Cardiovascular system

The system of blood circulation

Heart

mid Moztarzadeh

The system of blood circulation

- **Function:** transport of O2, nutrients, hormones, metabolic products, drugs...
  heat distribution
- **Blood – sanguis:** volume - 6% of the total weight (5-6l)

Plasma :

(3.5 l) - minerals, proteins, sugars, nutrients, waste products

Blood elements:

Erythrocytes- number (4.6-5.5 million/µl) - hemoglobin makes up 35% of the total weight of RBC

Leukocytes- number (4000-11000/µl):

Neutrophils (60-70 %)
Basophils (0.5-1.0 %)
Eosinophils (3-5 %)
Lymphocytes (25-30 %)

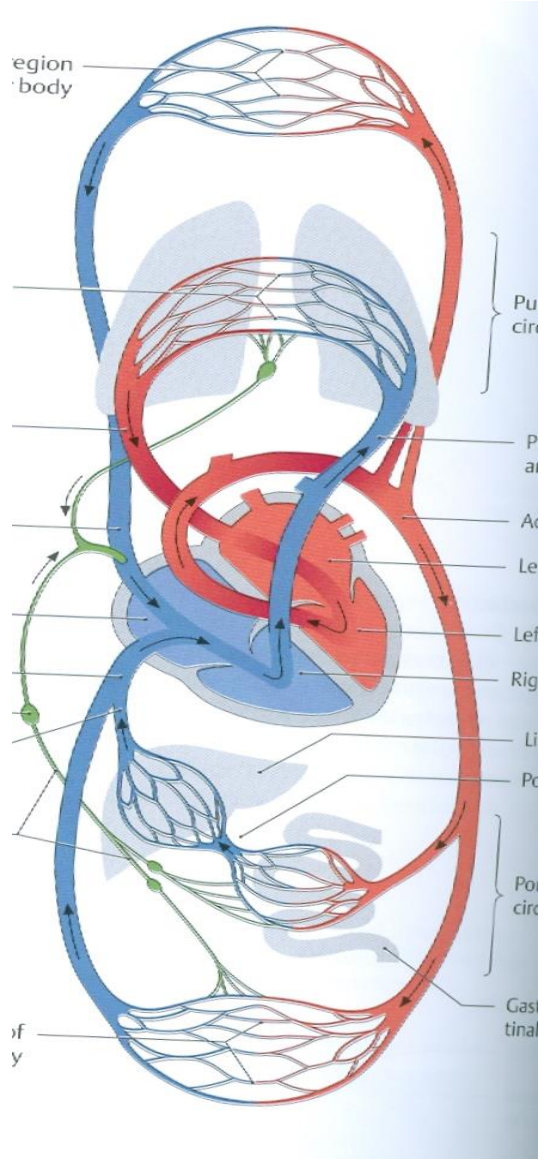
Thrombocytes- number 150000-400000/µl

Hematocrit : is the ratio between the volume of red blood cells and whole blood = 40-45 %

The system of blood circulation

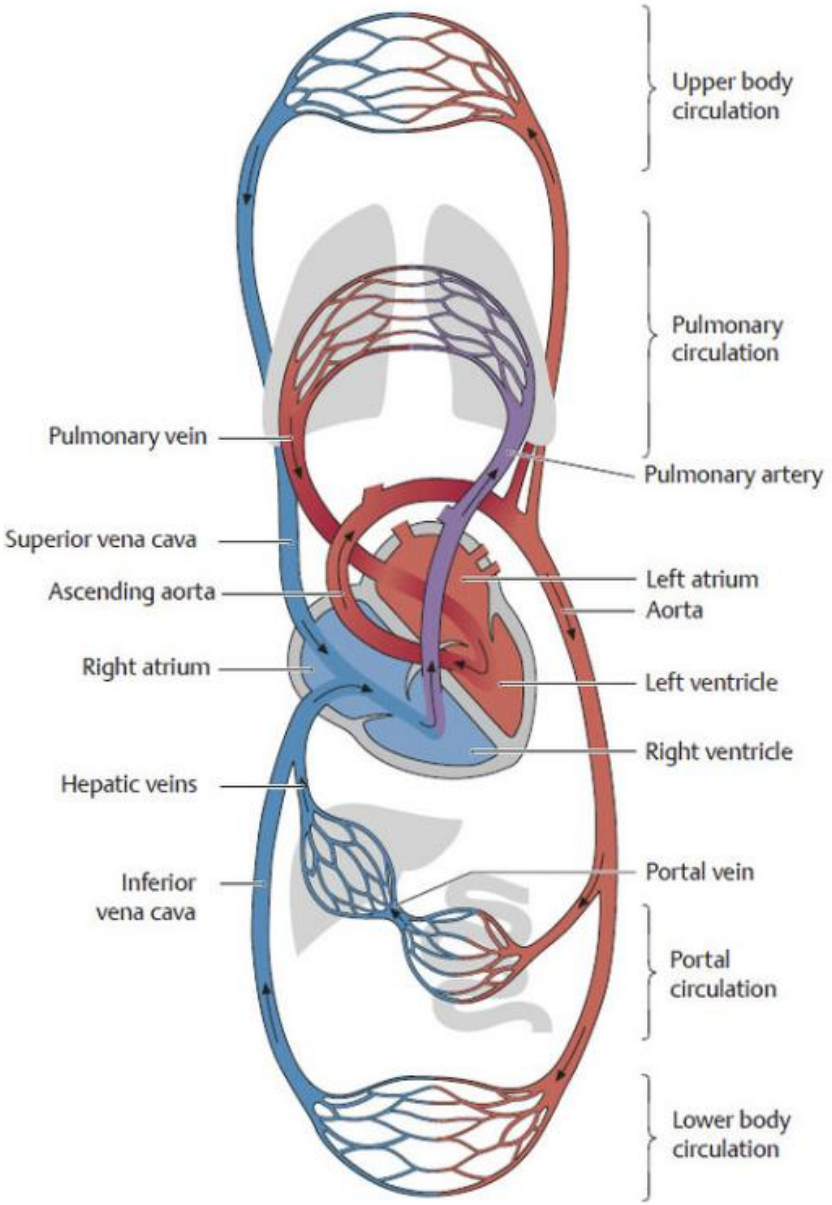
- Heart – cor
- Arteries - arteriae
- Arterioles – Arteriolae
- Capillary – vasa capillaria
- Venules -venulae
- Veins – venae

- Minor circulation – Pulmonary
- Major circulation – Systemic
- Portal circulation



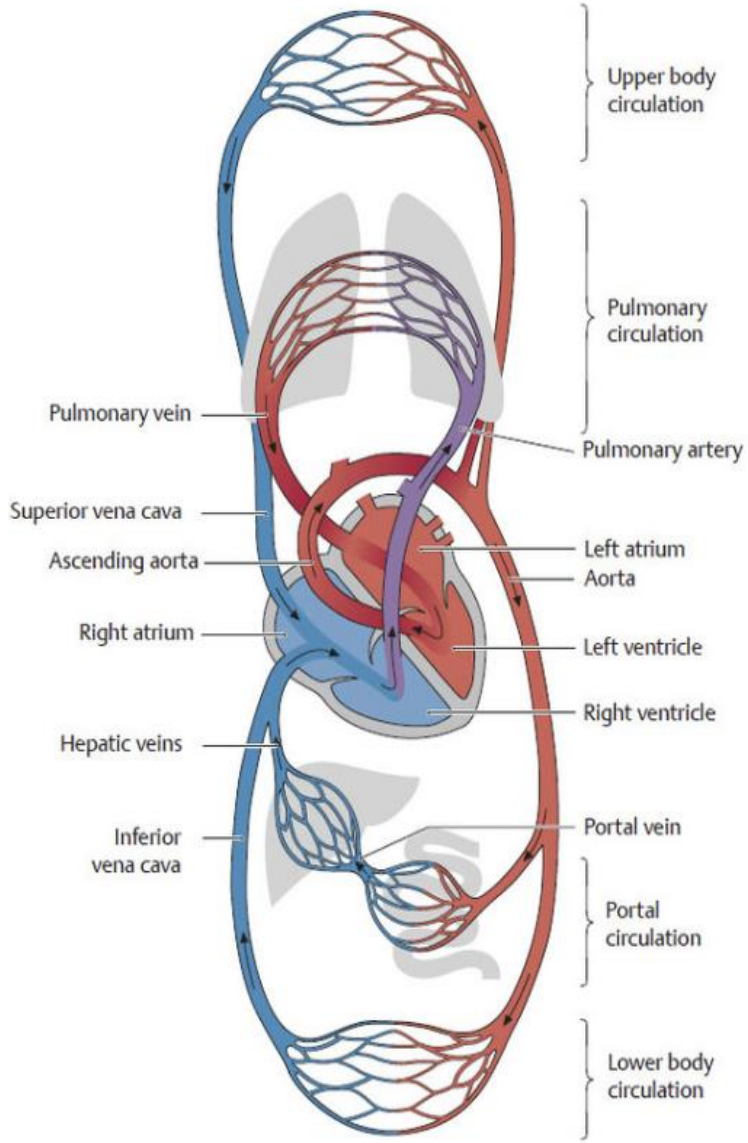
Minor blood circulation – Pulmonary circulation

- The pulmonary trunk (truncus pulmonalis) from the right ventricle branches to the right and left pulmonary arteries for the right and left lung. From the lungs, oxygenated blood returns to the left atrium through the pulmonary veins (venae pulmonales).



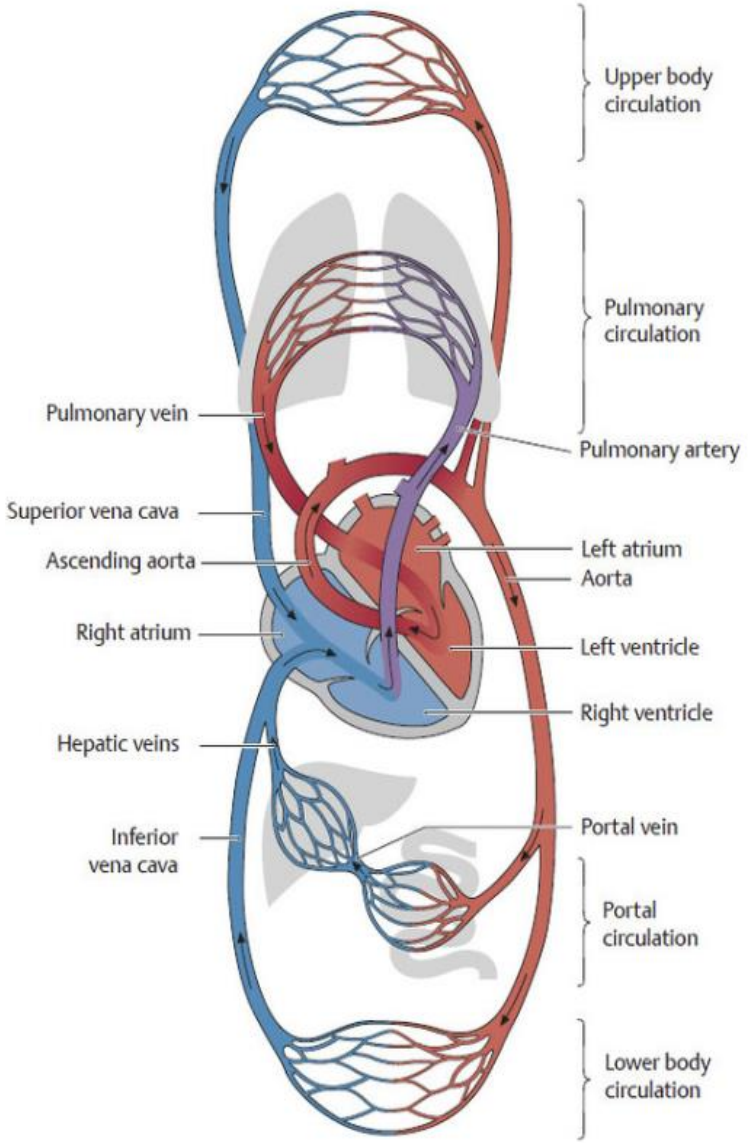
Major blood circulation – sytemic circulation

- The left ventricle gives off the aorta and all other arteries are formed by its gradual division. The capillaries join to the veins. Their final branches, the superior and inferior vena cava, enter the right atrium.
- An exception is the portal circulation.

