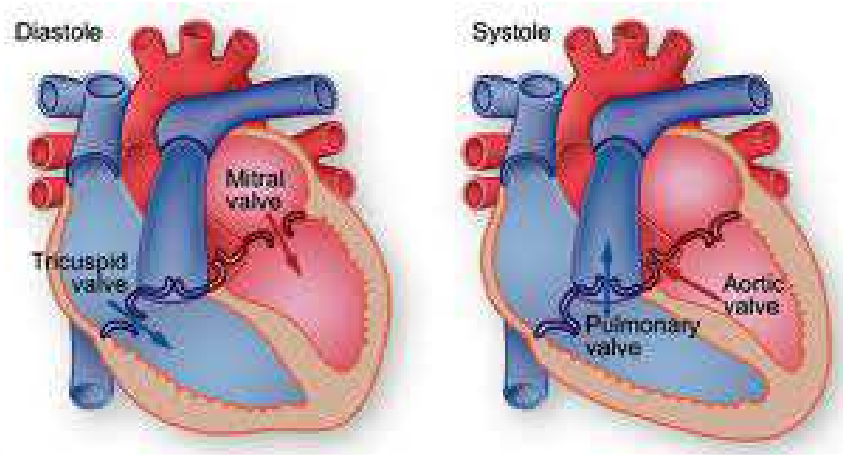
- External morphology:
  - ✓ shape – an irregular cone
  - ✓ weight – ~300 g (♂); 220 g (♀)
  - ✓ size:
    - ➢ longitudinal – 12-12 cm
    - ➢ transverse – 9-10.5 cm
    - ➢ anterior-posterior – 6-7 cm
- Cavities – four chambers:
  - ✓ two atria – left and right
  - ✓ two chambers – left and right

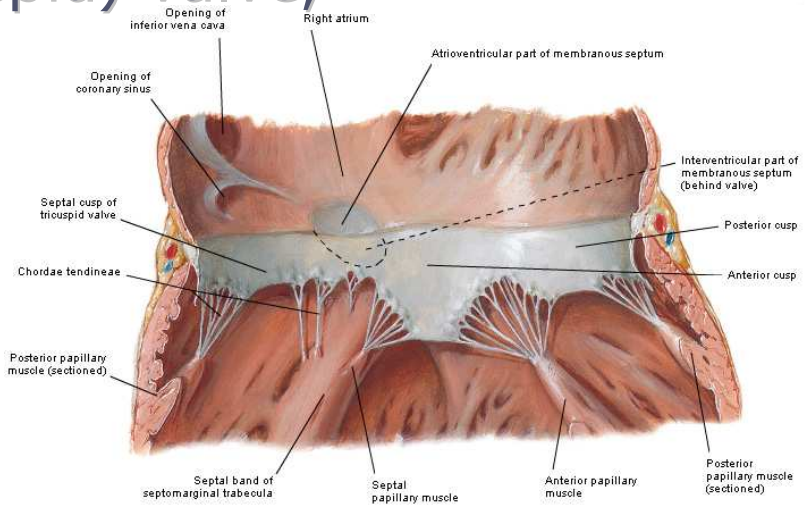


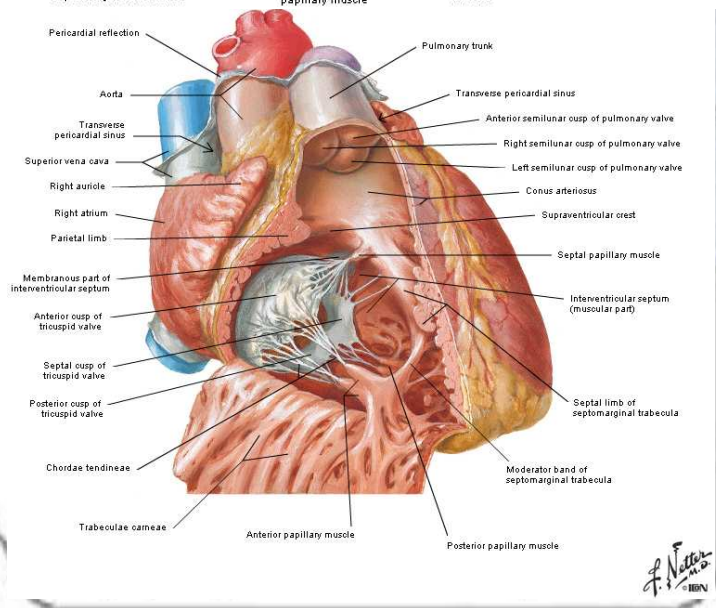


Heart valves

- Right atrioventricular (tricuspid) valve, *valva antricularis dextra s. valva tricuspidalis:*
  - ✓ *cuspis anterior, posterior et septalis*
  - ✓ *chordae tendineae*
  - ✓ *mm. papillaris anterior, posterior et septalis*

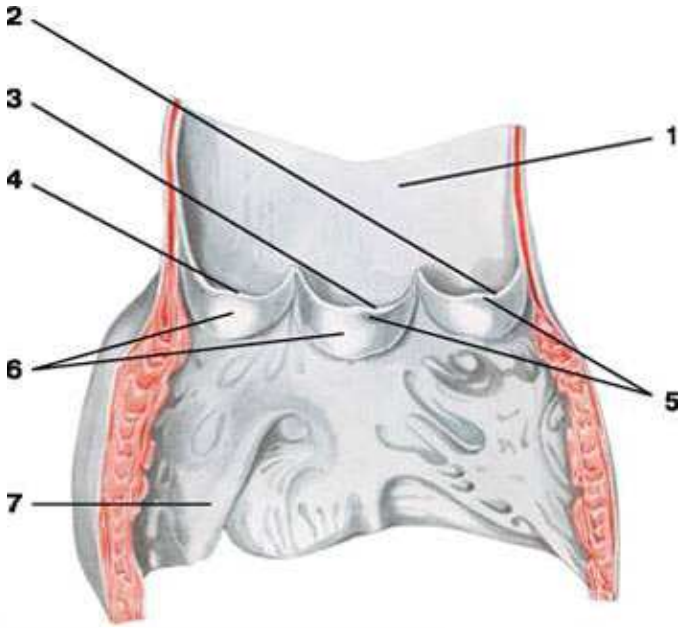


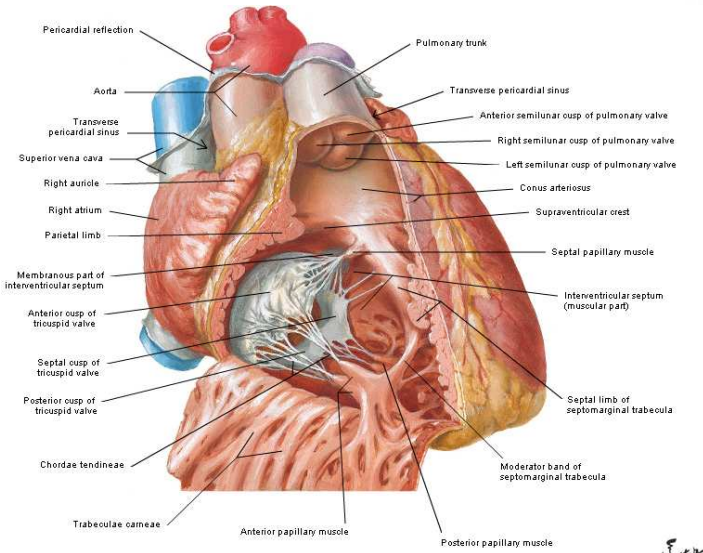


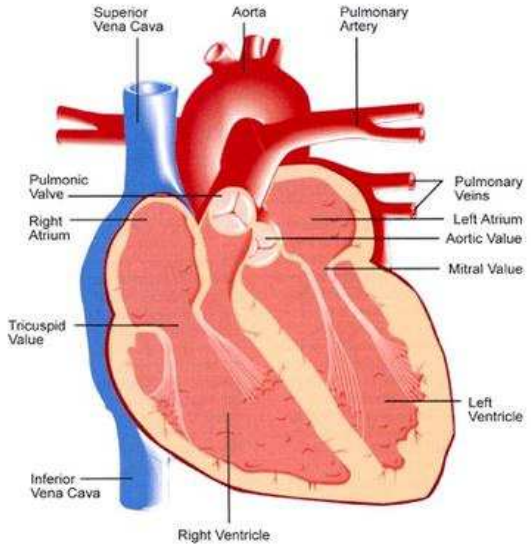


Heart valves

- Pulmonary valve,
  valva trunci pulmonalis:
  - ✓ *valvula semilunaris anterior, dextra et sinistra*
  - ✓ *lunula et nodulus valvulae semilunaris*

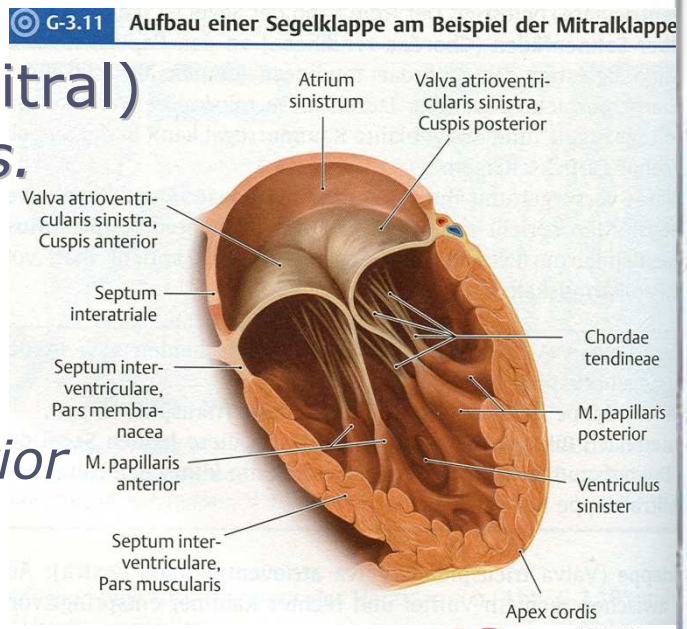


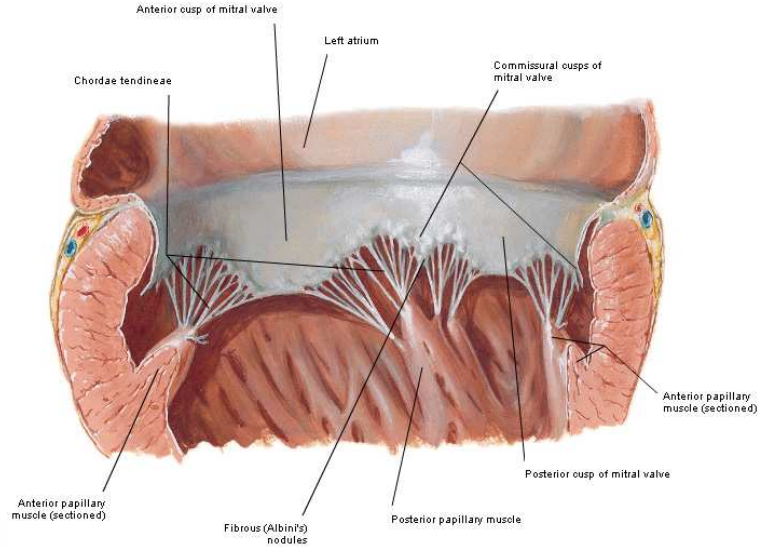


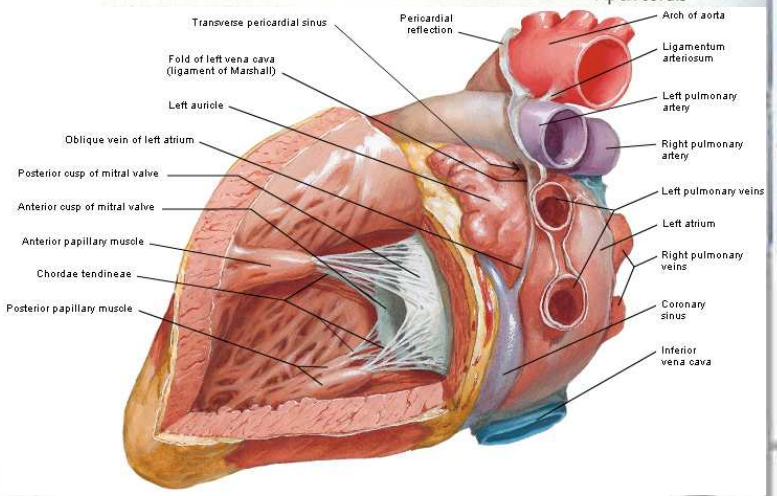


Heart valves

- Left atrioventricular (bicuspid, mitral) valve, *valva antricularis sinsitra s. valva bicuspidalis (mitralis):*
  - ✓ *cuspis anterior et posterior*
  - ✓ *chordae tendineae*
  - ✓ *mm. papillaris anterior et posterior*
  - ✓ *trabeculae carneae*

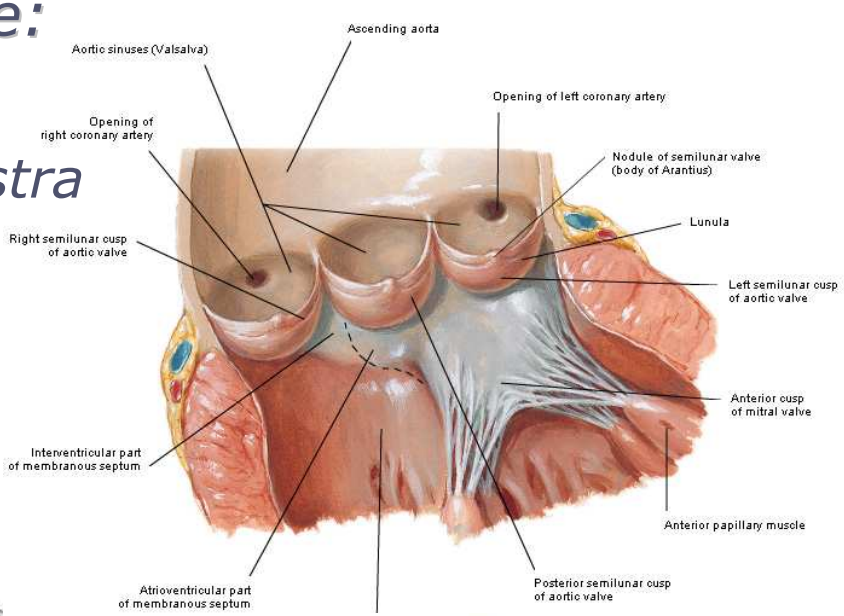


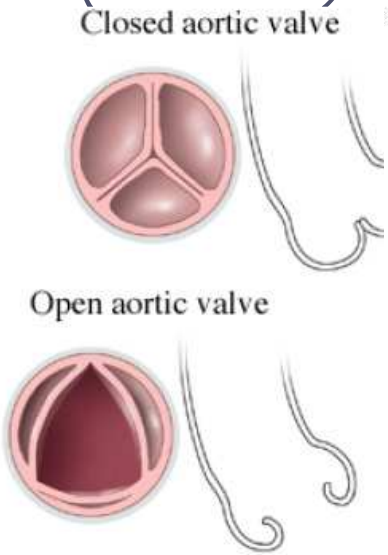




Heart valves

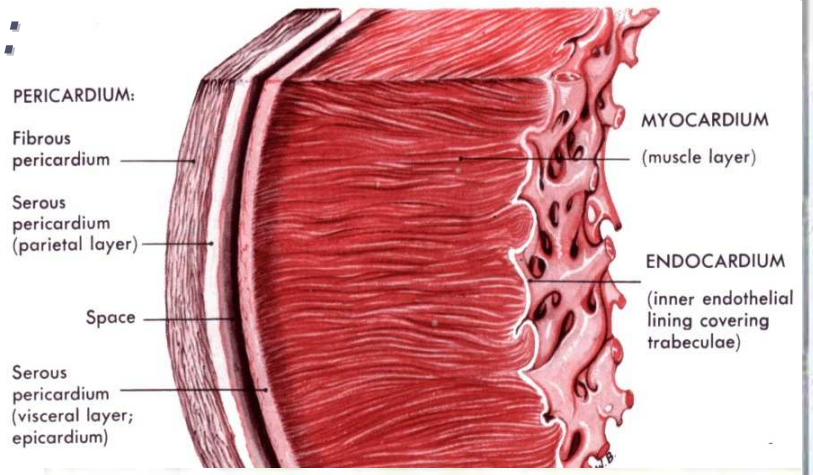
- Aortic valve, *valva aortae:*
  - ✓ *valvula semilunaris posterior, dextra et sinistra*
  - ✓ *lunula et nodulus valvulae semilunaris*
  - ✓ *sinus aortae (Valsalva)*

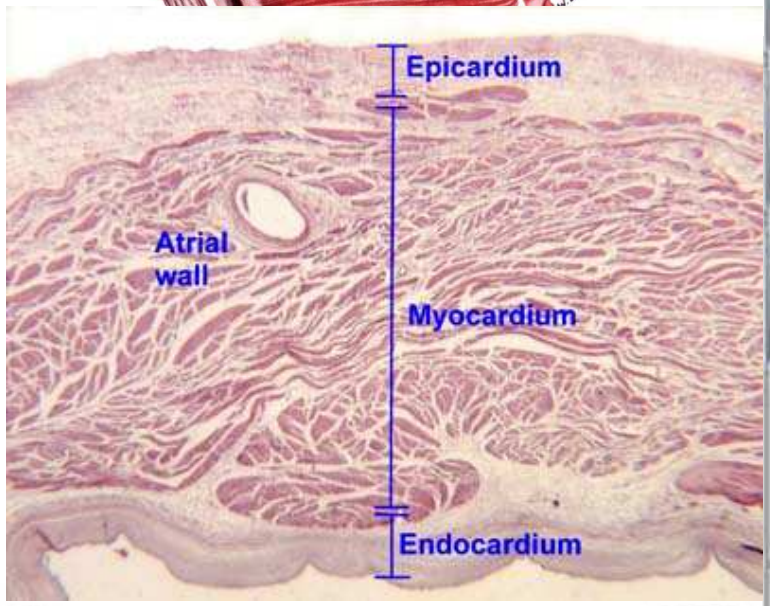




Structure of the heart wall

- internal layer, *endocardium:*
  - ✓ *stratum endotheliale*
  - ✓ *stratum subendotheliale*
  - ✓ *stratum myoelasticum*
  - ✓ atrioventricular valves
- *tela subendocardialis*
  - ✓ cells of *Purkinje*
- middle layer, *myocardium*
- external layer, *epicardium*
- *pericardium*

