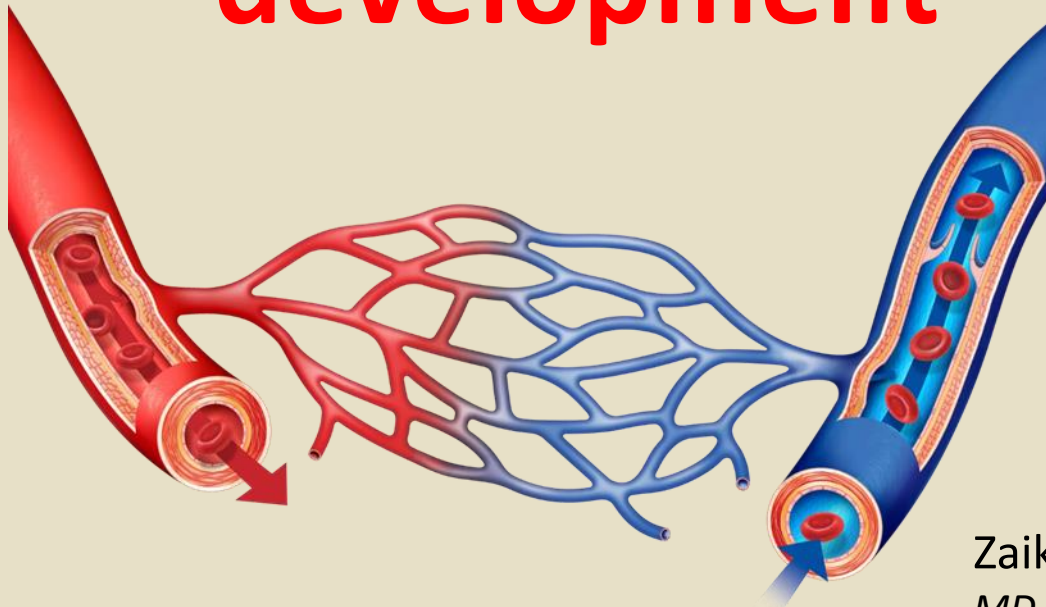


KAZAN FEDERAL (VOLGA REGION) UNIVERSITY  
INSTITUTE OF FUNDAMENTAL MEDICINE AND BIOLOGY  
DEPARTMENT OF MORPHOLOGY AND GENERAL PATHOLOGY

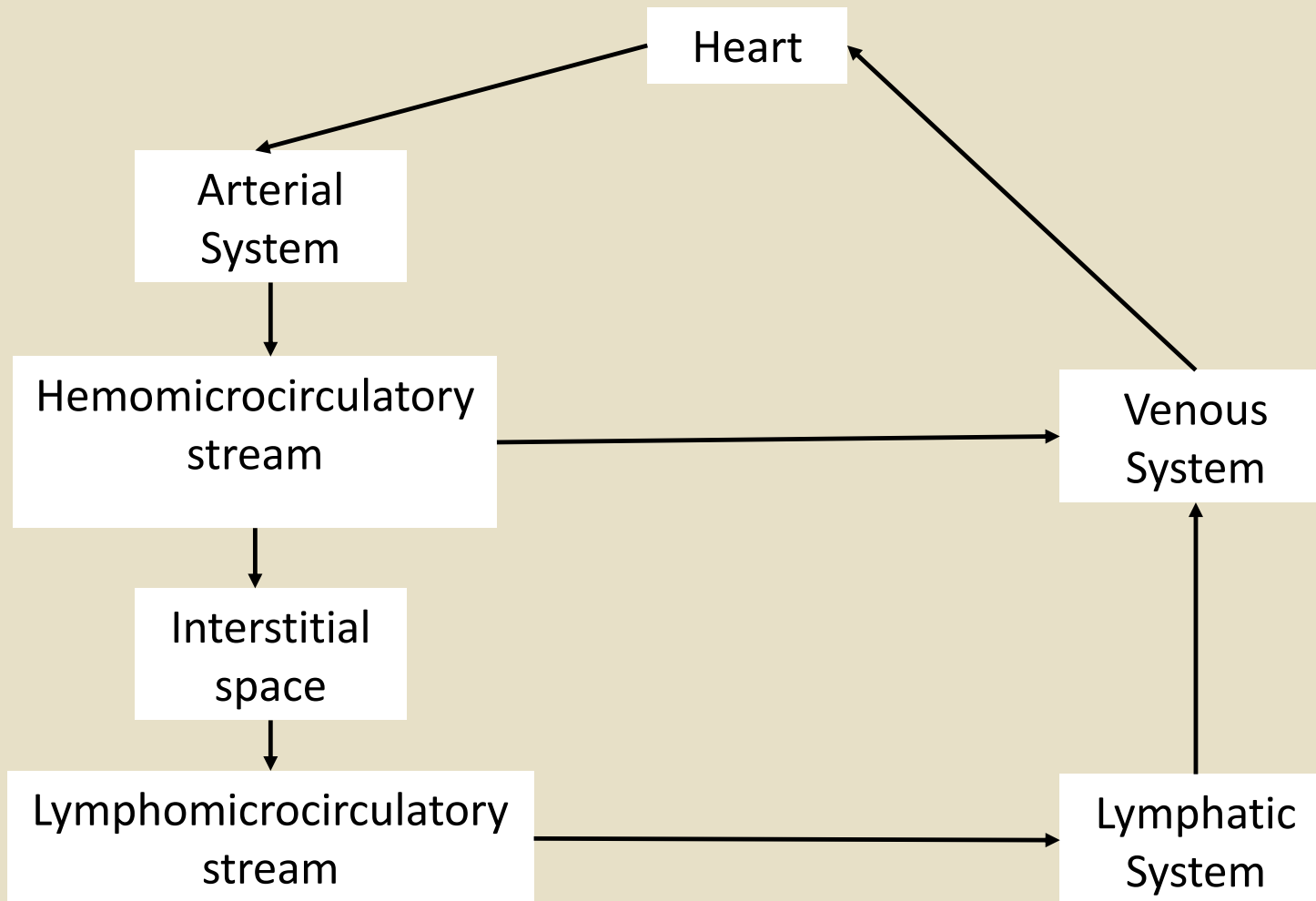
Lecture 5

# Blood vessels development



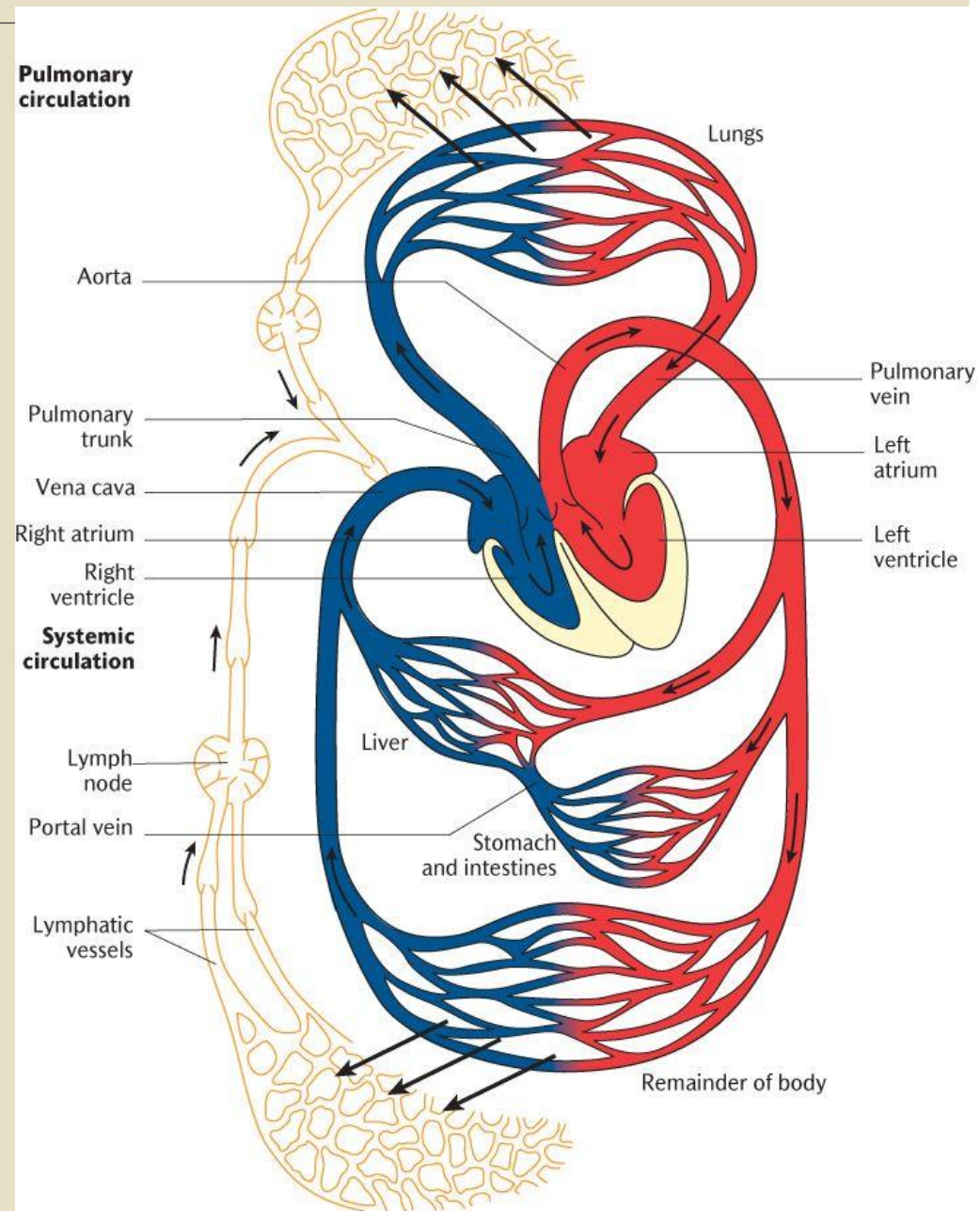
Zaikina Elvira Ildarovna,  
MD, PhD, Senior lecturer

# Cardiovascular System



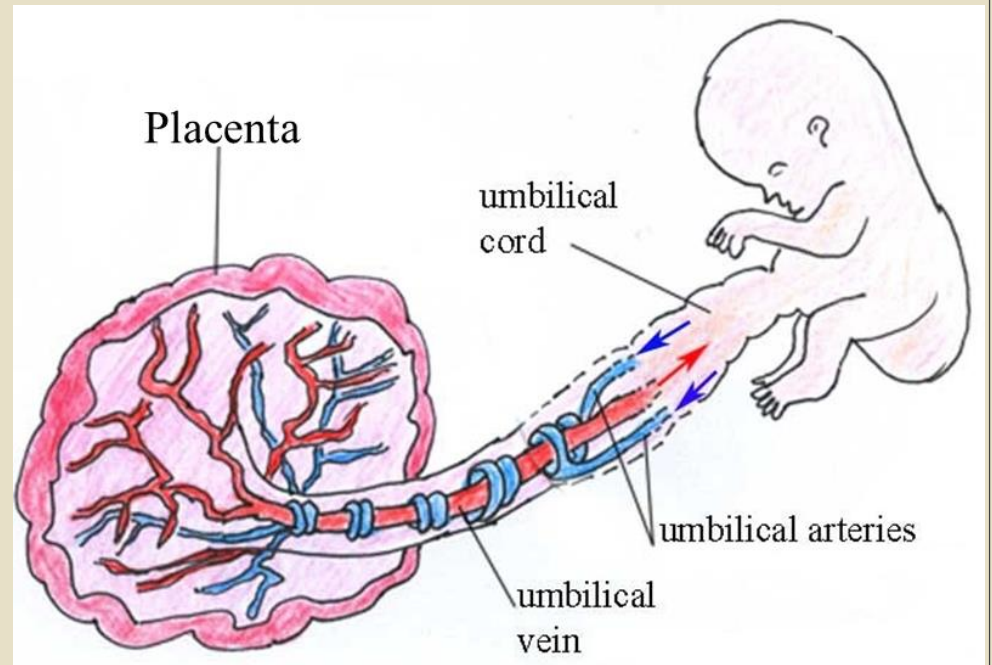
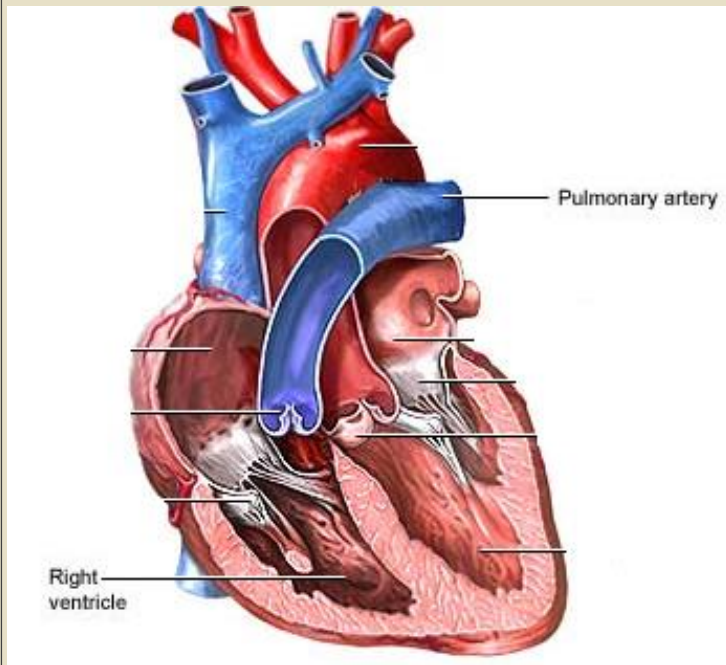
# Arteries

- Arteries of pulmonary circulation
- Arteries of systemic circulation
- Arteries of the heart



# Arteries

blood vessels that carry **blood** (most often **arterial blood**)  
from heart ventricle to organs and tissues.



## Exceptions:

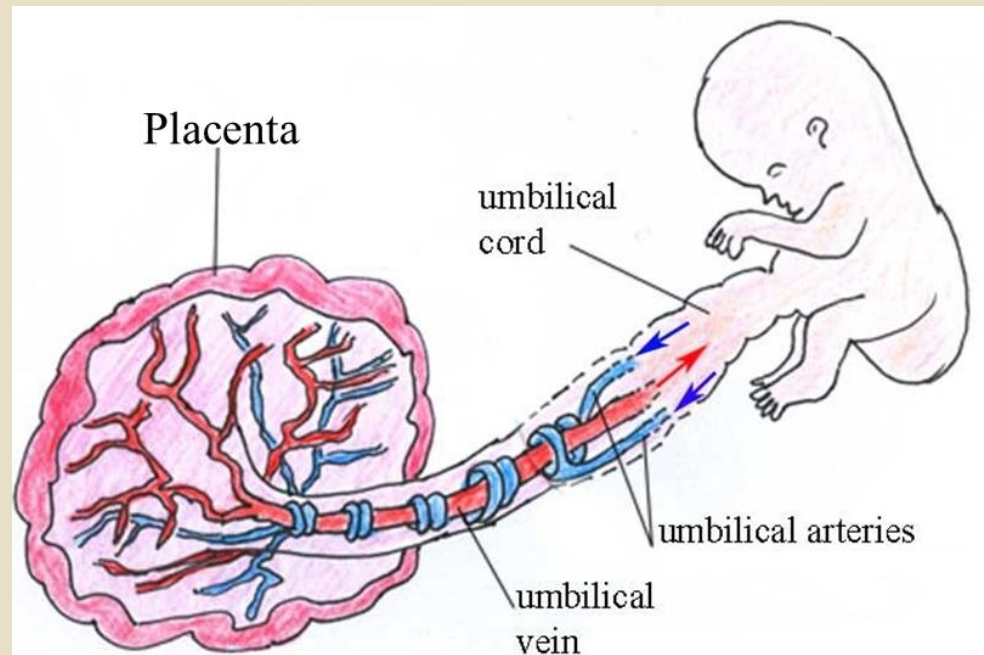
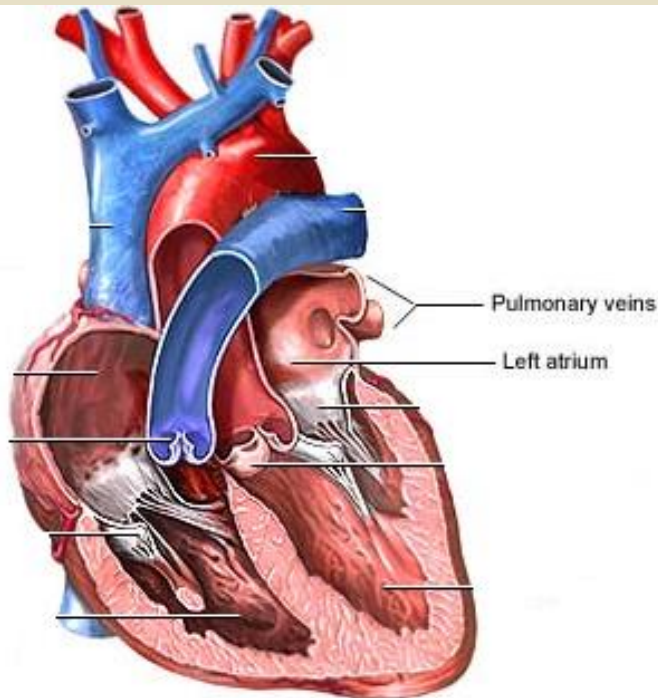
- 1) **Pulmonary arteries** – conduct **venous blood** from right ventricle to lungs
- 2) **Umbilical arteries** – conduct **venous blood** from fetus to placenta

# Veins

blood vessels that carry **blood** (most often **venous blood**)  
from organs and tissues to heart atrium

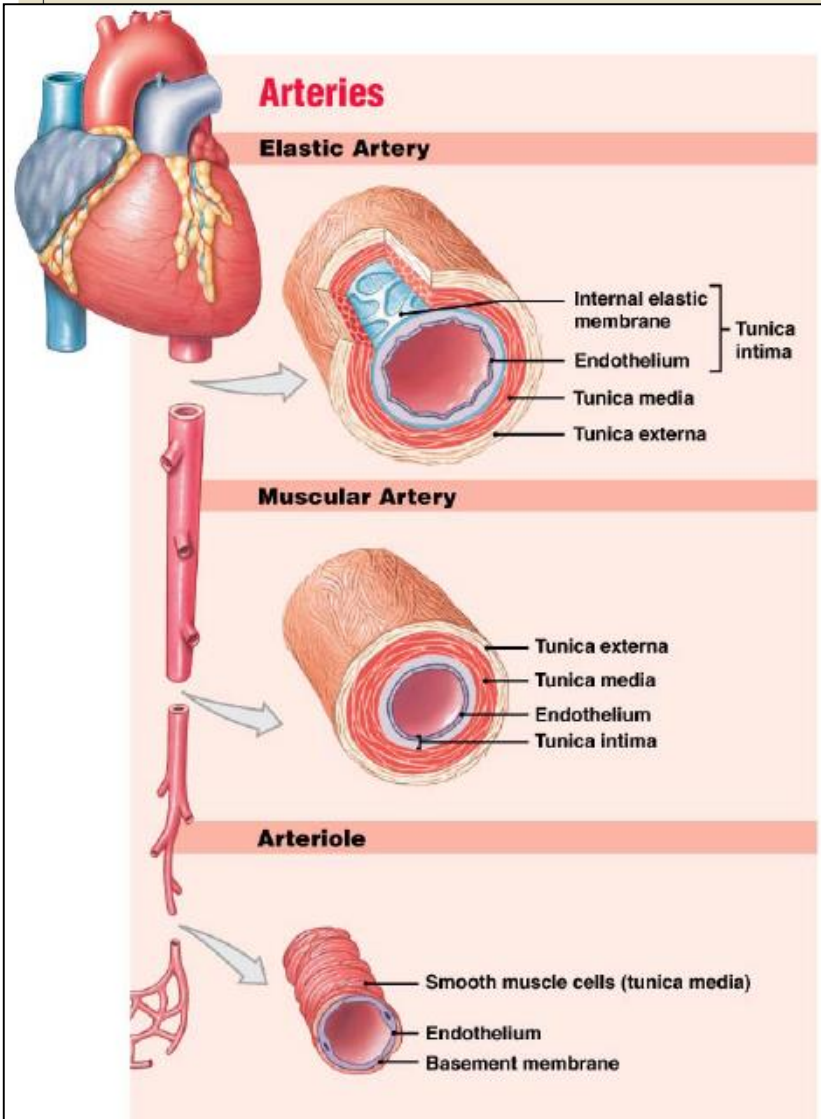
## Exceptions:

- 1) **Pulmonary veins** – conduct arterial blood from lungs to left atrium
- 2) **Umbilical veins** – conduct arterial blood from placenta to fetus



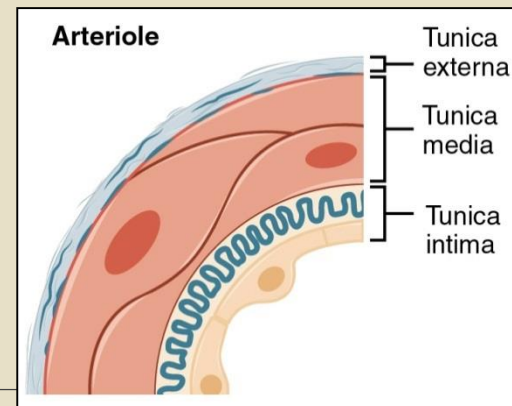
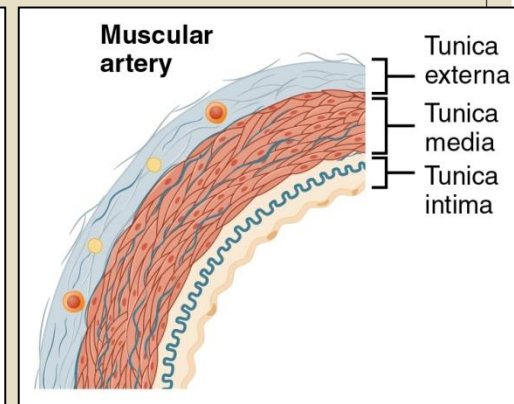
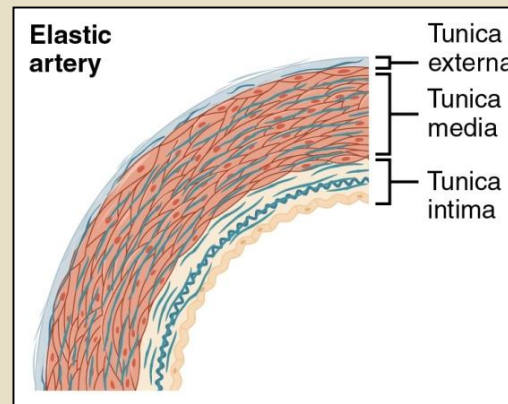


# Arteries

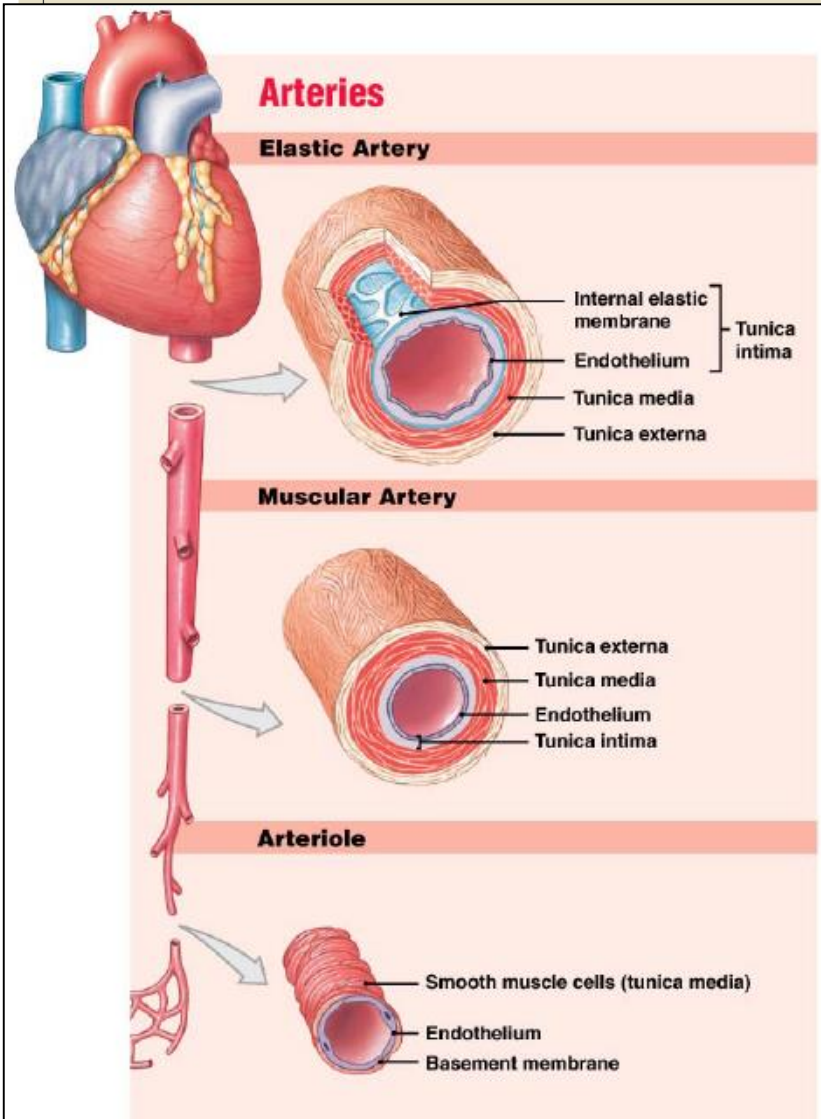


Types of arteries (wall anatomy):

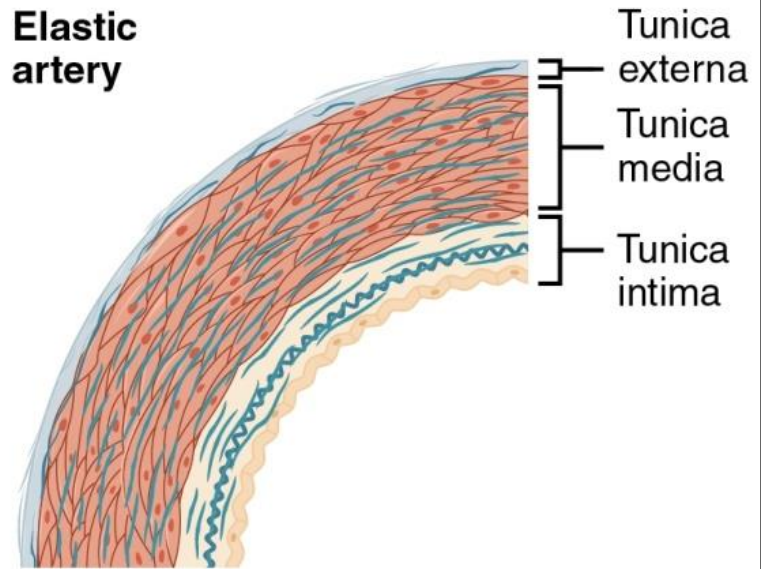
- Elastic
- Muscular
- Combined (mixed)



# Arteries

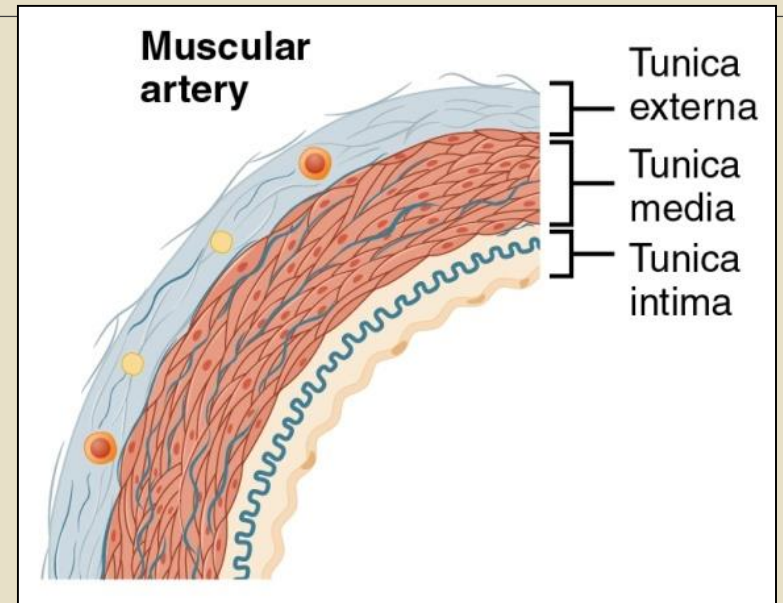
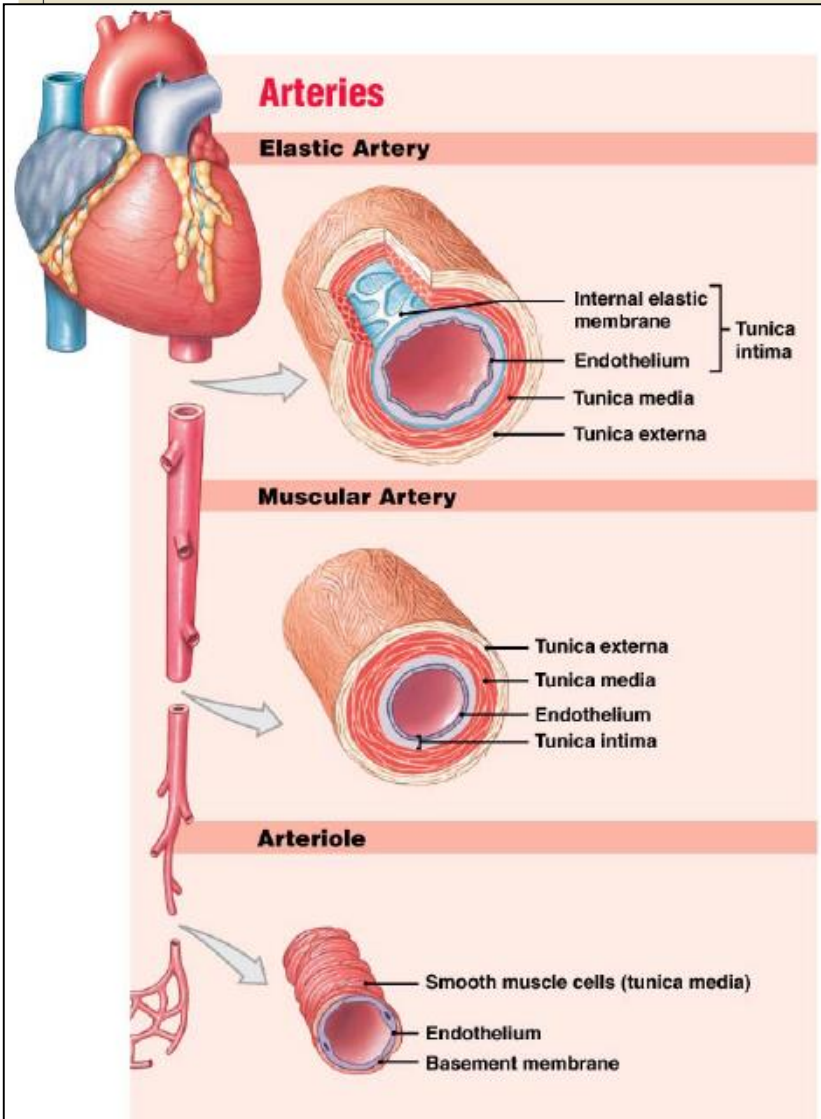