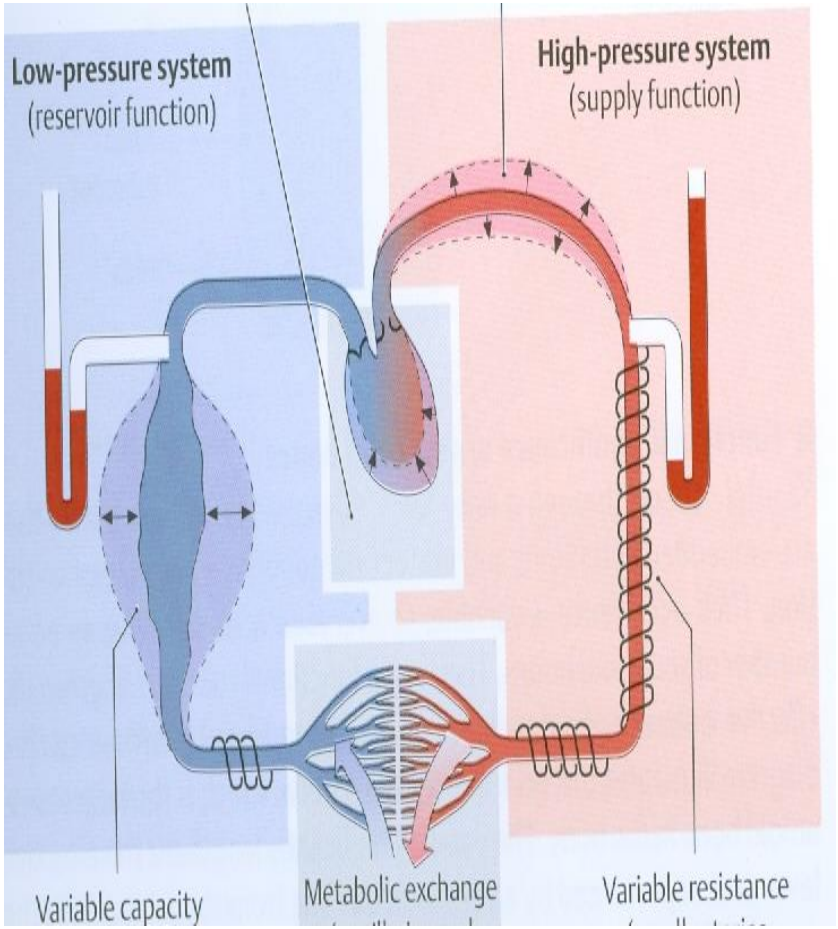


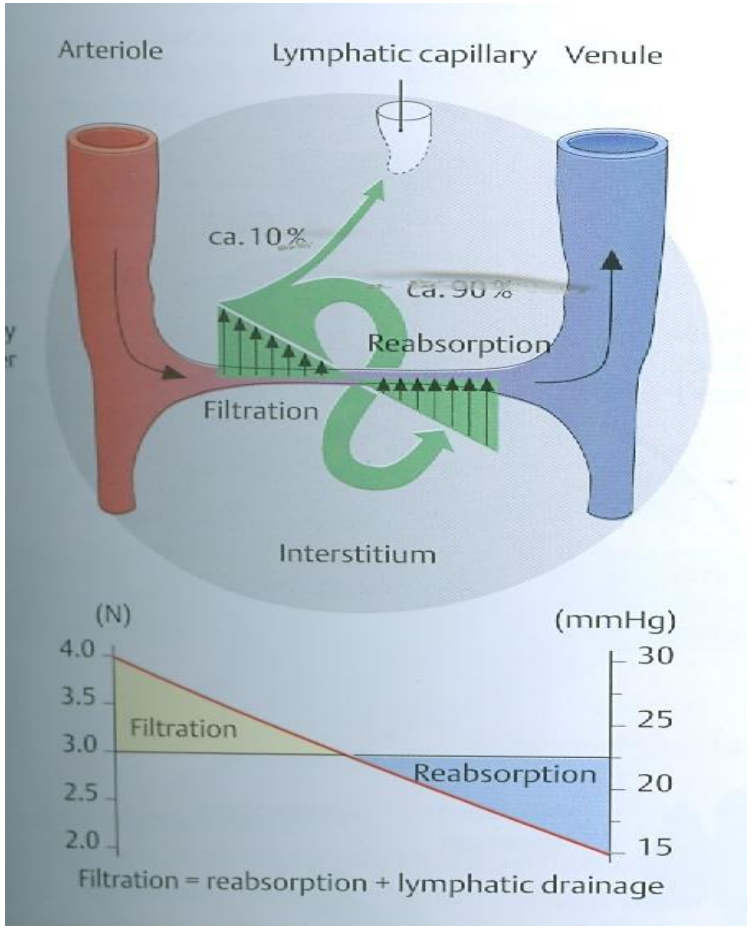
Portal blood circulation

- Blood from the unpaired organs of the abdominal cavity is delivered to the liver via the portal vein (vena portae). From the liver by the hepatic veins (venae hepaticae) to the inferior vena cava.



In terms of pressures, the bloodstream can be divided into a high-pressure part (arteries) and a low-pressure part (veins).
At the level of capillaries, substances are exchanged between blood and tissues. The capillary network is very rich, especially in organs demanding oxygen and nutrient supply.





Blood vessels

- **Arteries – carrying the blood from the heart.**

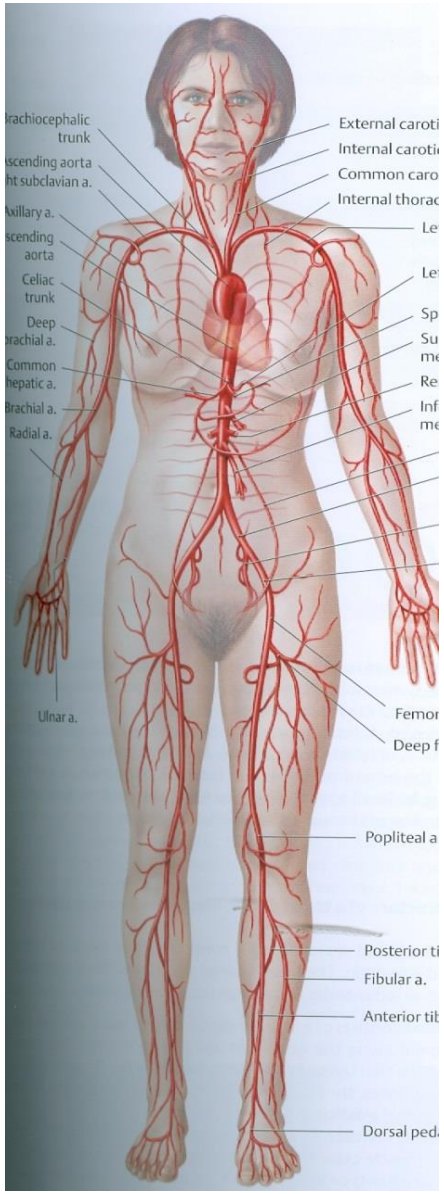
Aorta – the main artery of the major circulatory system

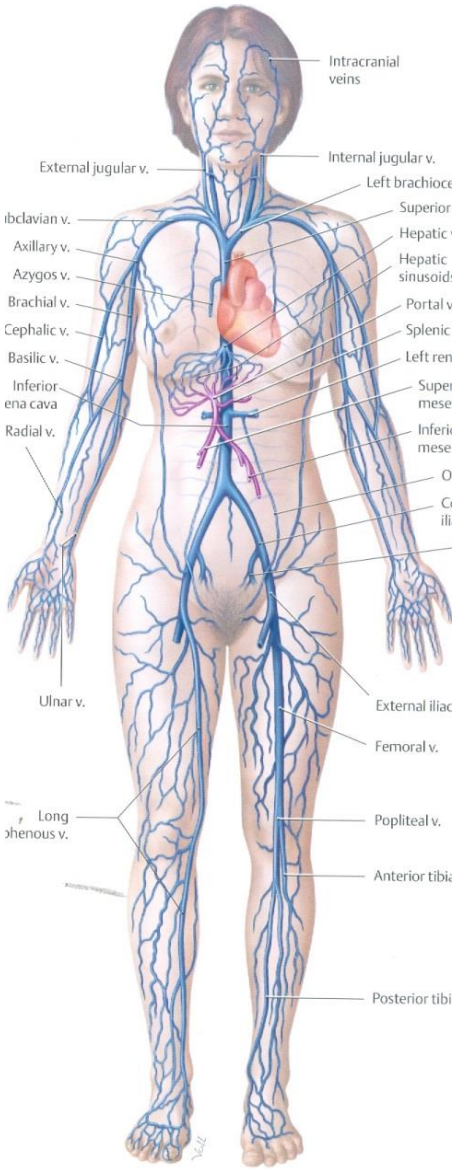
- **Veins – bring the blood to the heart.**

Vena cava superior and inferior – the main veins of the major circulation, the wall is thinner and more compliant than the wall of the arteries