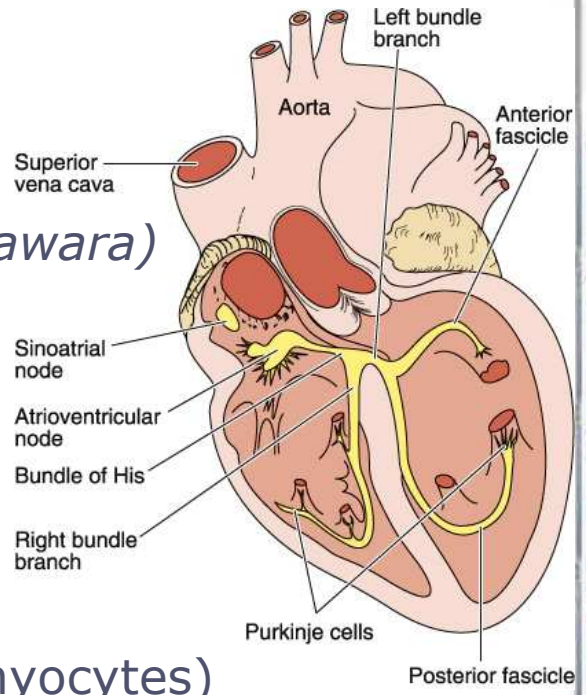


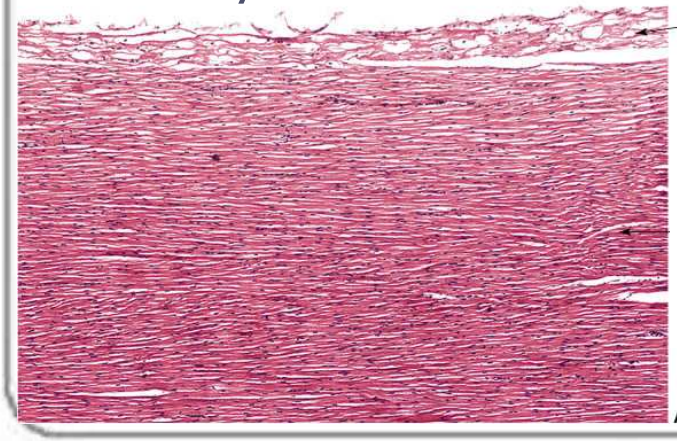


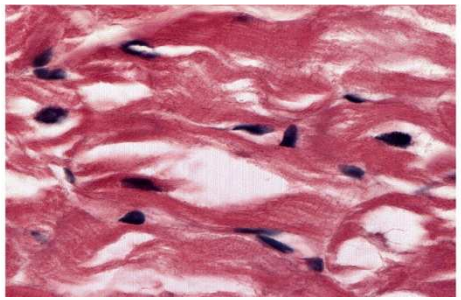
Conducting system

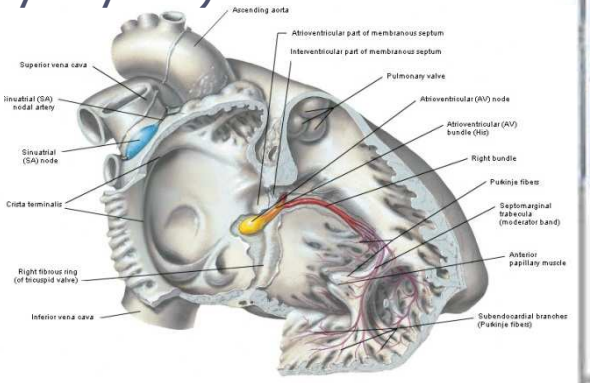
- *Systema conducens cordis:*
  - ✓ sinuatrial (SA) node *(Keith & Flack)*
  - ✓ atrioventricular (AV) node *(Aschoff-Tawara)*
  - ✓ atrioventricular bundle *(His)*

    - ➢ trunk
    - ➢ left and right bundle branch
    - ➢ conducting myofibers *(Purkinje)*
  - ✓ nodal myocytes (Purkinje cells)
  - ✓ myoendocrine cells (secretory cardiomyocytes)



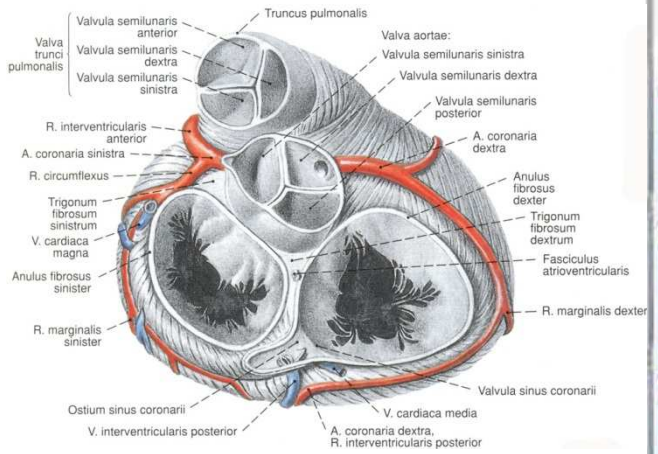


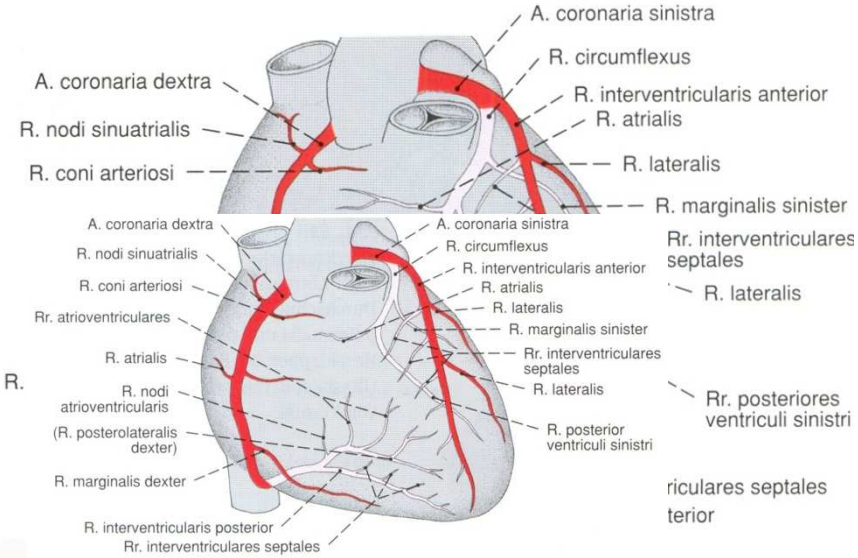


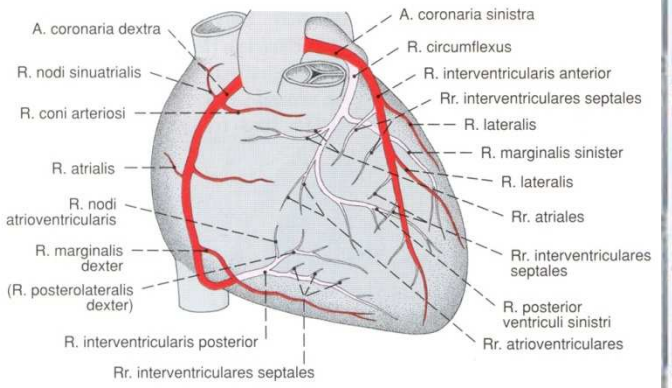


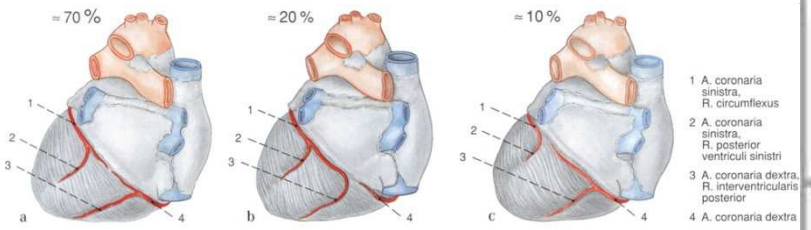
Blood supply of the heart

- Arteries of the heart, *aa. cordis:*
  - ✓ left coronary artery
  - ✓ right coronary artery
  - ✓ beginning of aortic sinuses
- Varieties in arterial blood supply:



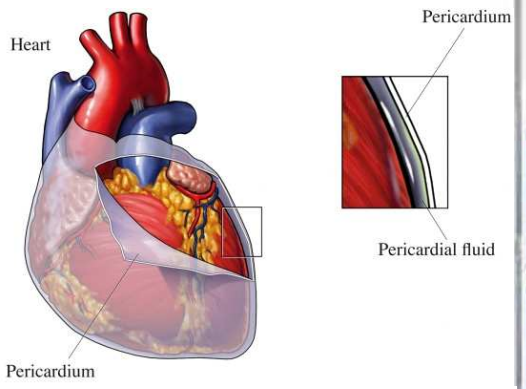


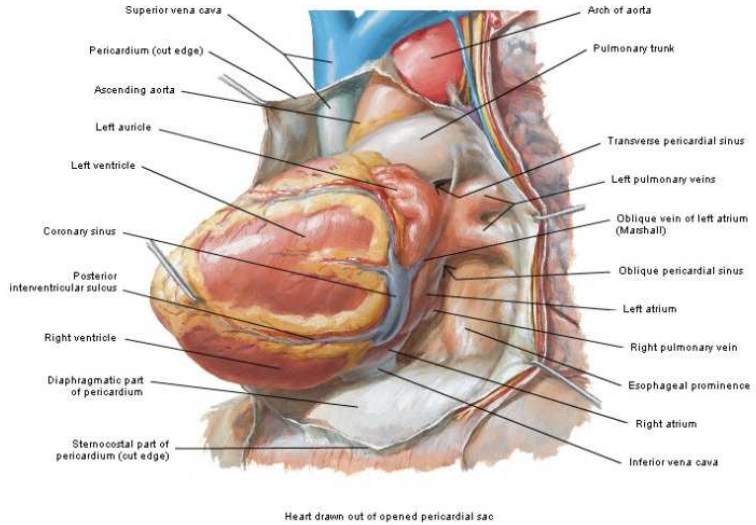




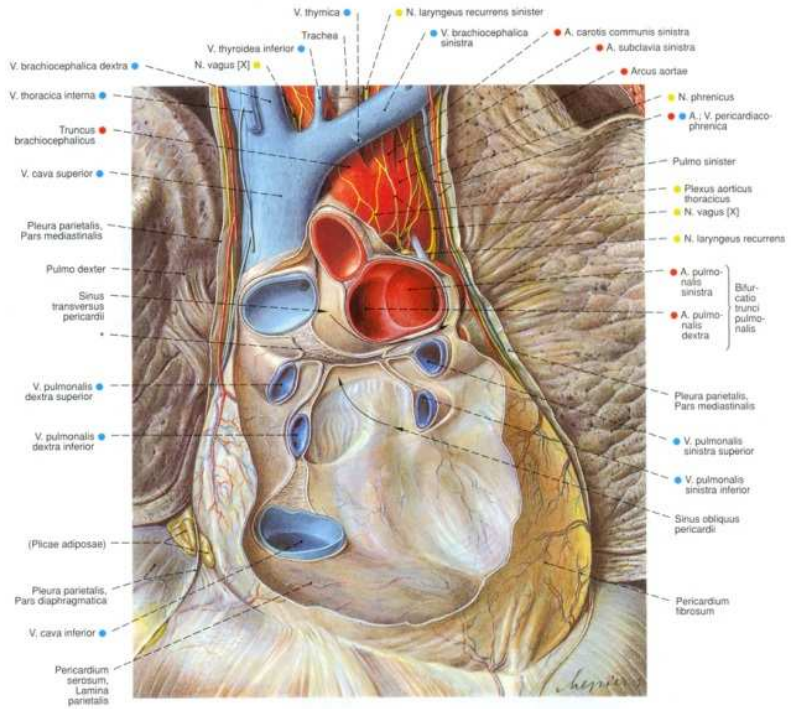
Pericardium

- *Pericardium serosum:*
  - ✓ *lamina visceralis (epicardium)*
  - ✓ *lamina parietalis ⇨ pericardium fibrosum*
  - ✓ *cavitas pericardii; liquor pericardii*
- *porta arteriosa et porta venosa*
- *sinus transversus pericardii*
- *sinus obliquus pericardii*



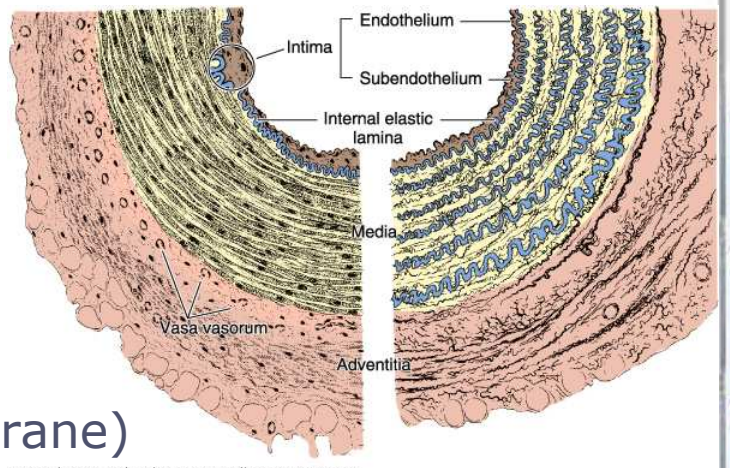


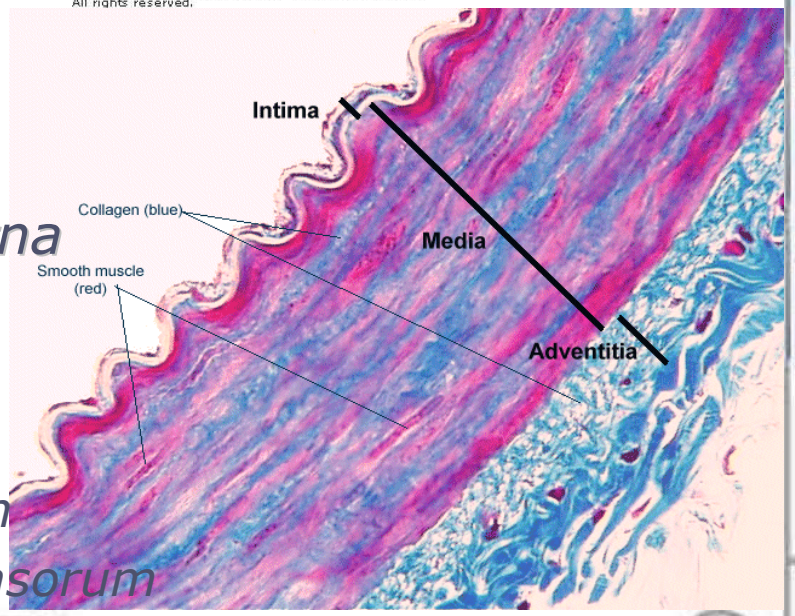
Heart drawn out of opened pericardial sac



Structural plan of blood vessels

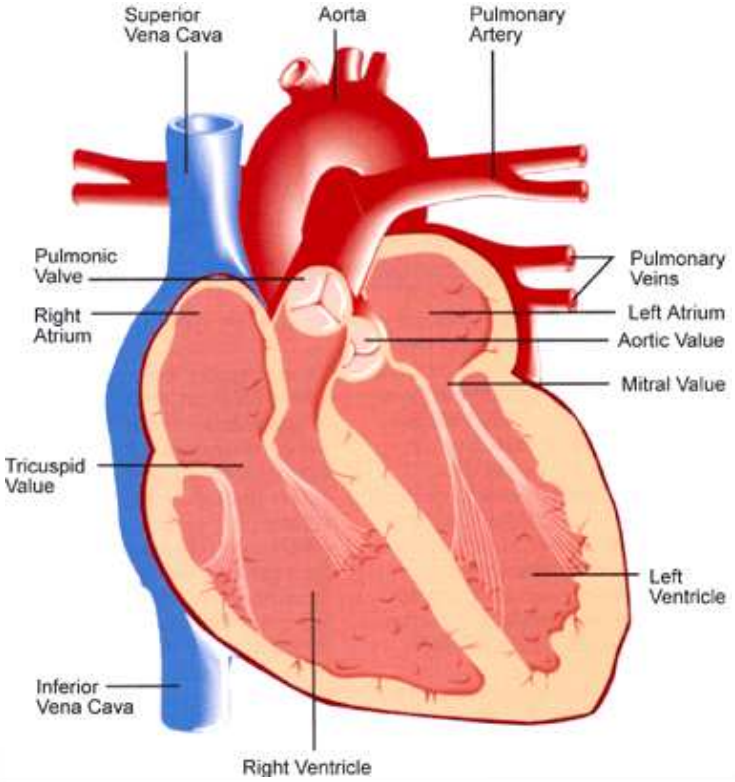
- Three layers:
  - ✓ internal layer – *tunica interna (intima)*
    - ➢ *endothelium*
    - ➢ subendothelial layer
    - ➢ internal elastic lamina (membrane)
  - ✓ middle layer – *tunica media*
    - ➢ smooth muscle cells
    - ➢ elastic and collagen fibers
  - ✓ external layer – *tunica externa (adventitia)*
    - ➢ loose connective tissue
    - ➢ smooth muscle tissue
    - ➢ blood vessels, *vasa vasorum*
    - ➢ vasomotor nerves, *nervi vasorum*

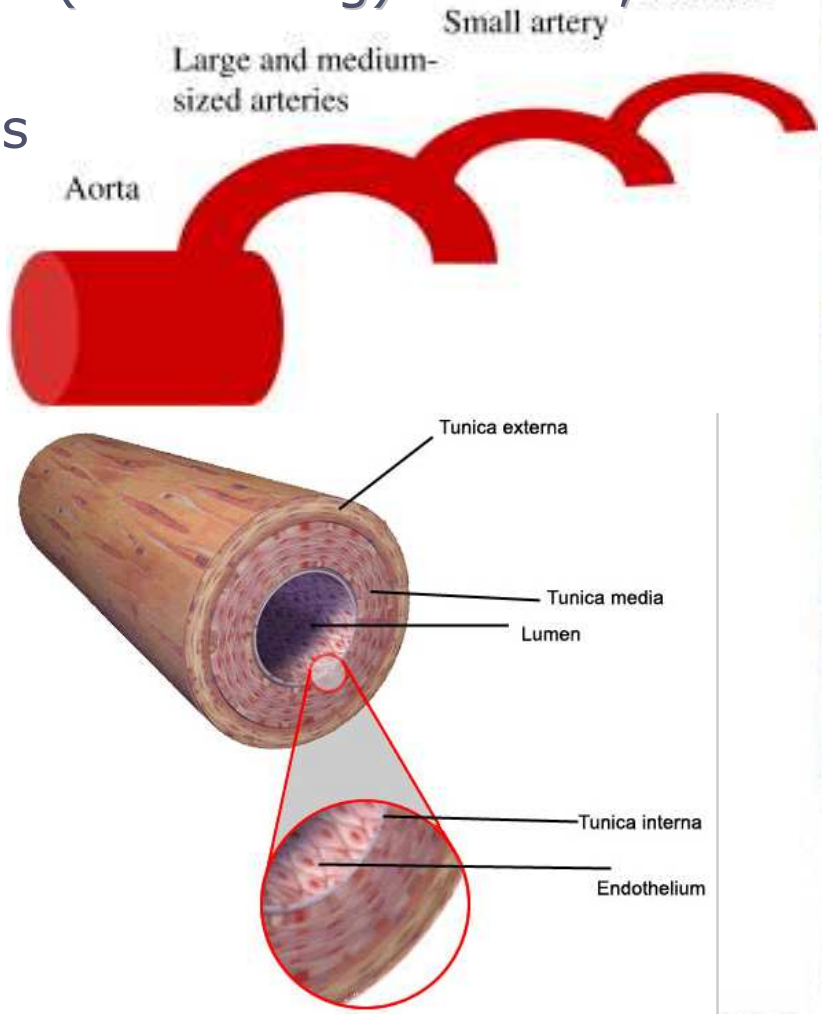




Structure of arterial wall

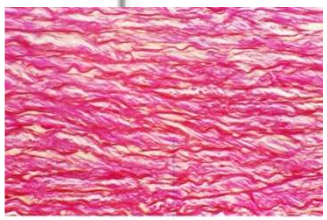
- Large-sized arteries = elastic (conducting) arteries, *arteriae elastotypicae:*
  - ✓ aorta and its large branches
  - ✓ pulmonary trunk