## Elastic artery



- **Elastic arteries**- large thick walled, aorta and its branches
  - has elastin in all tunics, especially tunica media
  - has “pressure smoothing effect”

# Arteries



- **Muscular arteries-** most of the arteries
  - thickest media - more smooth muscle
  - active in vasoconstriction



# Arterioles

- 3mm-10 $\mu$ m diameter of lumen
- blood flow to capillaries is determined by diameter of arterioles

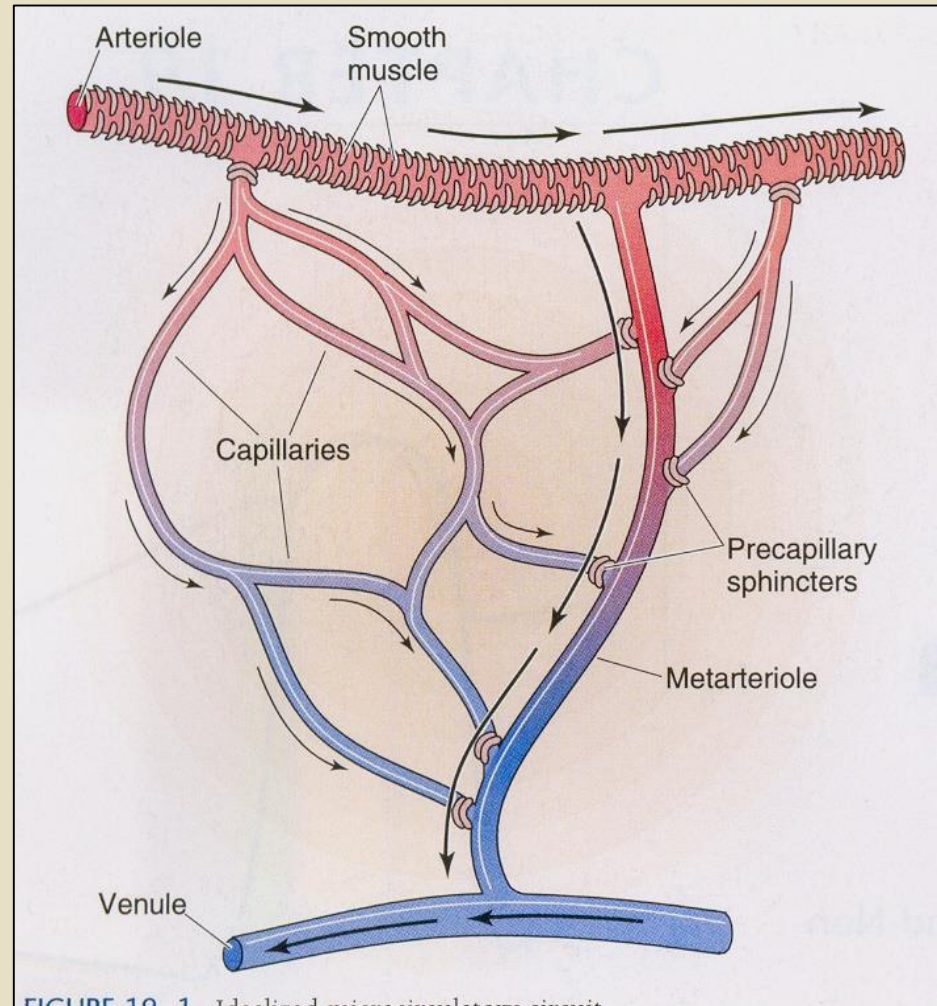
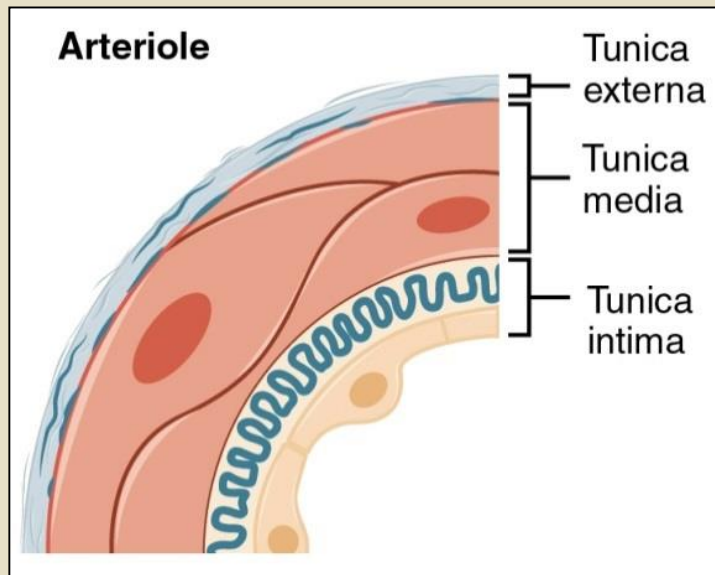
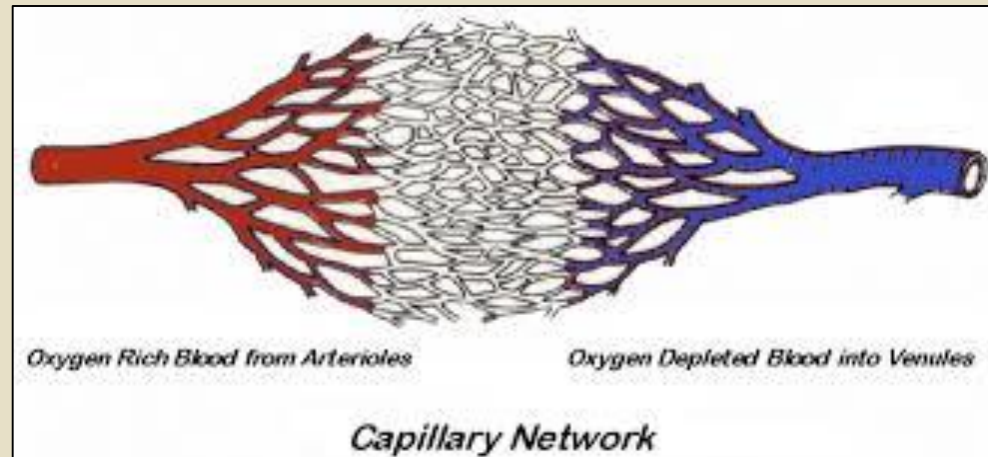
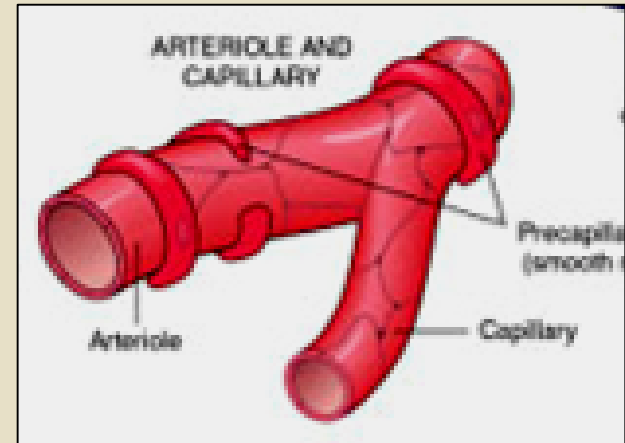


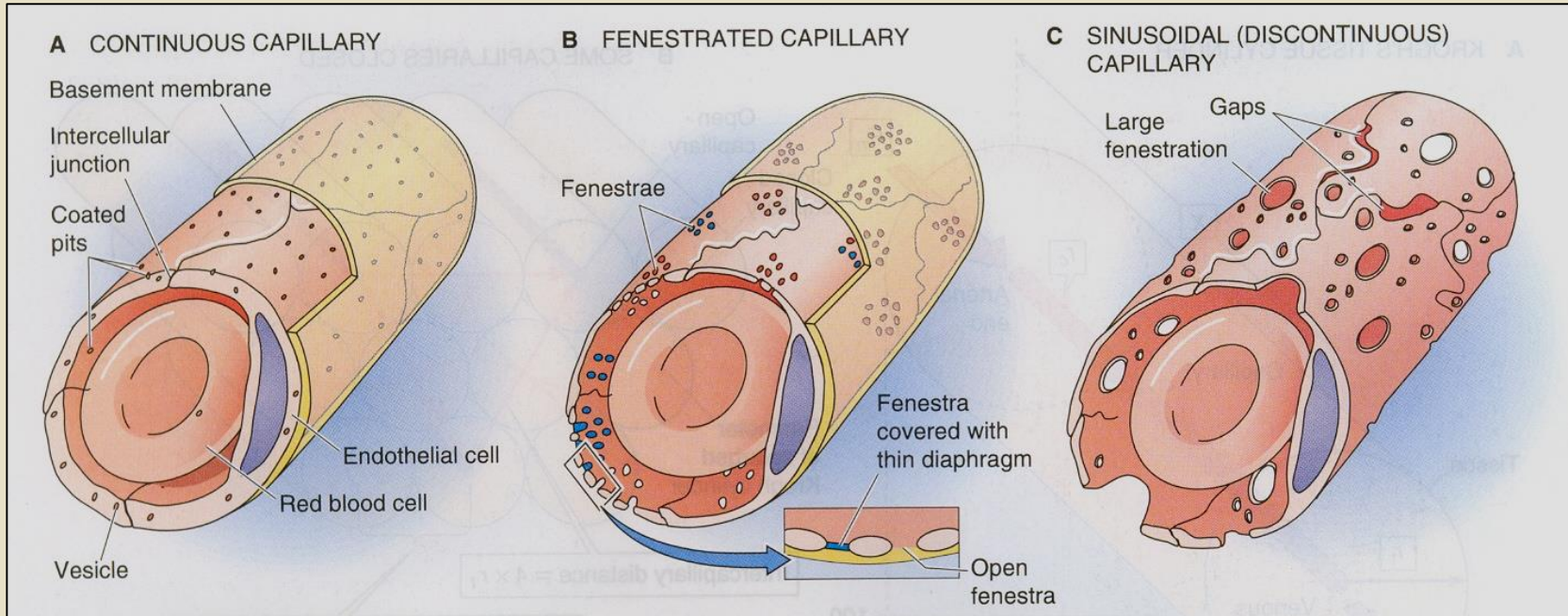
FIGURE 19-1 Idealized microcirculatory circuit

# CAPILLARIES

- smallest 1mm long x 8-10 $\mu$ m diameter
- tunica intima only - endothelium
- exchange of gases, nutrients with interstitial fluid



# Types of Capillaries



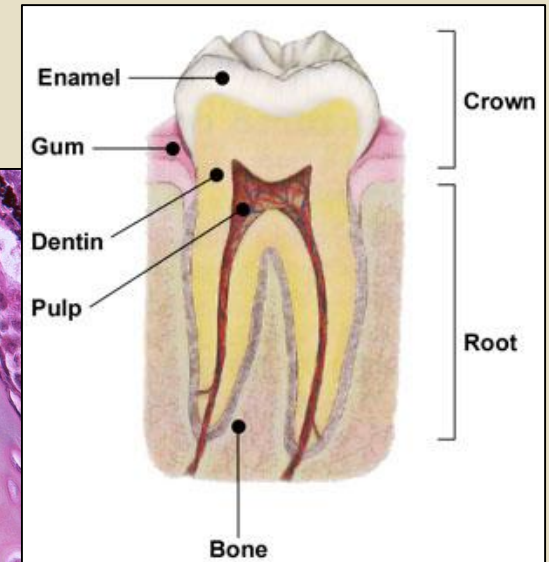
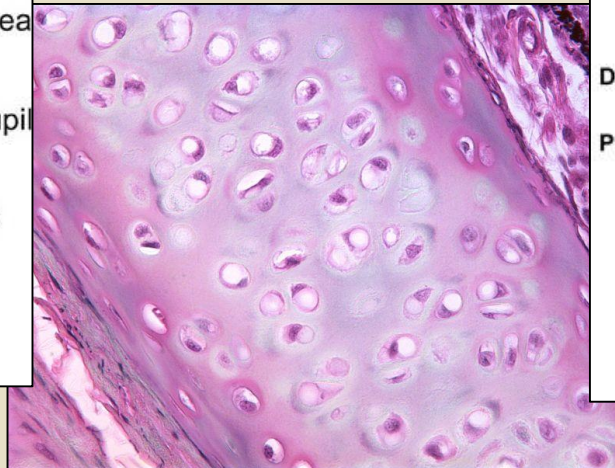
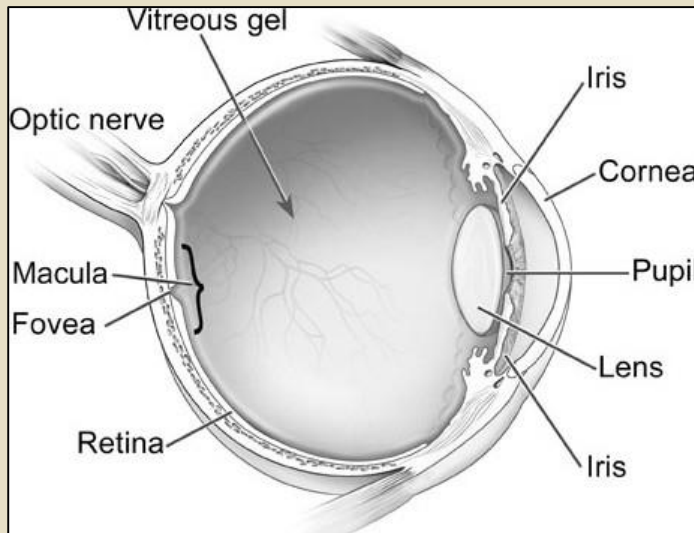
- **Continuous** - one endothelial cell wraps all around ends joined by tight junctions (brain)
- **Fenestrated** have windows very permeable to fluids and solutes
- **Sinusoidal** - modified, very leaky



# Tissues without vessels

- transparent tissues of the eye (cornea, corpus vitreum, lens)
- cartilage
- epithelium
- endothelium
- dentin and enamel

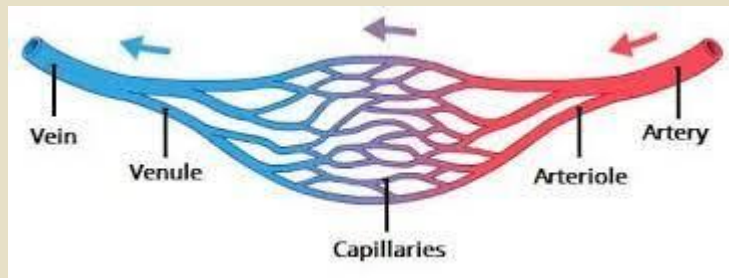
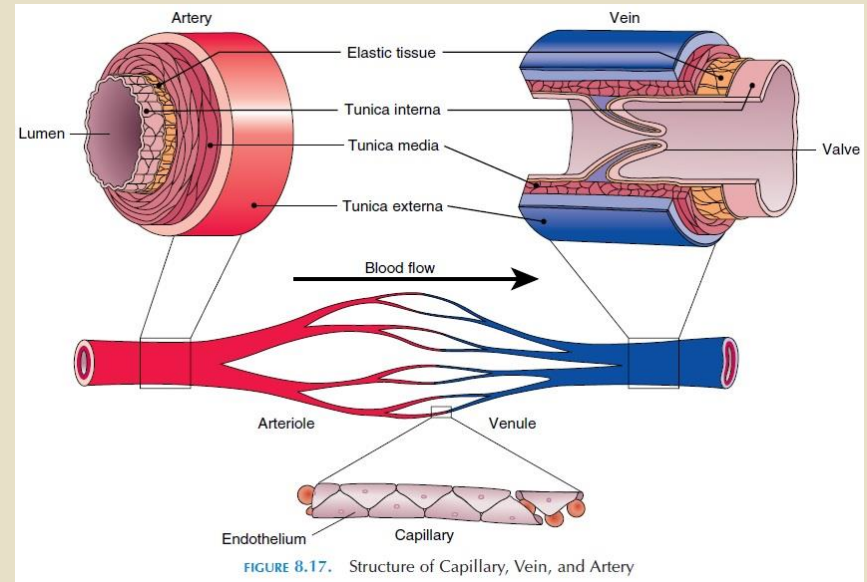
They are tolerant and can be transplanted without risk of rejection



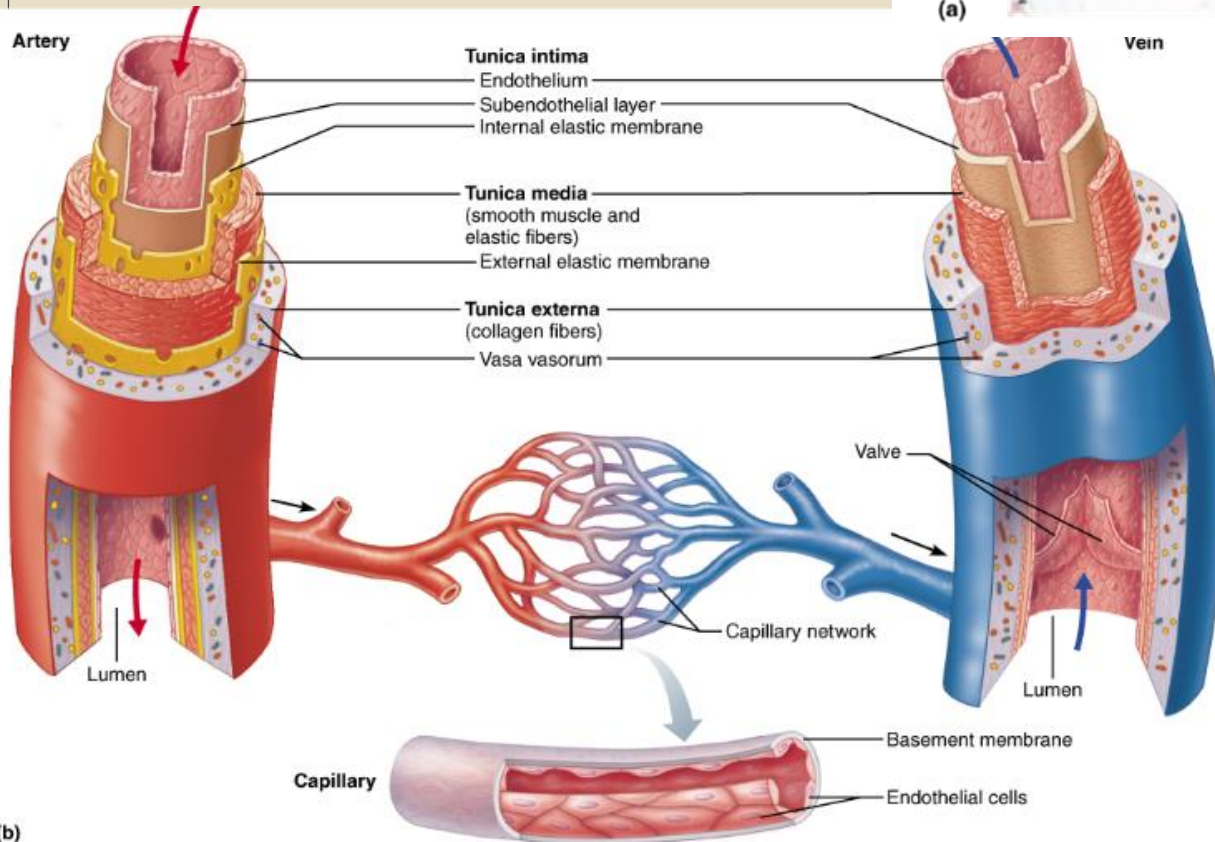
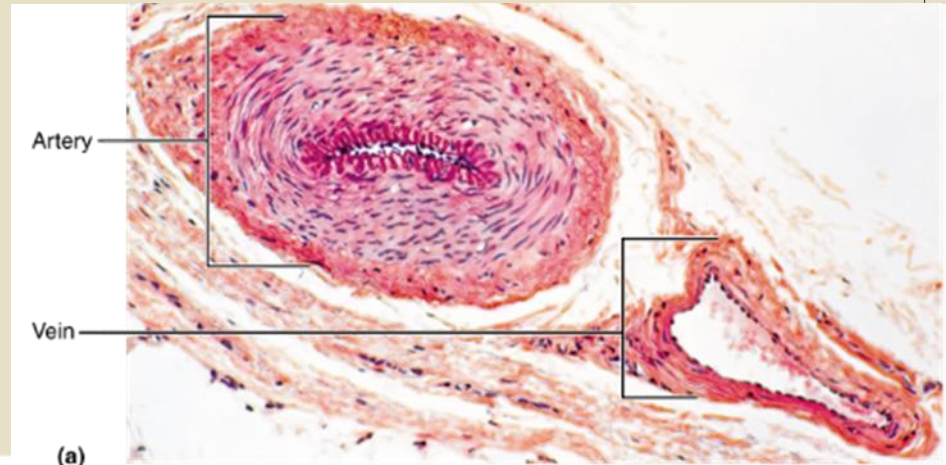


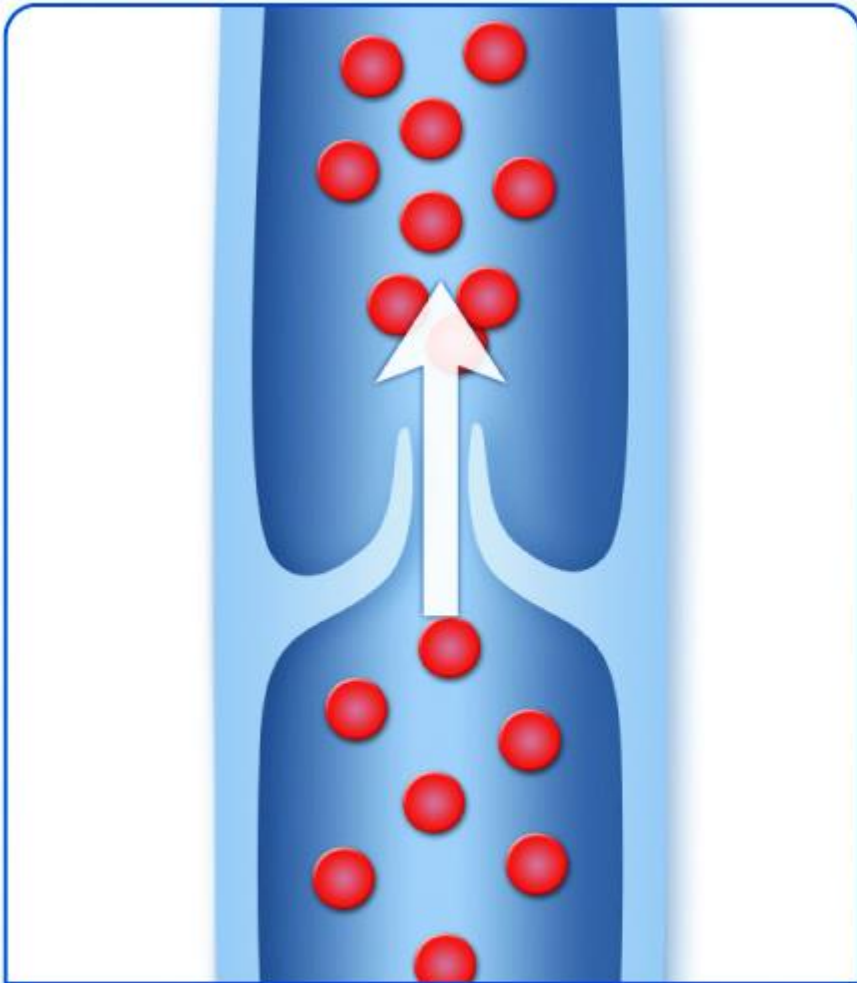
# VENULES

- diameter are usually big 8-30 mcm
- the wall of postcapillary venules is similar in structure to the capillary wall
- the architectonics of venules is the same as that of arterioles.

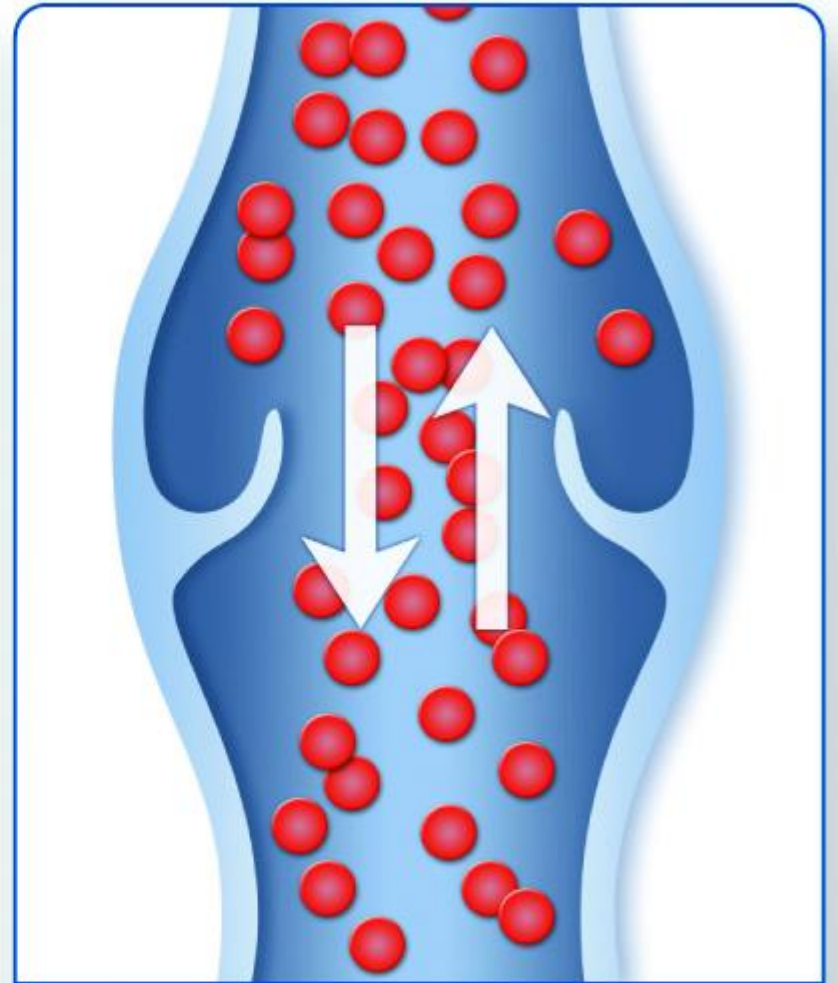


# VEINS





**Healthy Vein Valves  
& Correct Blood Flow**

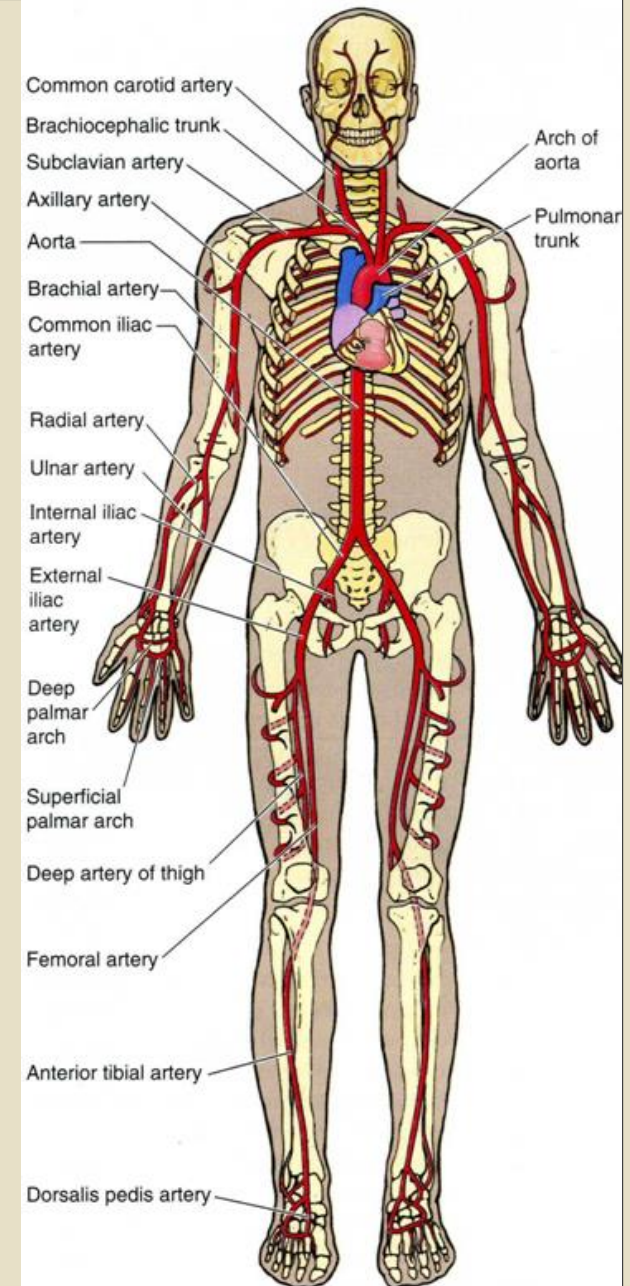


**Damaged Vein Valve  
& Incorrect Blood Flow**



# Arteries. Some features

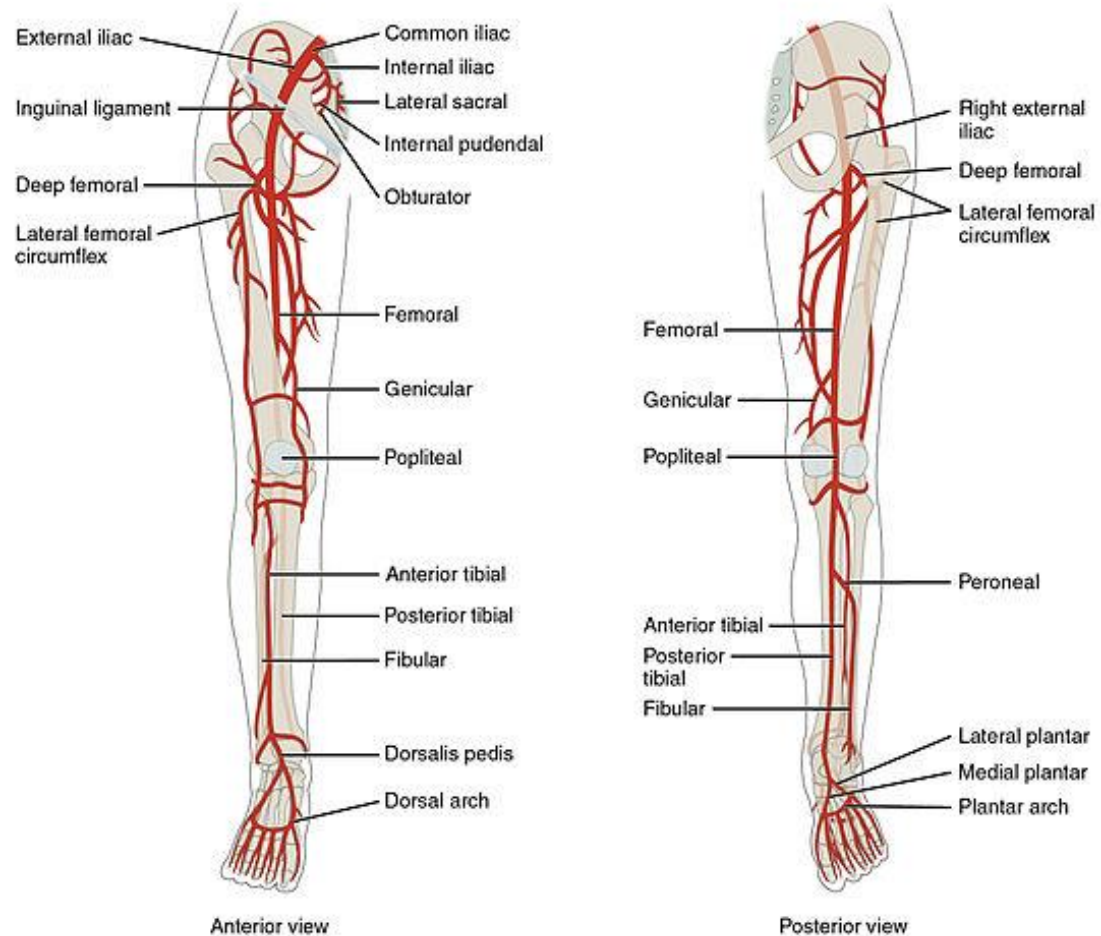
- in the trunk – **parietal and visceral** branches of aorta
- The parietal branches are paired: they are symmetrical and segmental. The visceral branches can be unpaired or paired: this depends on the supplied organs.
- arteries reach organ along the **shortest ways**, usually together with nerves
- every region has its own **original main artery** (head and neck – carotid artery, abdomen – abdominal part of aorta, etc.)
- with or without **anastomoses** (connections)