- **Capillaries – mediating the exchange of gases and substances**

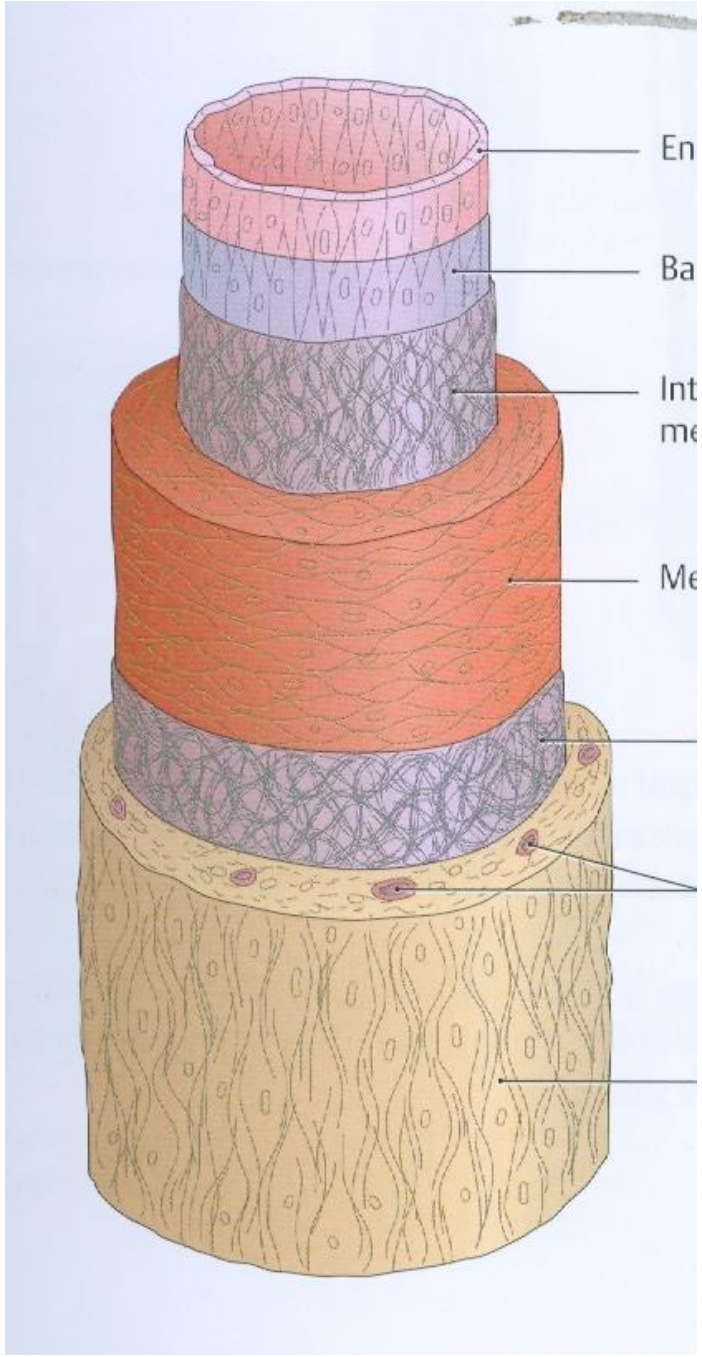
Blood vessels



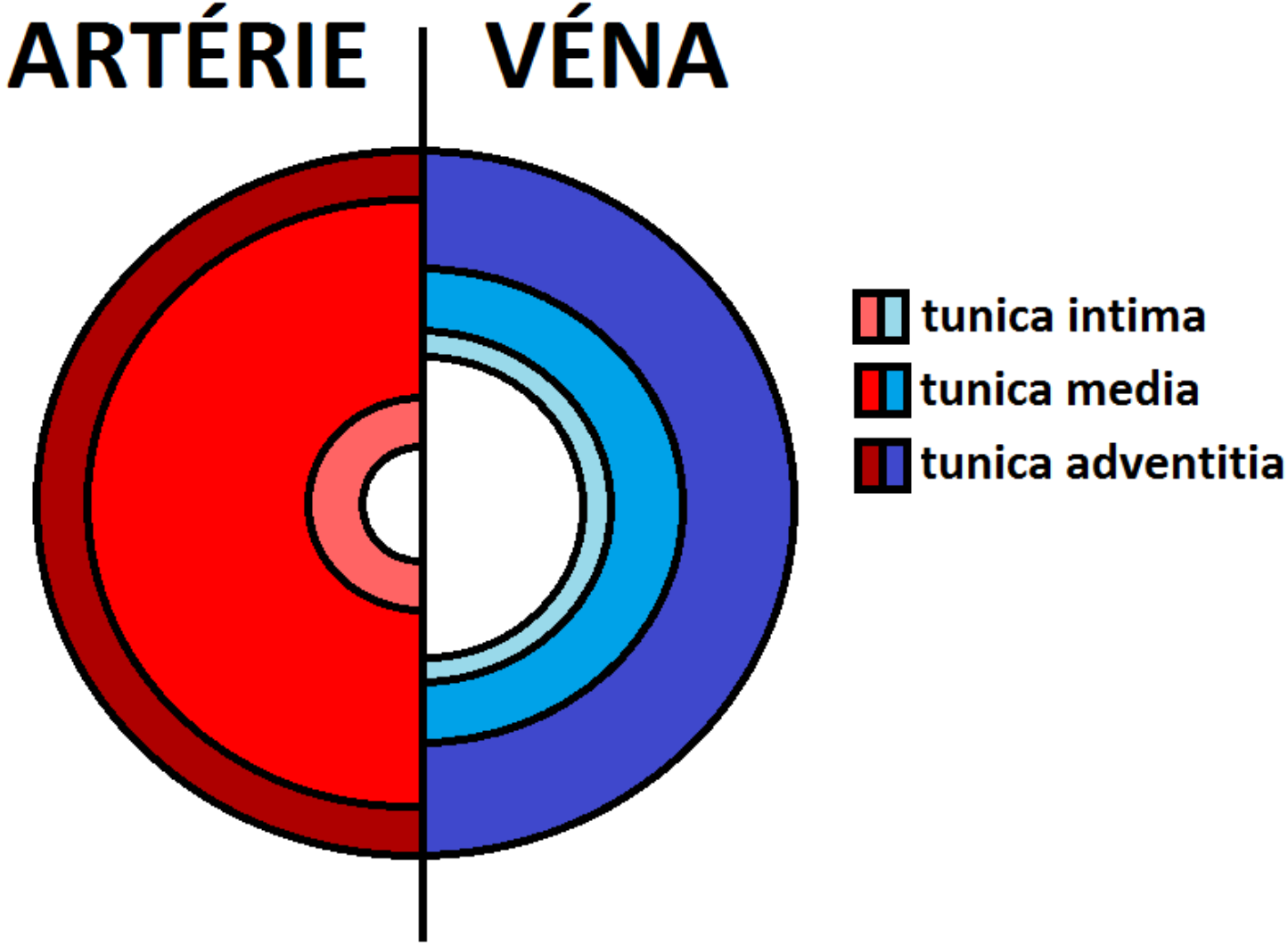


The wall of vessels

- **Tunica intima –** endothelium, lamina basalis
- **Tunica media –** (membrana elastica interna, smooth muscle, membrana elastica externa)
- **Tunica adventitia –** connective tissue, nerves, blood vessels (vasa vasorum)



Comparison of artery and vein structure at the same thickness



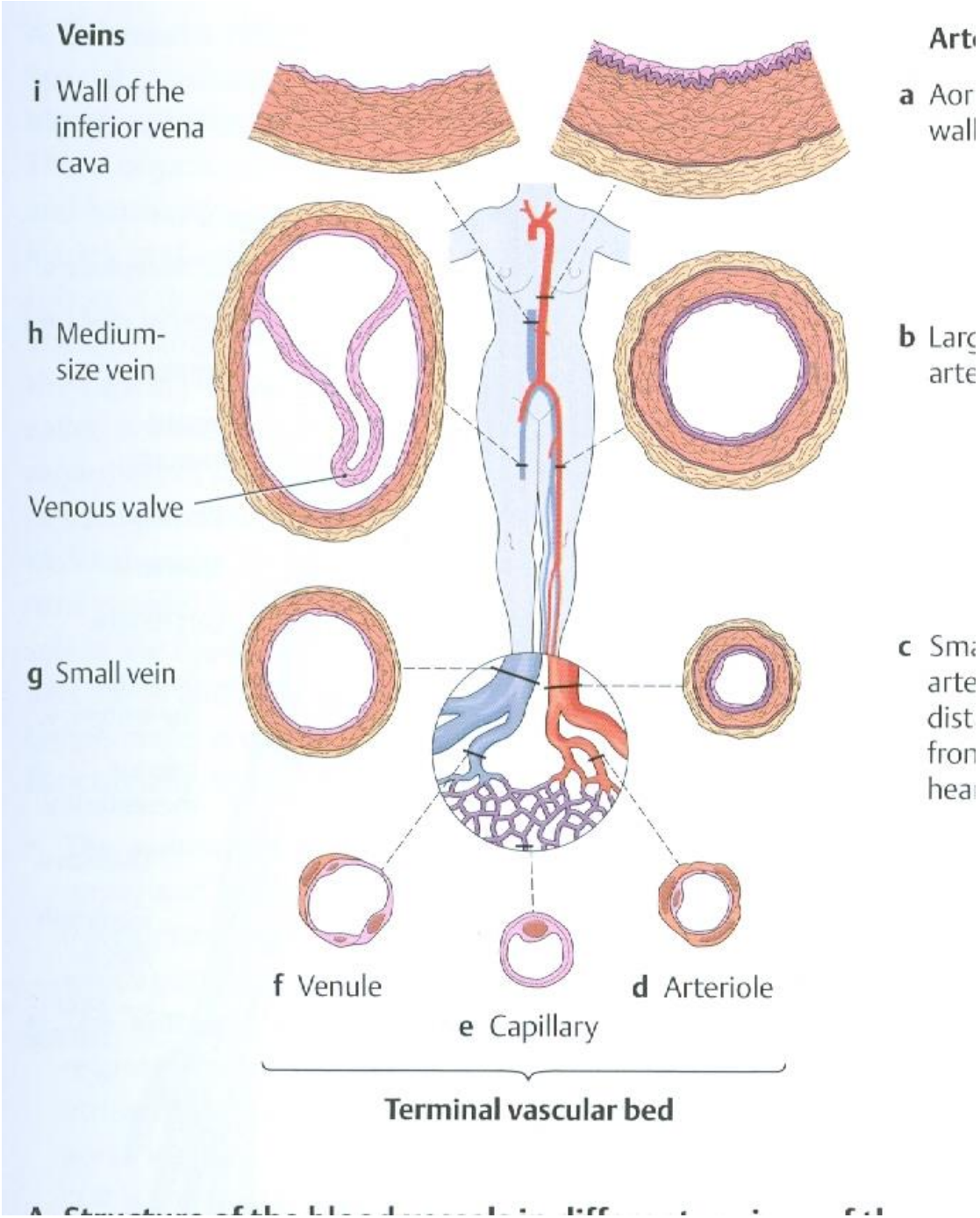
Types of blood vessels

- **Main delivery – arteries of elastic type- (aorta - diameter 30 mm, area 7 cm2)**
- **Distributor – arteries of muscular type (brachial a., femoral a.)**
- **Resistant - arterioles**

(diameter 10 µm, area 150 cm2)