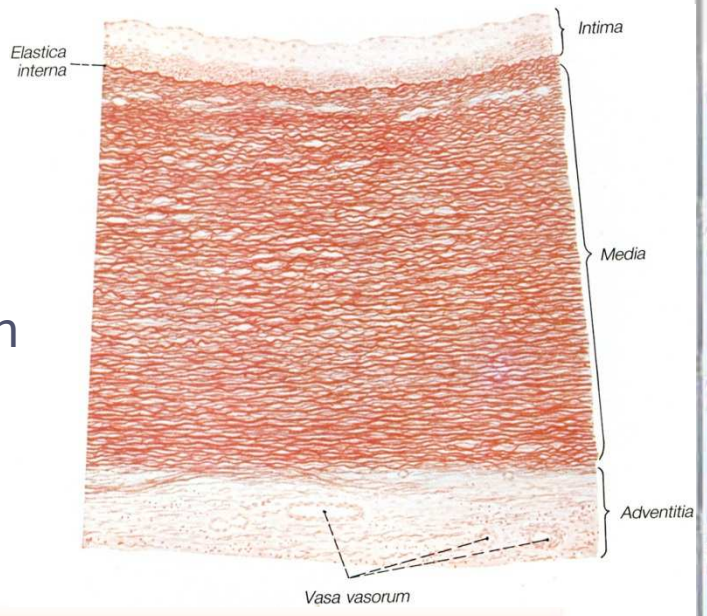


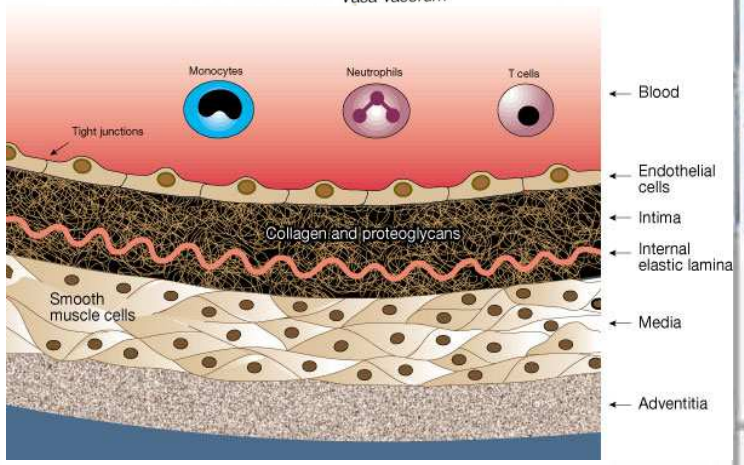
Structure of arterial wall

- Large elastic arteries:
  - ✓ *tunica interna (intima)* – thick
    - ➢ endothelium
    - ➢ well-developed subendothelium
    - ➢ internal elastic lamina – longitudinal elastic fibers



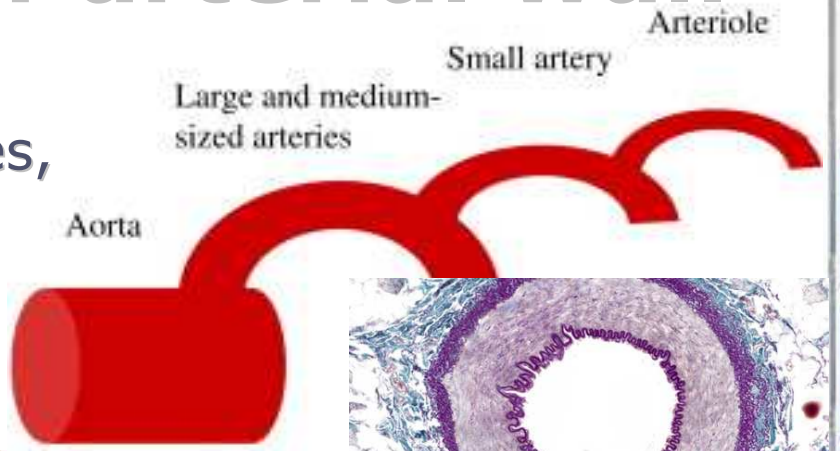
  - ✓ *tunica media* – main layer
    - ➢ parallel elastic membranes
  - ✓ *tunica externa (adventitia)*
    - ➢ loose connective tissue; abundant elactic fibers
    - ➢ *vasa et nervi vasorum*

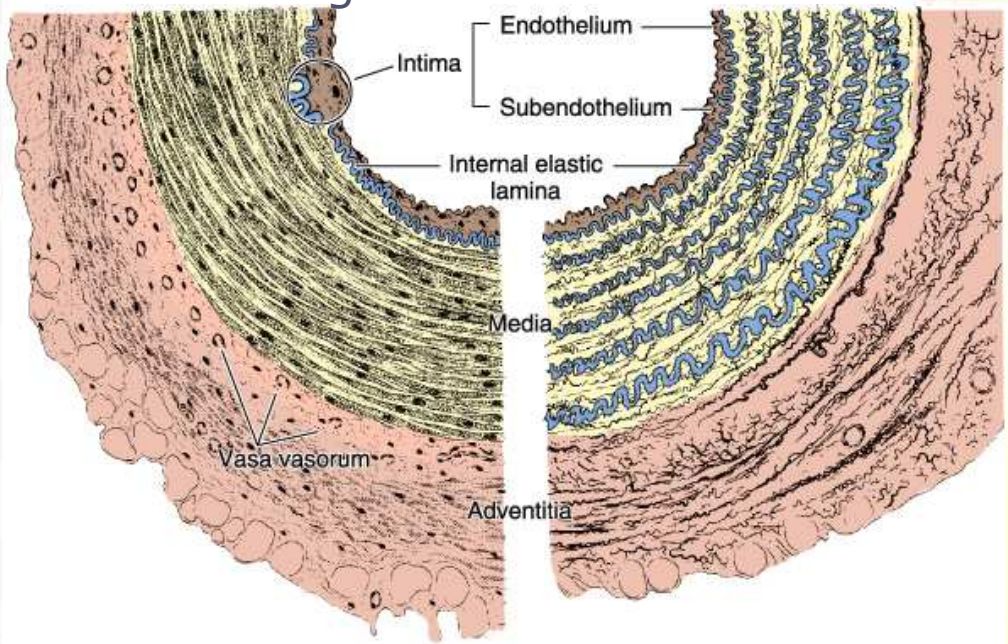


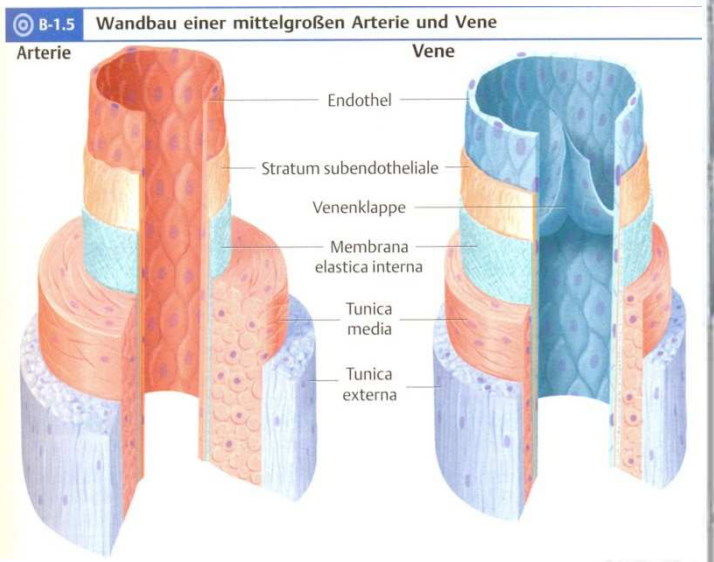


Structure of arterial wall

- Medium-sized arteries = muscular (distributing) arteries, *arteria myotypica:*
  - ✓ arteries of limbs
  - ✓ intercostal arteries
  - ✓ intraorgan arteries

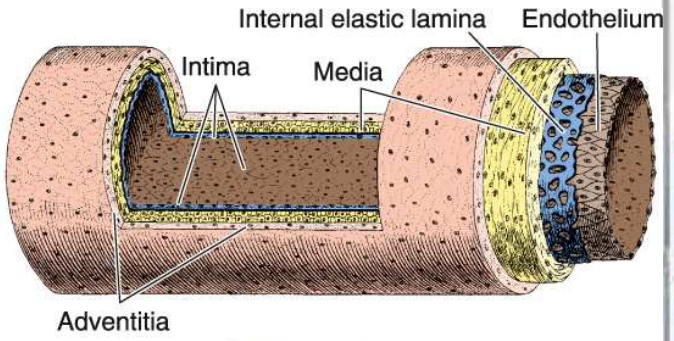


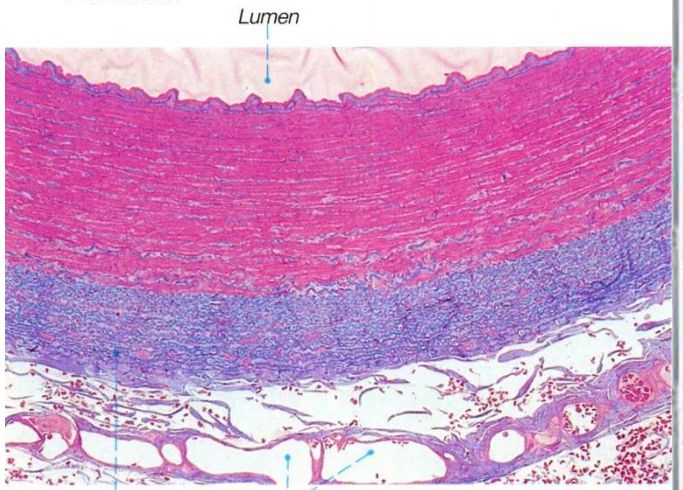


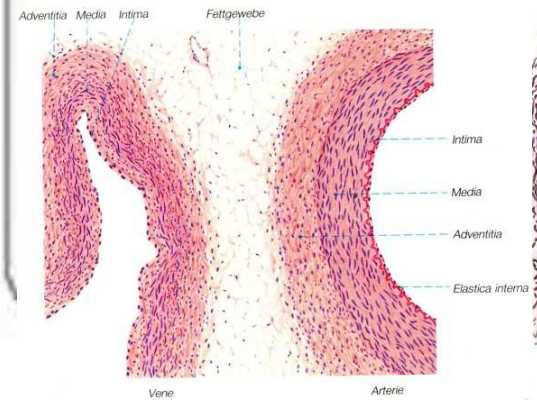


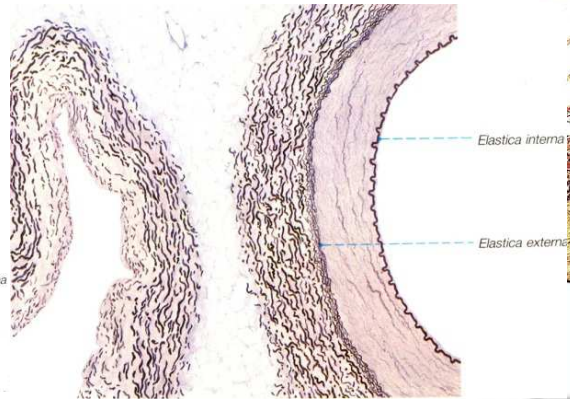
Structure of arterial wall

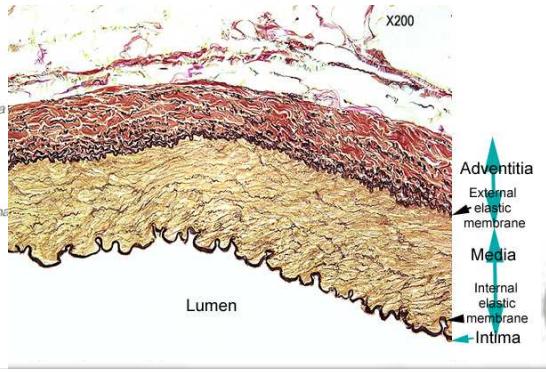
- Medium (muscular) arteries:
  - ✓ *tunica interna (intima)*
    - endothelium
    - thin subendothelial layer
    - internal elastic lamina
  - ✓ *tunica media* – the widest layer
    - circular muscle fibers
    - external elastic lamina
  - ✓ *tunica adventitia* – thick
    - connective tissue – collagen fibers
    - lymphatic capillaries, *vasa vasorum* and nerves





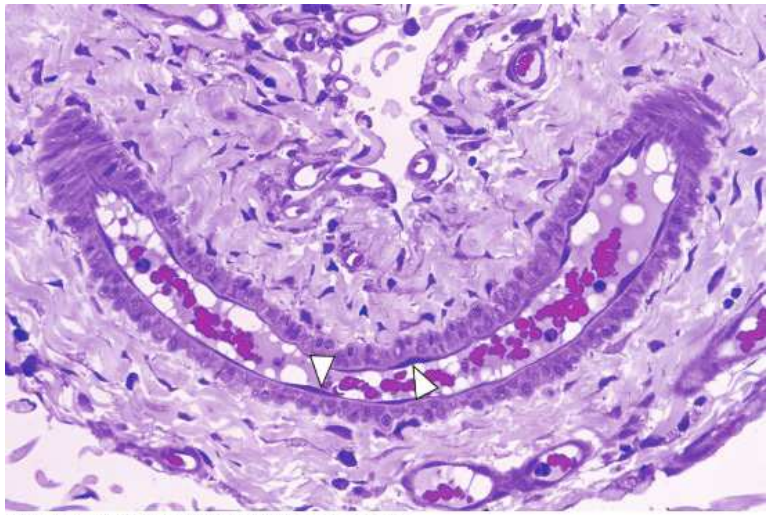


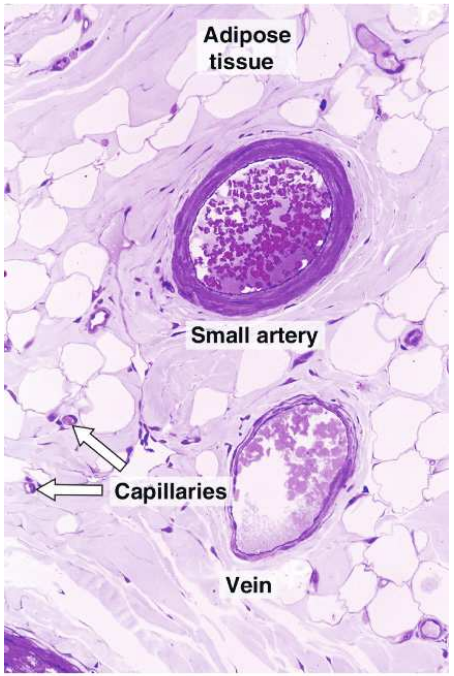


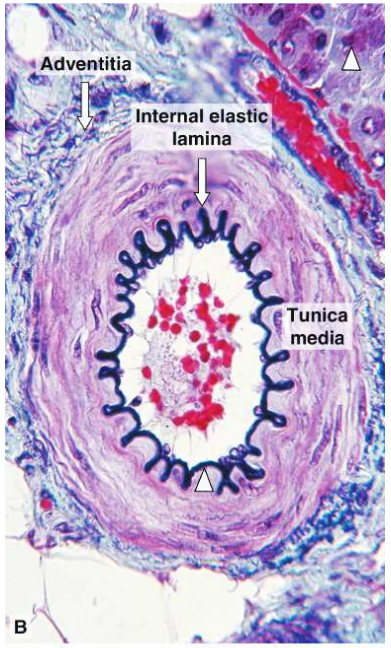


Structure of arterial wall

- Small-sized arteries – ≤ 0.4 mm:
  - ✓ *tunica intima*
    - ➢ thinner subendothelial layer
    - ➢ reduction of internal elastic lamina
  - ✓ *tunica media*
    - ➢ decrease of muscle fibers
  - ✓ *tunica adventitia*
    - ➢ very thin

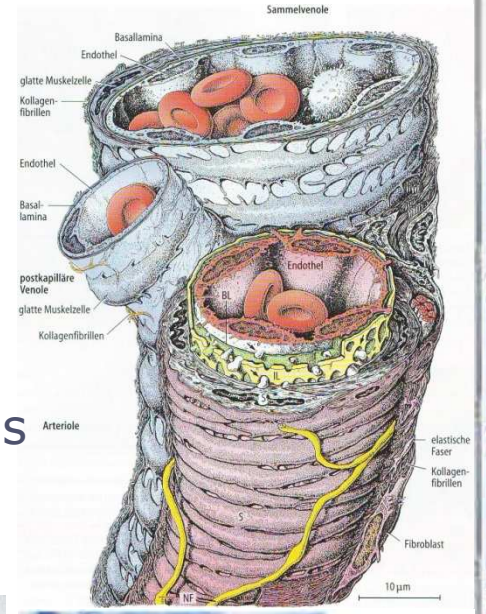


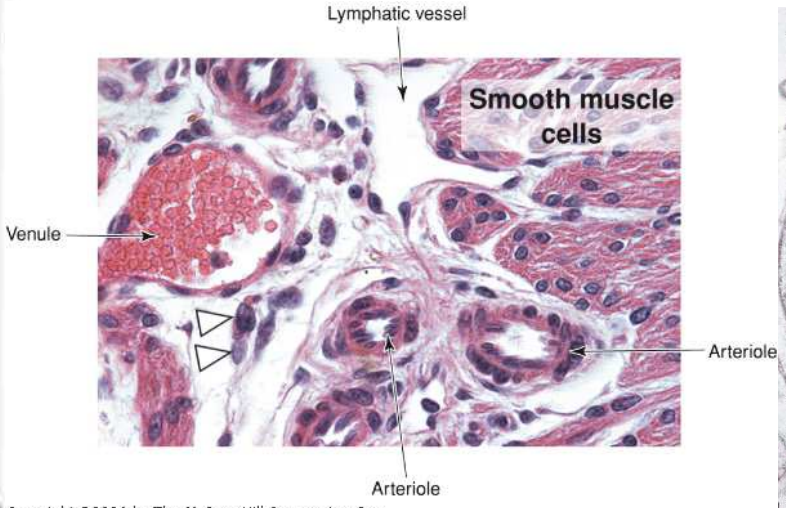


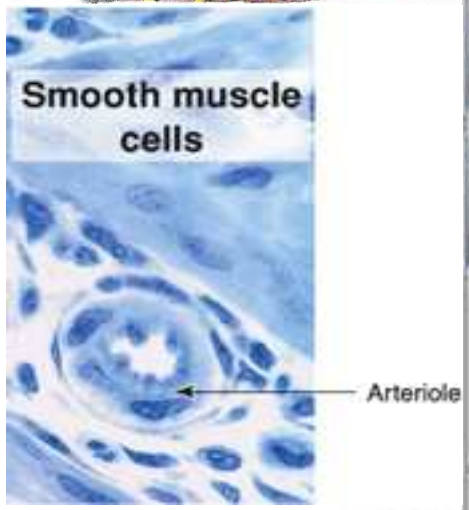


Structure of arterial wall

- Arterioles – ≤ 0.5 mm:
  - ✓ *tunica intima*
    - ➢ very thin subendothelial layer
    - ➢ absent internal elastic membrane
  - ✓ *tunica media*
    - ➢ 1-2 circular layers of smooth muscle cells
  - ✓ *tunica adventitia*
    - ➢ very thin to absent