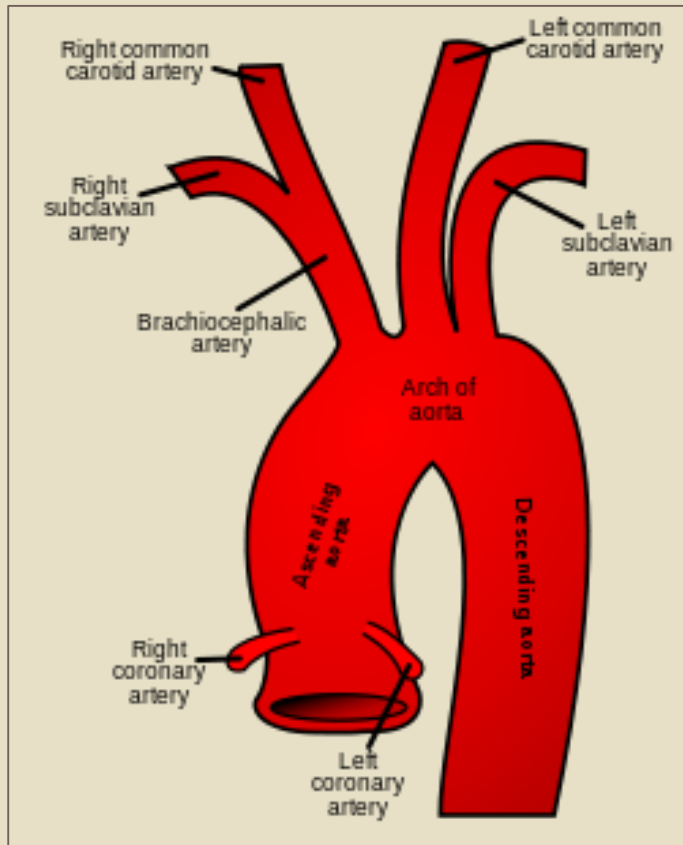


# Arterial blood supply of the limbs

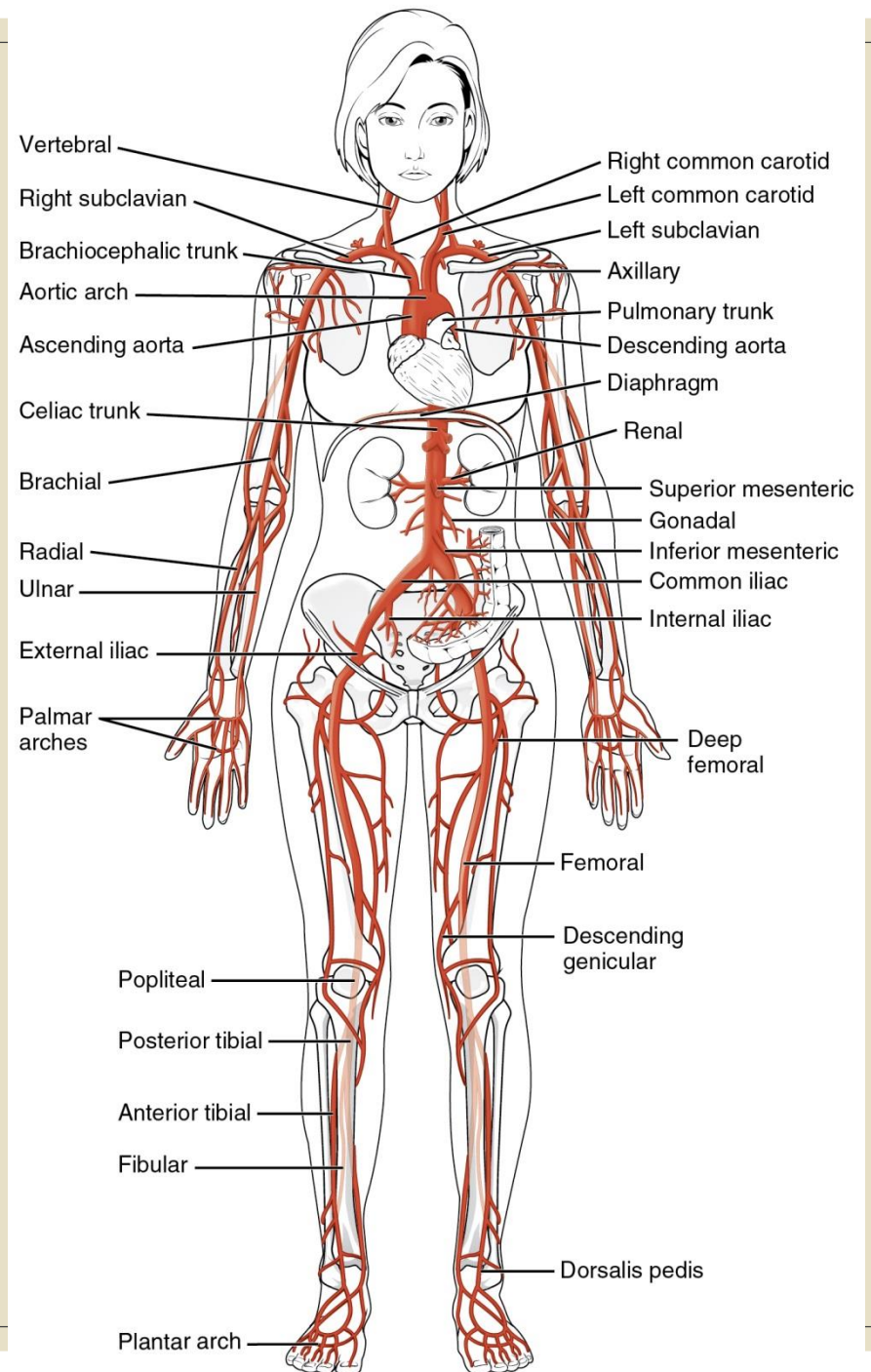
- mostly on the *flexor side* of the limbs
- around joints form *arterial network*
- on the palm and foot form *arterial arches*

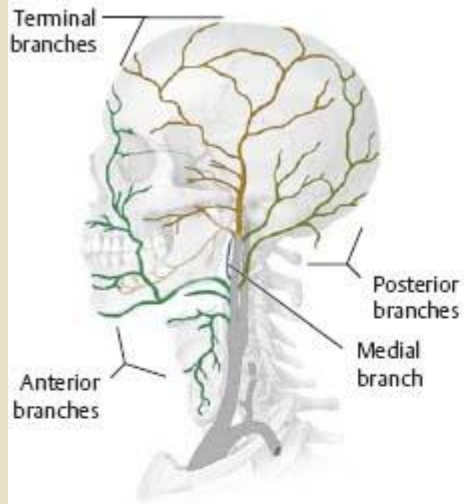


# The main arteries



Diameter of aortal bulb – 25-30mm  
 Diameter of descending aorta – 21-22mm

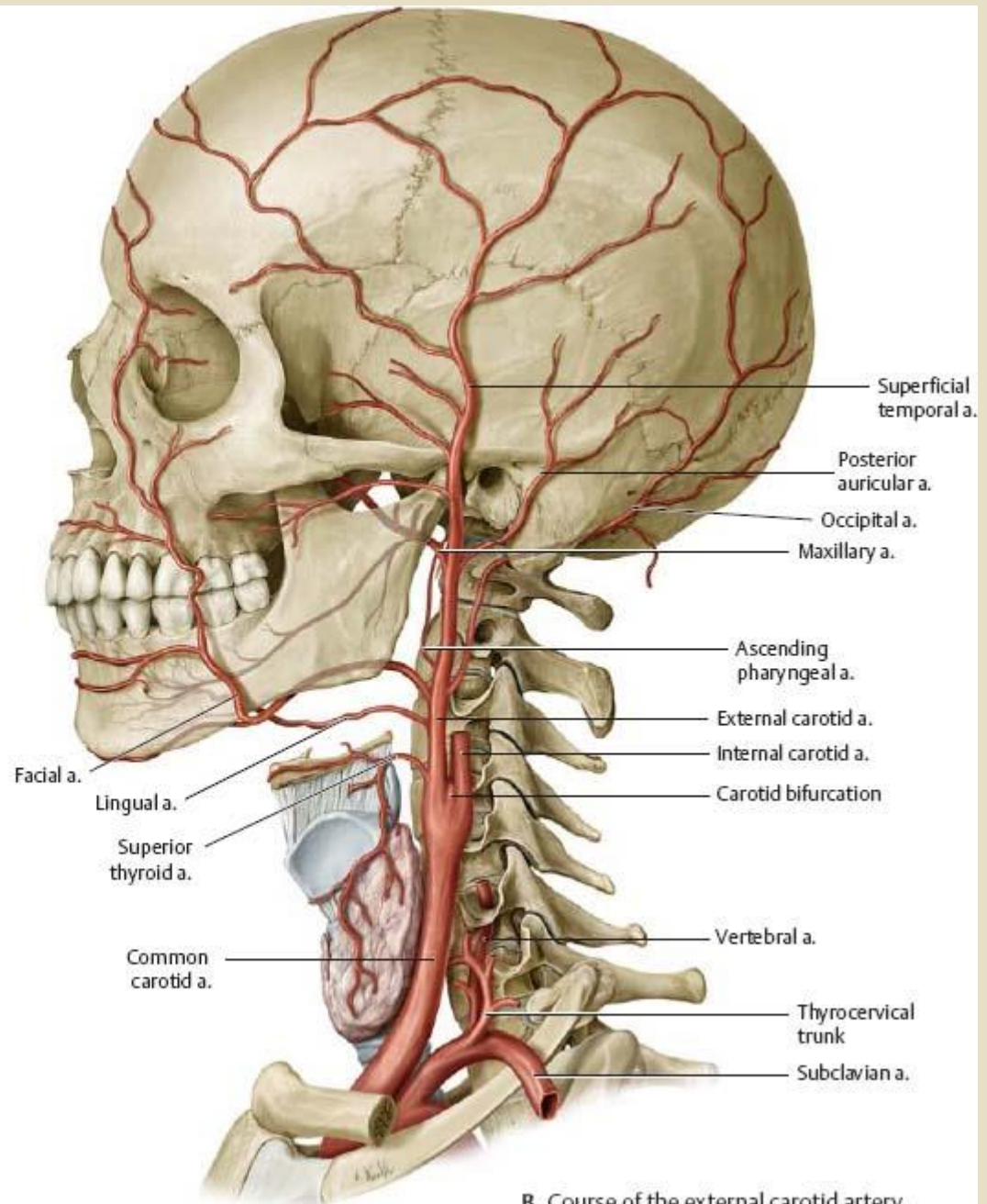




A Schematic of the external carotid artery.

### Branches of external carotid artery:

- 1) Superior thyroid artery
- 2) Lingual artery
- 3) Facial artery
- 4) Maxillary artery
- 5) Ascending pharyngeal artery
- 6) Occipital artery
- 7) Posterior auricular artery
- 8) Superficial temporal artery



B Course of the external carotid artery.



# Development of the arteries

Blood of the 3-4 week embryo flows from heart into:

*Truncus arteriosus (aortic sac)*



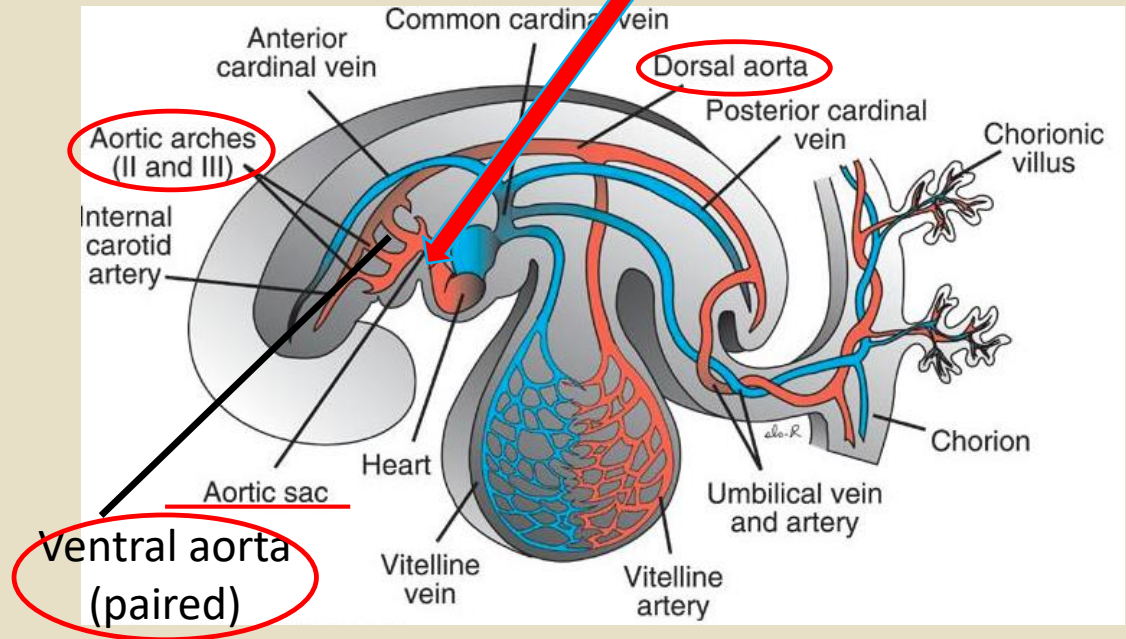
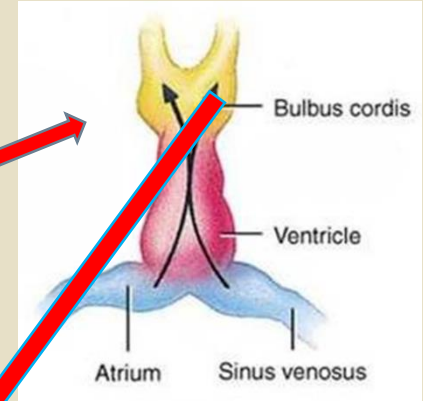
*ventral aorta (paired)*



*aortic arches (6 pairs)*



*dorsal aorta*



The structure of the embryo resembles the vascular system of animals with a gill apparatus

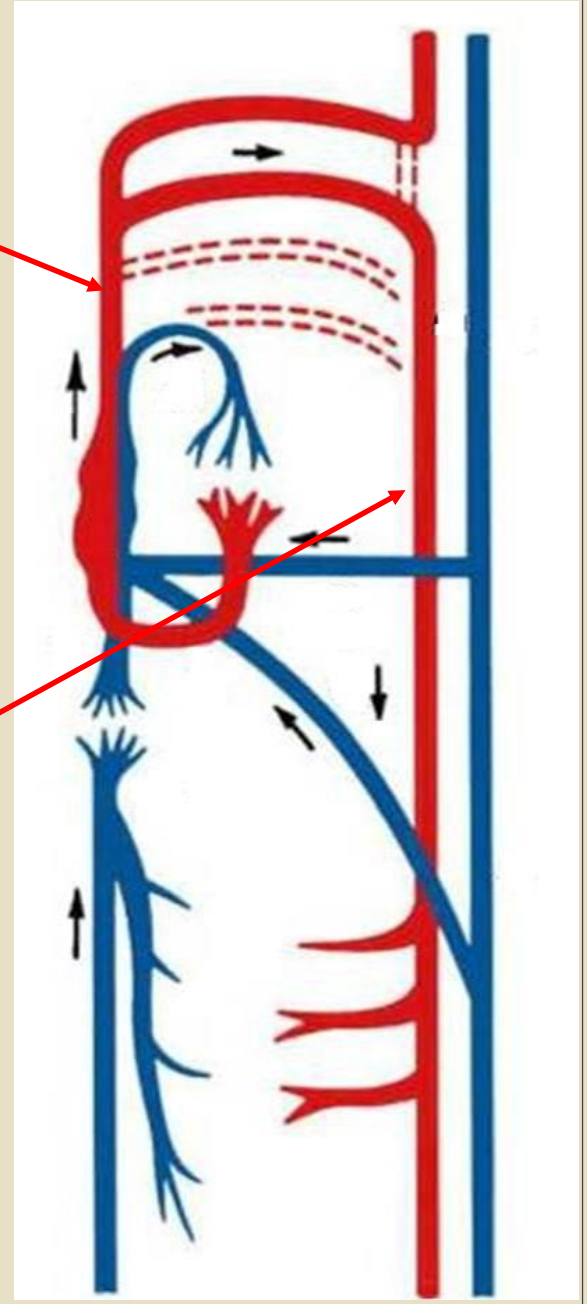
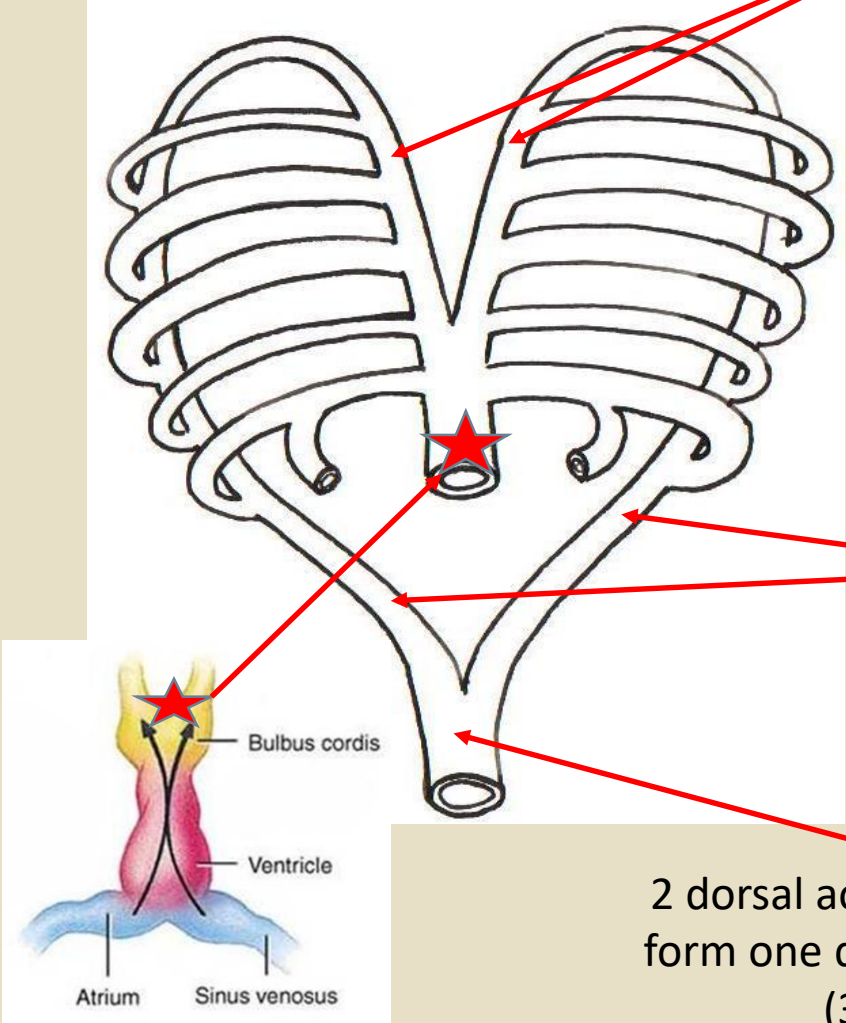


2 ventral aortae

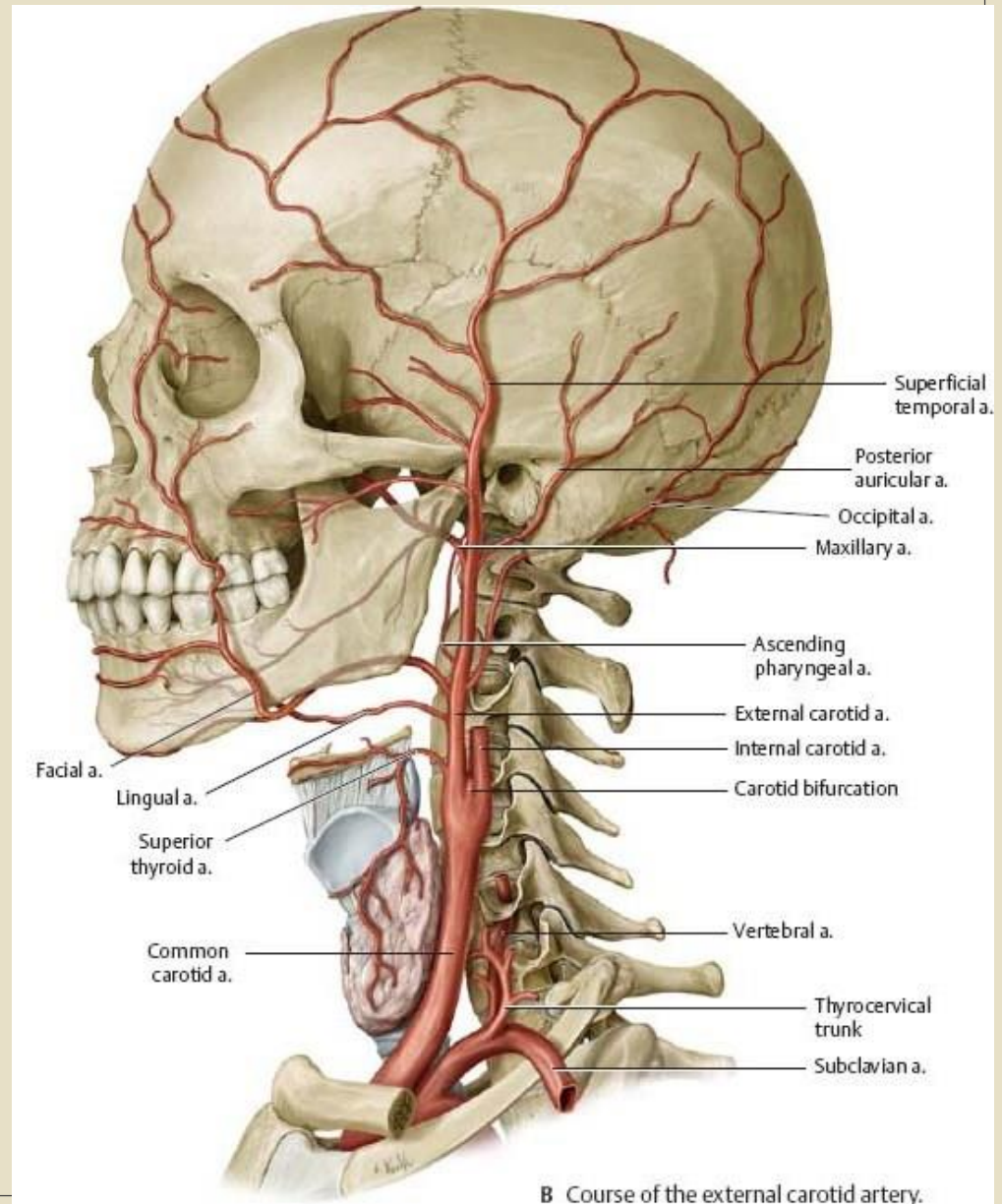
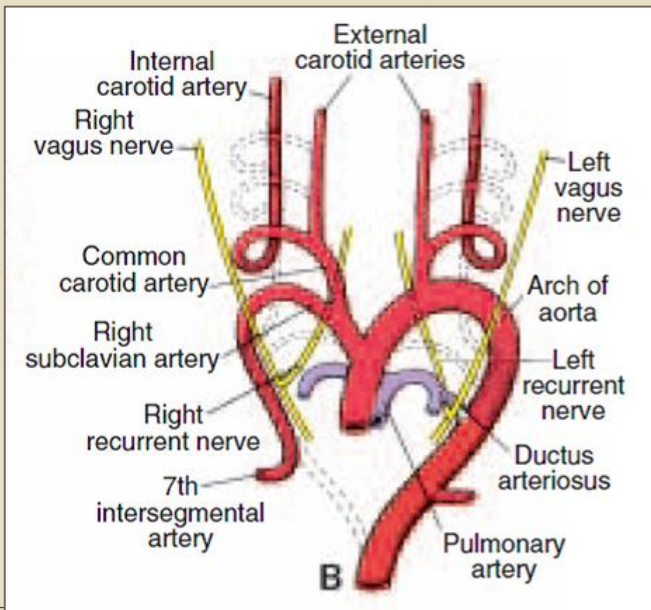
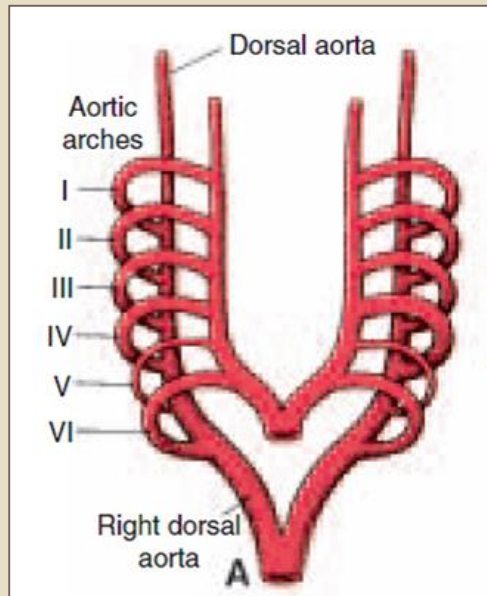
aortic arches  
(6 pairs)