. Exchanging – Capillaries

- **Capacitive (reservior)– venous system**

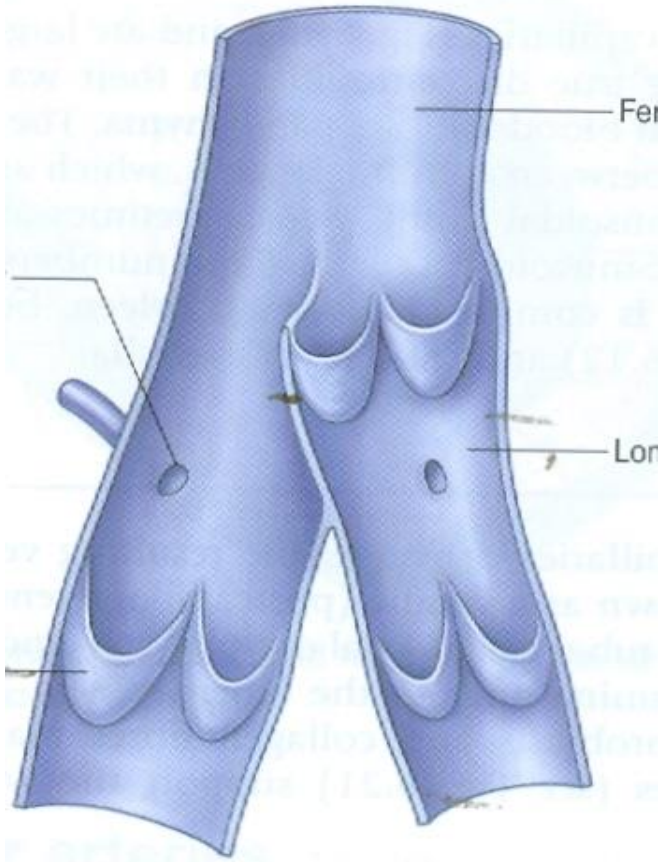


Nutrition of blood vessels

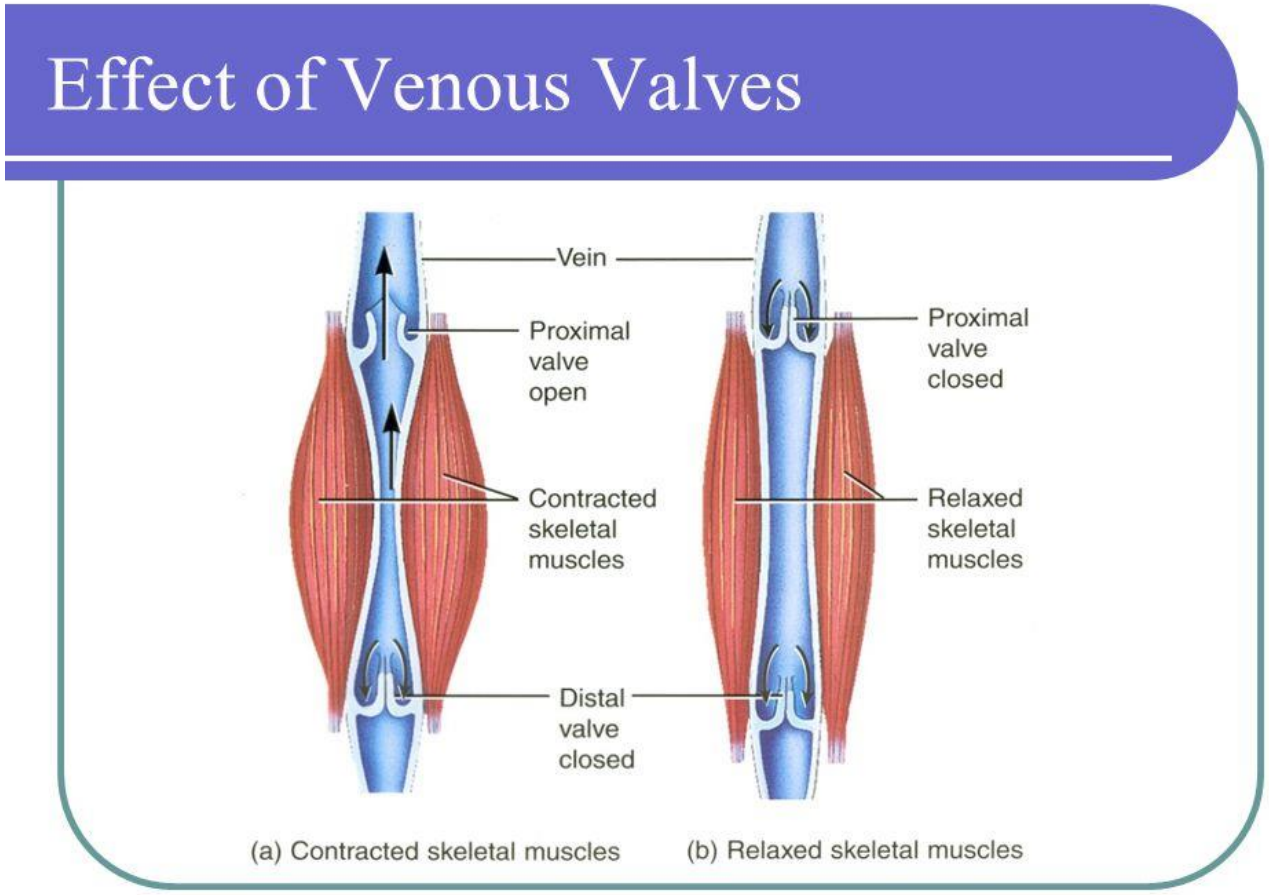
- Nutrition of the wall of small blood vessels is provided by the diffusion of nutrients and oxygen from the blood flowing inside the vessel.
- Blood vessels that are larger than 1 mm in diameter have developed a system of blood vessels in their walls. This system is called the vasa vasorum. Vasa vasorum arise as branches of their own artery or an adjacent artery. These vessels branch in the tunica adventitia and in the outer regions of the tunica media.
- Because there is a lower concentration of oxygen in venous blood, vasa vasorum occur more frequently in the walls of veins than in the walls of arteries.

Vein valves - valvulae venosae:

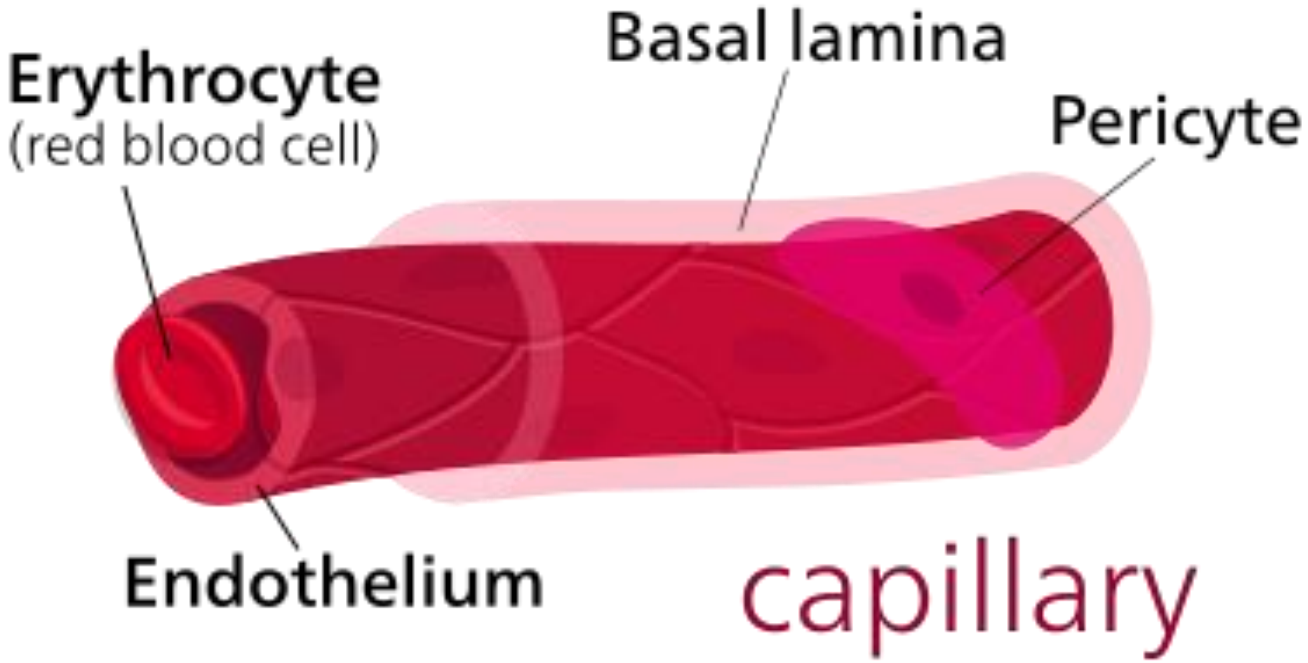
are duplicates of the tunica intima reinforced with connective tissue to prevent blood backflow. They usually occur as two opposing crescentic valves that allow flow only centripetally