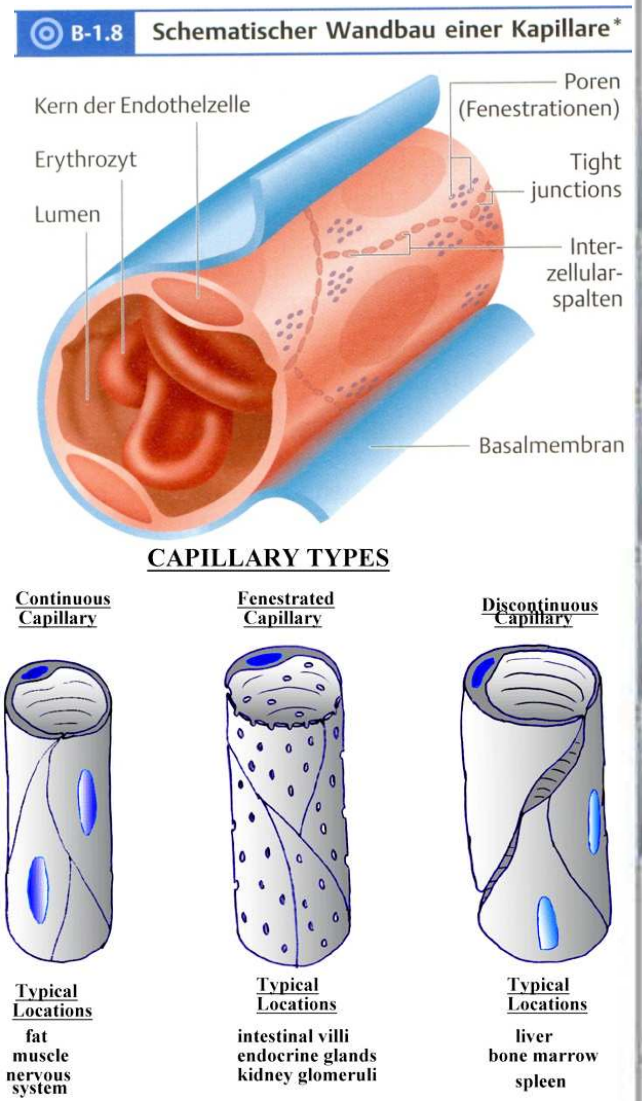






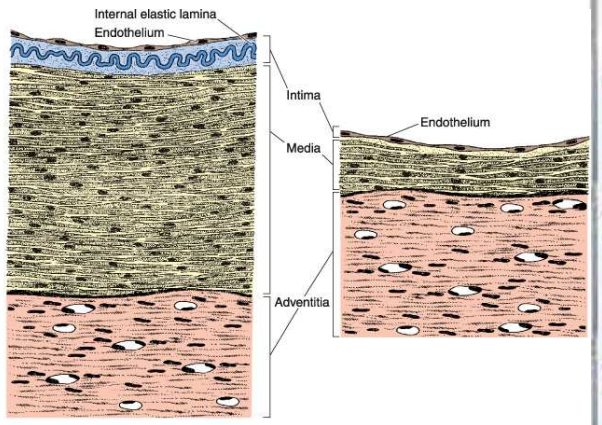
Structure of capillaries

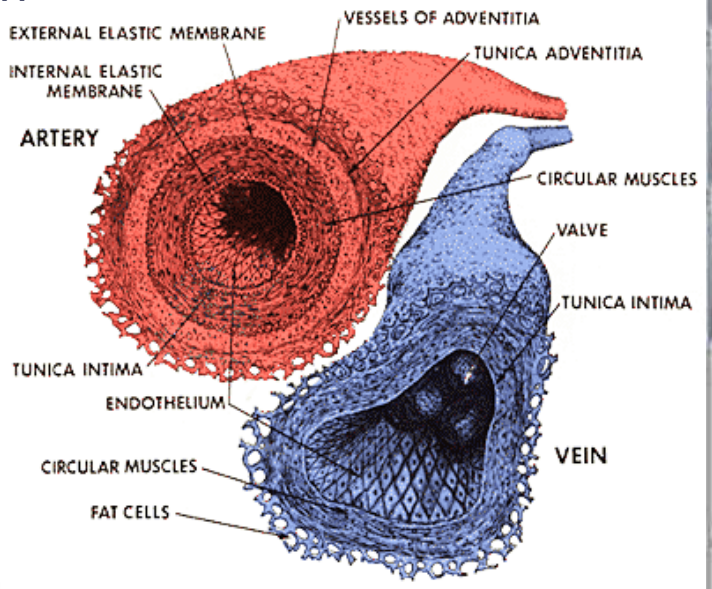
- Capillaries, *vas (hemo)capillare:*
  - ✓ part of terminal blood supply – capillary loops and networks
  - ✓ the sites for metabolic exchange
  - ✓ endothelial tubes
  - ✓ have a basement membrane
  - ✓ two functional portions
    - ➢ arterial – 2-7 μm
    - ➢ venous – 7-12 μm
- Three types of capillaries:
  - ✓ continuous (somatic)
  - ✓ fenestrated (visceral)
  - ✓ discontinuous (sinusoidal)



Structure of venous wall

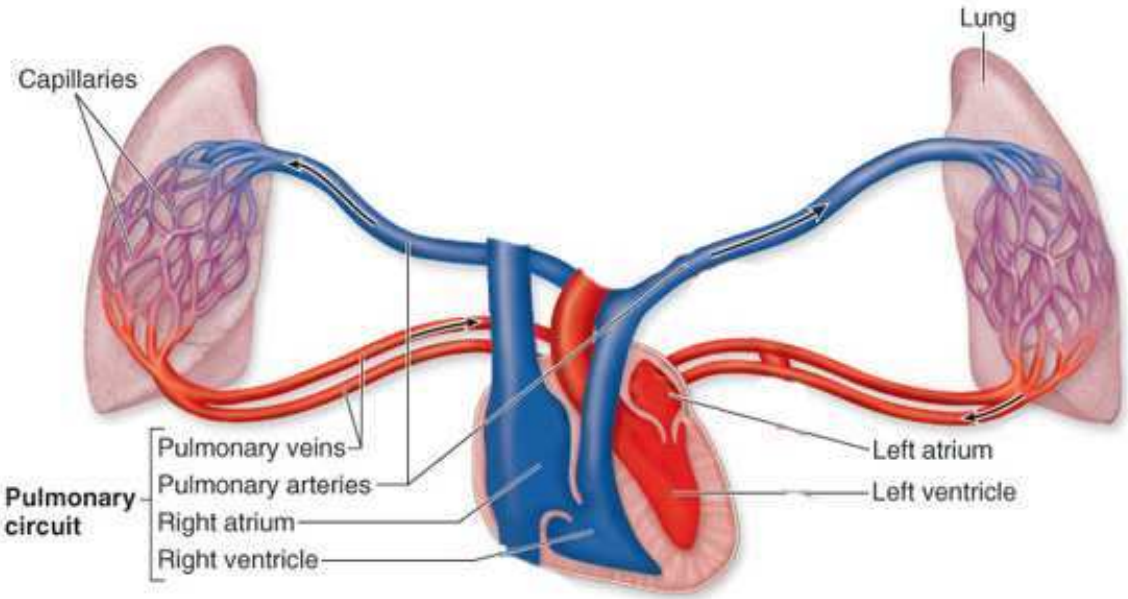
- Venous wall – three provisional layers:
  - ✓ *tunica intima*
  - ✓ *tunica media* – thinner
  - ✓ *tunica adventitia* – main layer
- Structural peculiarities:
  - ✓ irregular lumen
  - ✓ thinner wall with prevailing collagen fibers and valve presence
- Morphological types:
  - ✓ venules and small veins
  - ✓ with prominent circular musculature in the media
  - ✓ with prominent longitudinal musculature in the adventitia
  - ✓ with less prominent musculature
  - ✓ nonmuscular veins

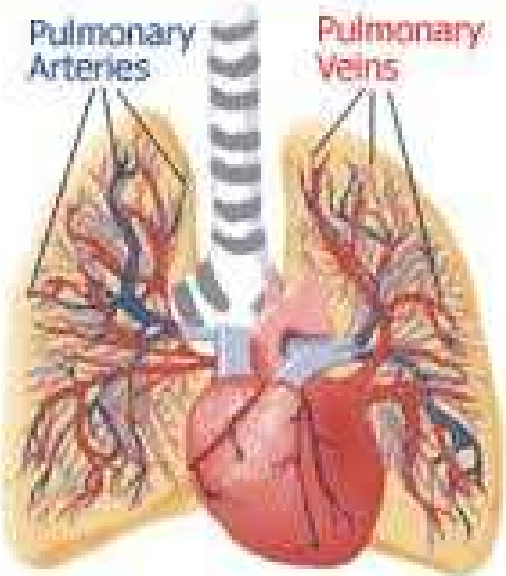


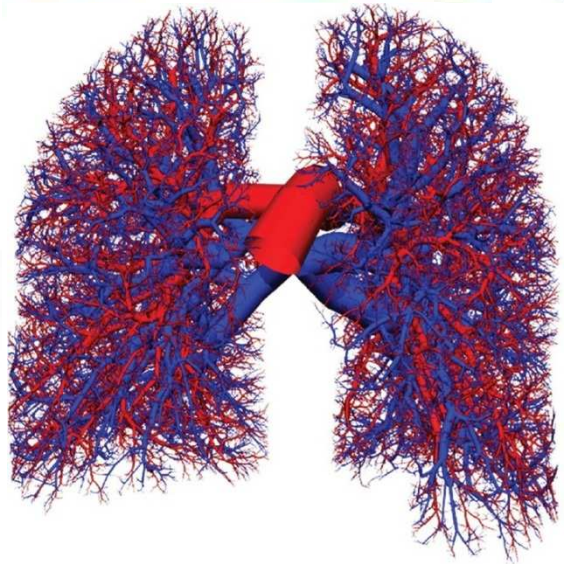


Pulmonary circuit

- Pulmonary trunk
  - ✓ pulmonary arteries – venous blood
    - ➢ right chamber ⇨ lungs
- Pulmonary veins – 4, arterial blood
  - ✓ lungs ⇨ left atrium

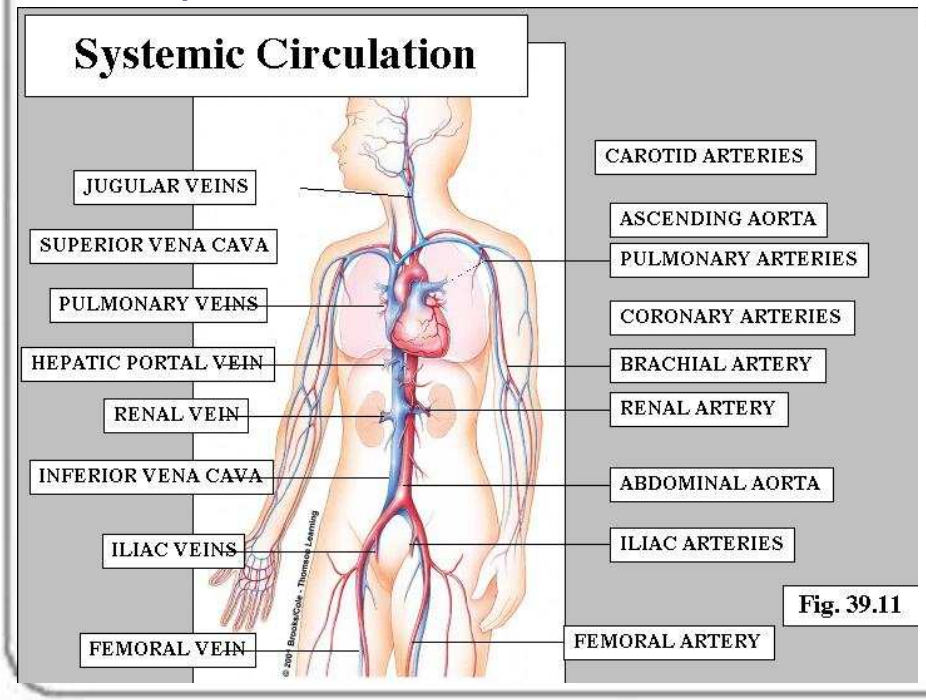


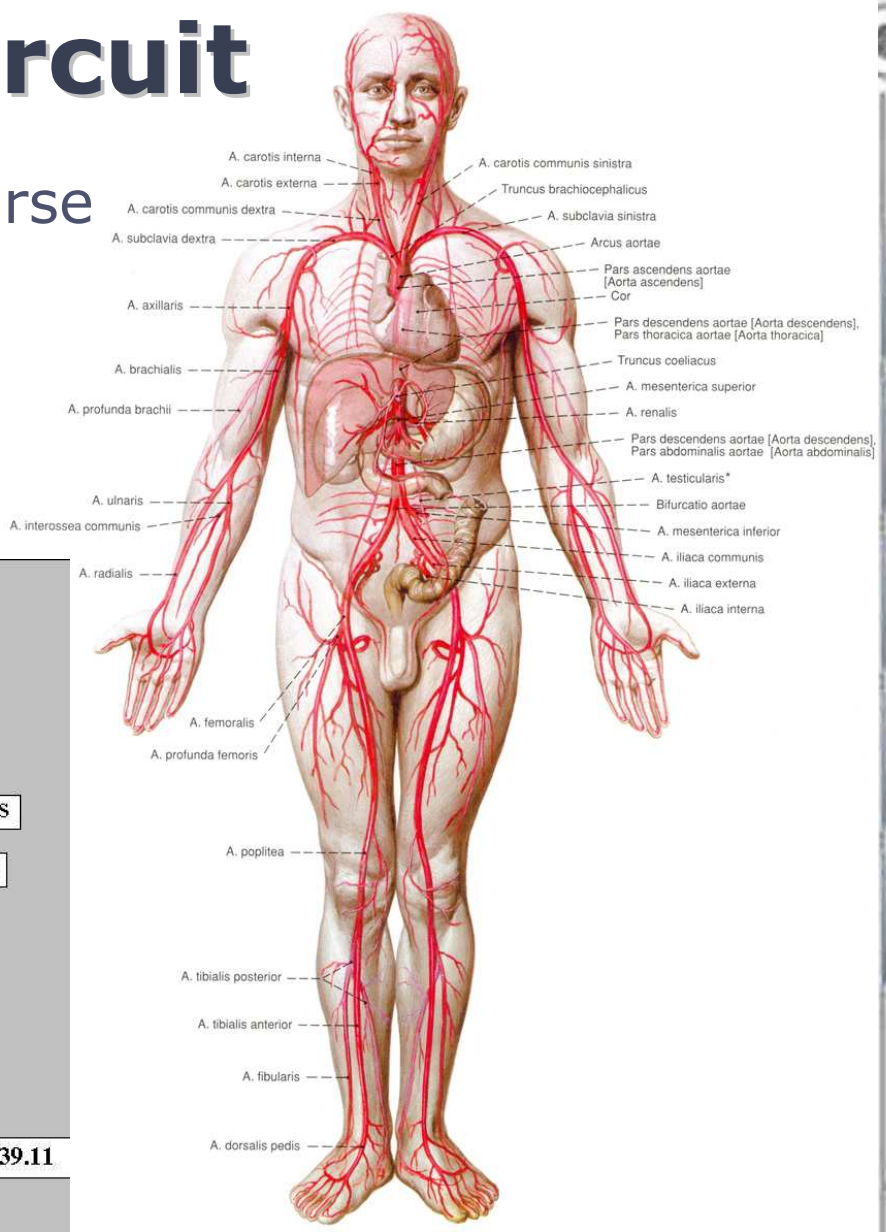




Systemic circuit

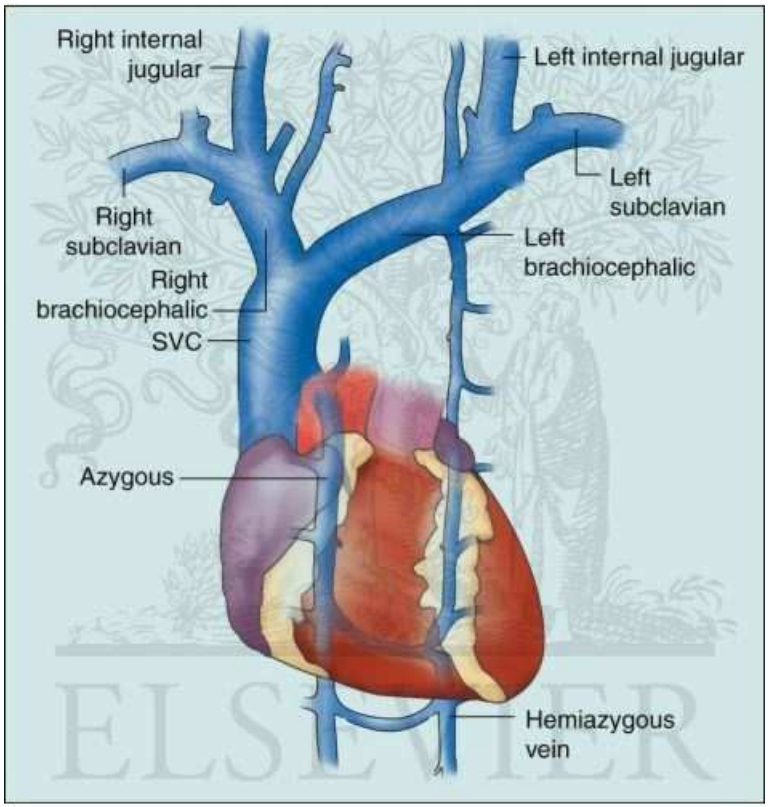
- Systemic circulation – course
  - ✓ arteries
  - ✓ capillaries
  - ✓ veins
  - ✓ coronary vessels
  - ✓ portal veins