2 dorsal aortae

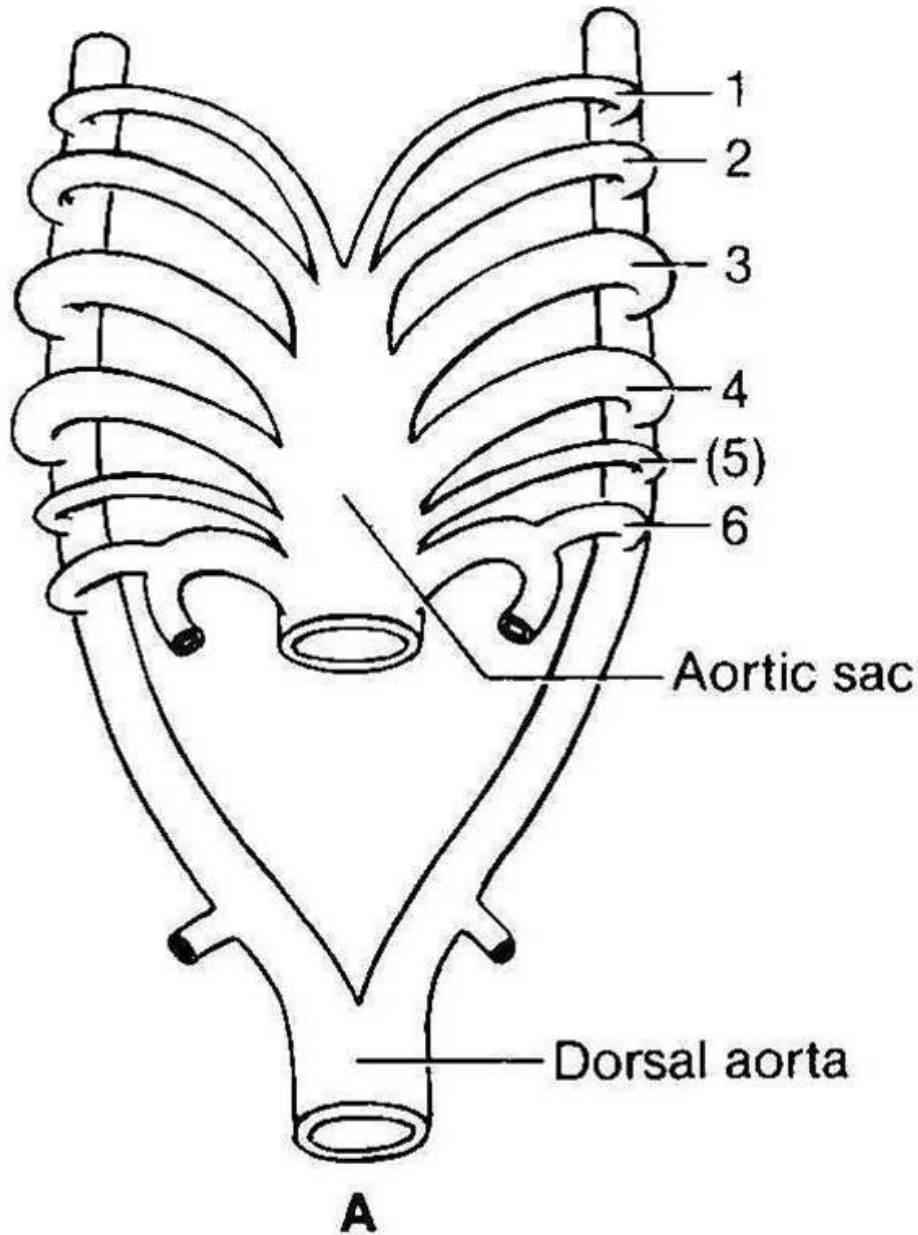
2 dorsal aortae merge and  
form one descending aorta  
(3 week)



# Dorsal end of ventral aorta – external carotid artery

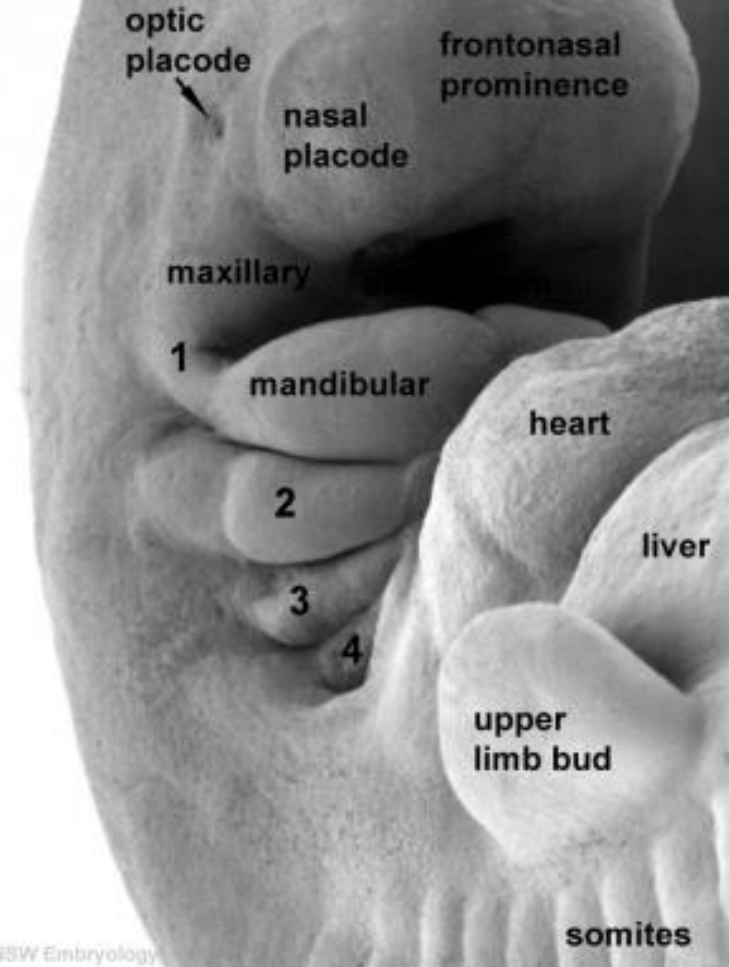


# Aortic arches – pharyngeal arches



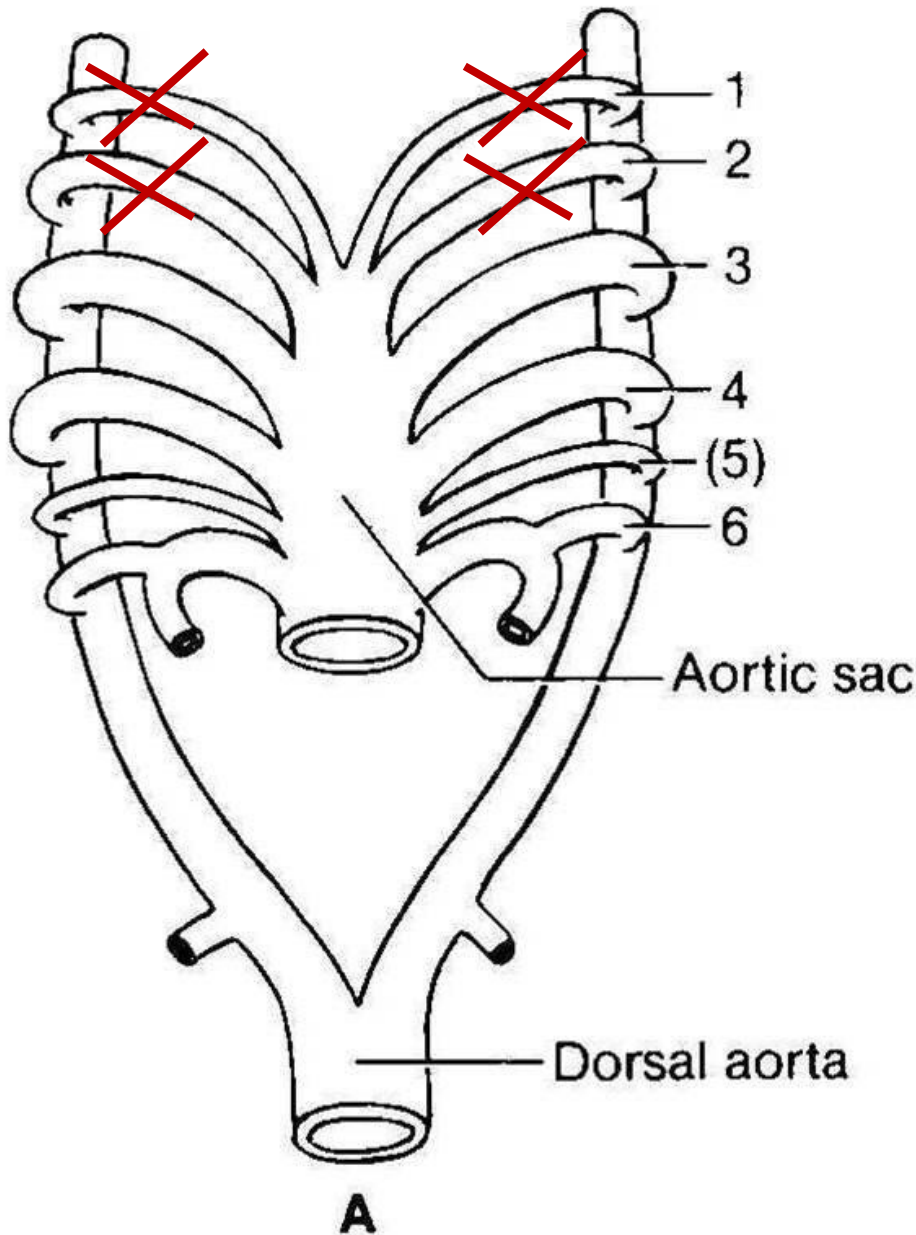
Stage 14

32 day  
35 somite



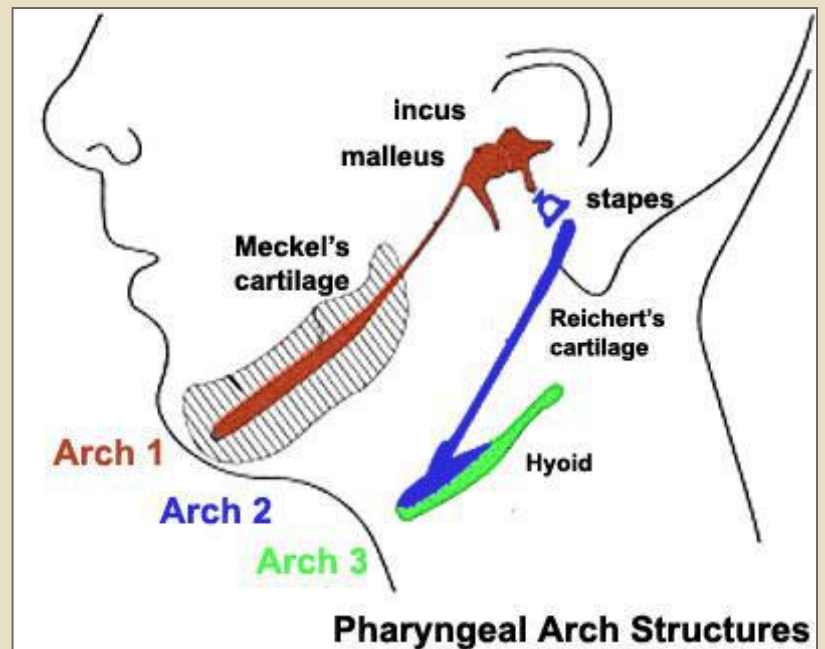


# Aortic arches – pharyngeal arches



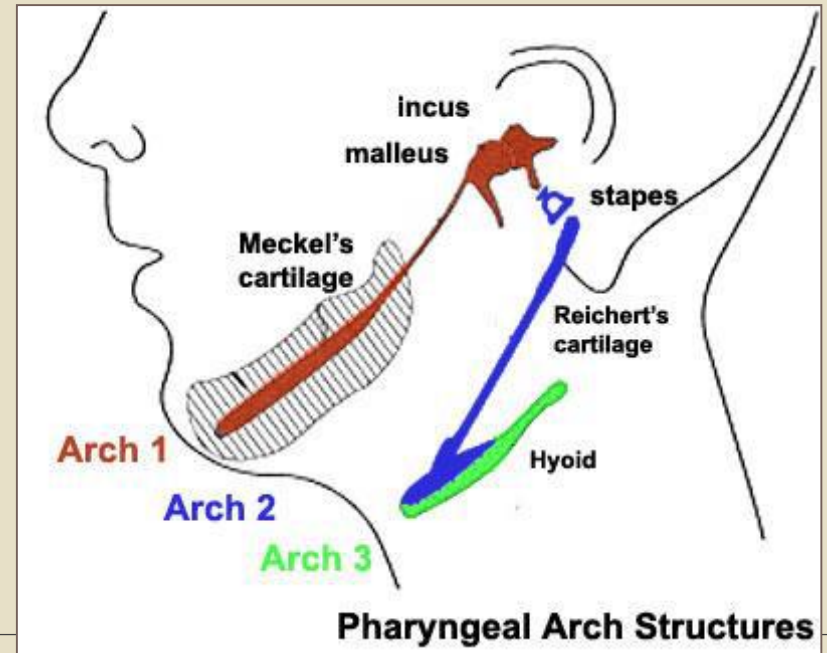
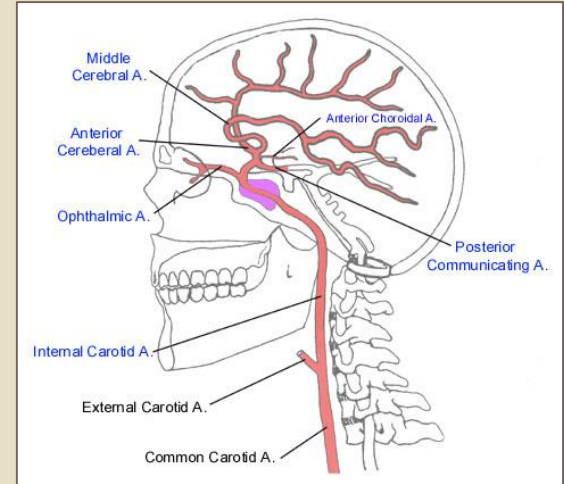
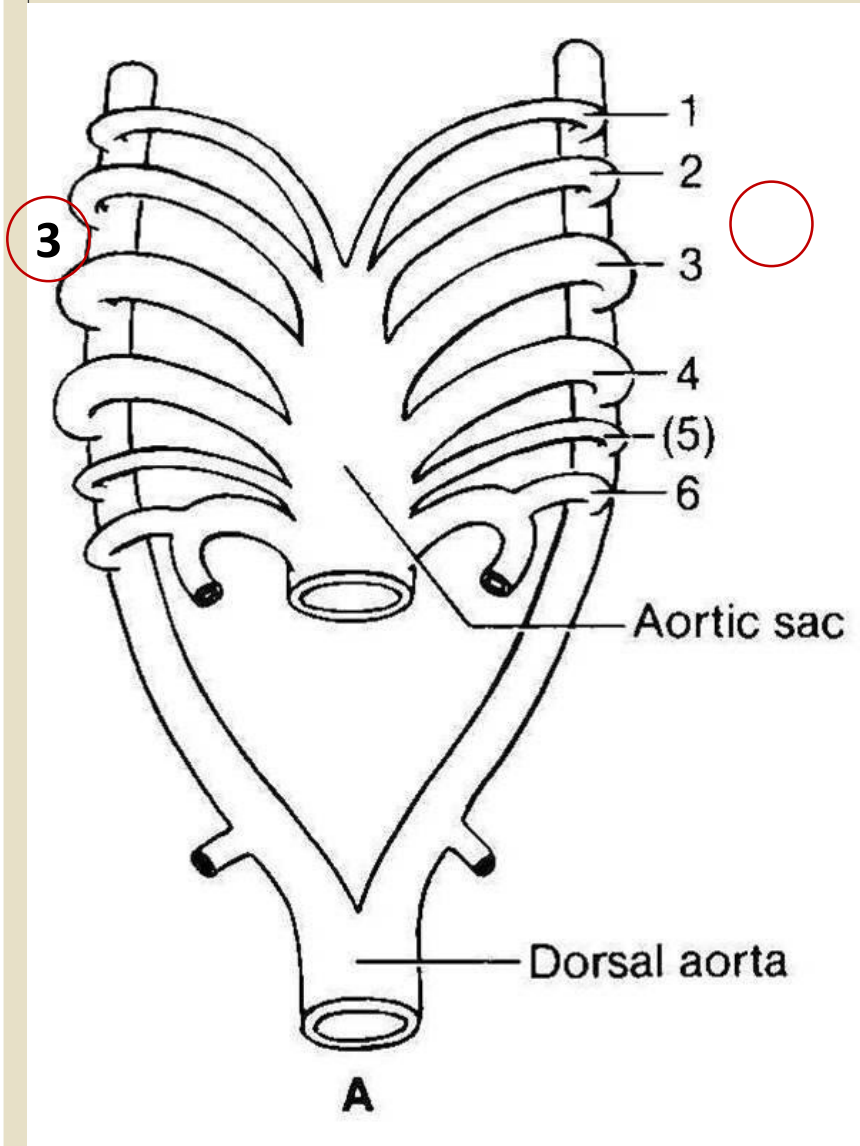
Aortic arches 1 completely regress except to form **maxillary artery**.

Aortic arches 2 completely regress except to form **stapedial and hyoid arteries**.

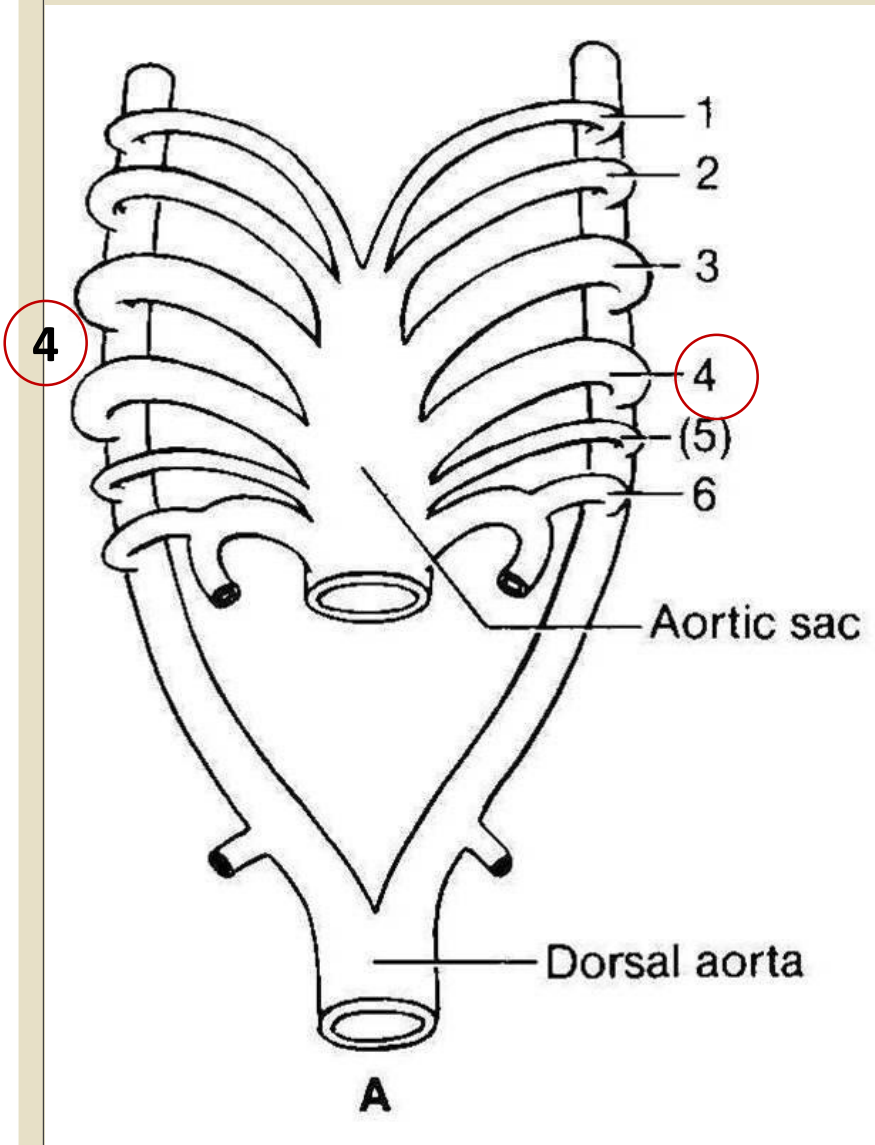




Aortic arches 3 forms **common, external** (partially) **and internal carotid arteries.**

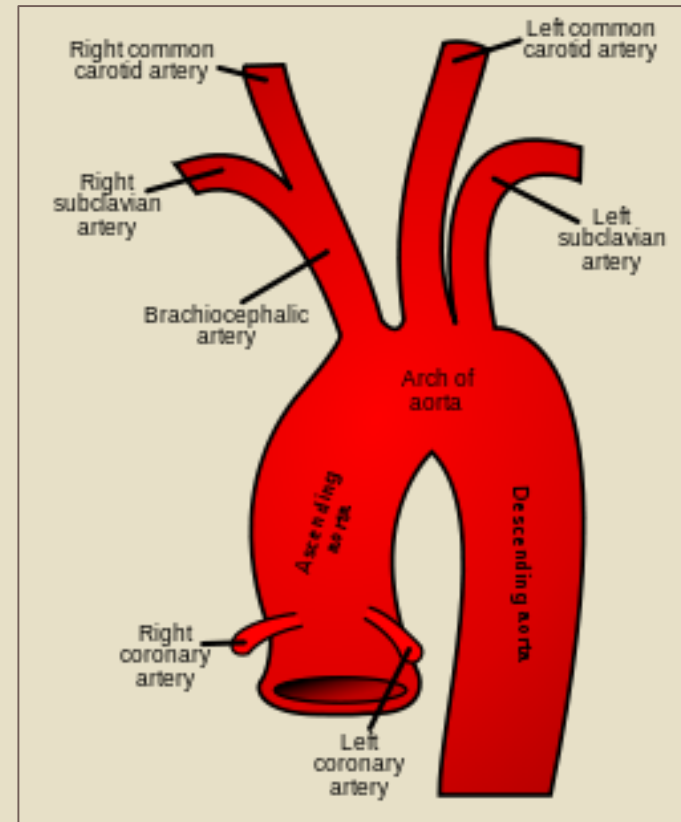


# Development of the arteries

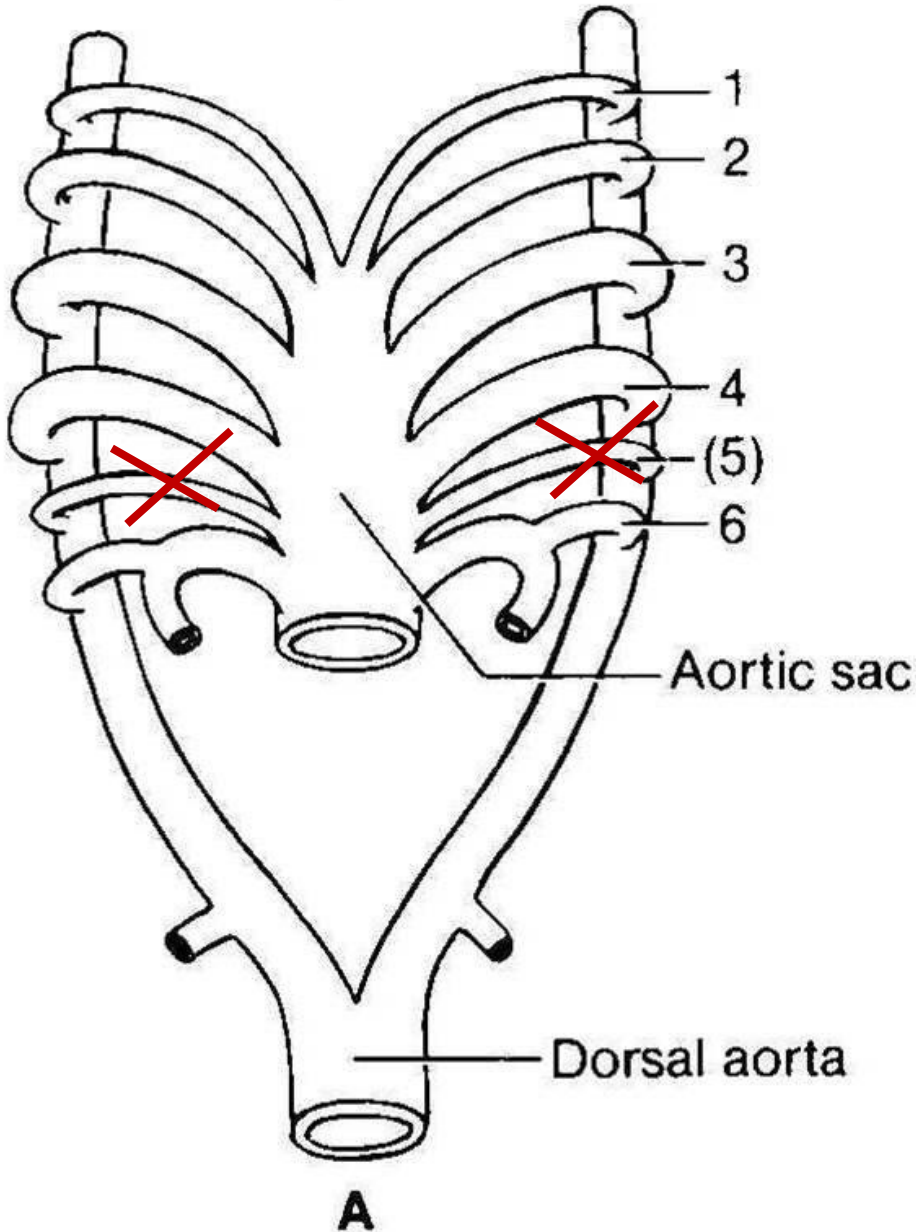


Aortic arch 4 left forms **arch of aorta**.

Aortic arch 4 right forms **right subclavian artery**.



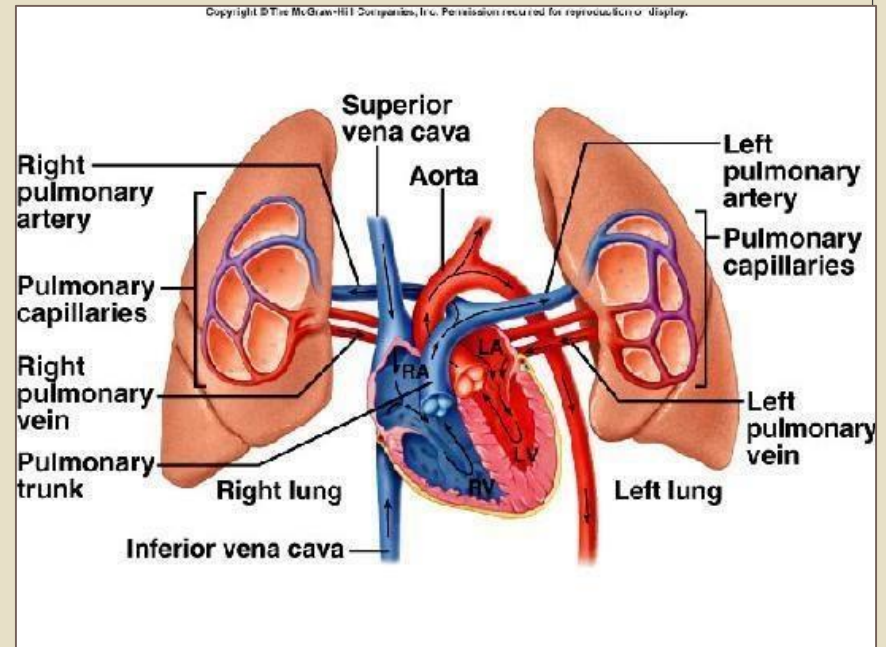
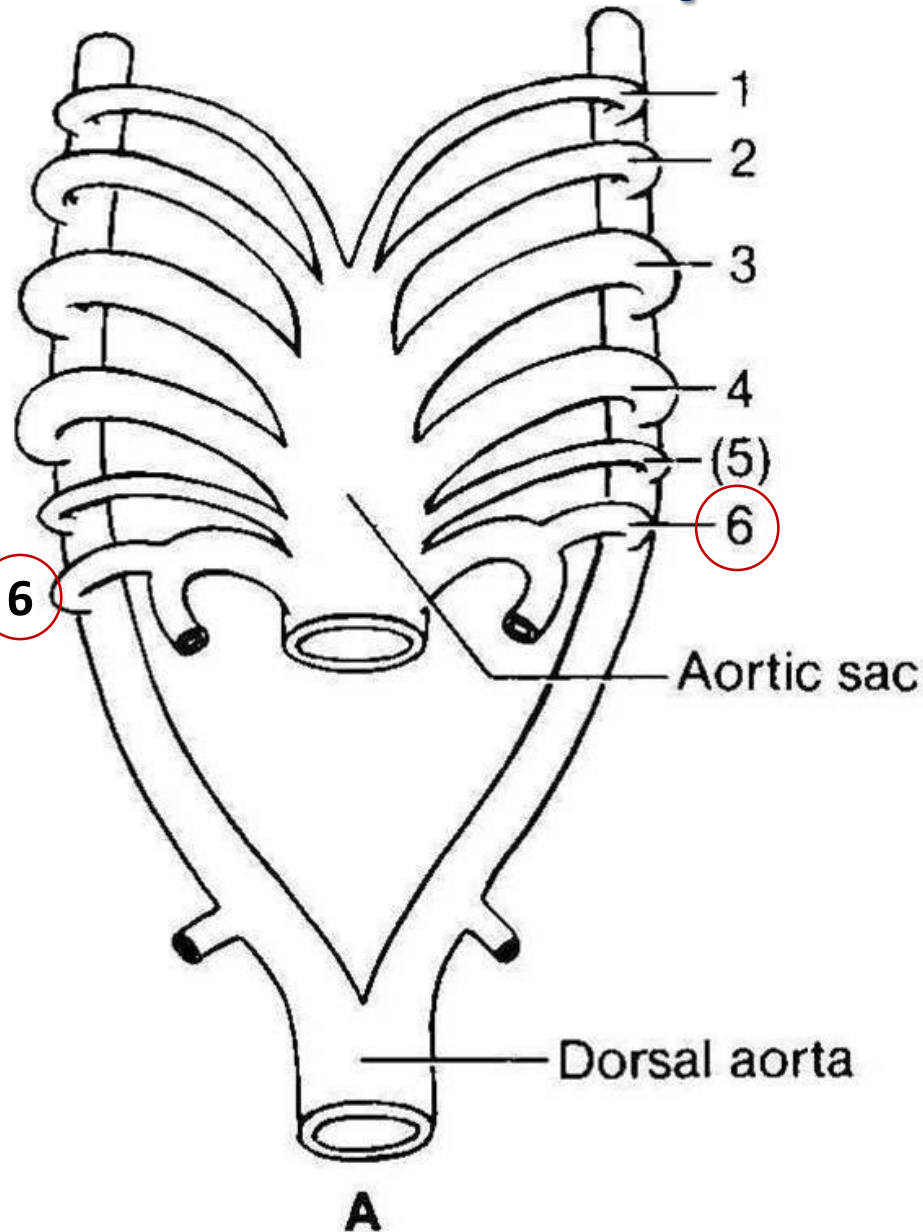
# Development of the arteries