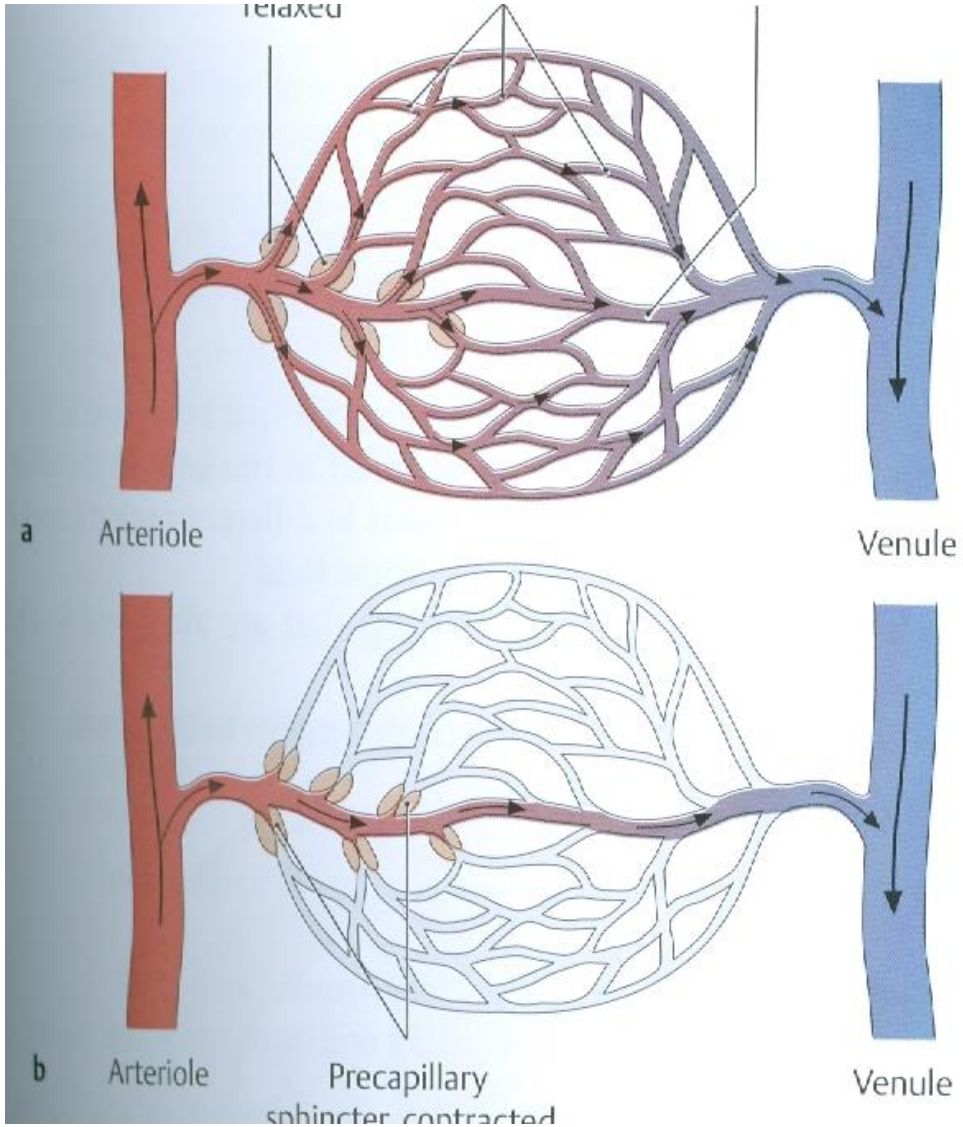
upper portions of the femoral and l



A capillary is a blood vessel with a very thin wall that forms a compartment of the microcirculation of the bloodstream.
The diameter of the capillary is 7-9 µm and the capillary length ranges from 0.25-1 mm. The total length of capillaries in the human body is estimated at 96 000 km.
The capillary wall consists of **a layer of endothelial cells, basal lamina and pericytes.**
The capillaries and postcapillary venules are surrounded by a layer of collagen and elastic fibers that replaces the adventitia.
Pericytes: cells that surround the capillary **externally.** They are capable of contracting and thus **constricting the blood vessel**. They replace the tunica media in capillaries.



The capillary bed

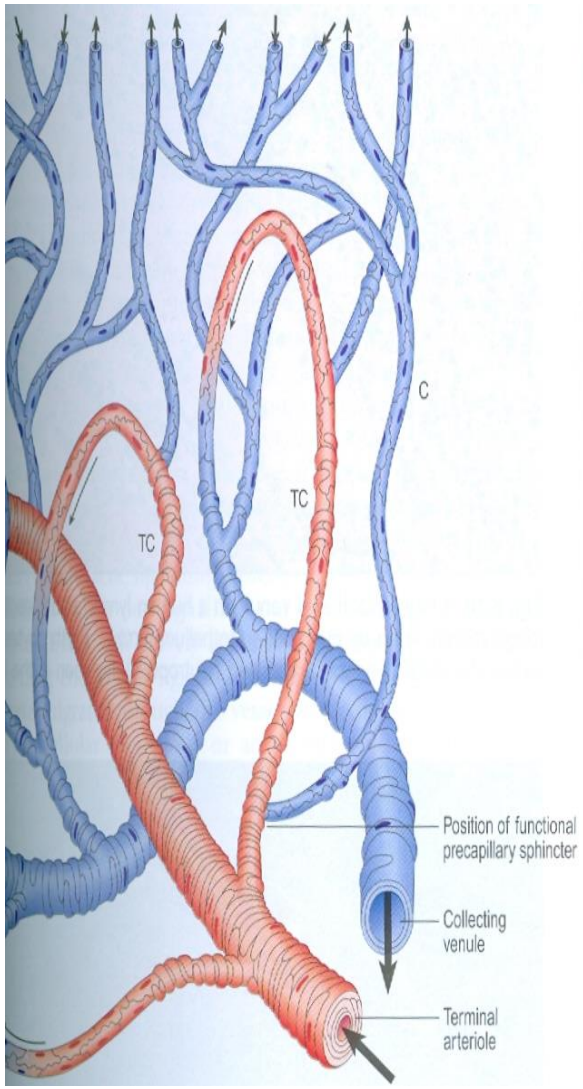


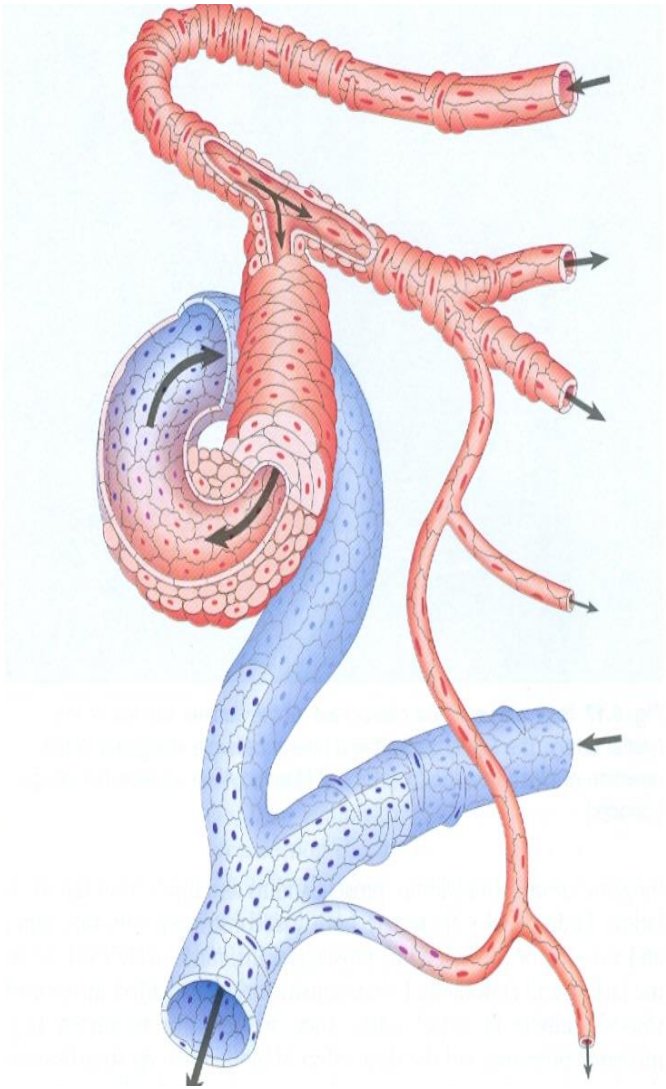
Blood flow through the tissues

- End-type arteries- arteria centralis retinae
- Collateral circulation - arterial anastomoses

(end to end, convergent, transverse)

- Arteriovenous anastomoses





Arteriovenous anastomosyes

- They are small-caliber arterial connections directly to the veins. The largest AVA- glomus coccygeum in front of the tip of the coccyx.
- The main importance of blood flow through the skin is its thermoregulatory activity.
- The cutaneous circulation contains arteriovenous anastomoses that accelerate the flow and apply to changes in skin blood flow.
- The most frequent anastomoses are on the fingers, toes, earlobes.

Heart - Cor

- Located in middle mediastinum
- Size: 8x12x6cm (fist size)
- Weight: M 300 g (0.45 % body weight), F 250 g (0.40 % body weight)
- Shape: conical
- Base- is facing right, up, backwards
- Apex- pointing forward, left, down
- facies sternocostalis (anterior)

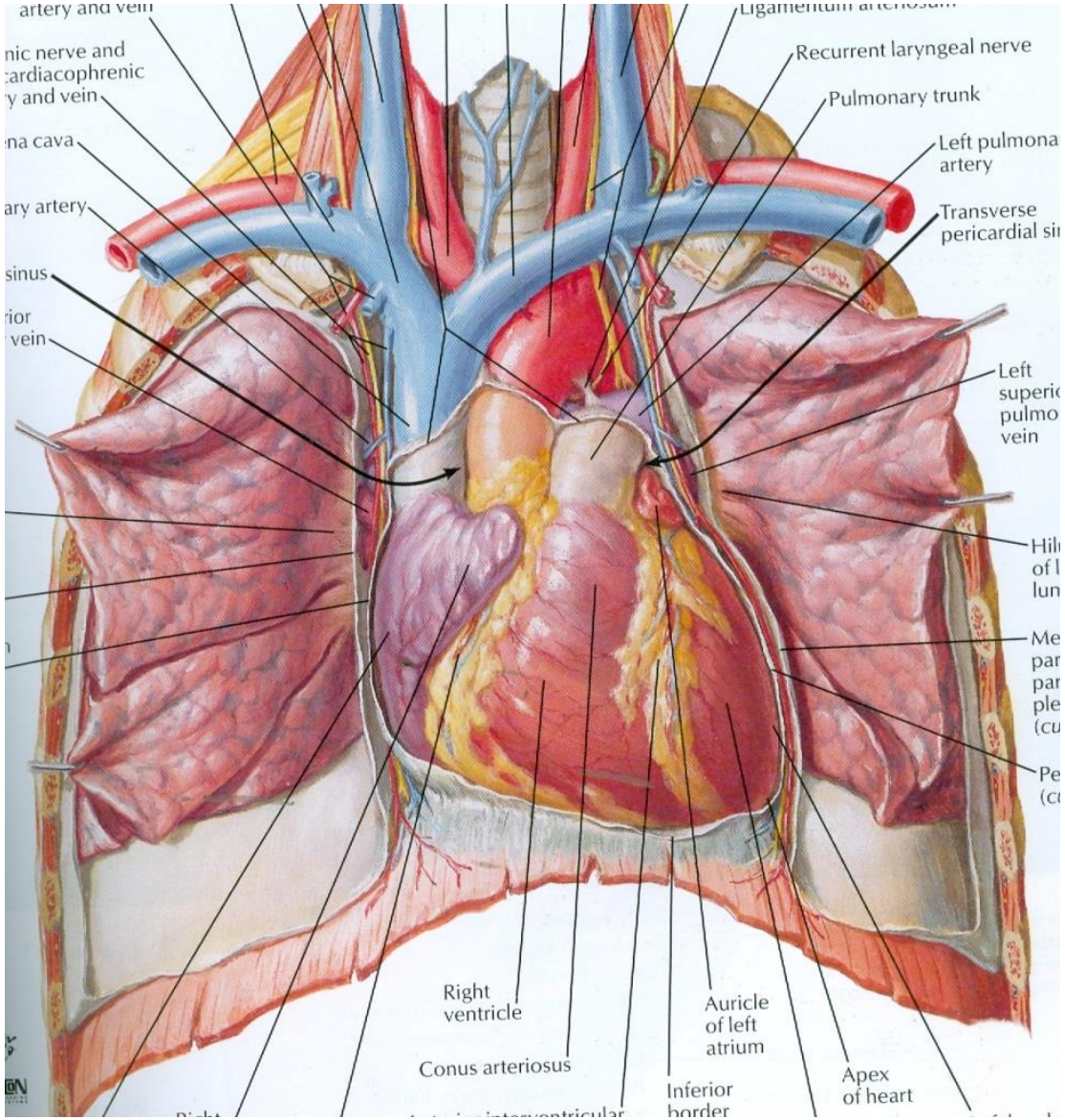
  facies diaphragmatica (inferior) (posterior walls of both right and left ventricles; clinically "posterior wall")