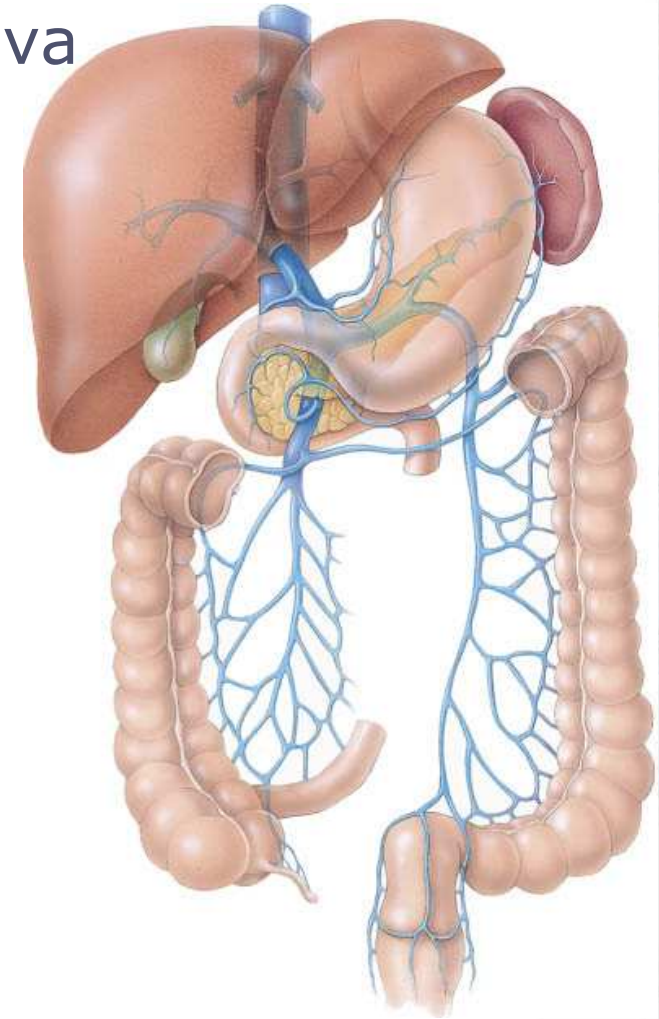




Venous system

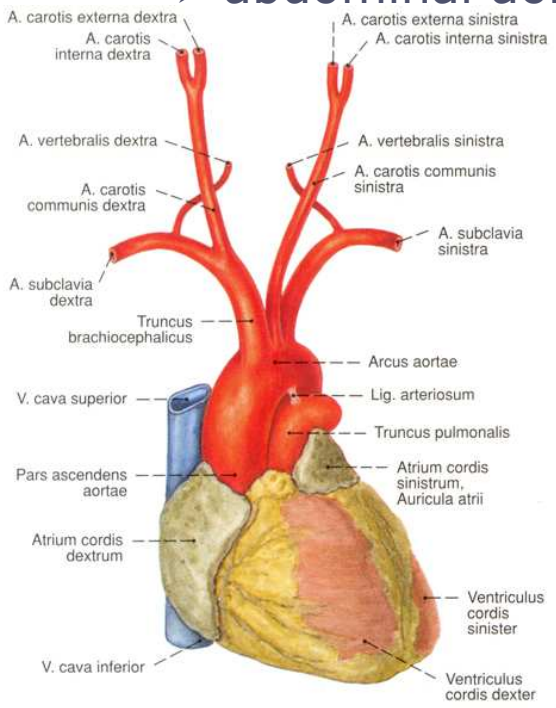
- ✓ system of superior vena cava
- ✓ system of inferior vena cava
- ✓ hepatic portal system

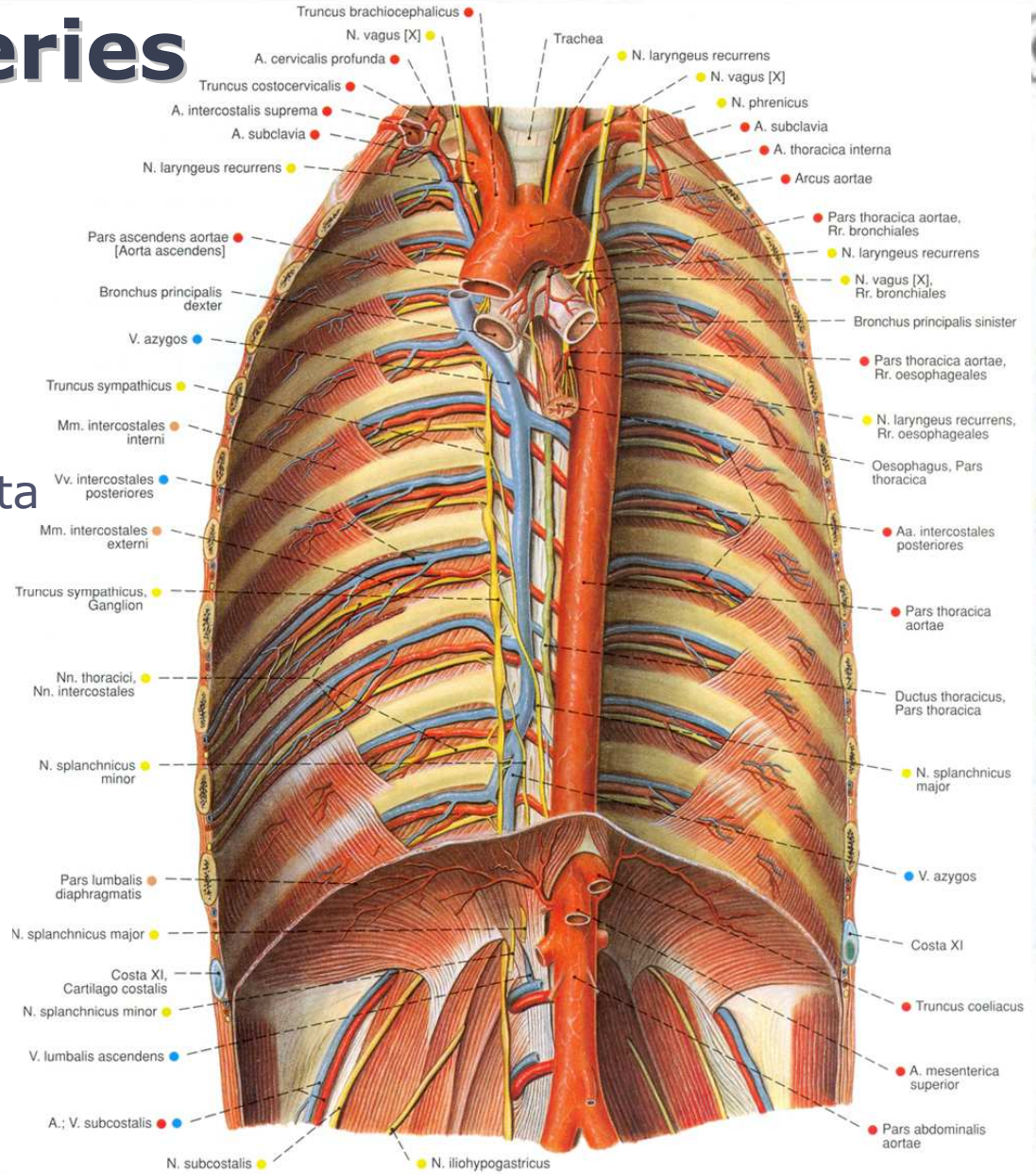




Major arteries

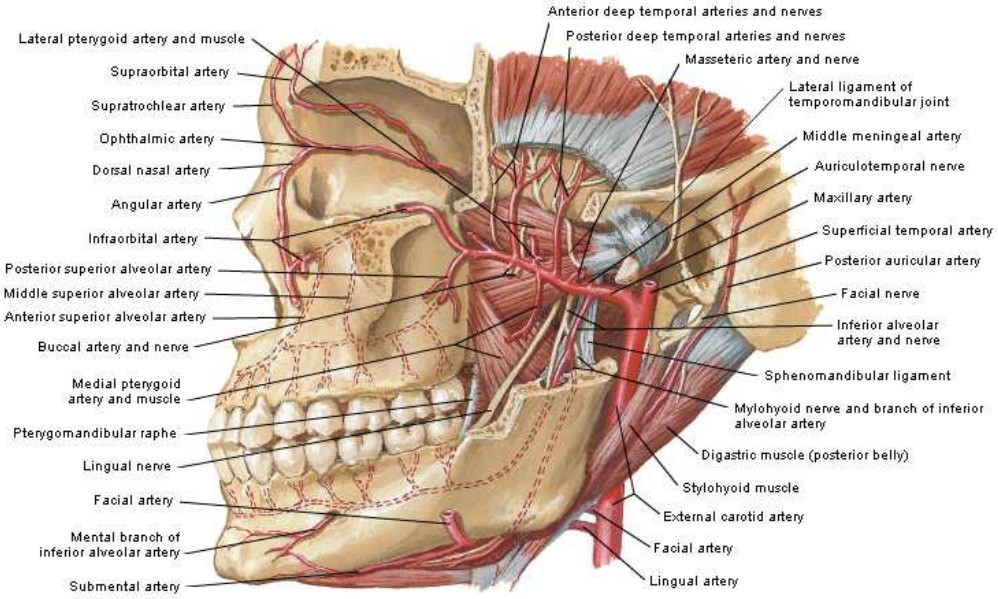
- Aorta – course
  - ✓ ascending aorta
  - ✓ arch of the aorta
  - ✓ descending aorta
    - ➢ thoracic aorta
    - ➢ abdominal aorta

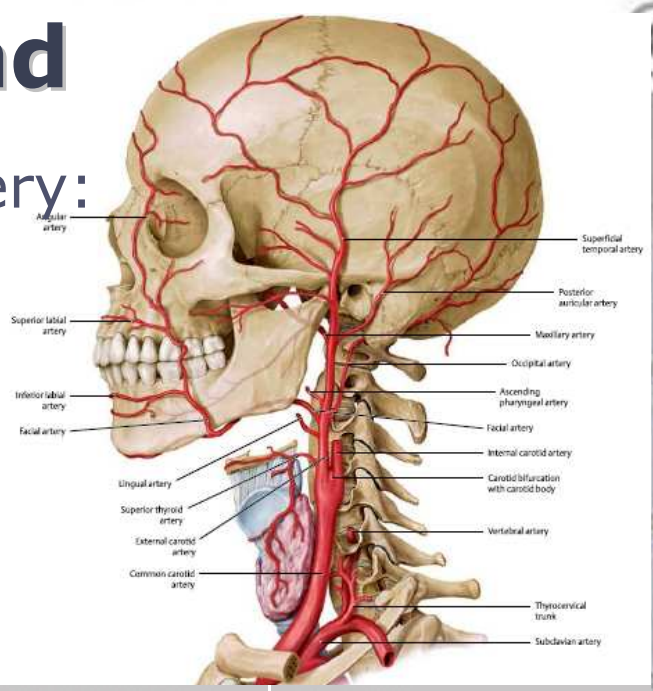




Arteries of the head

- Overview and external carotid artery:
  - ✓ facial artery
  - ✓ maxillary artery
  - ✓ superficial temporal artery

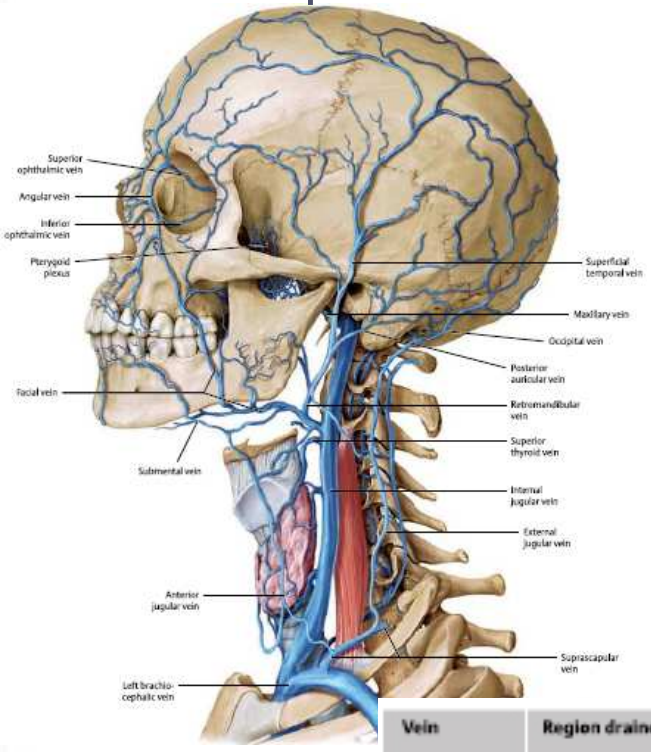


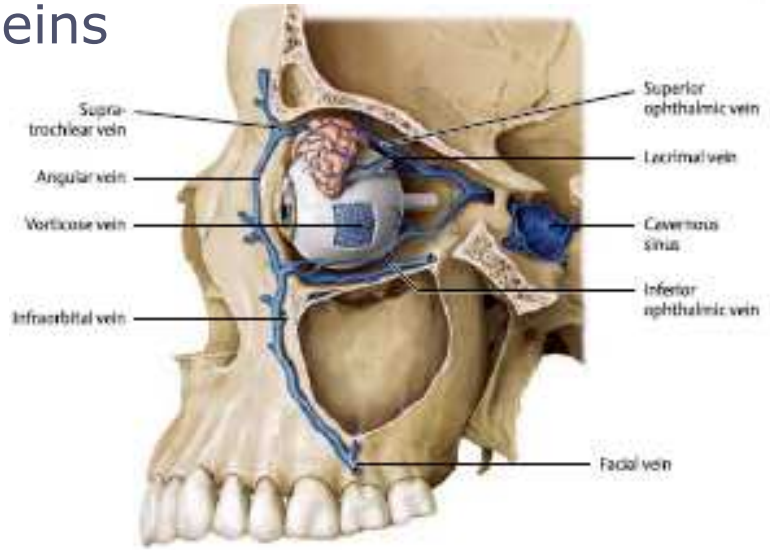


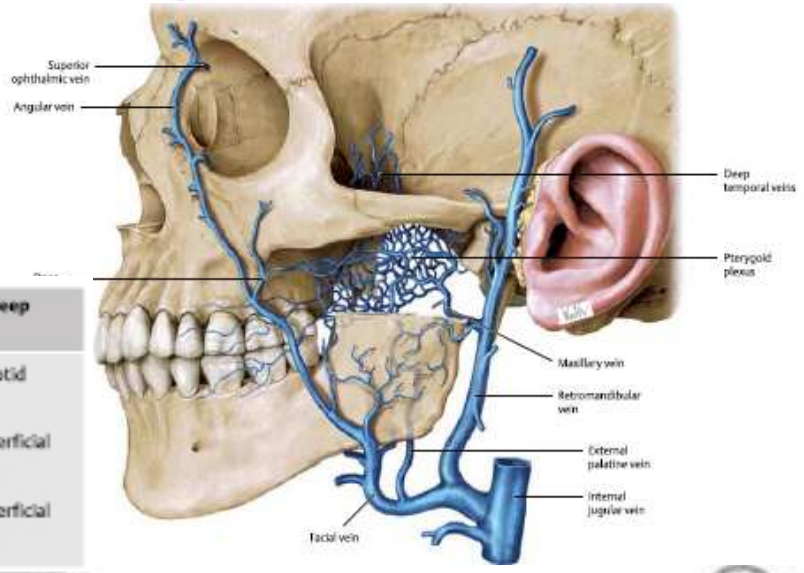
Name of the branches	Distribution
Anterior branches:	
• Superior thyroid artery	• Larynx, thyroid gland
• Lingual artery	• Oral floor, tongue
• Facial artery	• Superficial facial region
Medial branch:	
• Ascending pharyngeal artery	• Plexus to the skull base
Posterior branches:	
• Occipital artery	• Occiput
• Posterior auricular artery	• Ear
Terminal branches:	
• Maxillary artery	• Masticatory muscles, posteromedial part of the facial skeleton, meninges
• Superficial temporal artery	• Temporal region, part of the ear

Veins of the head and neck

- ✓ Superficial head and neck veins
- ✓ Deep head and neck veins

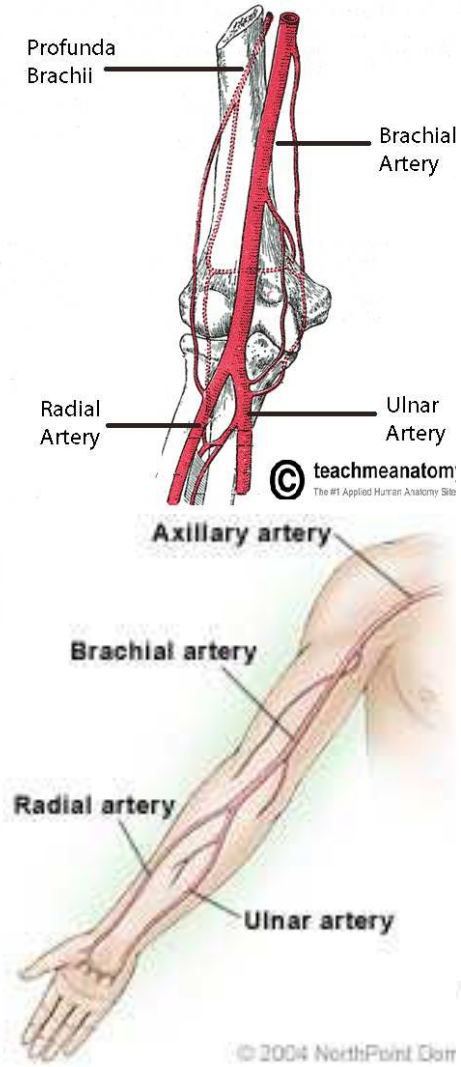


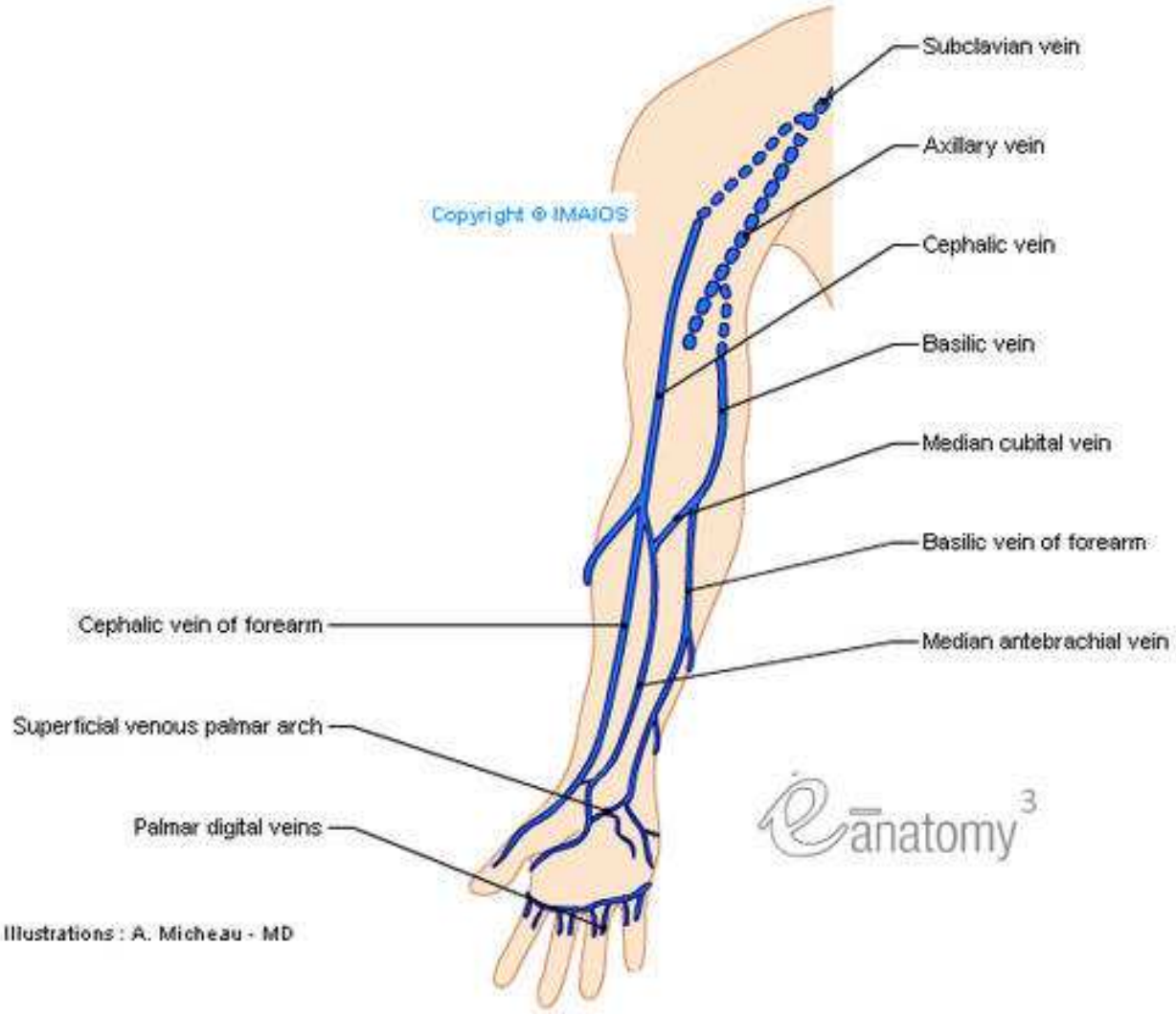




Vein	Region drained	Relationship to deep cervical fasciae
• Internal jugular vein	• Interior of the skull (including the brain)	• Within the carotid sheath
• External jugular vein	• Head (superficial)	• Within the superficial cervical fascia
• Anterior jugular vein	• Neck, portions of the head	• Within the superficial cervical fascia