**Aortic arches 5**  
completely  
**regress.**

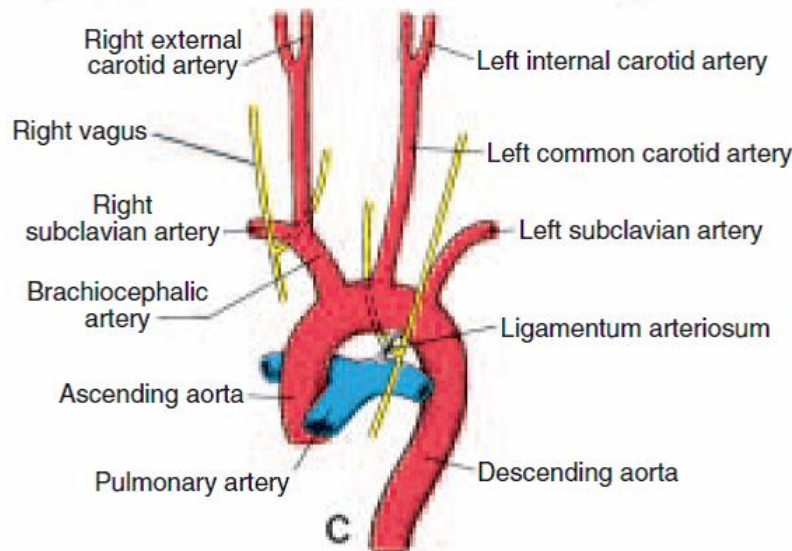
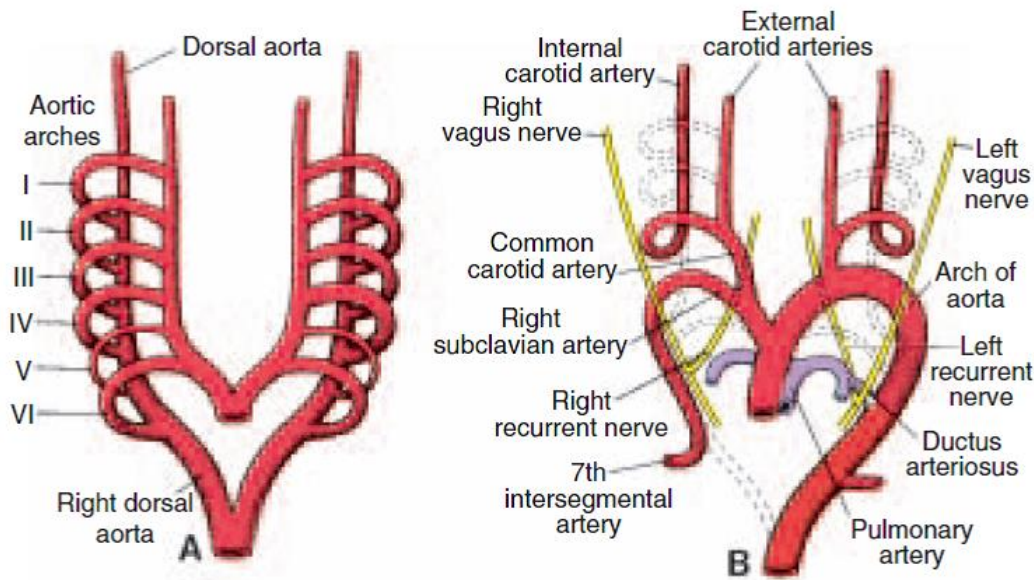
# Development of the arteries

Aortic arches 6 form **pulmonary arteries.**





# Development of the arteries



dorsal end of ventral aorta – external carotid artery

I and II aortic arches – reduce

III aortic arch – common, external and internal carotid arteries

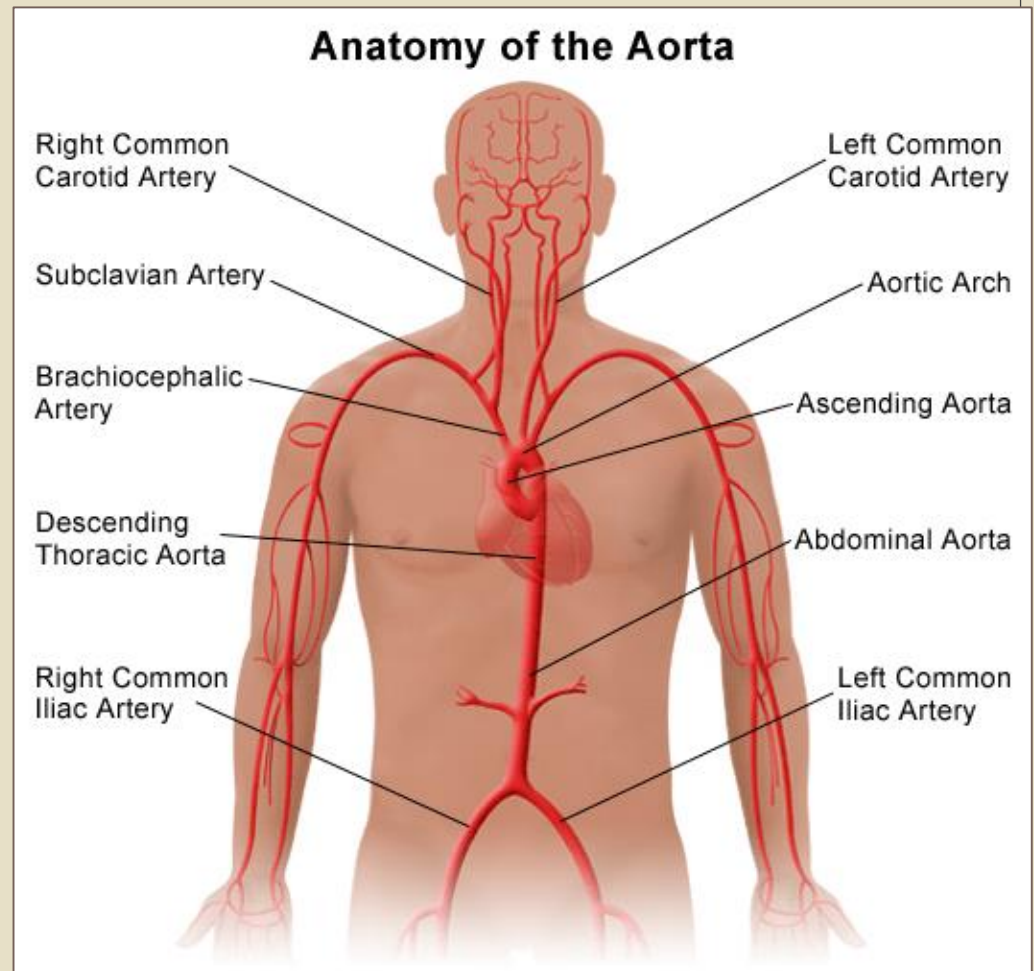
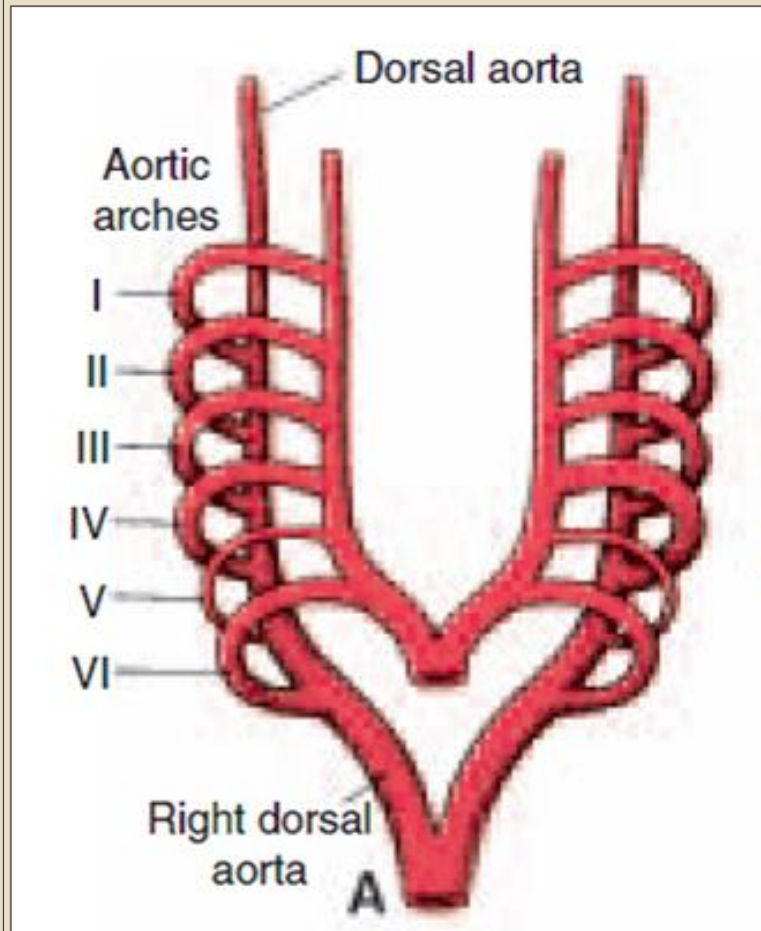
right IV aortic arch – right subclavian artery

left IV aortic arch – arch of aorta

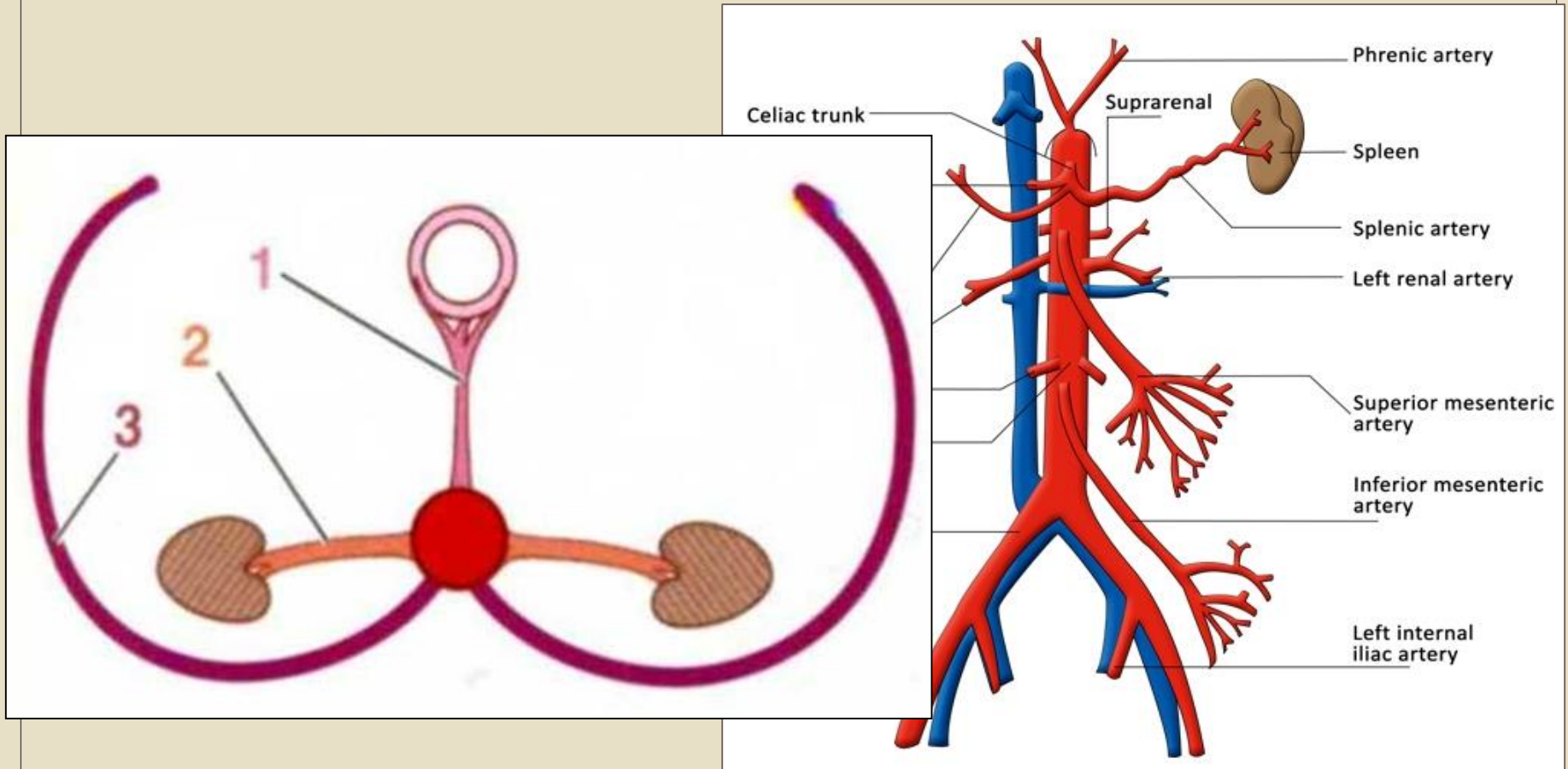
V aortic arch – reduce

VI aortic arch - pulmonary arteries

The right and left dorsal aorta fuse caudal to heart to form the definitive dorsal **descending aorta**



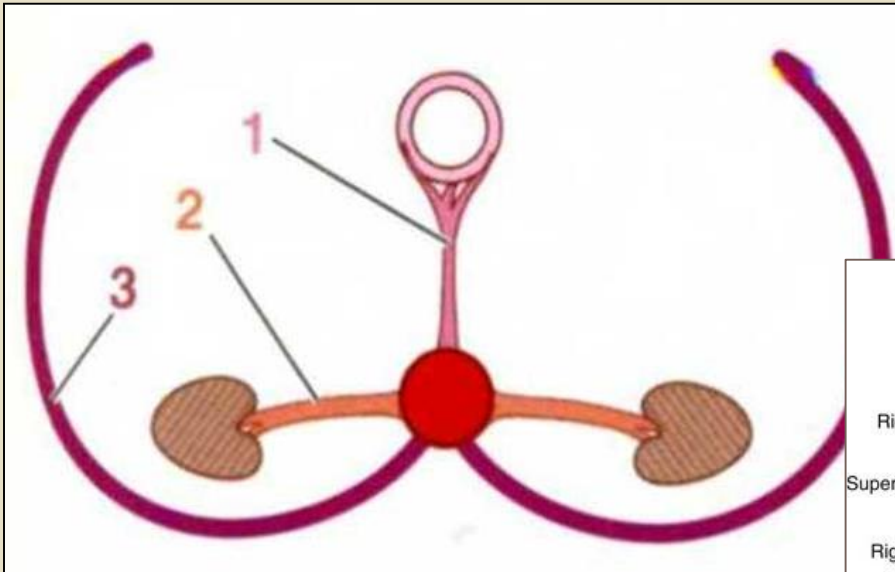
# Branches of dorsal aorta – **descending aorta** (thoracic and abdominal parts of aorta):



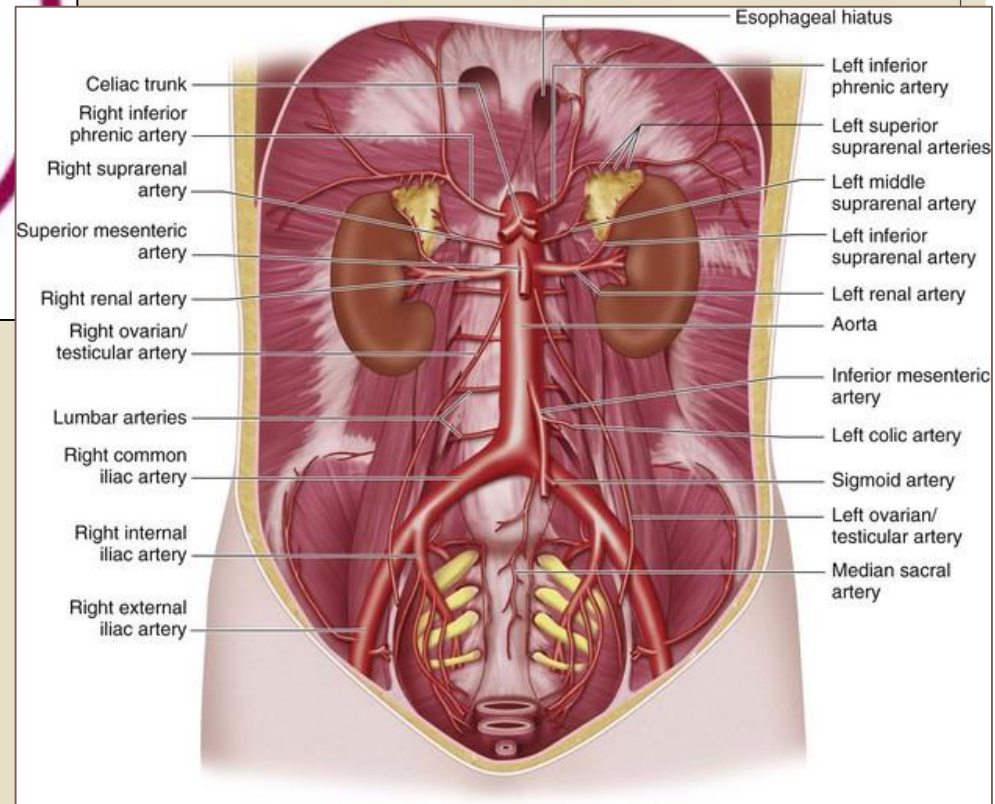
#1 - ventral – **vitelline arteries** (yolk sac, celiac, superior and inferior mesenteric arteries) and **umbilical arteries** (fetus-placenta)



# Branches of dorsal aorta – **descending aorta** (thoracic and abdominal parts of aorta):

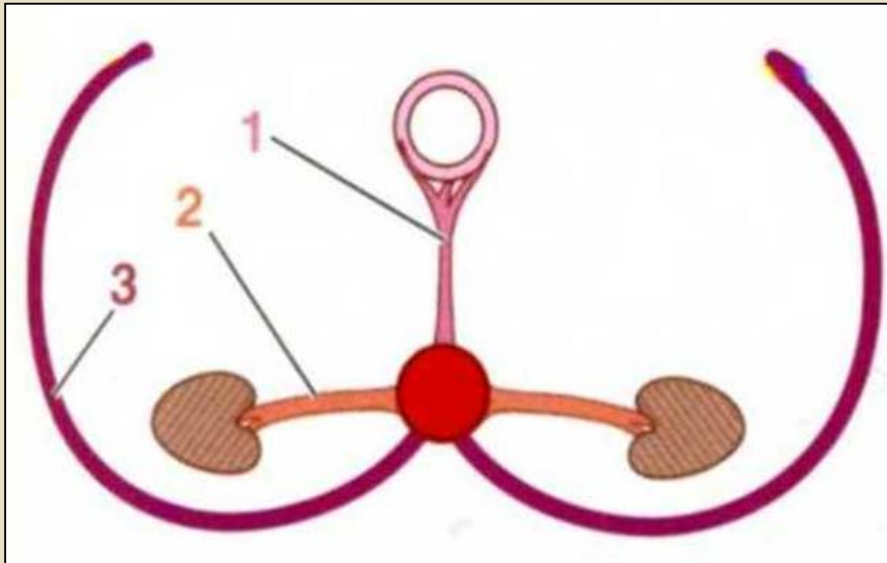


#2 - lateral – **visceral**  
arteries  
(kidneys, suprarenal  
glands, gonads)

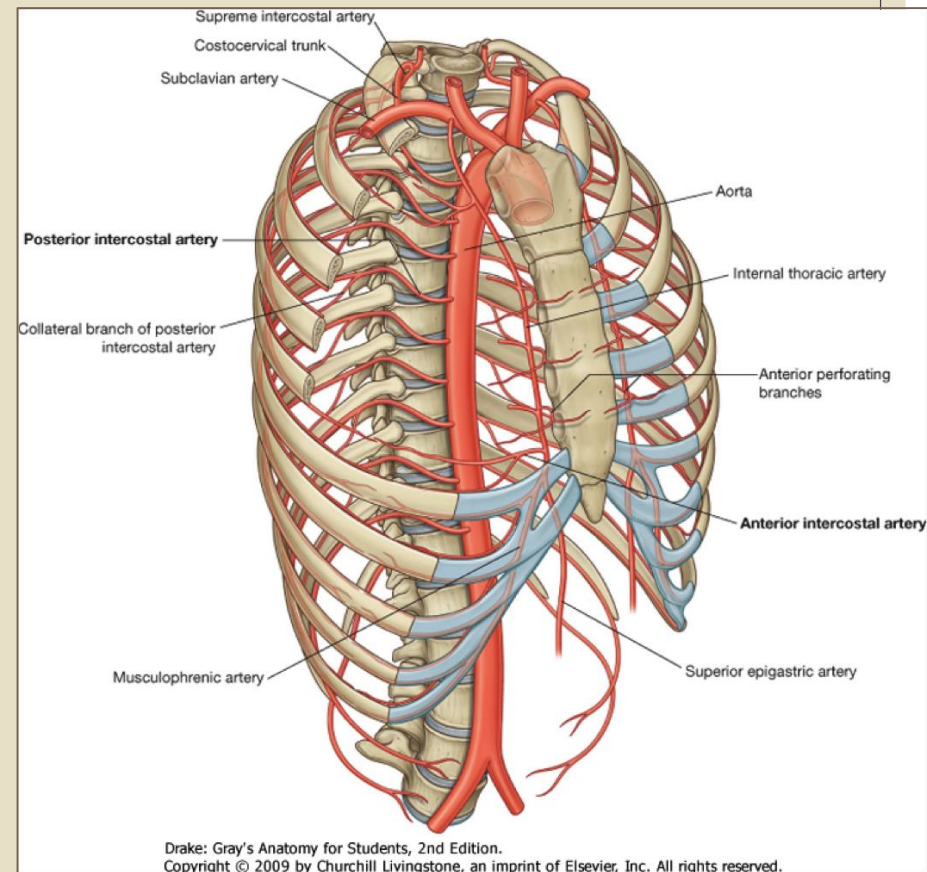




# Branches of dorsal aorta – **descending aorta** (thoracic and abdominal parts of aorta):

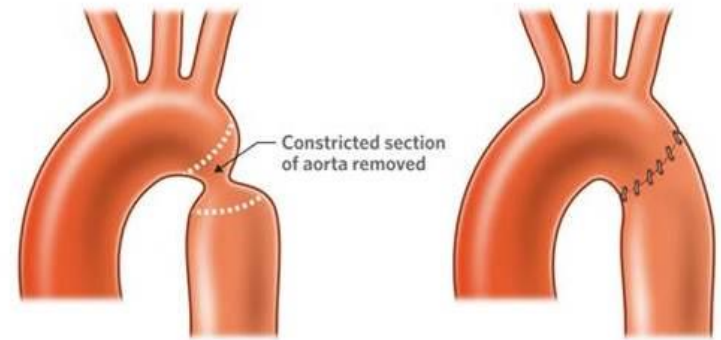
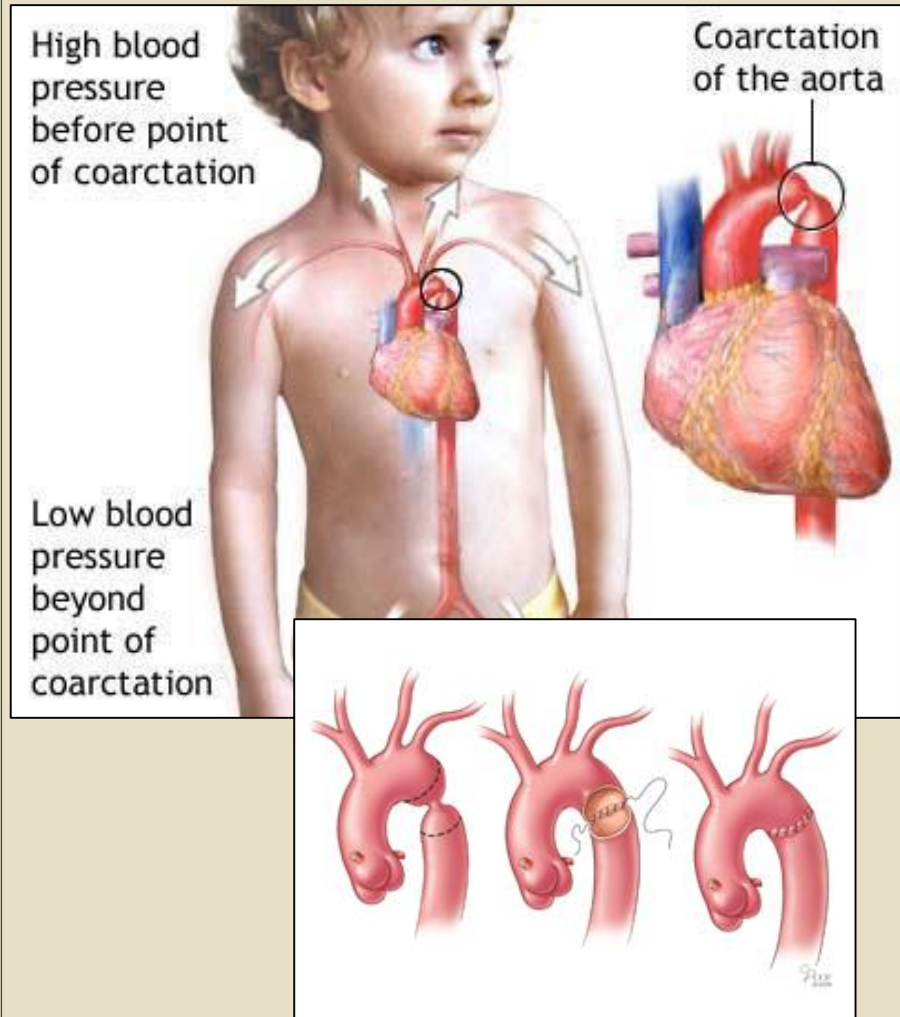


#3 - **intersegmental** arteries –  
supply neural tube, deep  
muscles of the back and skin

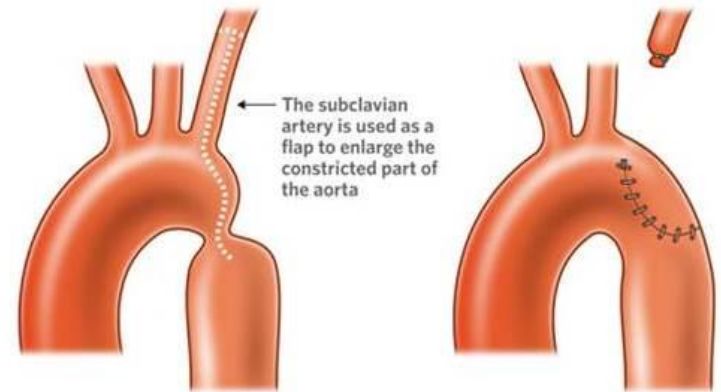


# Coarctation of aorta

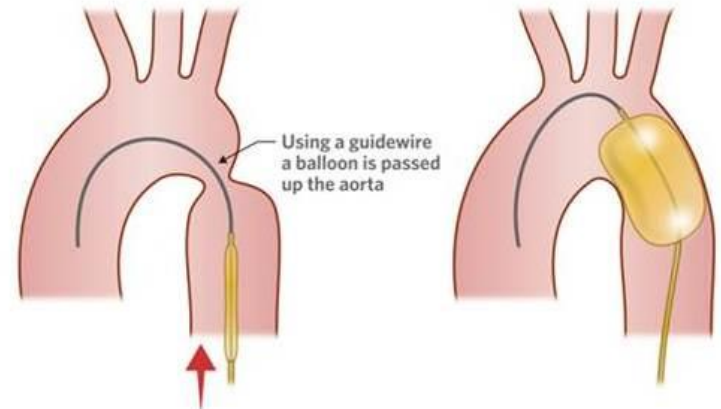
- Congenital pathology of aorta development
- Disproportional development of parts of the body