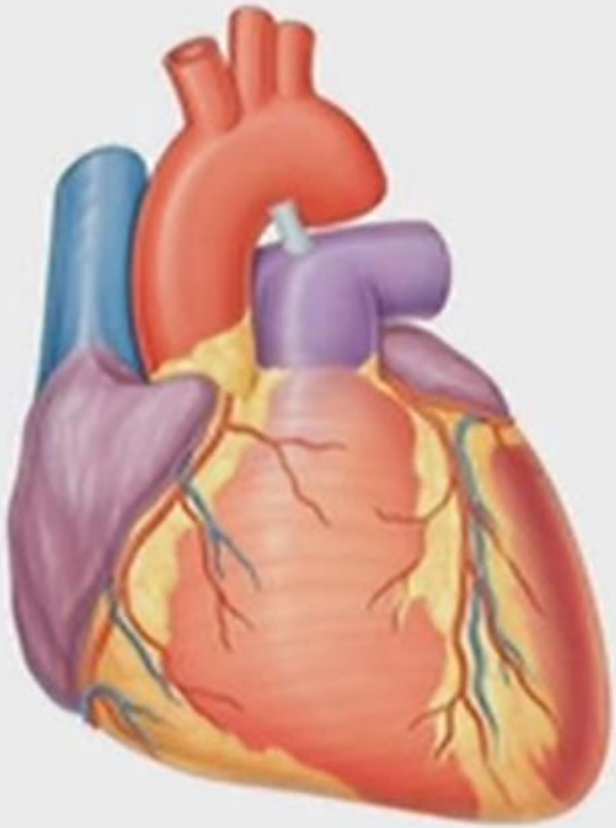
  facies pulmonalis (left surface)

  facies vertebralis: posterior part; bases in place of the walls of both atriums; against the spine

  margo dexter (acutus)

  margo sinister (obtusus)

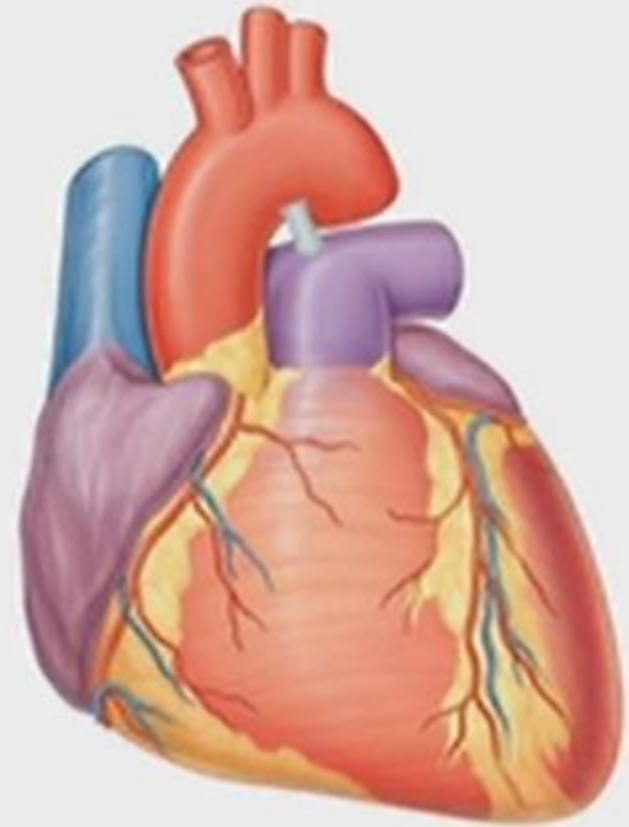




- Apex - basis 12 cm
- Maximum width 9 cm
- Antero-posterior 6 cm
- weight
- M 280 -340 g , average 300 g
- F 230 - 280 g, average 250 g

SIZE AND WEIGHT OF THE HEART

- Margo superior
  - Atrium sinistrum
- Margo dexter
  - Atrium dextrum
- Margo inferior (acutus)
  - Ventriculus dexter
- Margo sinister (obtusus)
  - Vericulus sinister



MARGINES CORDIS

The heart wall

- **Endocardium:** inner hydrophilic surface of the heart, covers valves and chordae tendineae
- **Myocardium:** striated muscle, cells 120x20-30 µm, connecting complex - Intercalated discs
- **Epicardium**

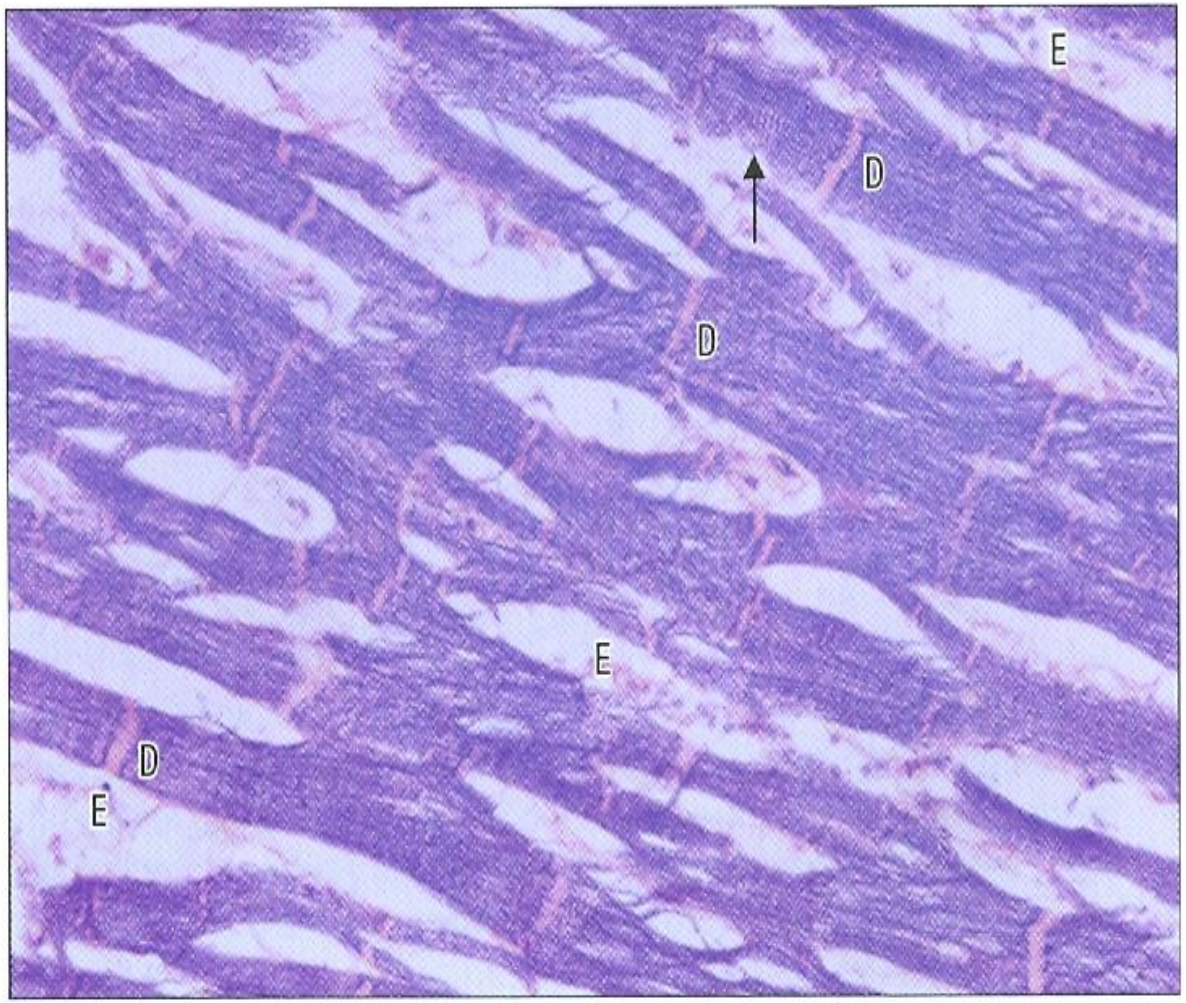


Fig. 6.23 Cardiac muscle fibres (human heart), sectioned longitudinally.

Cardiac compartments (chambers)

Atrium dextrum

Septum interatriale

Atrium sinistrum

Sulcus atrioventricularis (coronarius)