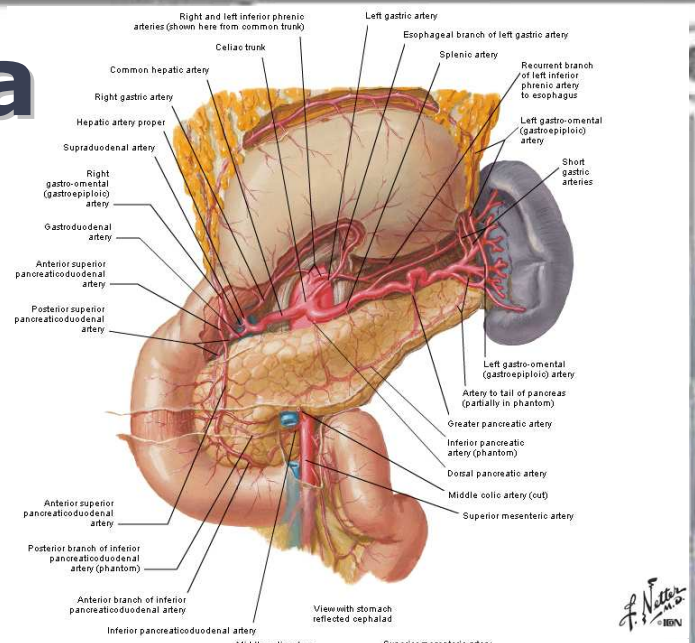
Arteries and veins of the upper limb

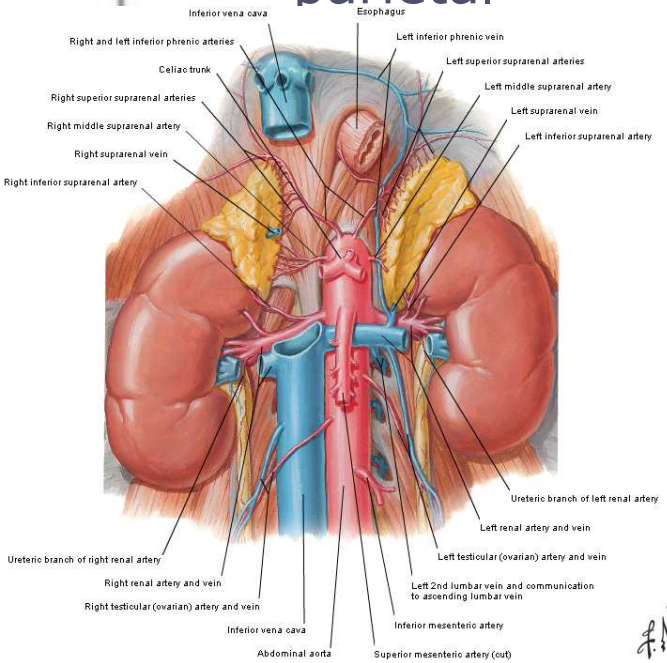


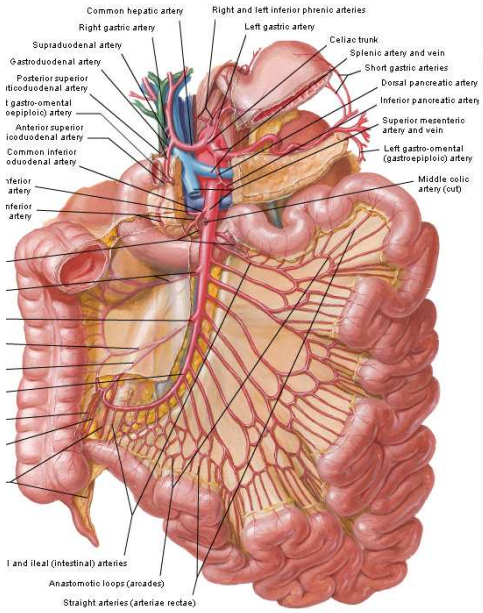


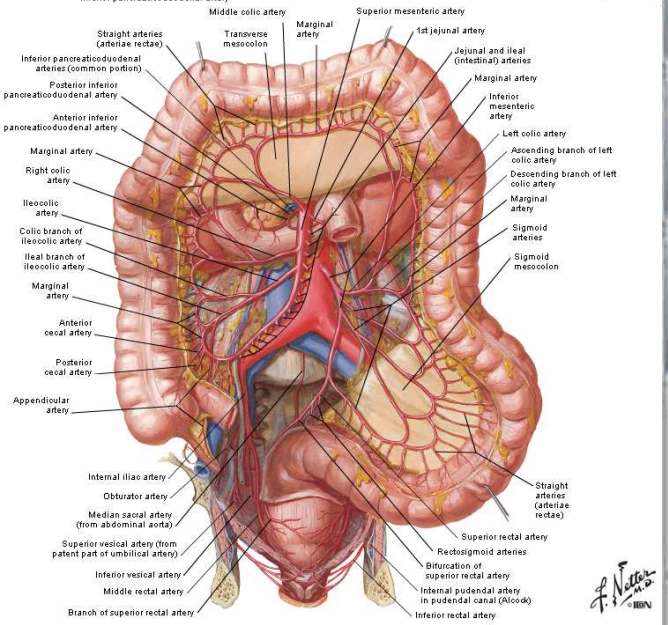
Abdominal aorta

- Unpaired visceral branches:
  - ✓ celiac trunk
  - ✓ superior mesenteric artery
  - ✓ inferior mesenteric artery
- Paired branches:
  - ✓ visceral
    - ➢ renal arteries
    - ➢ gonadal arteries
  - ✓ parietal

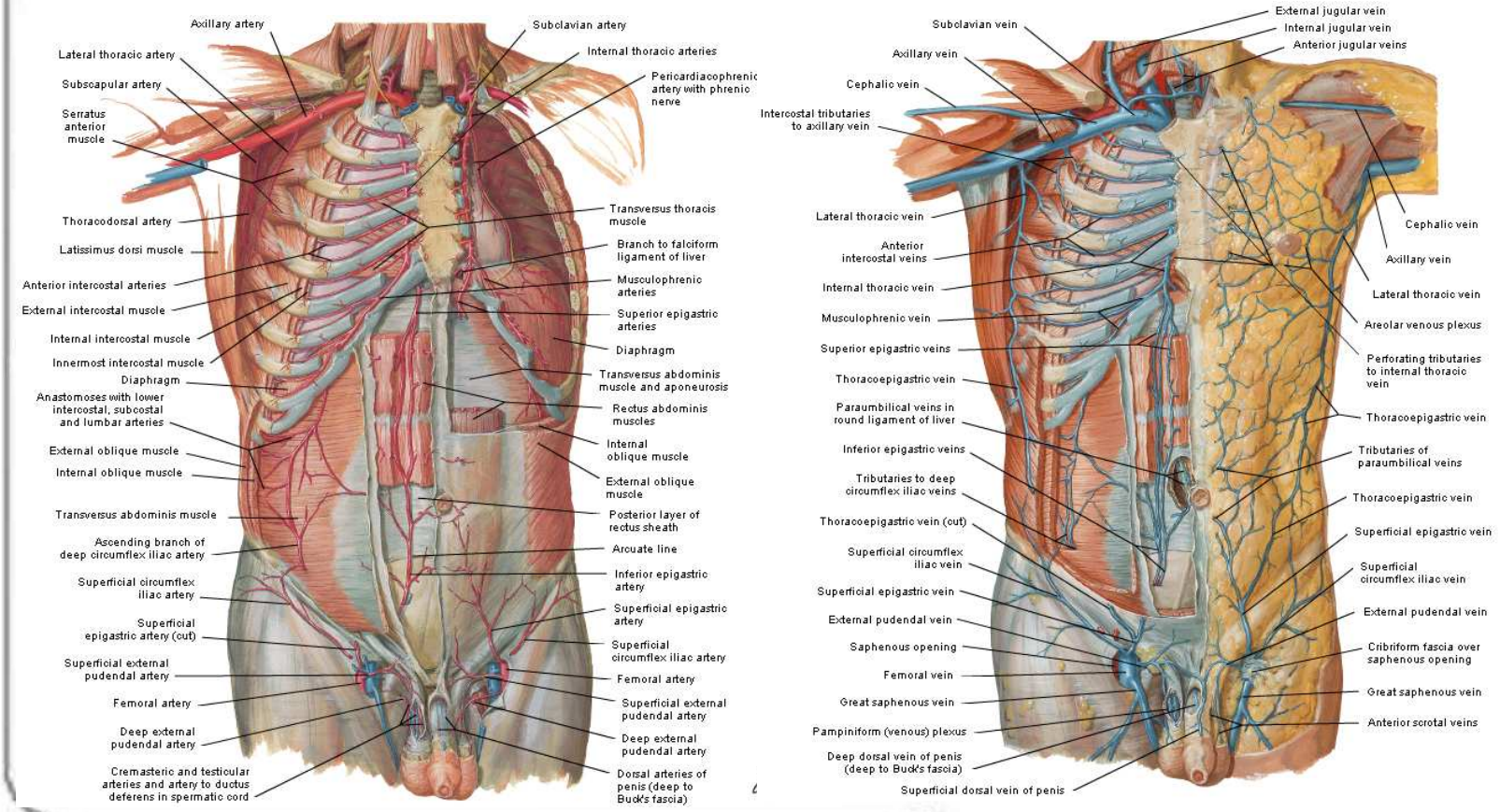






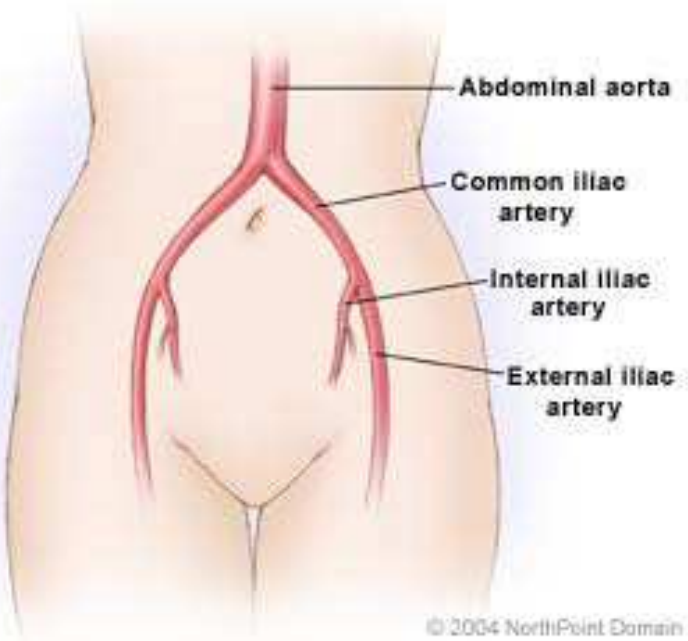


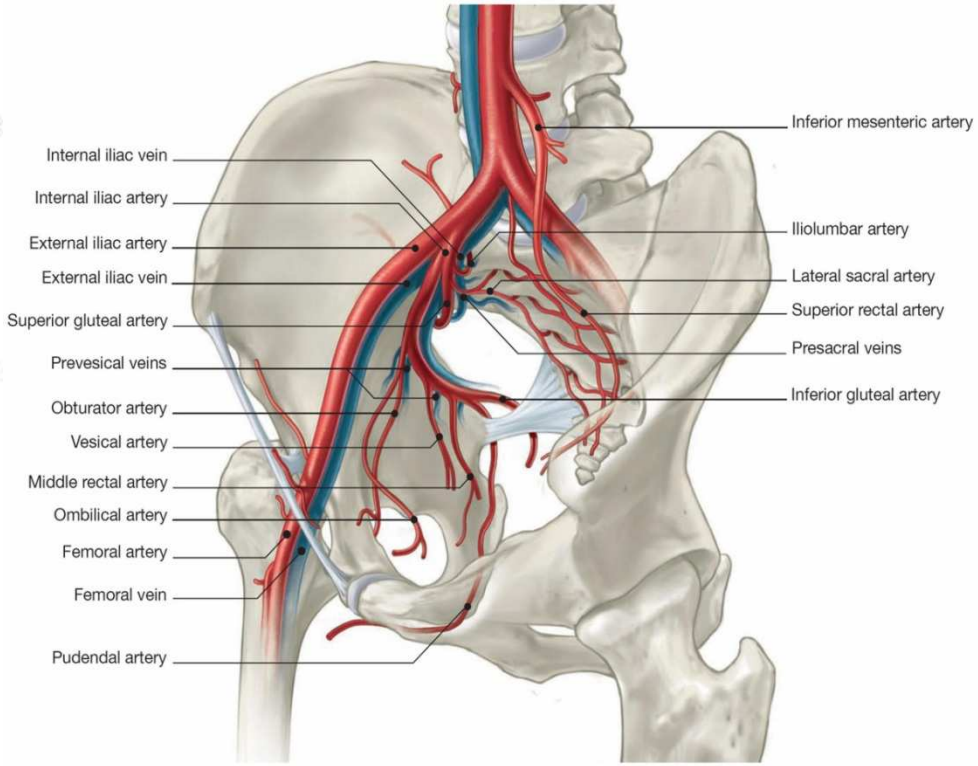
Arteries and veins of anterior abdominal wall



Arteries and veins of the pelvis

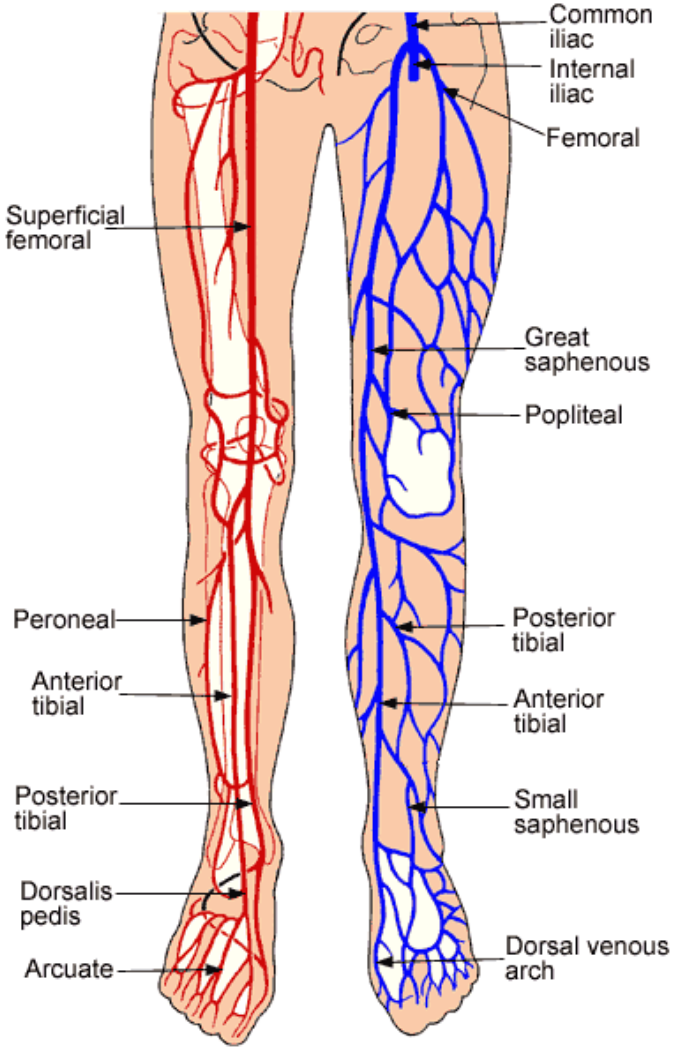
- Common iliac artery:
  - ✓ internal iliac artery
  - ✓ external iliac artery