Resection and end-to-end anastomosis



Subclavian flap



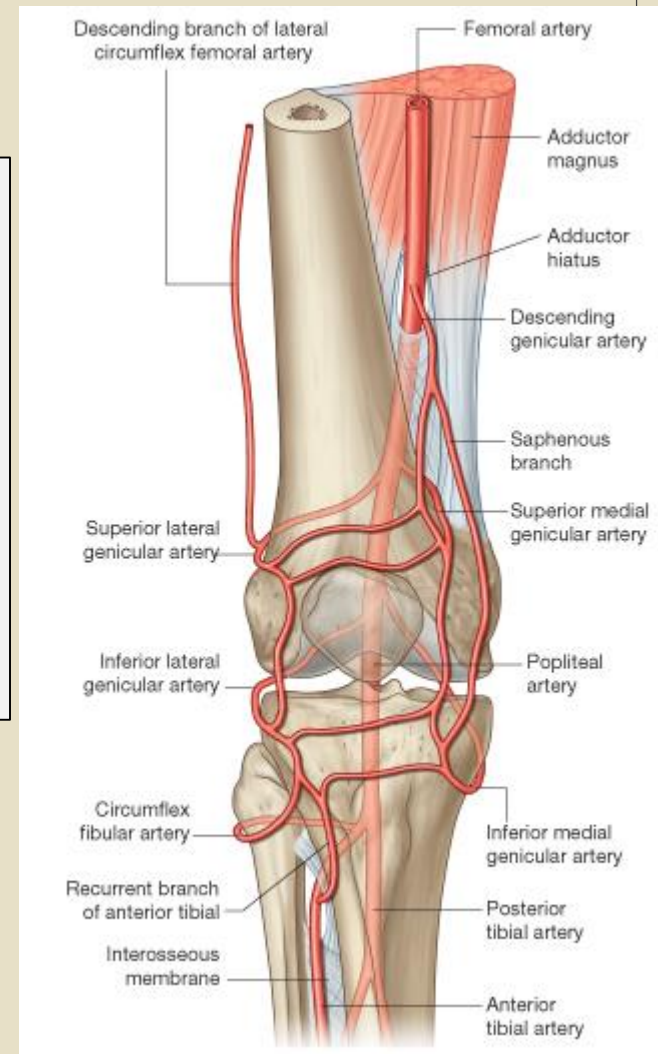
Balloon angioplasty

# Anastomoses

## 1) Between different systems of arteries:

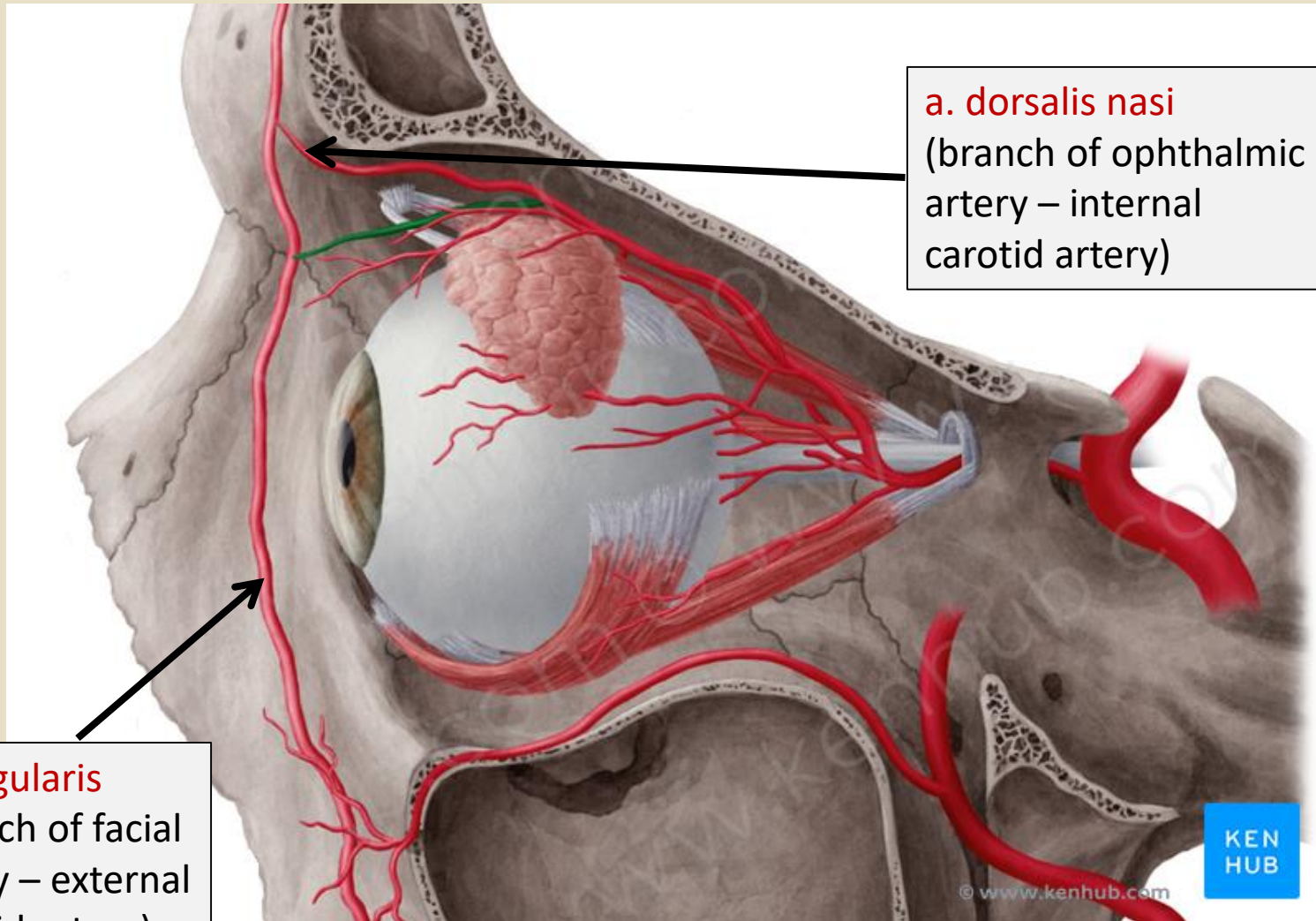
- external and internal carotid arteries
- external and internal iliac arteries
- vessels of the right and left parts of the body

## 2) Inside system of one artery





# Anastomoses on the head



**a. dorsalis nasi**  
(branch of ophthalmic  
artery – internal  
carotid artery)

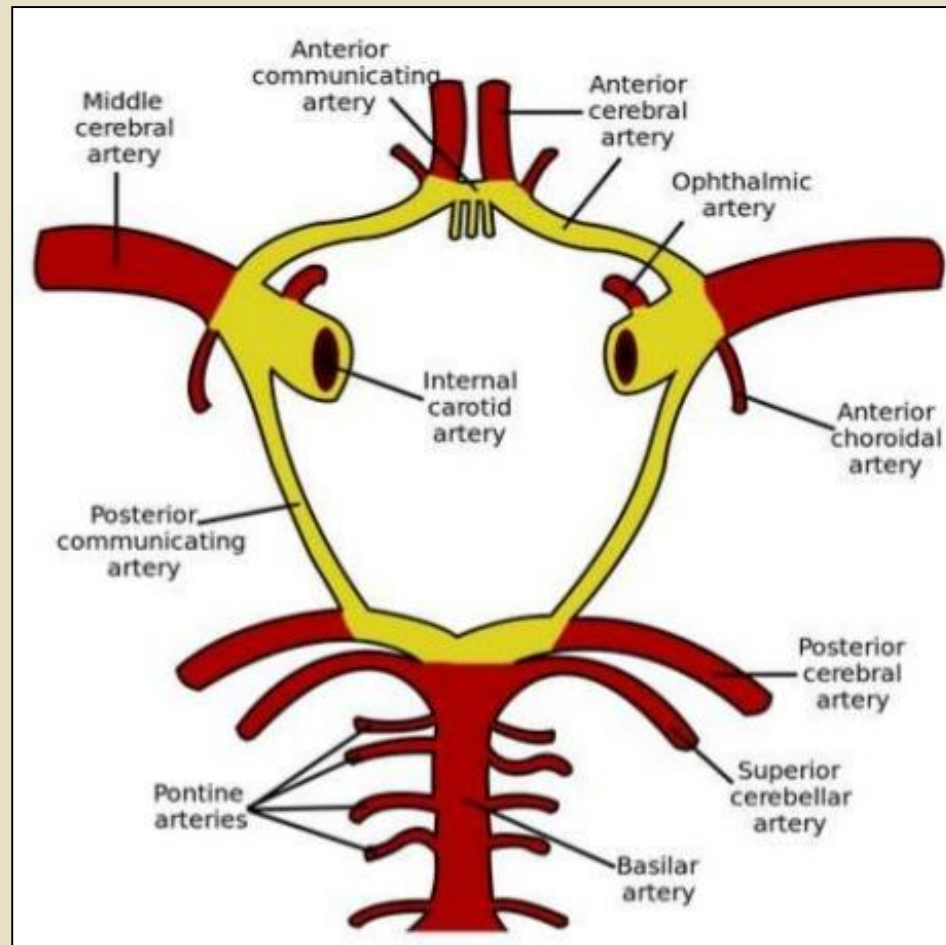
**a. angularis**  
(branch of facial  
artery – external  
carotid artery)

KEN  
HUB

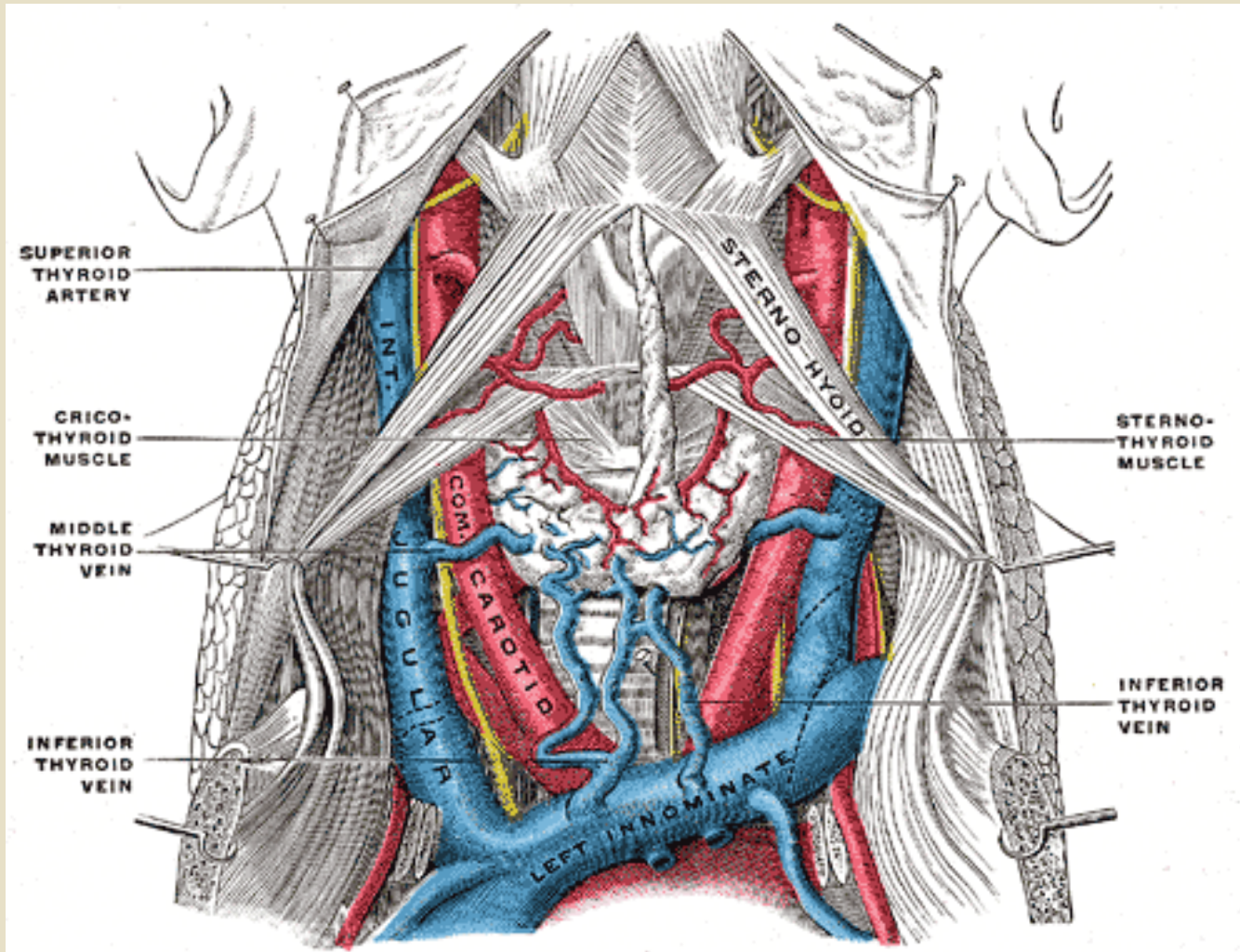
© www.kenhub.com



# Arterial blood supply of the brain – circle of Willis

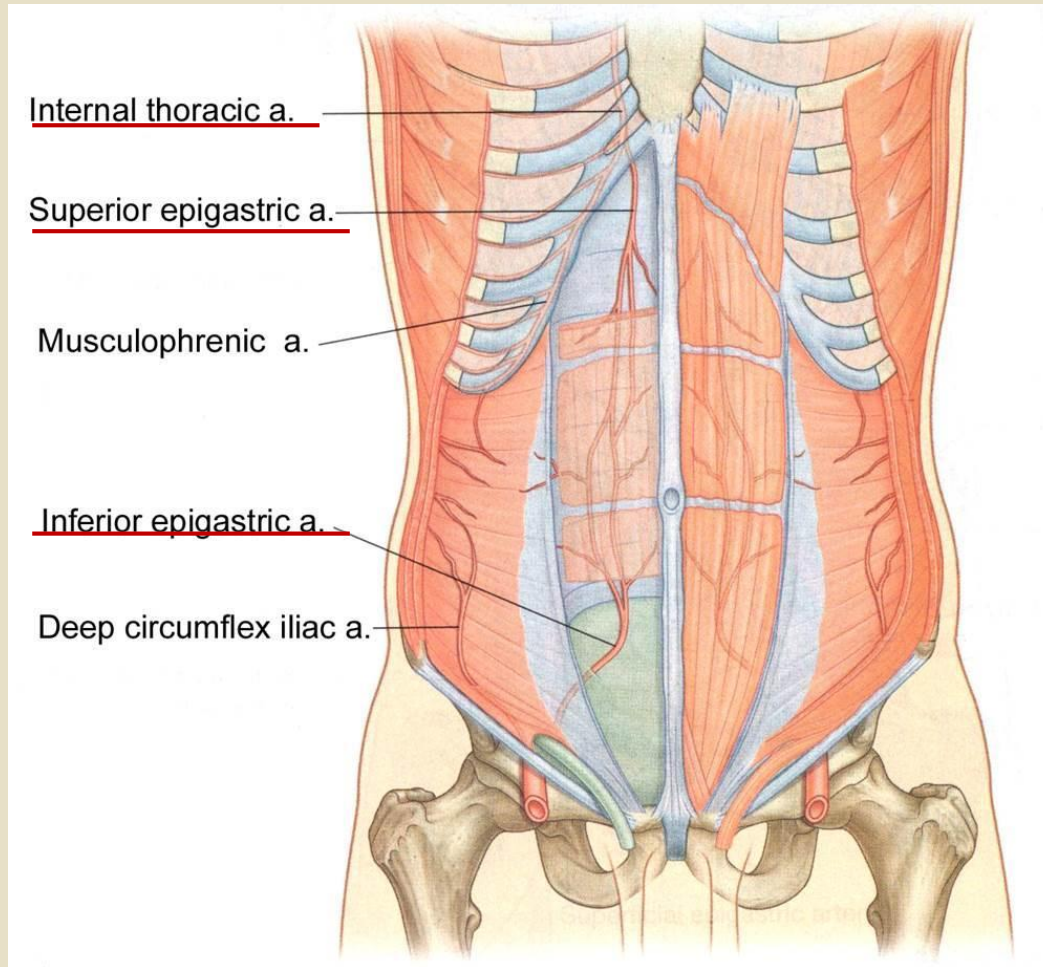


# Arterial anastomoses of the neck



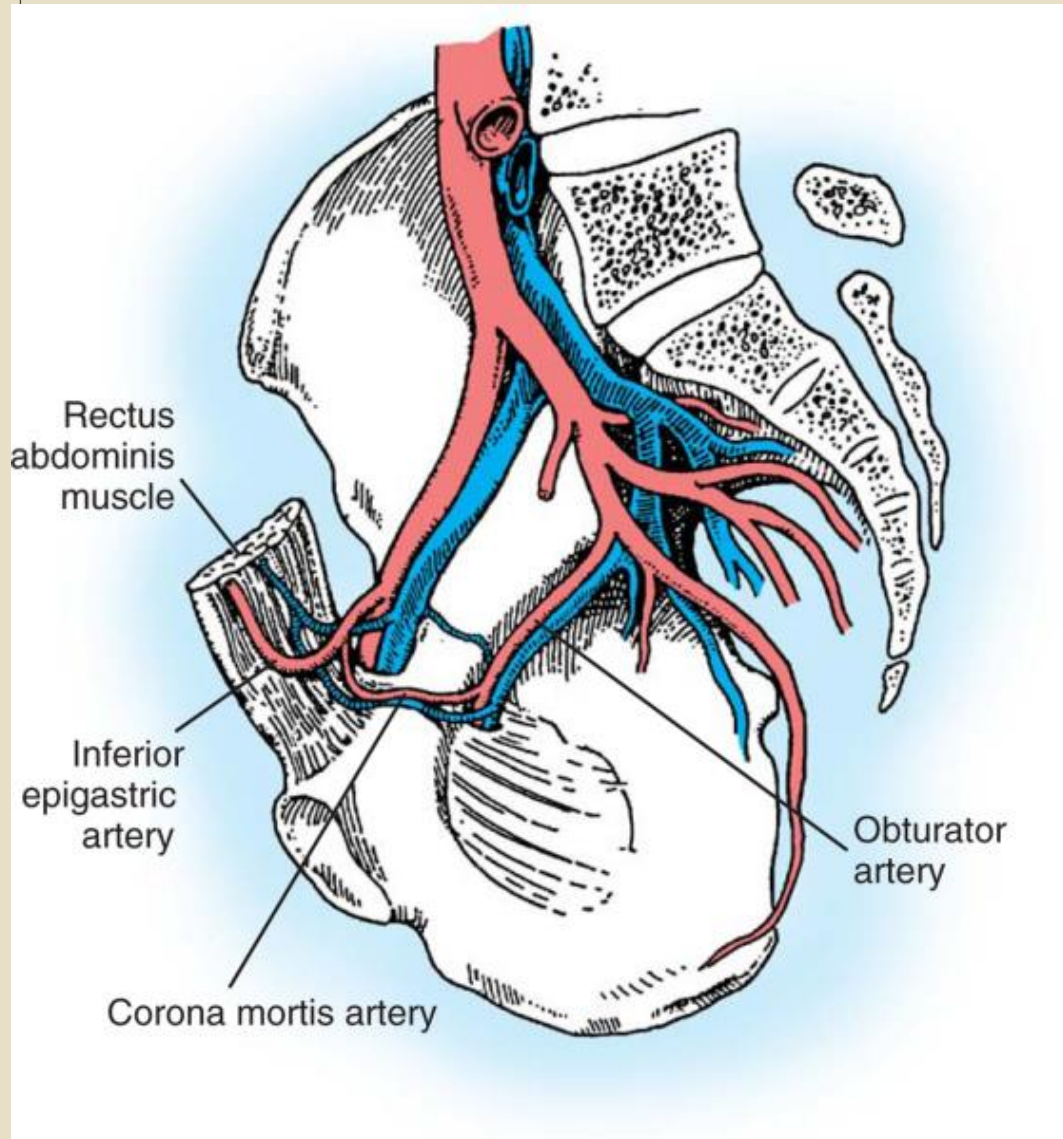
- between left and right external carotid arteries  
(arterial network of the organ)

# Arterial anastomoses of the anterior abdominal wall

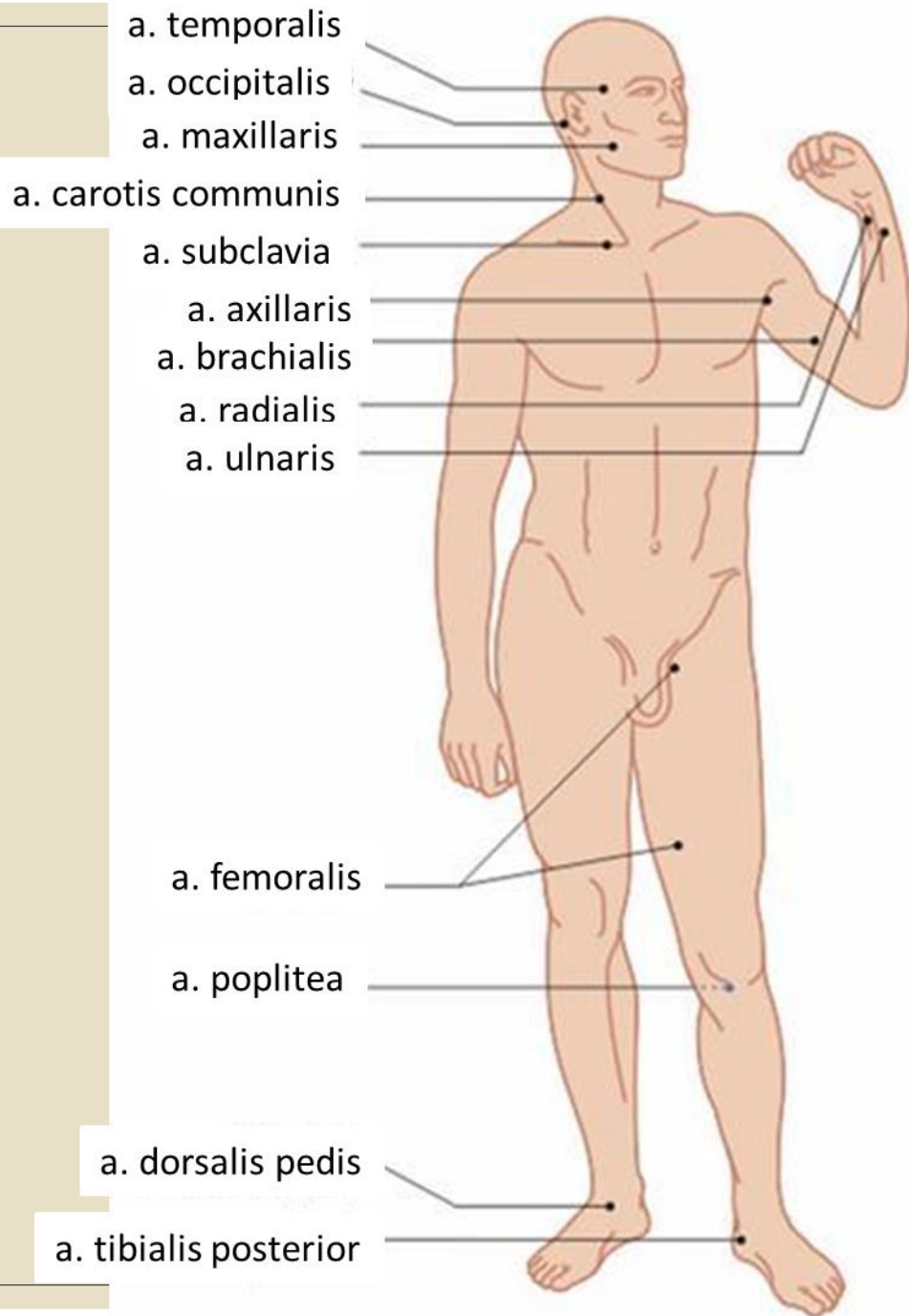




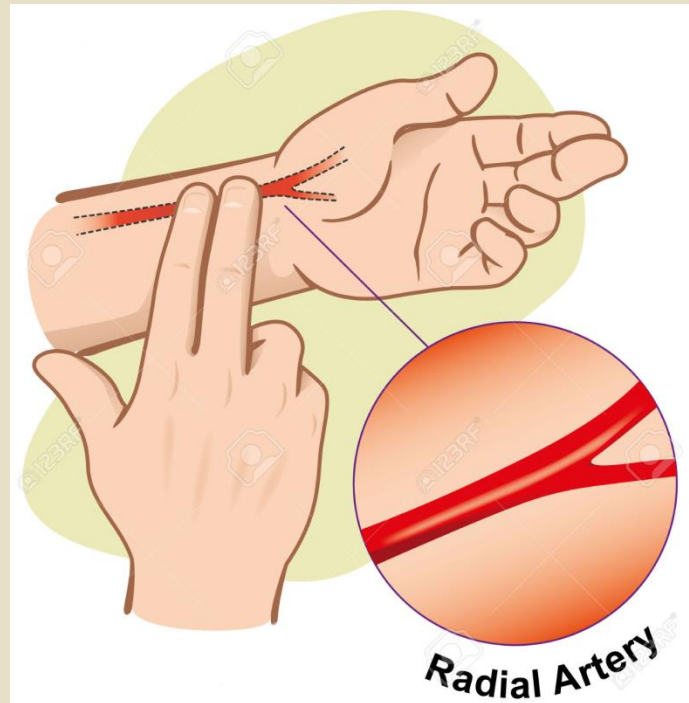
# Corona mortis – “crown of death”



- 15-30% of people
- wound of this anastomosis (during hernial sac operation) leads to strong bleeding, which is very hard to stop

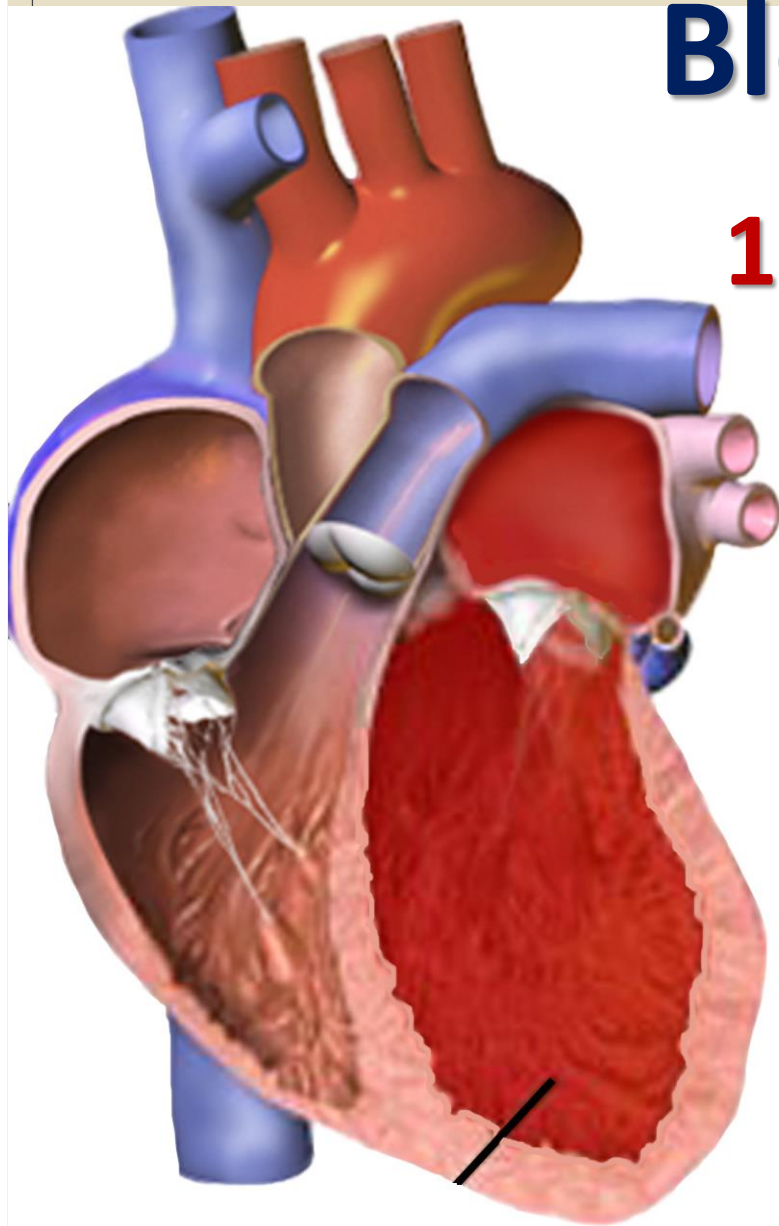


# Pulse points

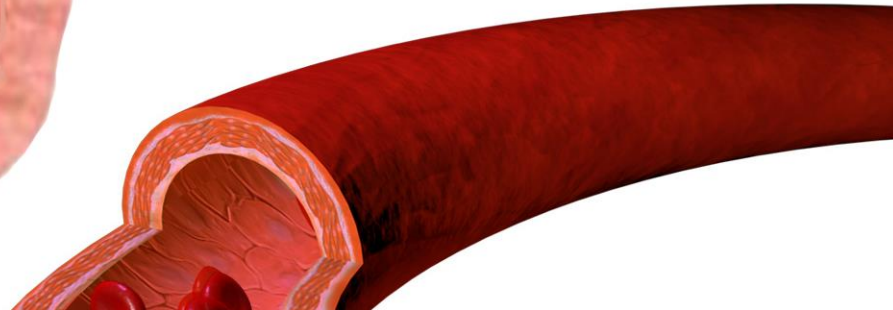


# Blood pressure

**120/80?**

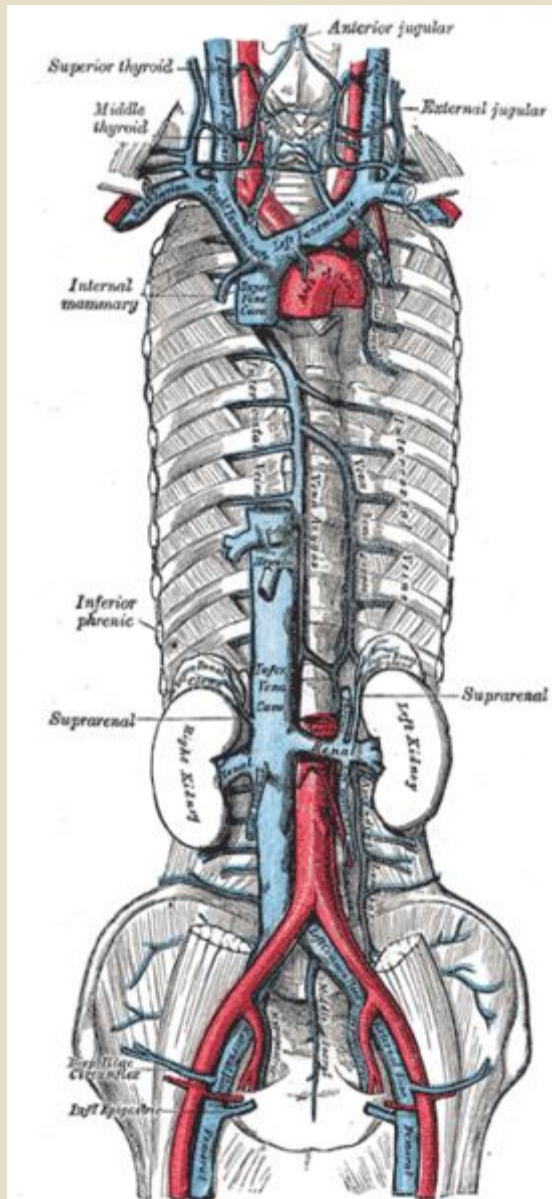


**120** – cardiac (force of the heart)  
**80** – tension of the vessels (“kidney”)





Veins has:  
✓ roots  
✓ tributaries  
(influents)