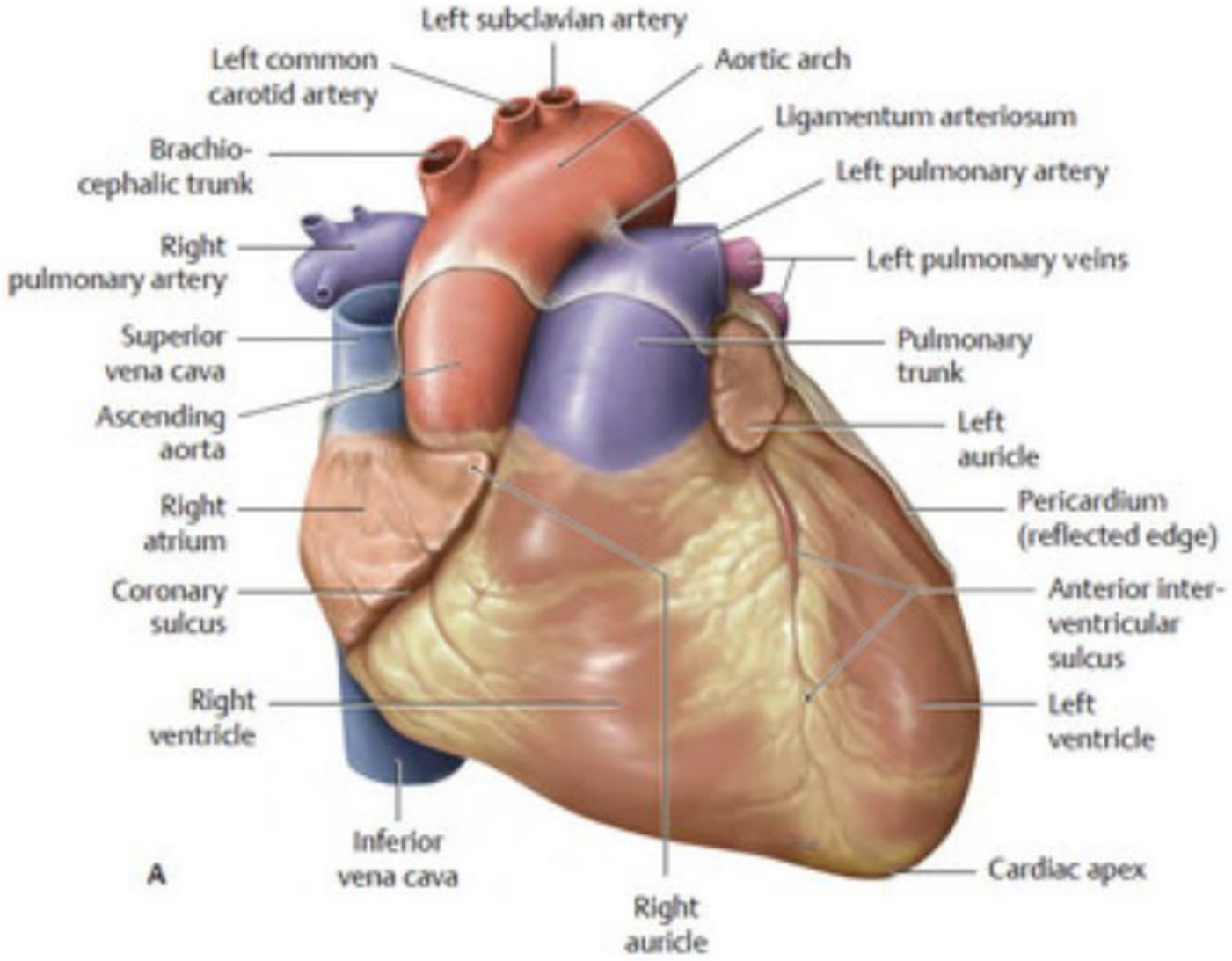
Ventriculus dexter

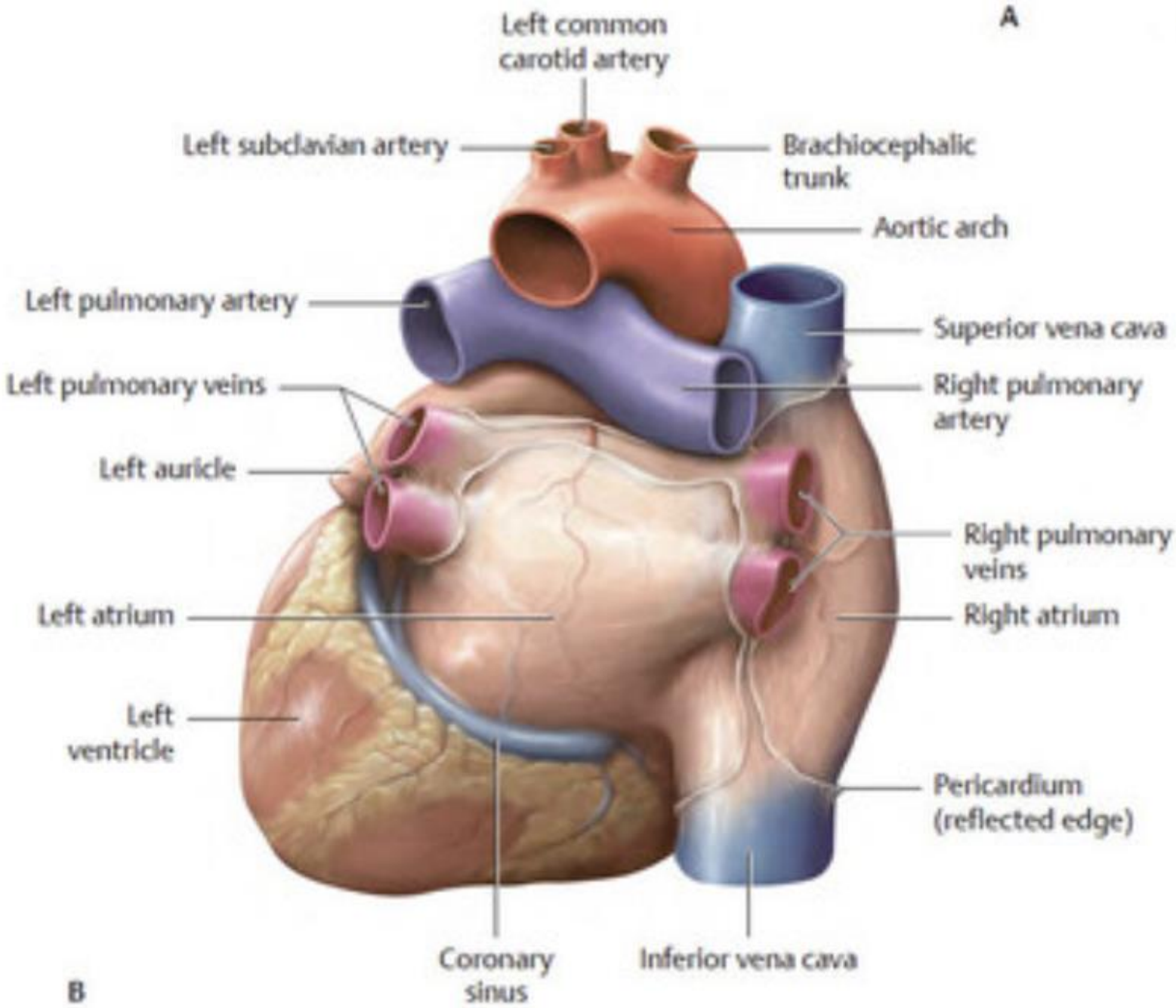
Septum interventriculare - pars membranacea