- Common iliac vein
  - ✓ internal iliac vein
  - ✓ external iliac vein

Arteries and veins of the lower limb



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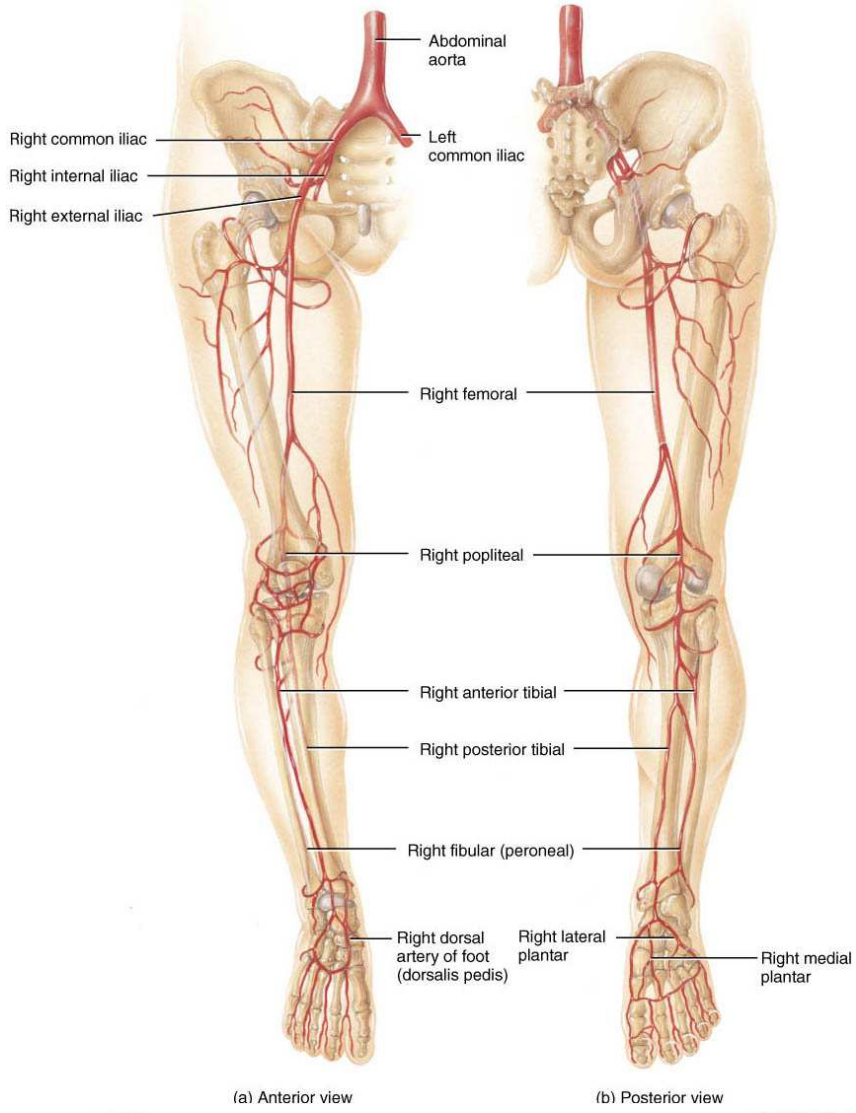
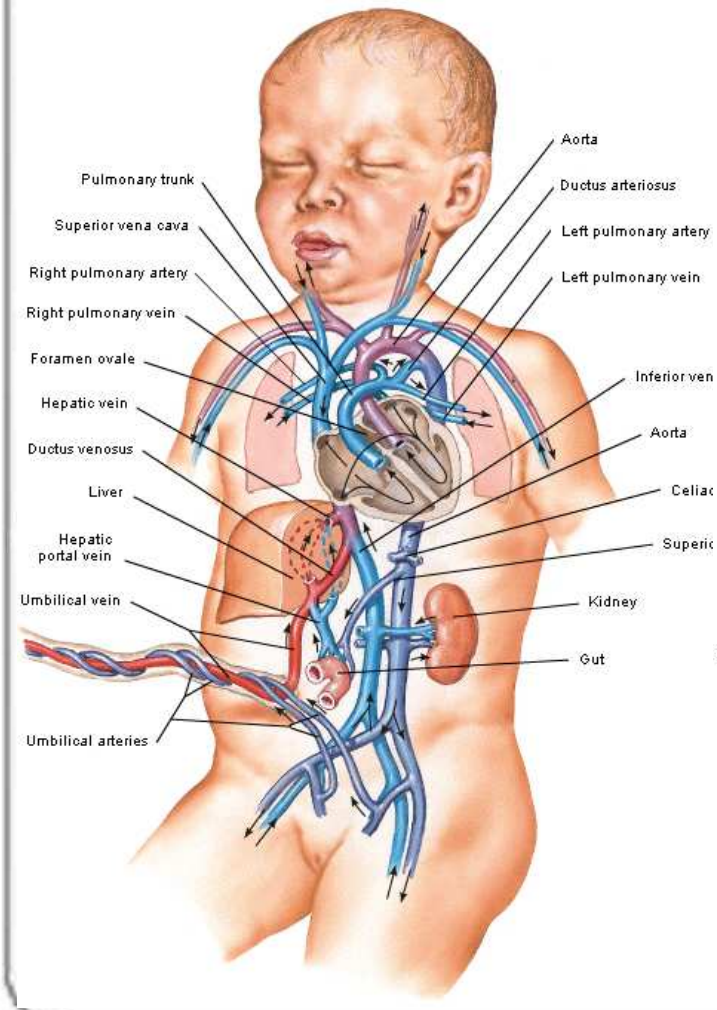
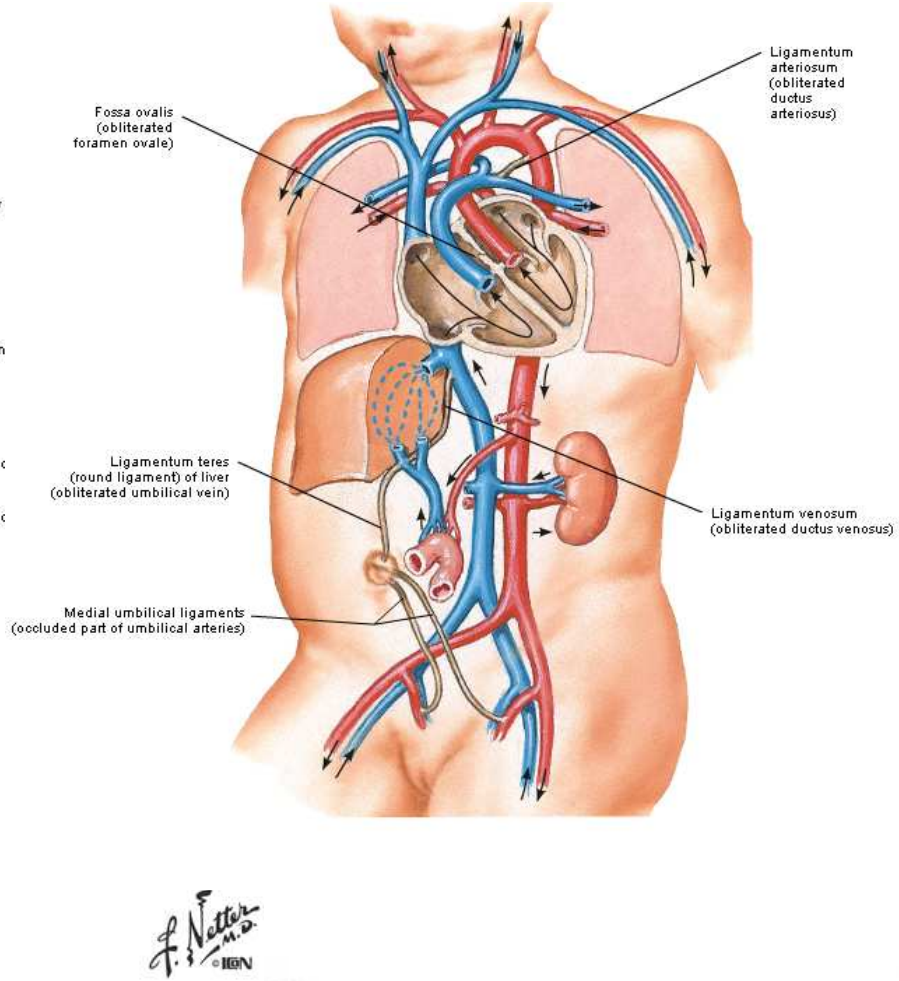


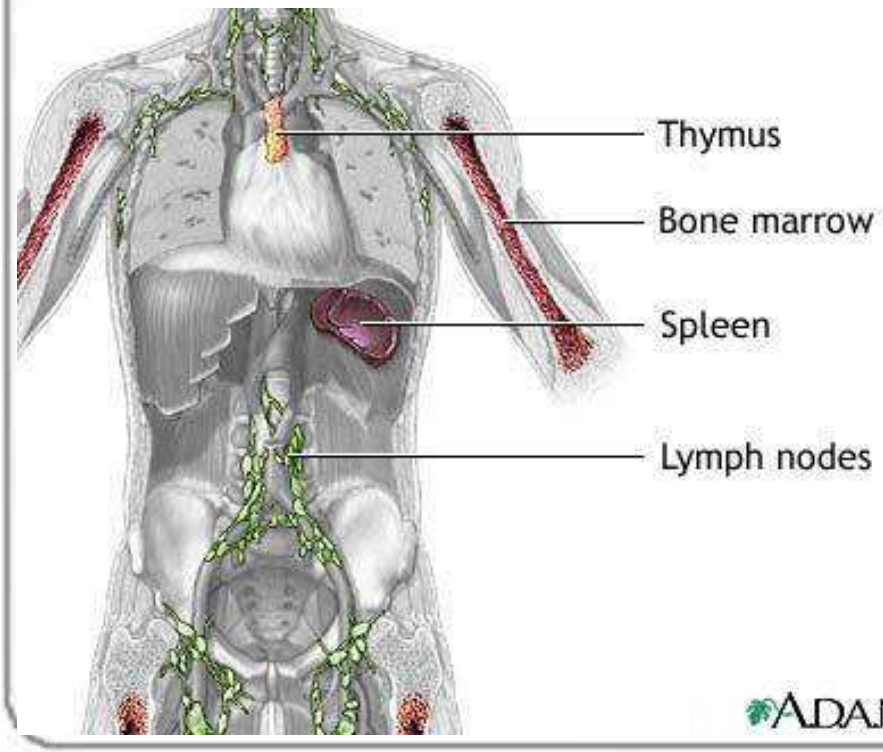
Pre- and postnatal circulation

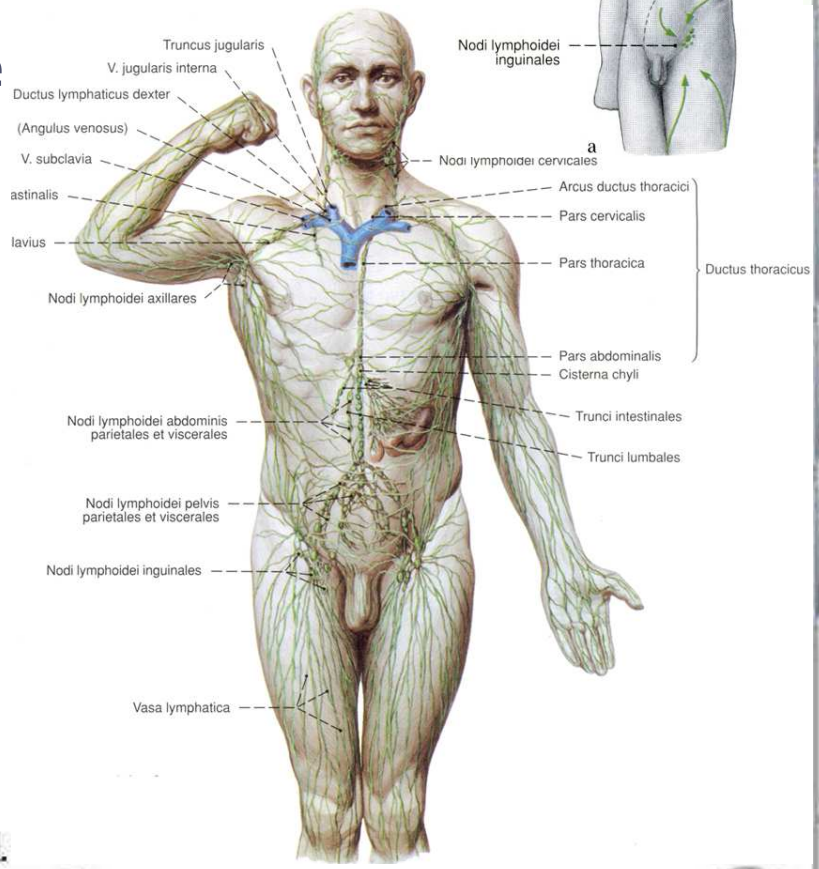


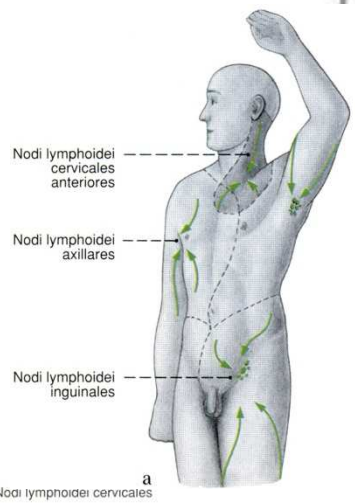


Lymphatic system

- lymph vessels and nodes
- hemopoietic and lymphatic organs
  - ✓ central lymphoid tissue
  - ✓ peripheral lymphoid tissue

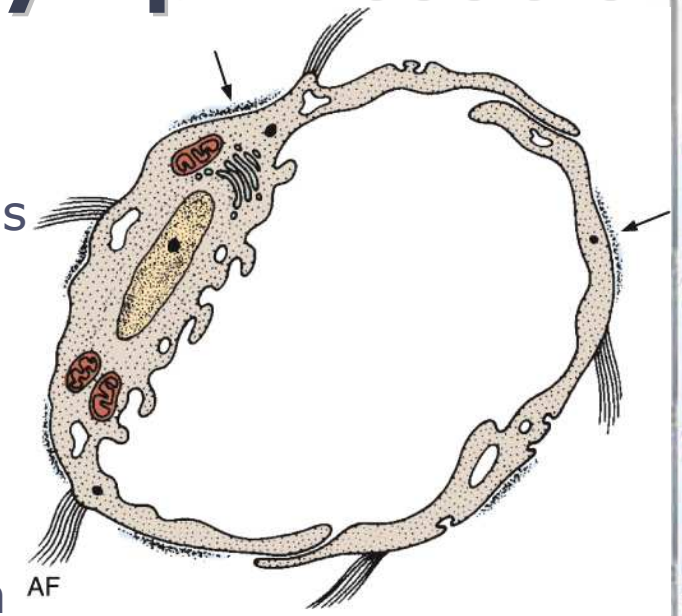


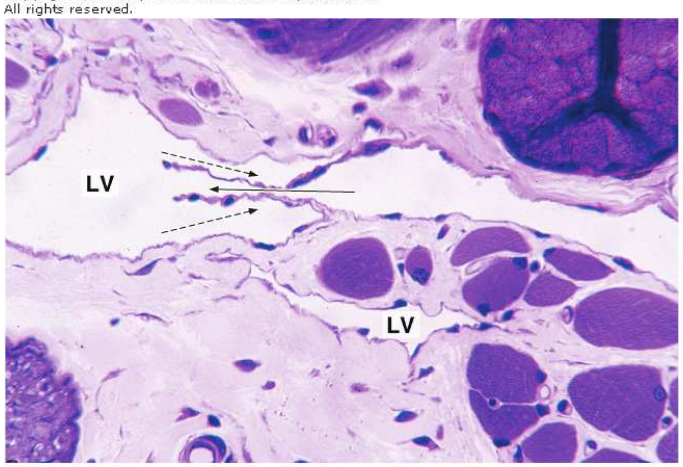




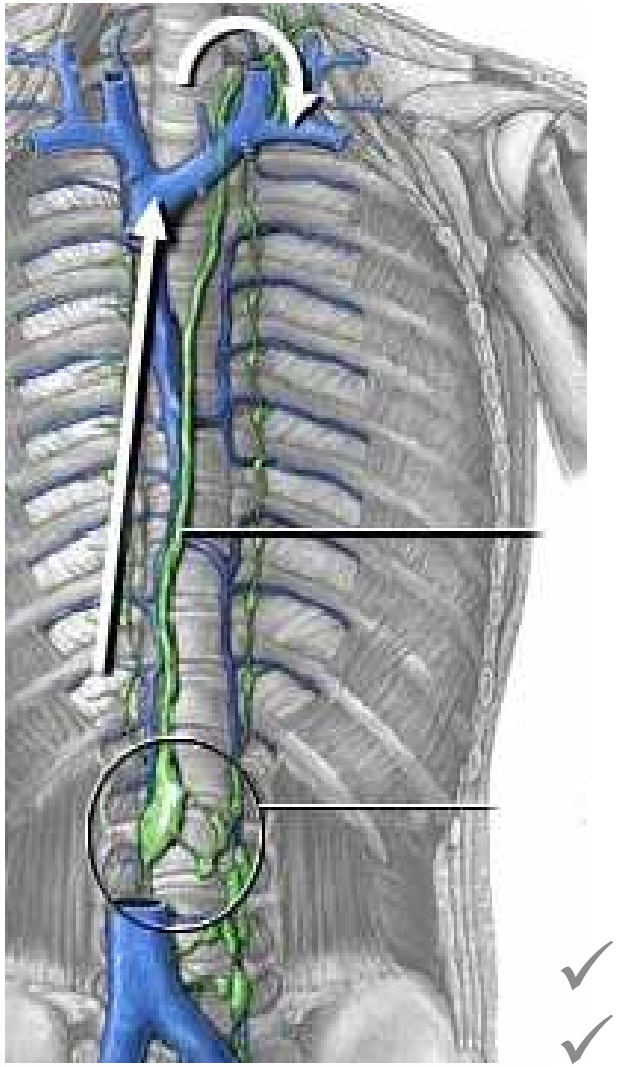
Structural plan of lymph vessels

- Lymphatic capillaries:
  - ✓ single layer of endothelium
  - ✓ incomplete basal lamina, no pericytes
- Small lymphatic vessels:
  - ✓ presence of internal valves
  - ✓ elastic and collagen fibers around the endothelium
  - ✓ single muscle cells
- Large lymphatic vessels >0.2 mm
  - ✓ *tunica intima*
- ➢ endothelium
- ➢ longitudinal elastic fibers
  - ✓ *tunica media*
- ➢ 1-3 layers of muscle cells
  - ✓ *tunica adventitia*
- ➢ collagen and elastic fibers
- ➢ longitudinal muscle cells