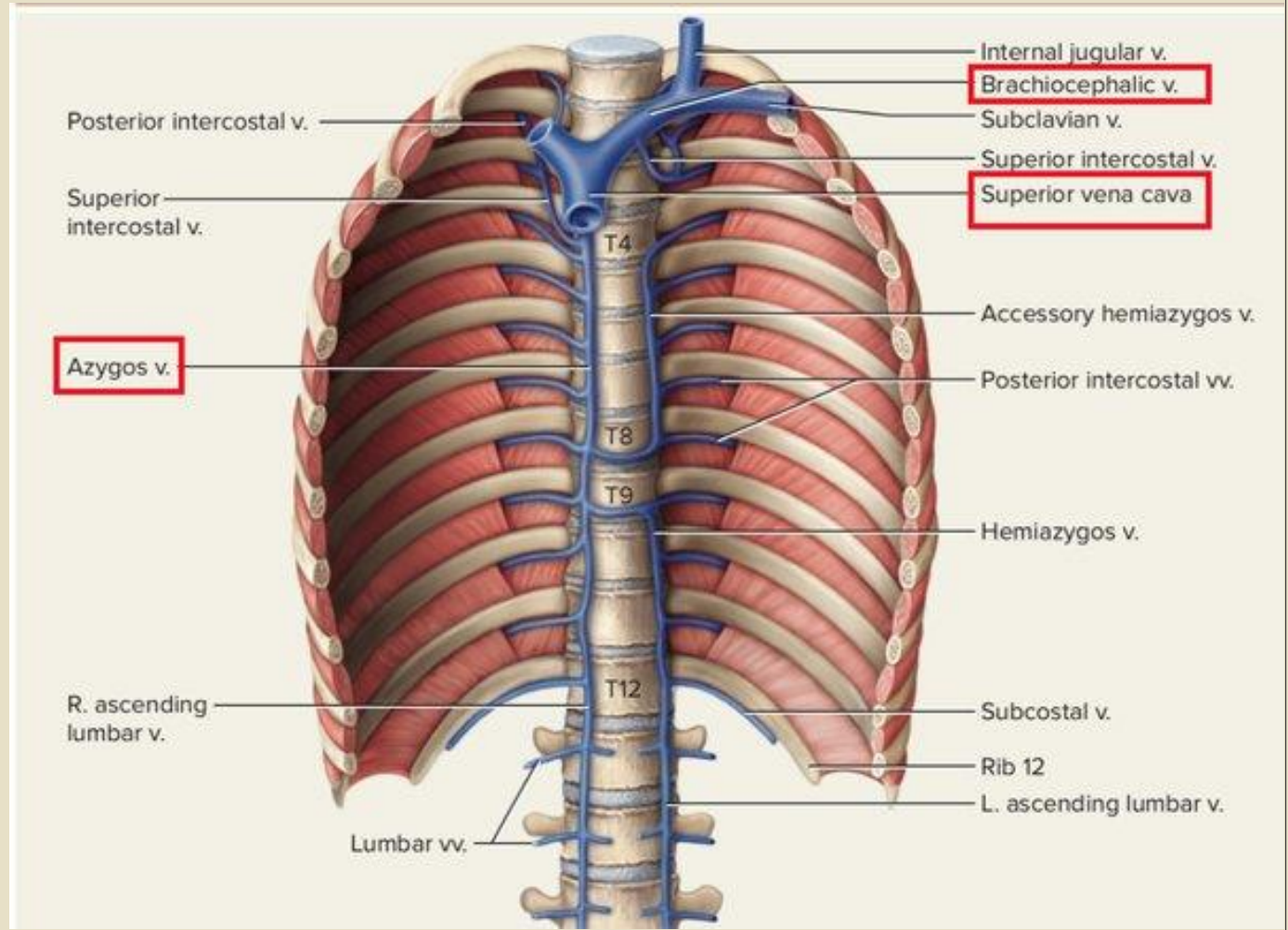


Arteries has  
branches

# Vena cava superior

✓ Roots:  
left and right  
brachiocephalic  
veins

✓ Tributary  
(influent):  
Azygos vein



# Vena cava inferior

✓ Roots:  
left and right common  
iliac veins

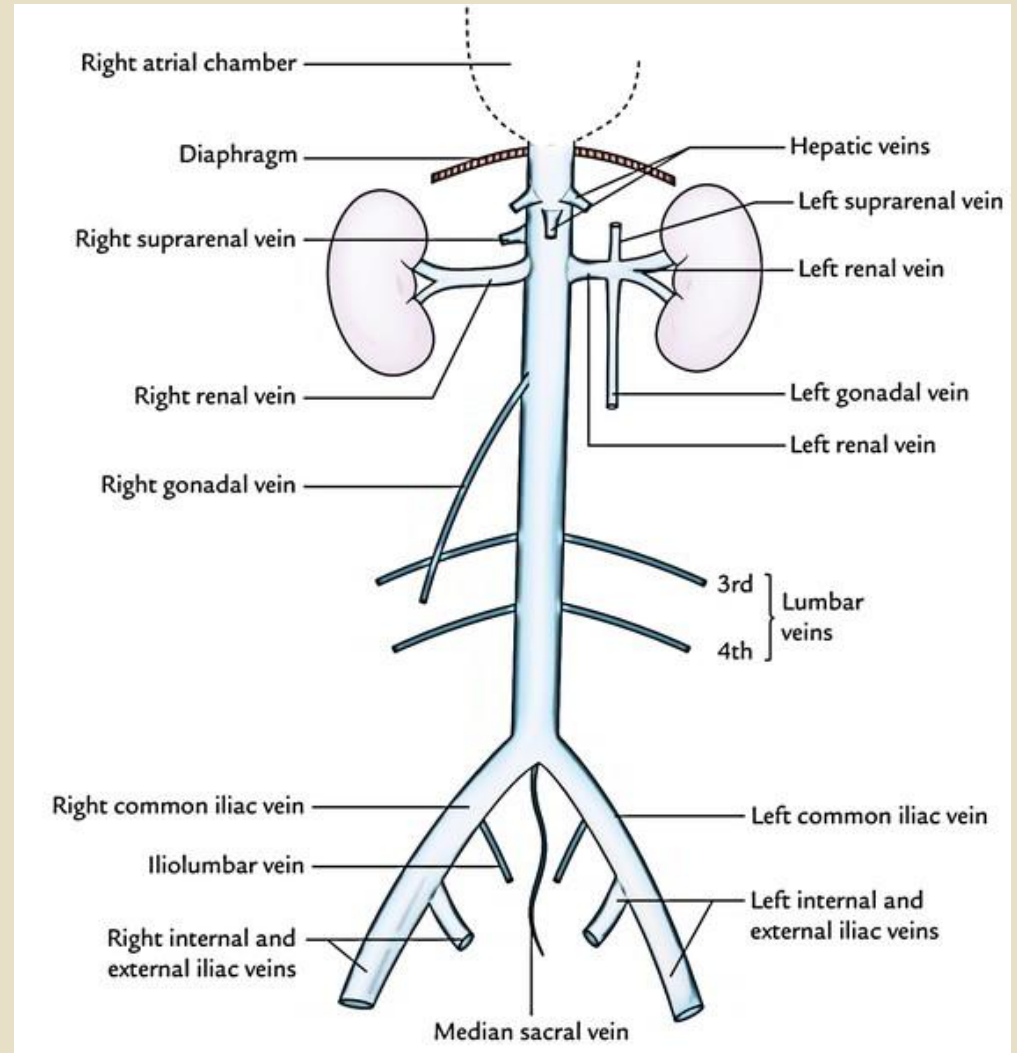
✓ Tributaries (influents):

## 1. Parietal

- Lumbar veins
- Phrenic veins

## 2. Visceral

- Testicular/Ovarian veins (more often right one only)
- Renal veins
- Suprarenal veins (more often right one only)
- Hepatic vein





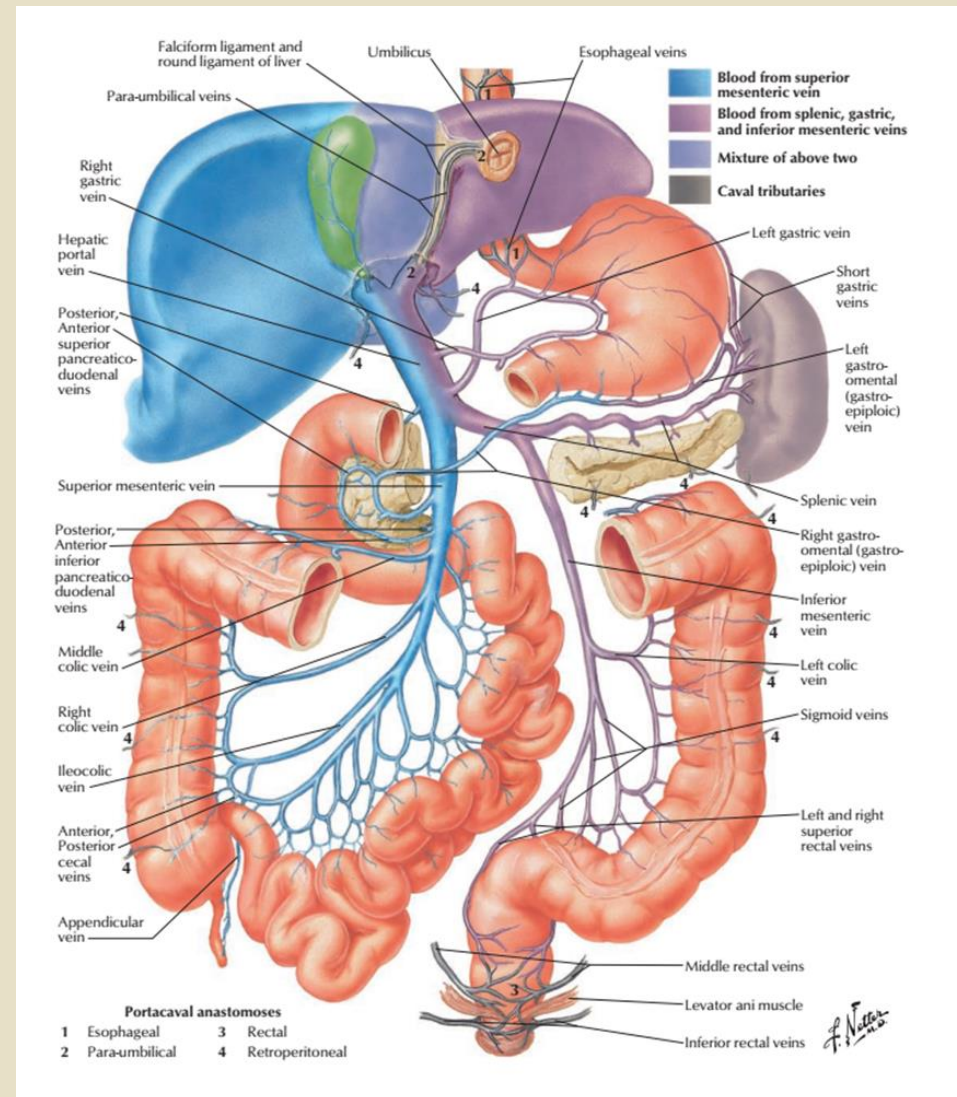
# Vena porta

## ✓ Roots:

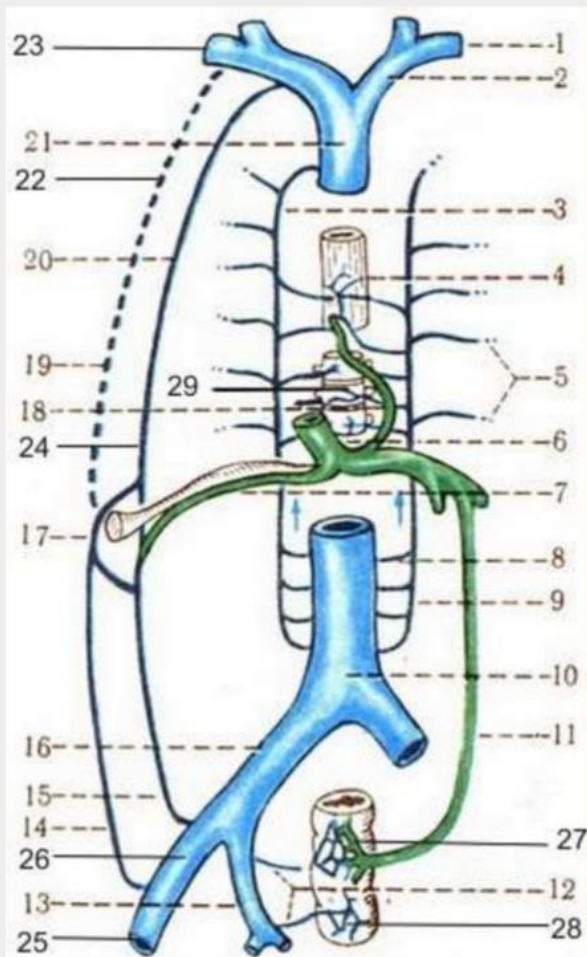
- Splenic vein
- Superior mesenteric vein
- Inferior mesenteric vein

## ✓ Tributaries (influents):

- Gastric veins
- Umbilical |/paraumbilical vein



# Cava-caval anastomosis



- 1 — v. subclavia;
- 2 — v. brachiocephalica;
- 3 — v. azygos;
- 4 — v. esophagea;
- 5 — vv. intercostales posteriores;
- 6 — v. portae;
- 7 — vv. paraumbilicales;
- 8 — v. lumbalis;
- 9 — lumbalis ascendens;
- 10 — v. cava inferior;
- 11 — v. mesenterica inferior;
- 12 — vv. rectales media et inferiores;
- 13 — v. iliaca interna;
- 14 — v. epigastrica superficialis;
- 15 — v. epigastrica inferior;
- 16 — v. iliaca communis;
- 17 — plexus venosus umbilicalis;
- 18 — v. gastrica;
- 19 — v. thoracoepigastrica;
- 20 — v. thoracica interna;
- 21 — v. cava superior
- 22 — v. thoracica lateralis
- 23 — v. axillaris
- 24 — v. epigastrica superior
- 25 — v. femoralis
- 26 — v. iliaca externa
- 27 — v. rectalis superior
- 28 — plexus venosus rectalis
- 29 — vv. intervertebrales et plex. v. vertebrales

v.epigastrica superior (v.cava superior) 24  
+  
v.epigastrica inferior (v.cava inferior) 15

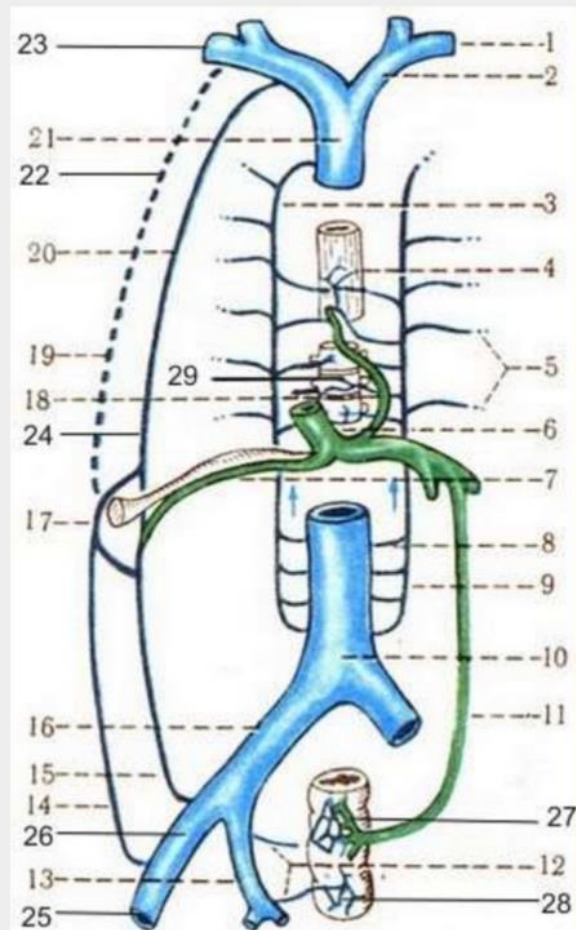
v.azygos/v.hemiazygos (v.cava superior) 3  
+  
v.lumbalis ascendens (v.cava inferior) 9

v.thoracoepigastrica (v.cava superior) 19  
+  
v.epigastrica superficialis (v.cava inferior) 14

plexus.v.vertebrales: 29

- neck: vv.vertebrales-v.brachiocephalica – (v.cava superior)
- thorax: vv.intercostales posteriors-v.azygos/v.hemiazygos – (v.cava superior)
- abdomen: vv.lumbales – (v.cava inferior)

# Porto-caval anastomosis



- 1 — v. subclavia;
- 2 — v. brachiocephalica;
- 3 — v. azygos;
- 4 — v. esophagea;
- 5 — vv. intercostales posteriores;
- 6 — v. portae;
- 7 — vv. paraumbilicales;
- 8 — v. lumbalis;
- 9 — lumbalis ascendens;
- 10 — v. cava inferior;
- 11 — v. mesenterica inferior;
- 12 — vv. rectales media et inferiores;
- 13 — v. iliaca interna;
- 14 — v. epigastrica superficialis;
- 15 — v. epigastrica inferior;
- 16 — v. iliaca communis;
- 17 — plexus venosus umbilicalis;
- 18 — v. gastrica;
- 19 — v. thoracoepigastrica;
- 20 — v. thoracica interna;
- 21 — v. cava superior
- 22 — v. thoracica lateralis
- 23 — v. axillaris
- 24 — v. epigastrica superior
- 25 — v. femoralis
- 26 — v. iliaca externa
- 27 — v. rectalis superior
- 28 — plexus venosus rectalis
- 29 — vv. intervertebrales et plex. v. vertebrales

v.epigastrica superior (v.cava superior) *24*

+

v.epigastrica inferior (v.cava inferior) *15*

+

v.thoracoepigastrica (v.cava superior) *19*

+

v.epigastrica superficialis (v.cava inferior) *14*

+

v.paraumbilicalis (v.porta) *7*

v.mesenterica superior and  
v.lienalis (v.porta)

+

v.renalis (v.cava inferior)

v.rectalis superior (v.porta) *27*

+

v.rectalis media and v.rectalis inferior (v.cava inferior) *12*

v.oesophagealis (v.cava superior) *4*

+

v.gastrica sinistra (v.porta) *18*

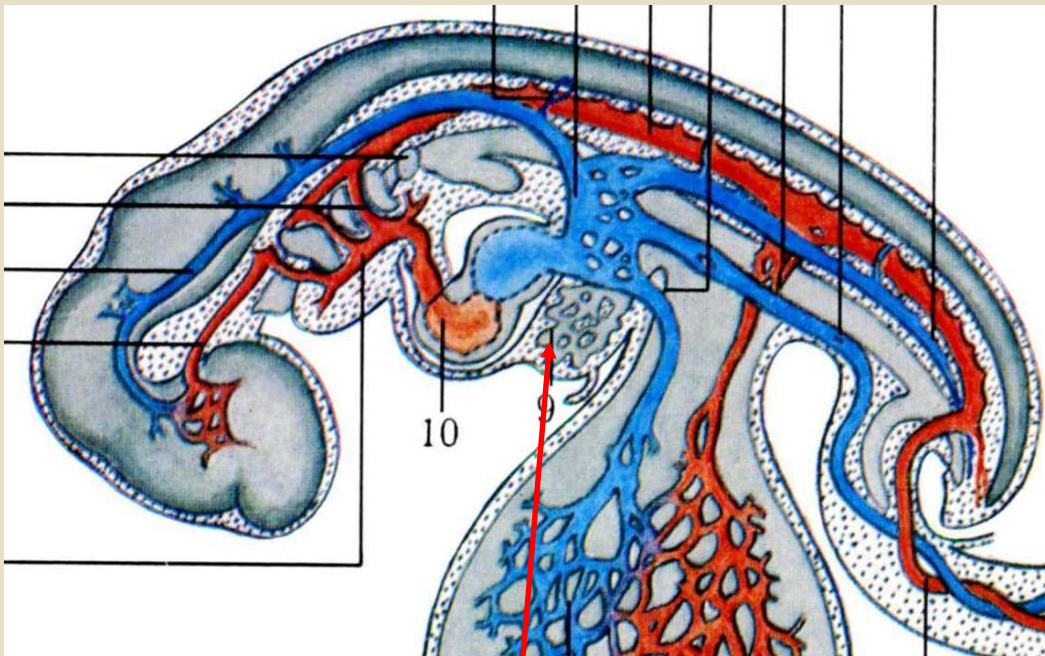


## Caput Medusae Gorgon

In portal hypertension, as in the case of cirrhosis of the liver, the porto-caval anastomoses become congested and form venous dilatations

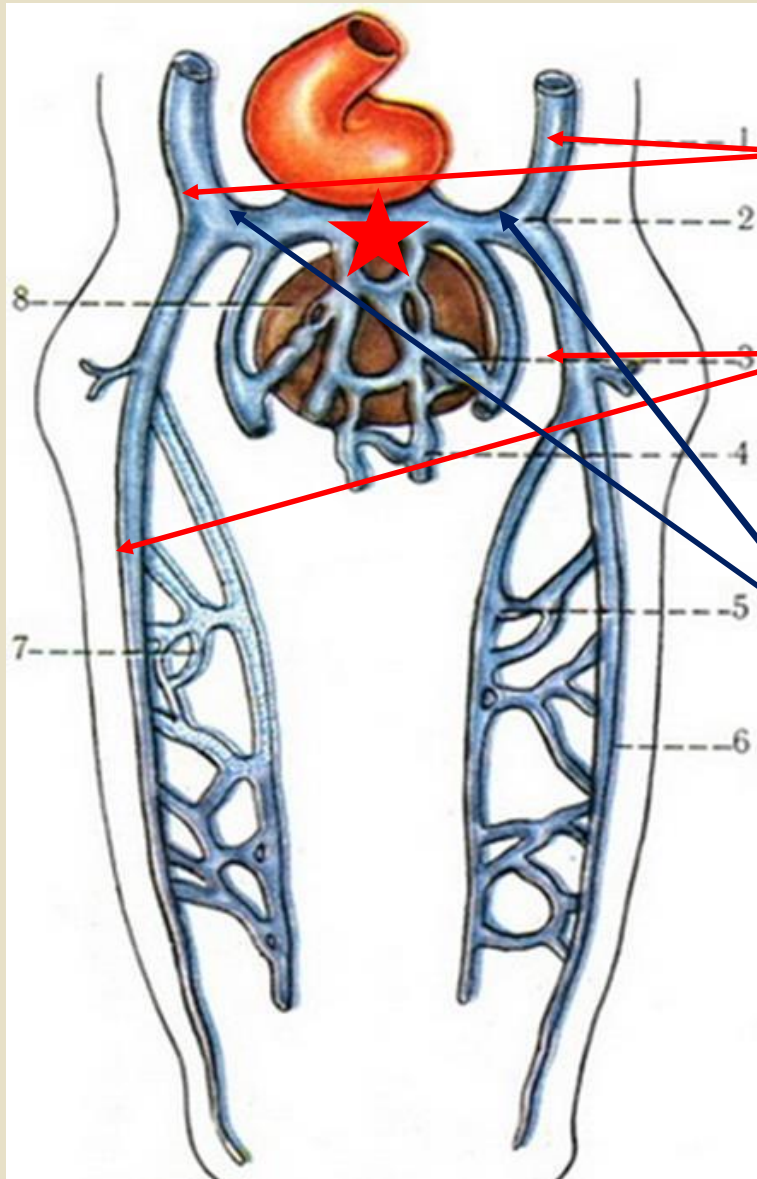


# Veins are formed during the fourth week of embryonic development



All the veins drains into the venous sinus of the heart

- vv. cardinales
- vv. vitellinae (which drain the yolk sac)
- vv.umbilicalis (develop due to the development of the placental blood circulation)
- primary vena cava inferior



Anterior cardinal veins (right and left)  
in the region of the head and neck  
and

Posterior cardinal veins (right and left)  
in the remaining (в остальной) part of the  
body

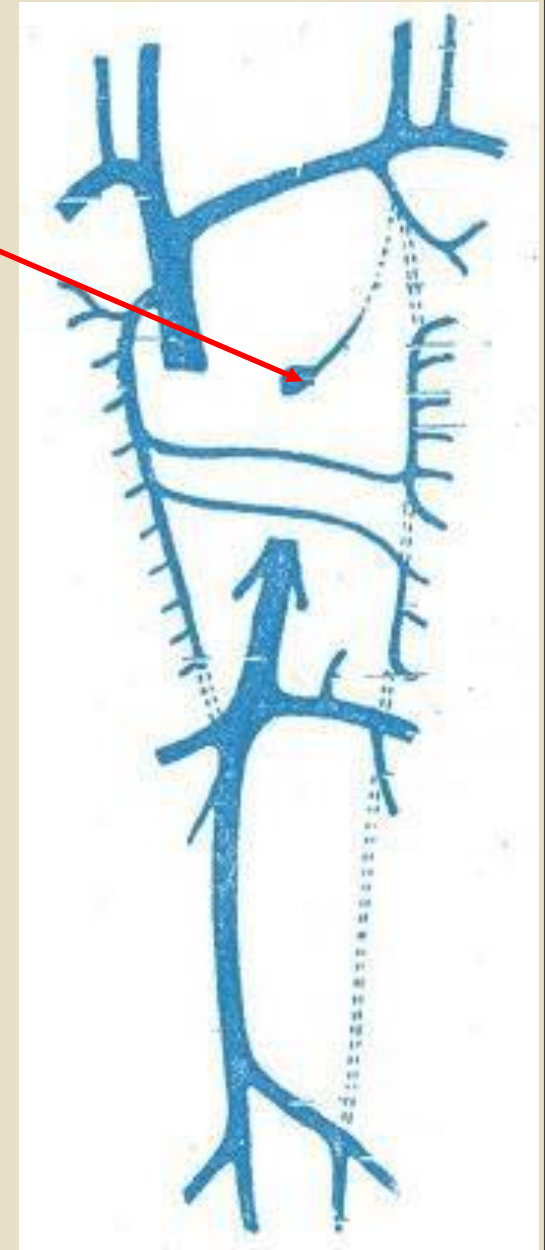
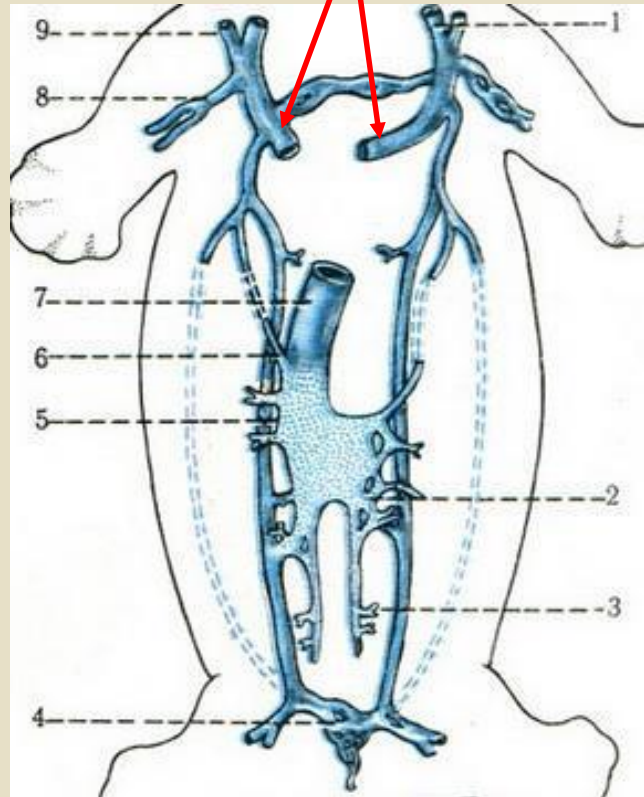
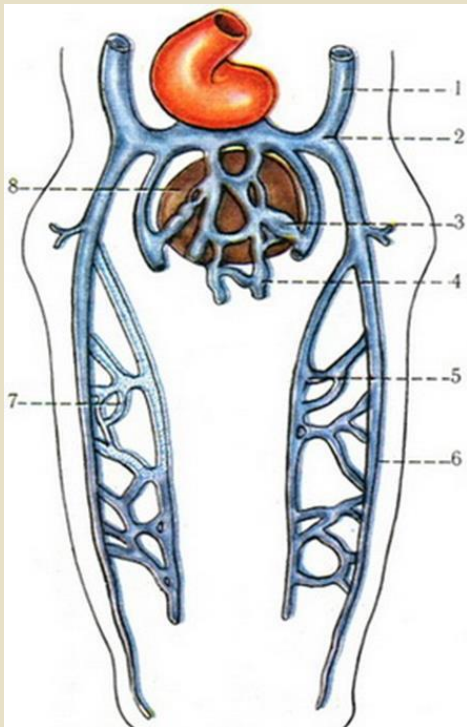
merge to form the ducts of Cuvier -  
*vv. cardinales communes dextra et sinistra,*

which drain into the venous  
sinus of the heart ★



Left Cuvier's duct ceases to function. Its walls collapse, and it obliterates, except for a small segment, which becomes the coronary sinus of the heart