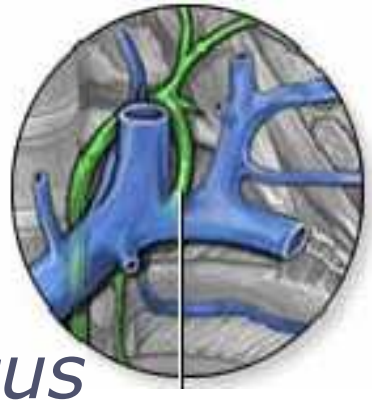




Cisterna chyli



- *angulus venosus sinister*

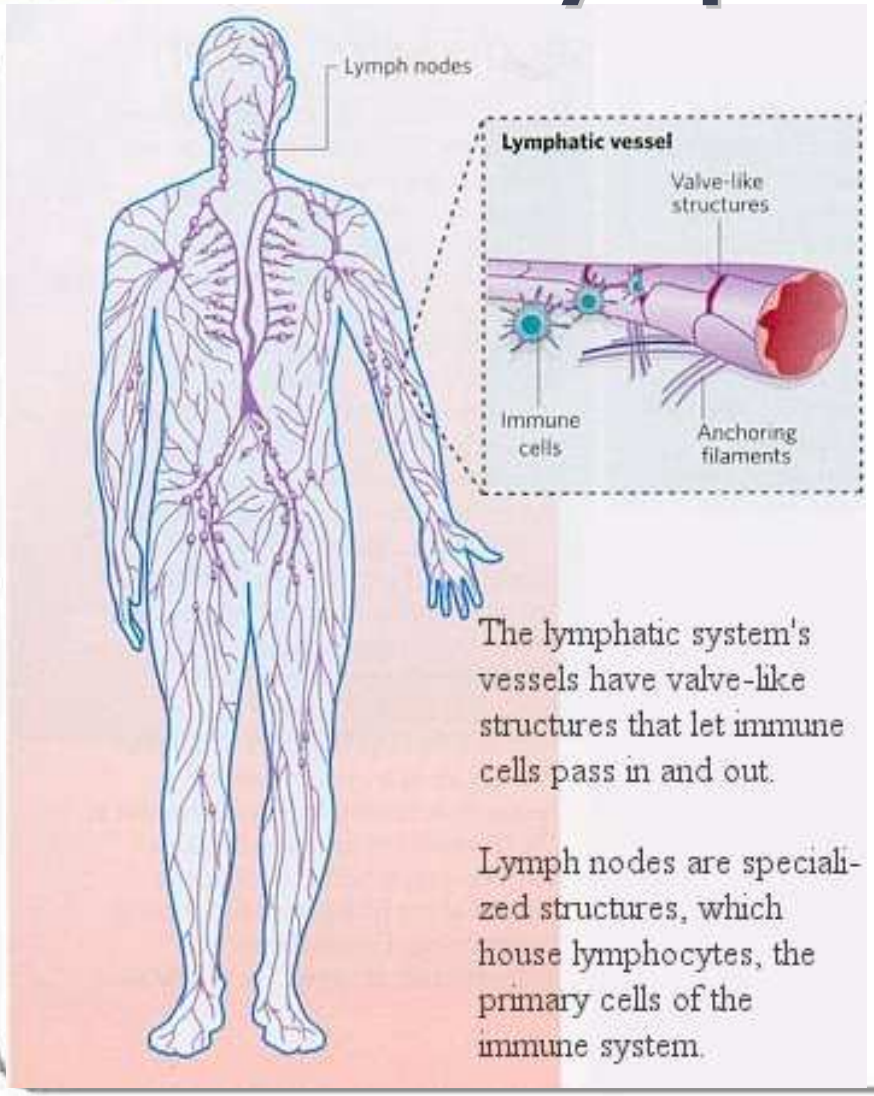


- *ductus thoracicus*

cisterna chyli

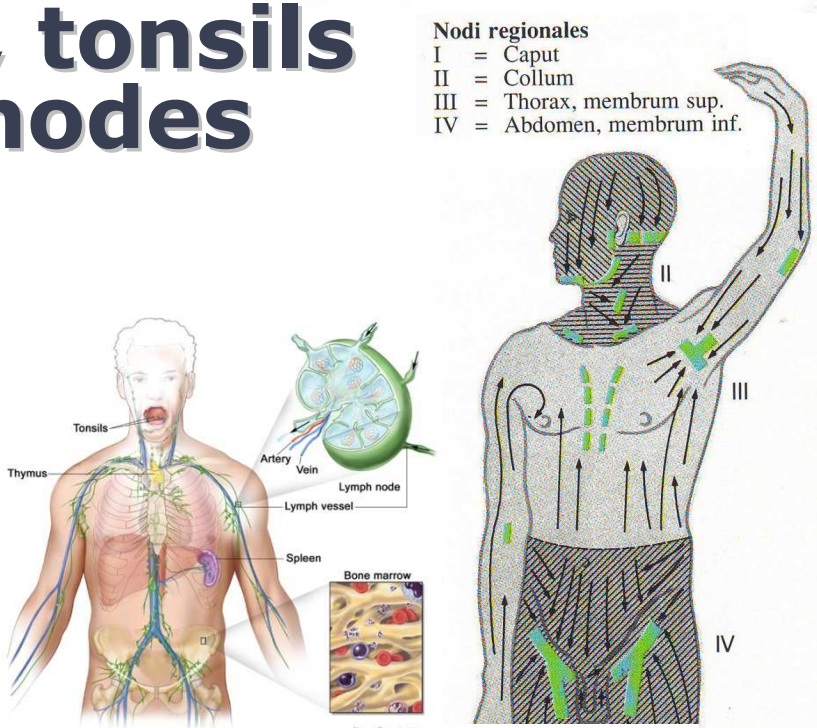
- ✓ *truncus intestinalis*
- ✓ *trunci lumbales*

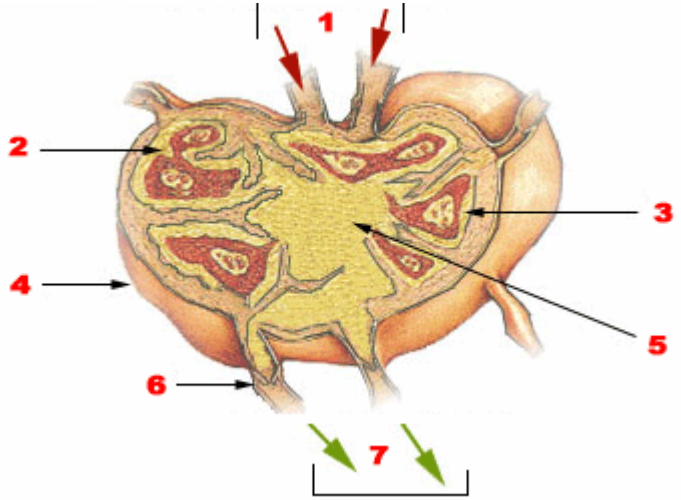
Bone marrow, tonsils and lymph nodes



The lymphatic system's vessels have valve-like structures that let immune cells pass in and out.

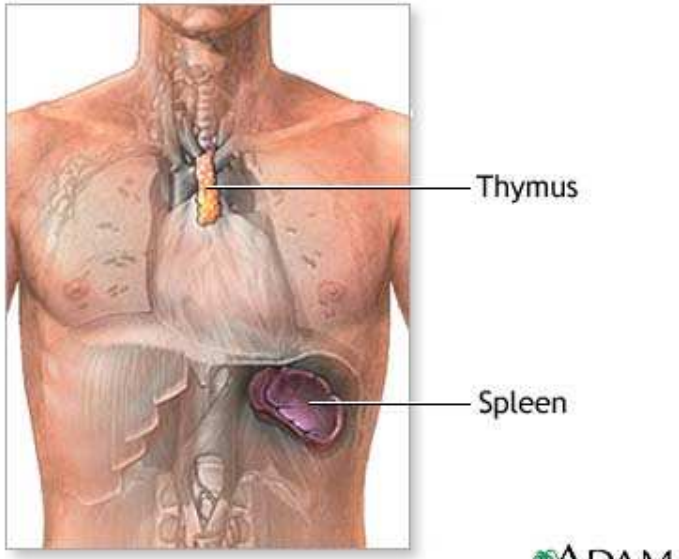
Lymph nodes are specialized structures, which house lymphocytes, the primary cells of the immune system.

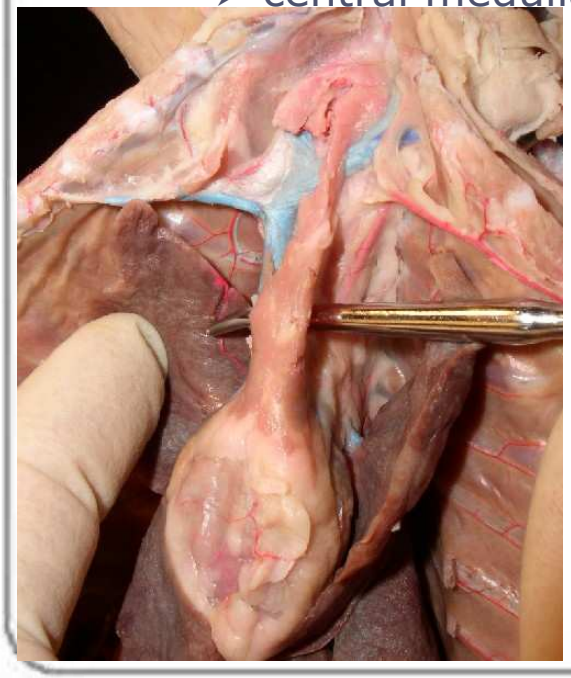


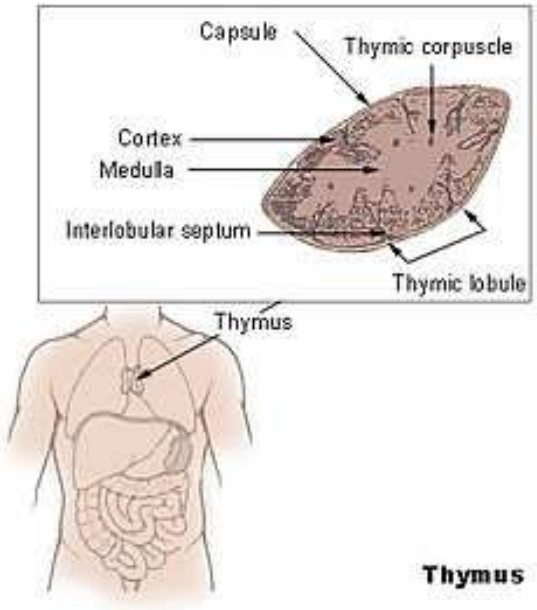


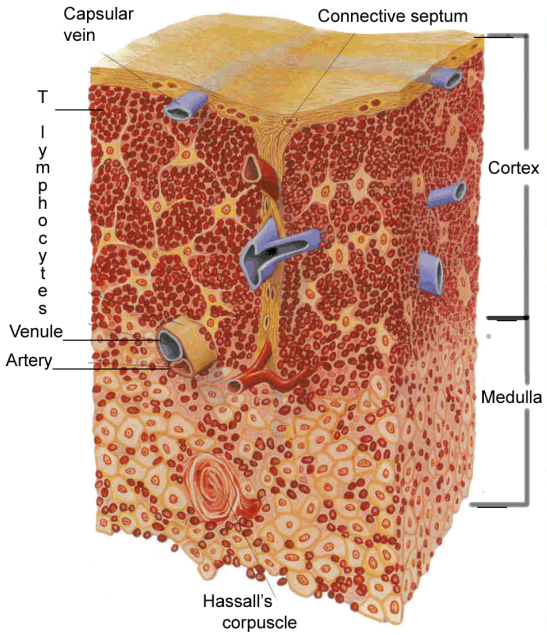
Thymus

- Thymus – an lymphoid organ
  - ✓ in anterior mediastinum, behind sternum
  - ✓ maximum weight at puberty
  - ✓ cell-mediated immunological functions – differentiation of T-lymphocytes
  - ✓ two parts – epithelial cells and lymphocytes:
    - ➢ peripheral cortex
    - ➢ central medulla



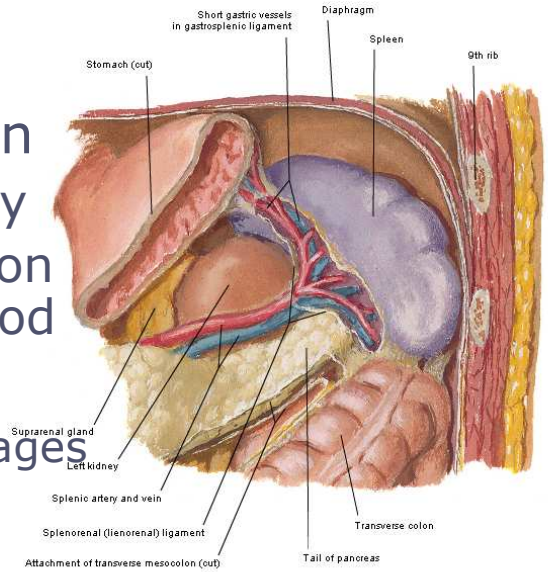


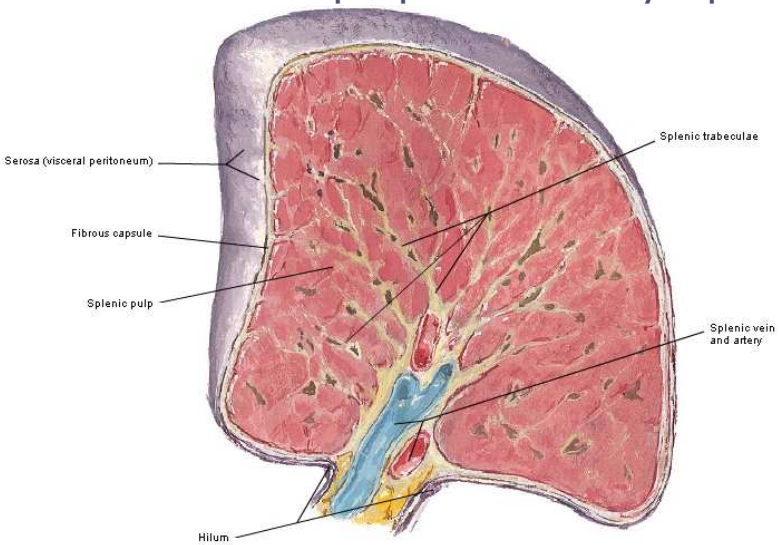


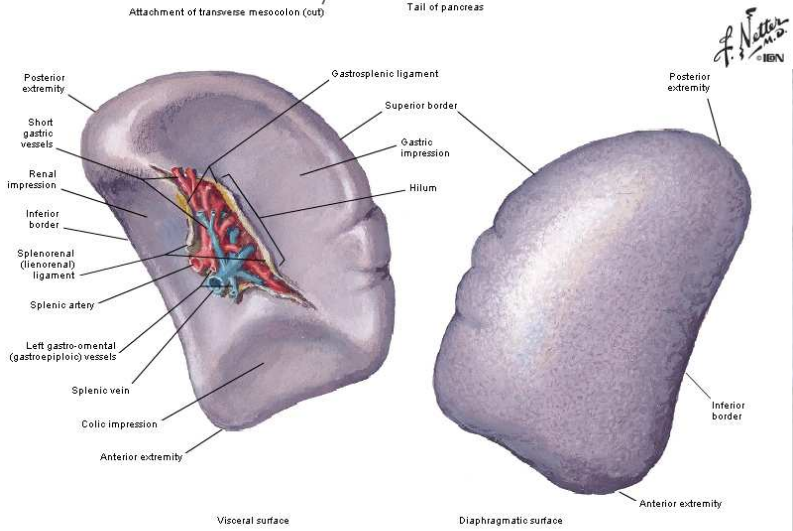


Spleen

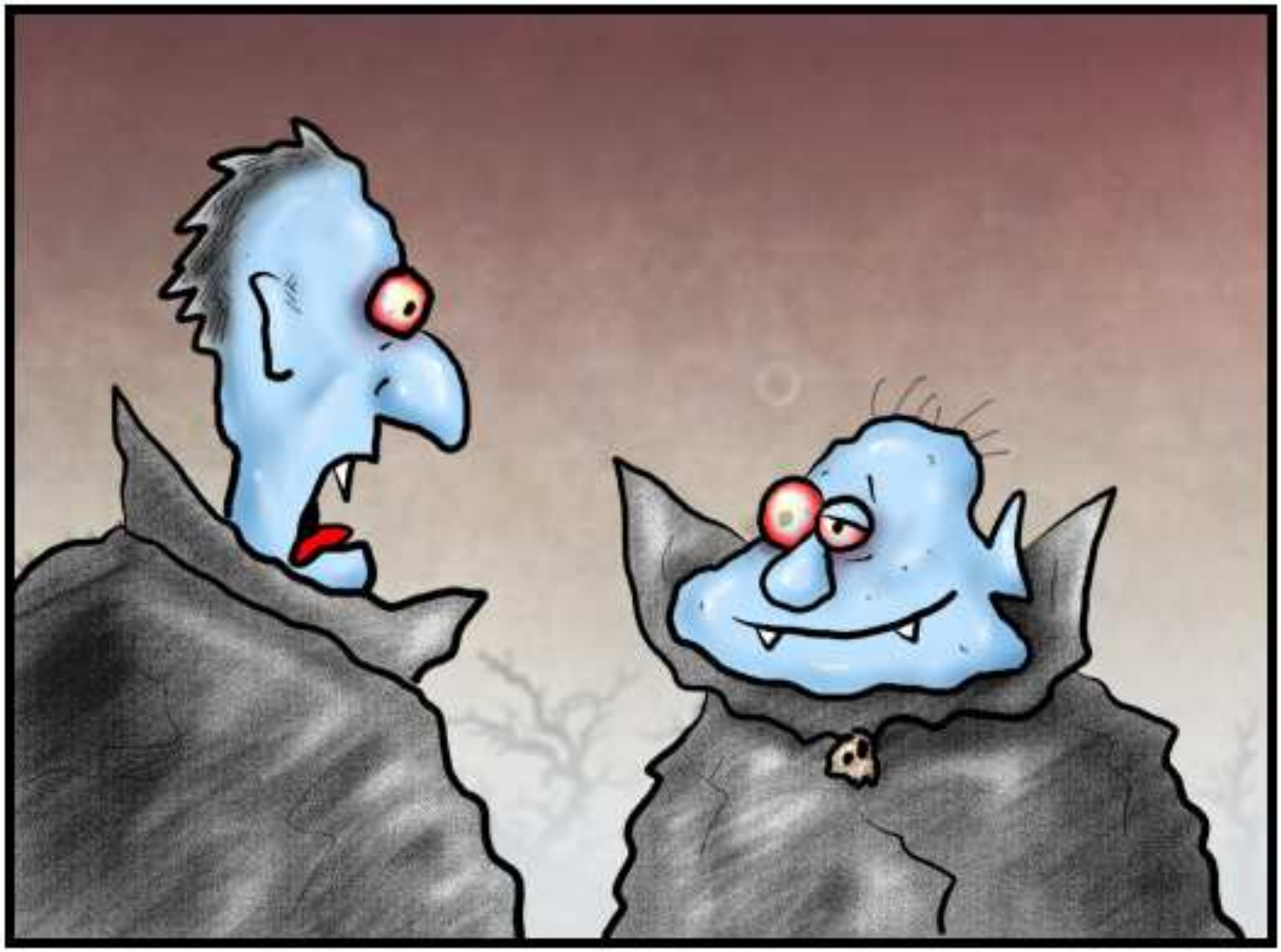
- Spleen – the largest lymphoid organ
  - ✓ in left upper part of abdominal cavity
  - ✓ immunological protection, destruction of Er&thrombocytes, reservoir of blood
  - ✓ two types of tissue:
    - ➢ red pulp – erythrocytes and macrophages
    - ➢ white pulp – stores lymphocytes







Doctor Fun



"For the last time - there's no major blood vessel in the buttocks!"

Thank you ...

Prof. Dr. Nikolai Lazarov