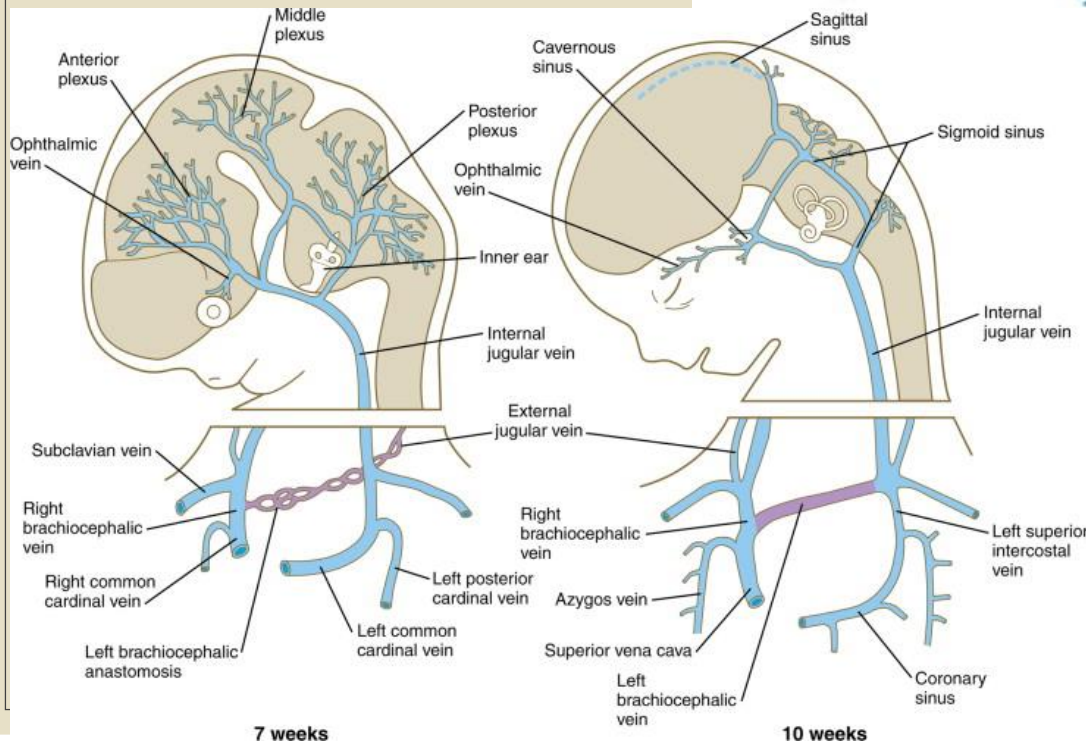
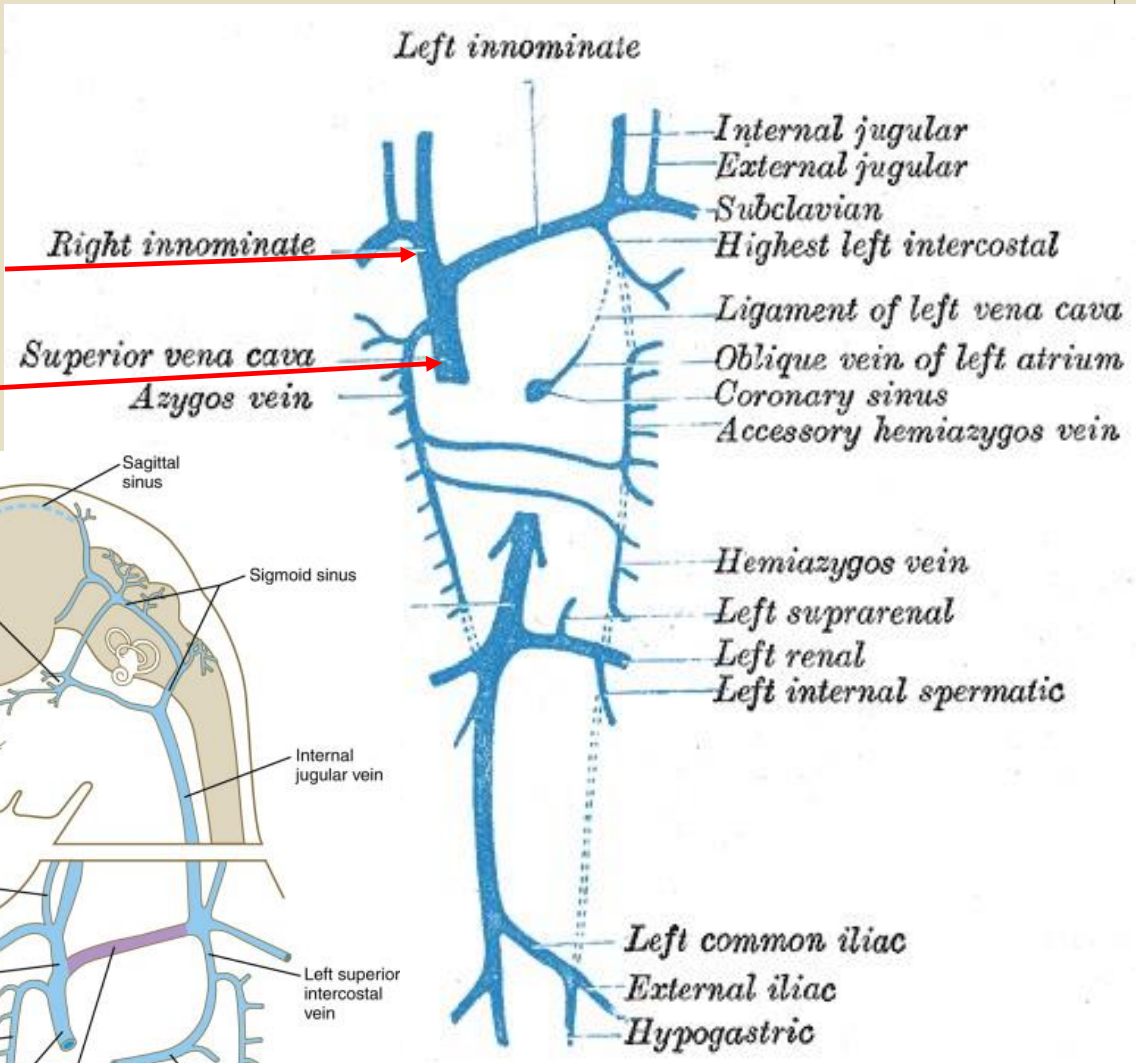
Brachiocephalic veins



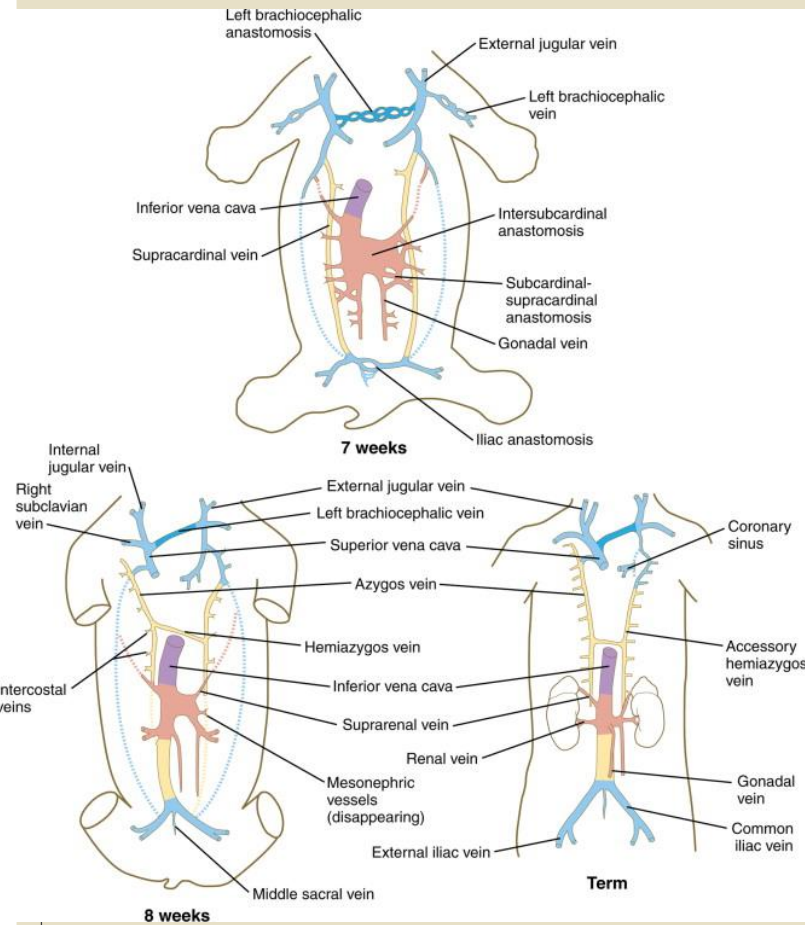


# The right anterior cardinal vein gives rise to two vessels:

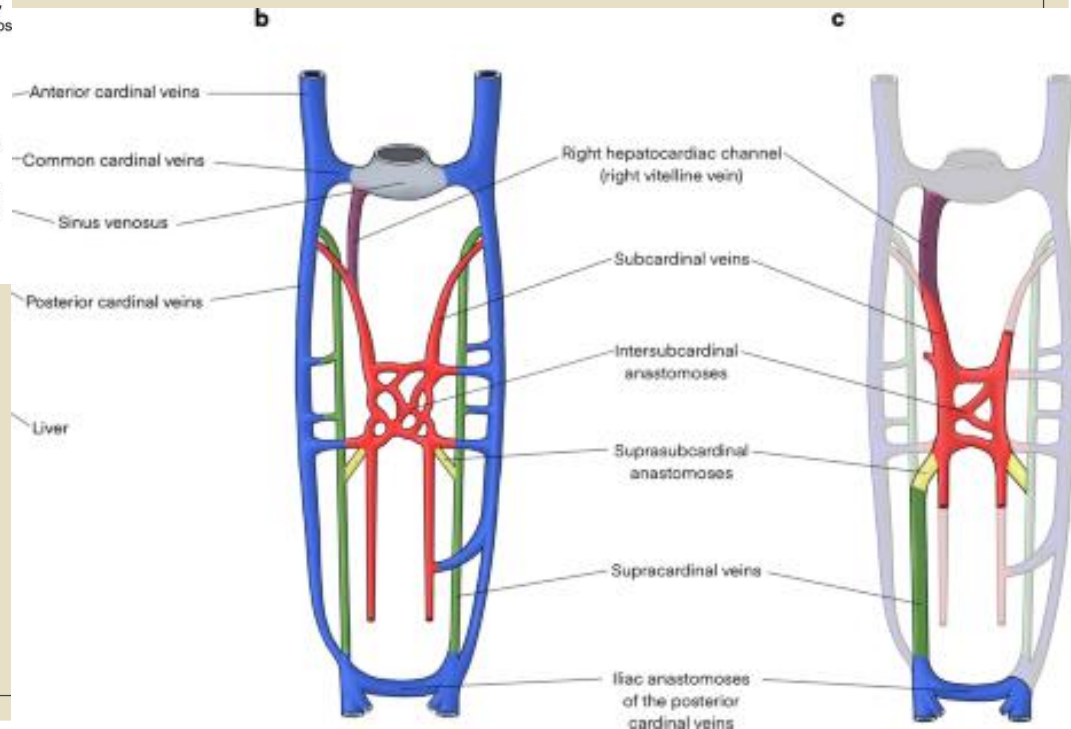
1. right brachiocephalic vein
2. the superior vena cava



- An anastomosis found in the iliac region drains blood from the left lower limb into the right posterior cardinal vein;
  - as a result, the segment of the left posterior cardinal vein above the anastomosis reduces, while the anastomosis itself transforms into the left common iliac vein.

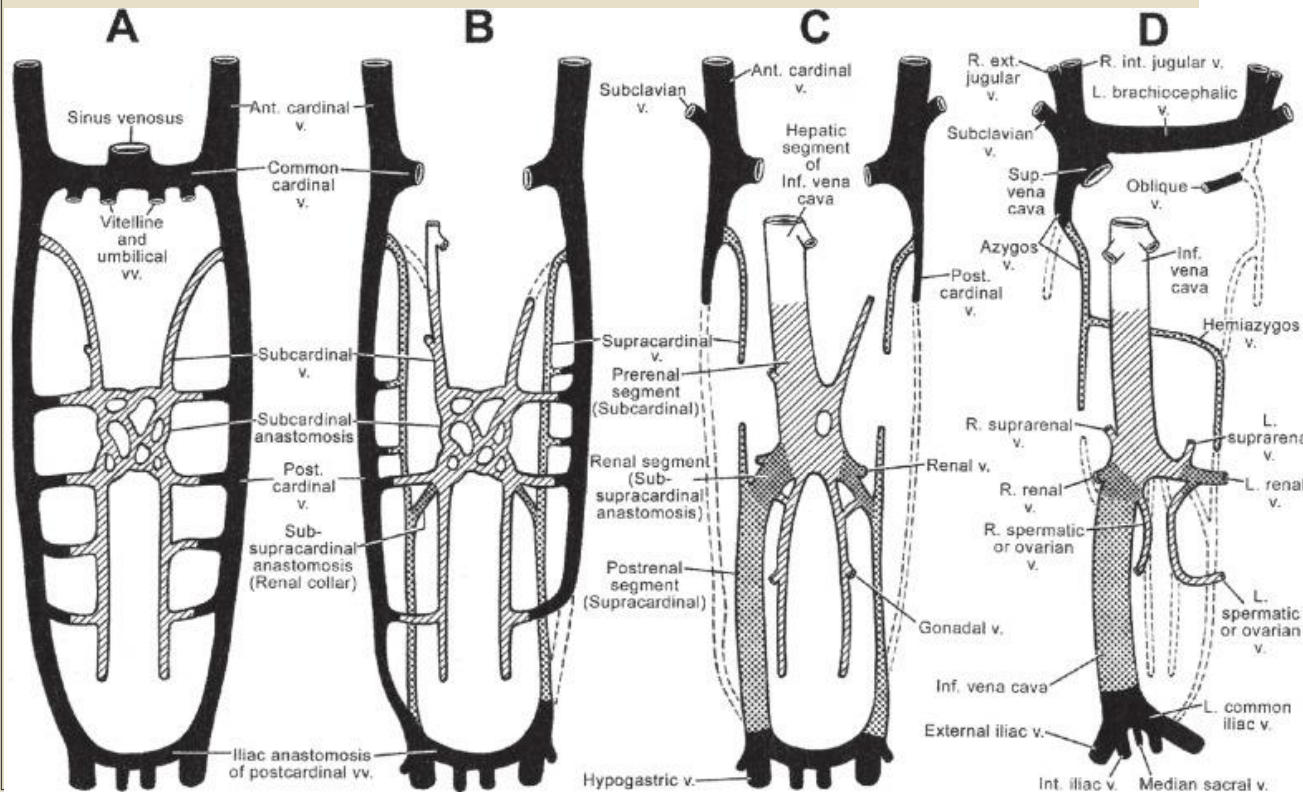
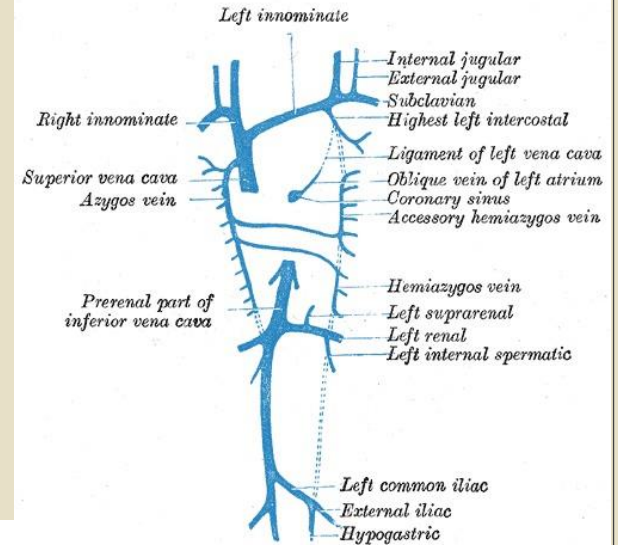


The formation of the inferior vena cava is associated with the appearance of anastomoses between the posterior cardinal veins.



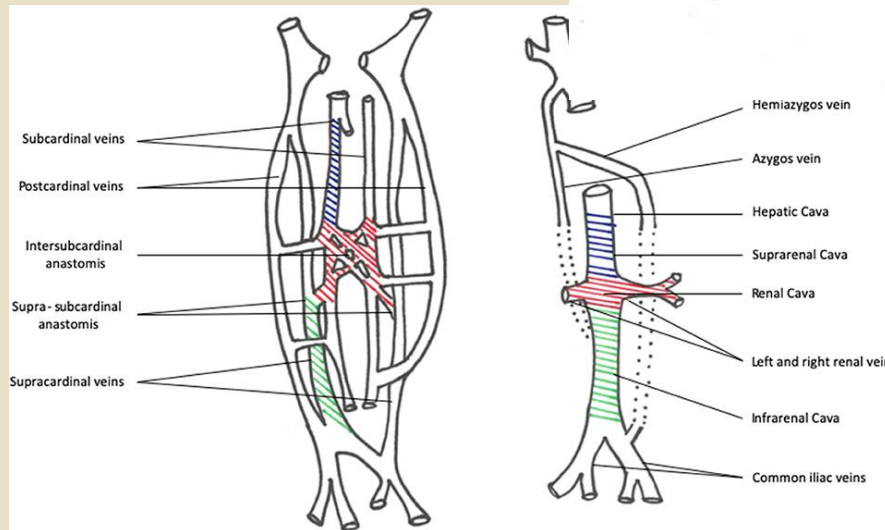
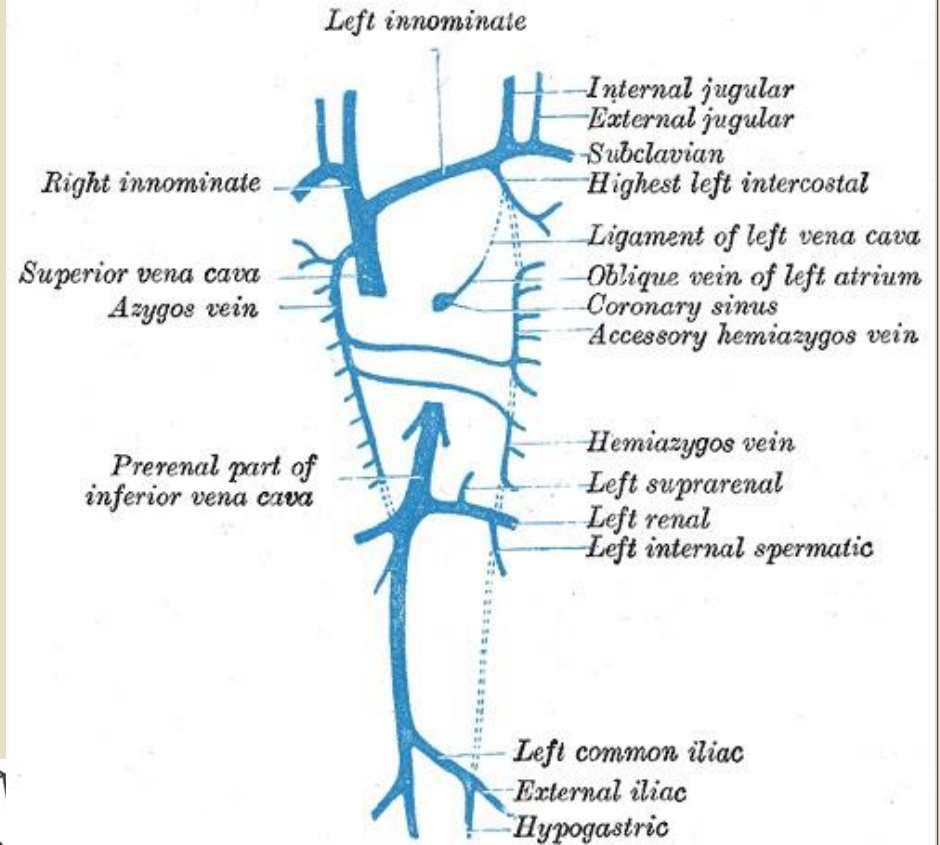
## The inferior vena cava is formed of two parts:

1. the right posterior cardinal vein (prior to the place where it receives the renal veins)
2. primary inferior caval vein (distal to this).

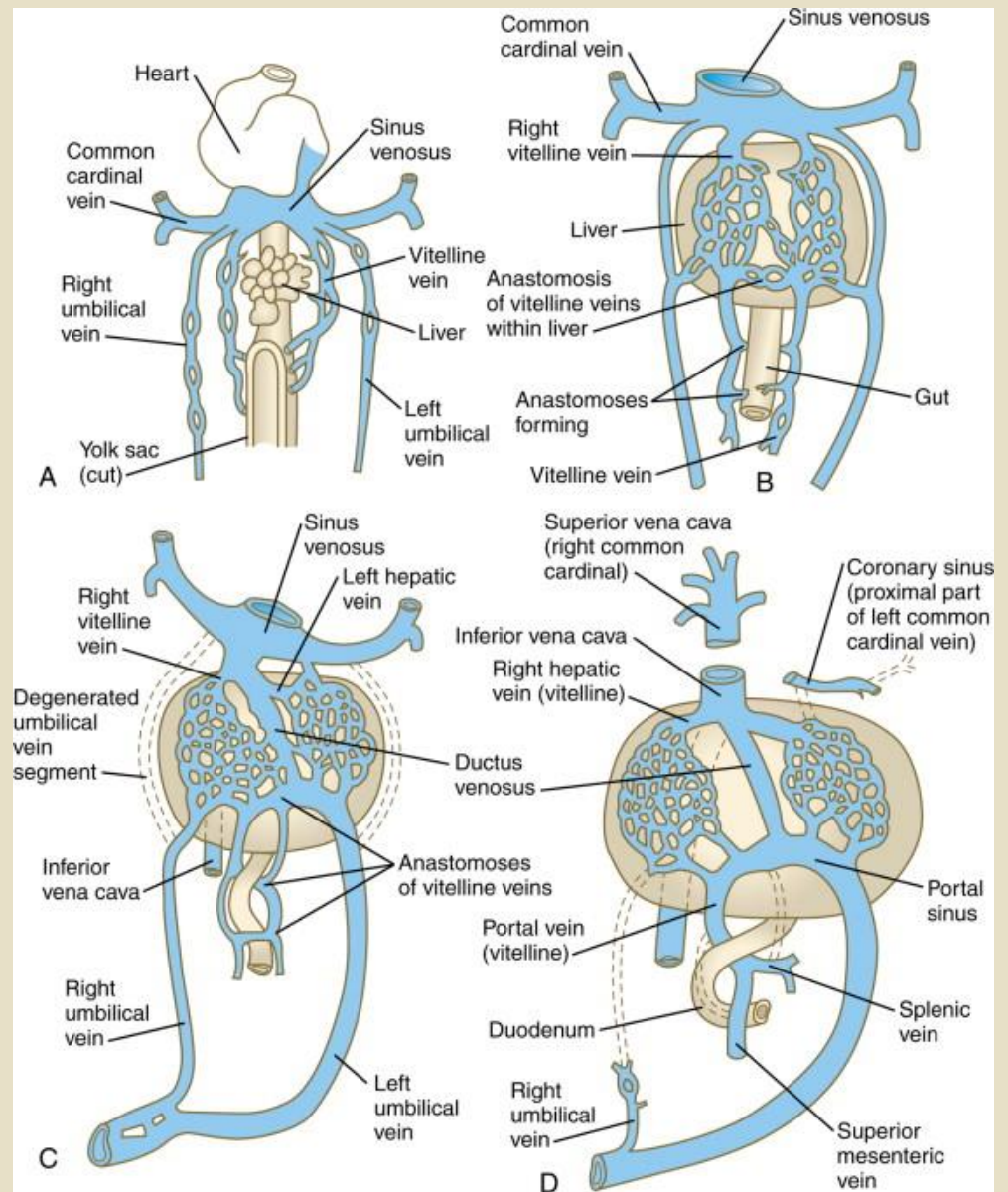




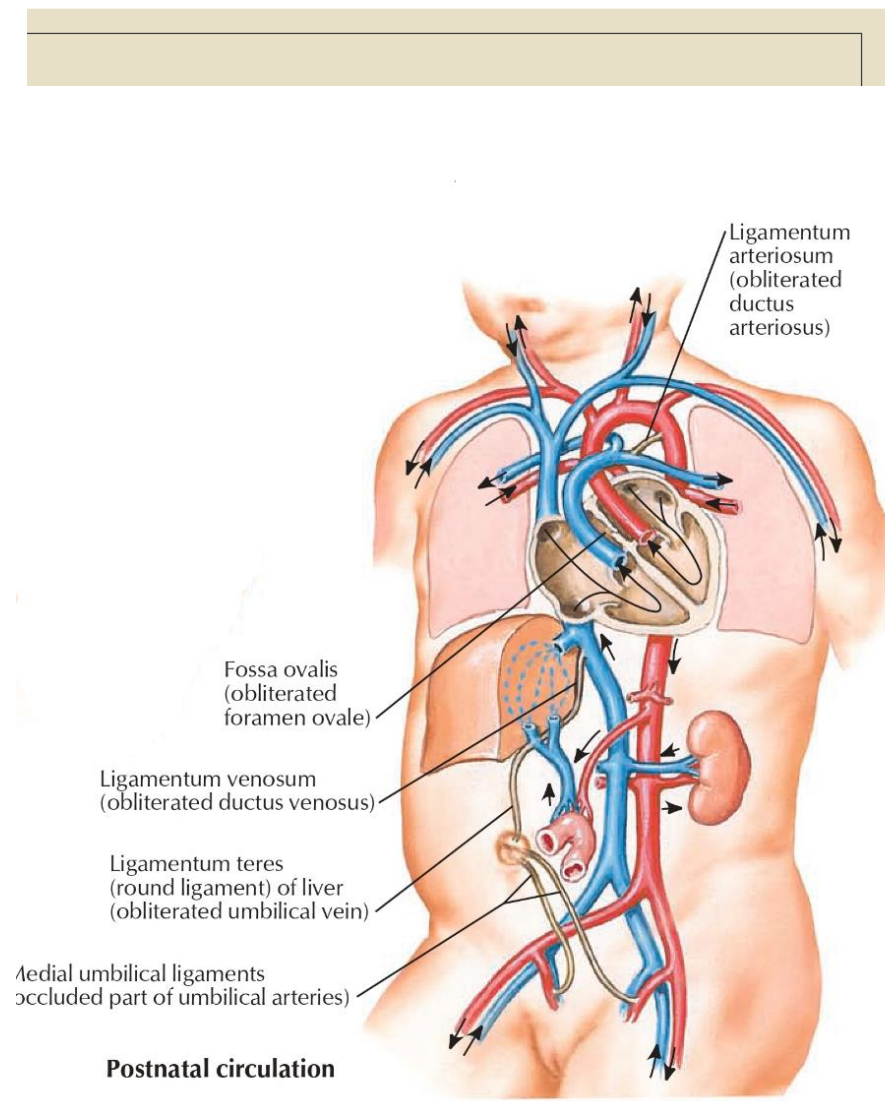
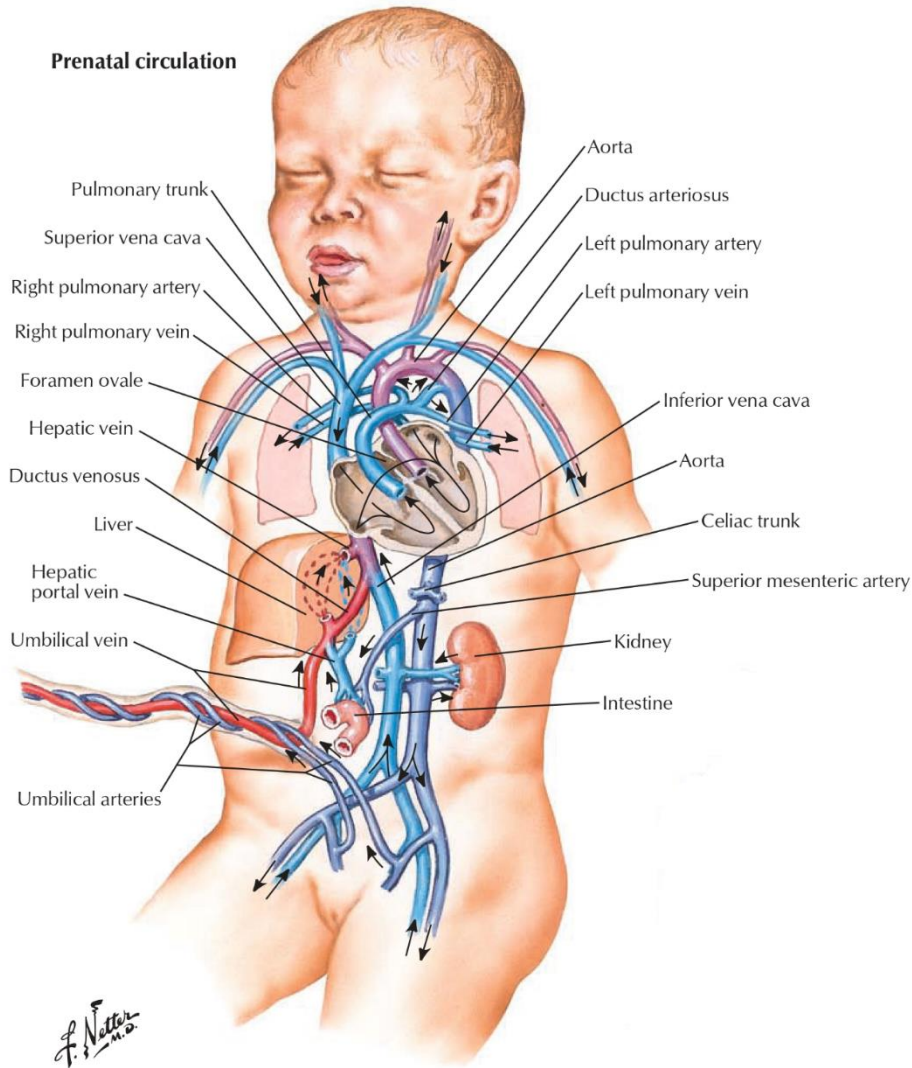
- Since the inferior vena cava brings blood to the heart from the entire caudal part of the body, the posterior cardinal veins become less important;
- their development is retarded, and they transform into the azygos vein (right posterior cardinal vein) and the hemiazzygos and accessory hemiazzygos veins (left posterior cardinal vein).



The portal vein is derived from the omphalomesenteric veins along which blood from the yolk sac reaches the liver. The segment of these veins between their junction with the mesenteric vein and the hepatic porta transforms into the portal vein.



**Prenatal circulation**



ductus venosus (duct of Arantius)



ligamentum venosum