pars muscularis

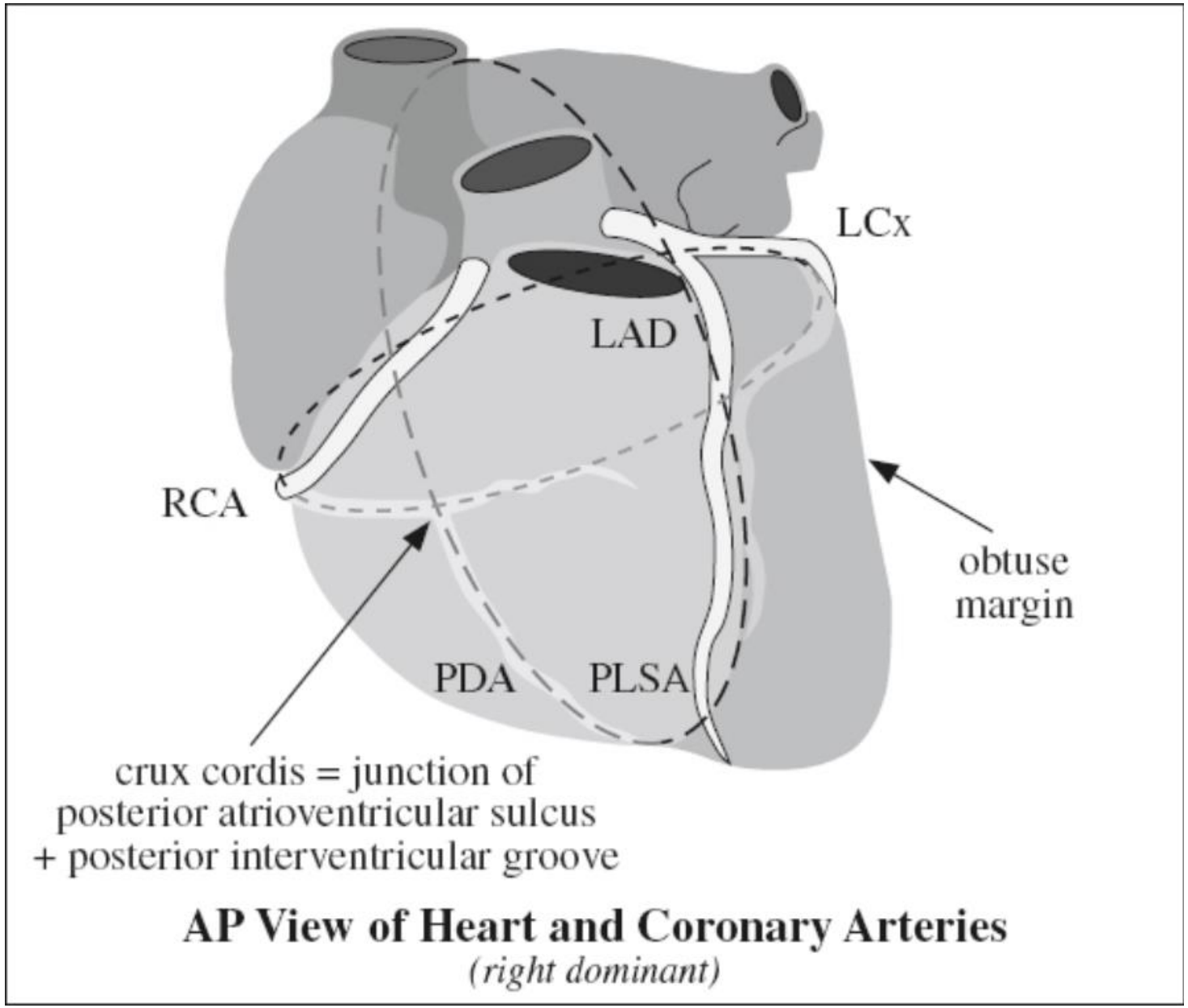
Ventriculus sinister

Sulcus interventricularis anterior/posterior

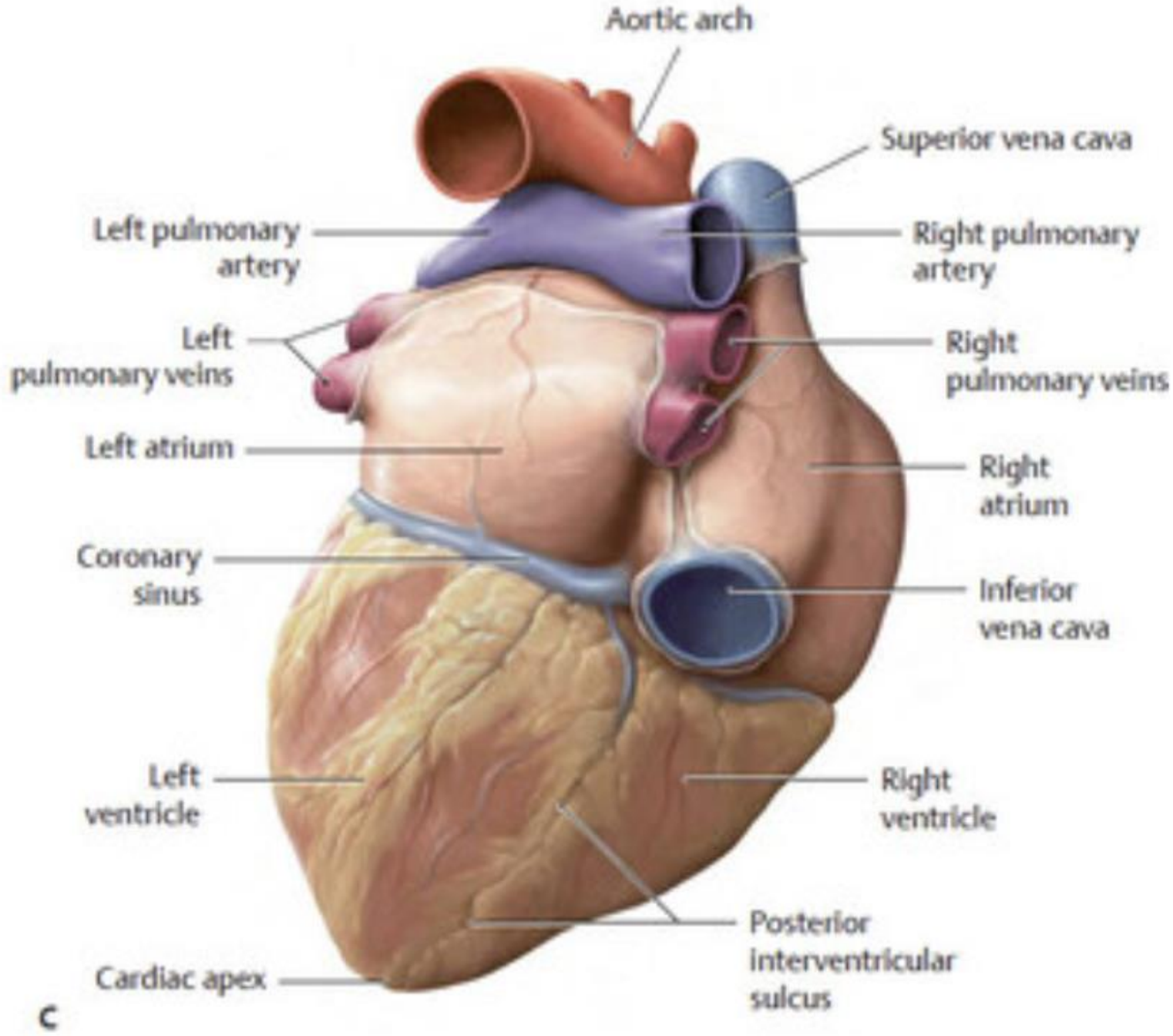



A
Left common carotid artery
Left subclavian artery
Brachiocephalic trunk
Aortic arch
Left pulmonary artery
Superior vena cava
Left pulmonary veins
Right pulmonary artery
Left auricle
Right pulmonary veins
Left atrium
Right atrium
Left ventricle
Pericardium (reflected edge)
Coronary sinus
Inferior vena cava
B

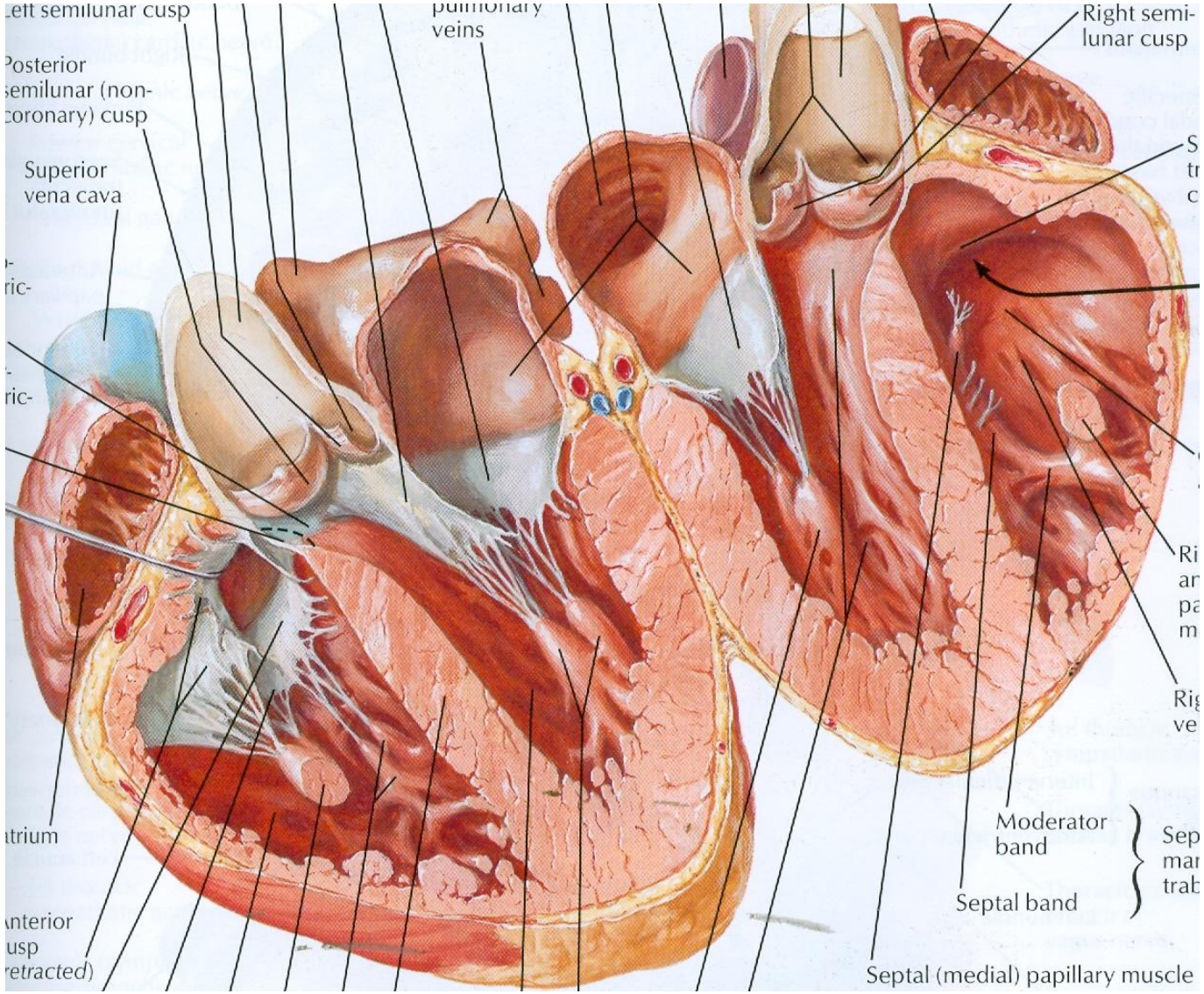
The crux cordis or crux of the heart (from Latin "crux" meaning "cross") is the area on the lower back side of the heart where the coronary sulcus (the groove separating the atria from the ventricles) and the posterior interventricular sulcus (the groove separating the left from the right ventricle) also interatrial groove meet . It is important surgically because the atrioventricular nodal artery, a small but vital vessel, passes in proximity to the crux of the heart. It is the anastomotic point of right and left coronary artery.



AP View of Heart and Coronary Arteries
(right dominant)


Aortic arch
Superior vena cava
Left pulmonary artery
Right pulmonary artery
Left pulmonary veins
Right pulmonary veins
Left atrium
Right atrium
Coronary sinus
Inferior vena cava
Left ventricle
Right ventricle
Posterior interventricular sulcus
Cardiac apex
C

Cardiac compartments (chambers)



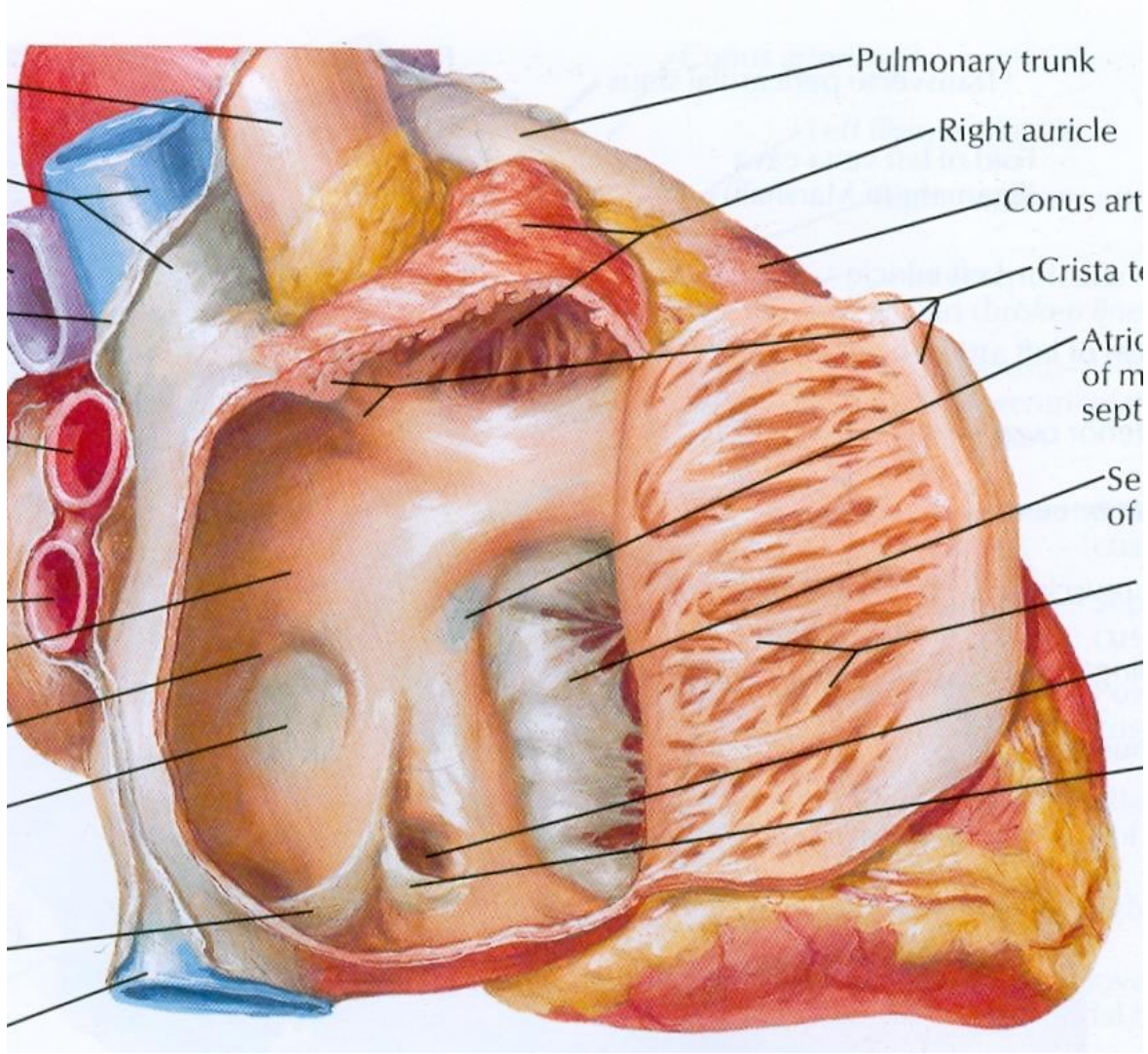
Atrium dextrum

- **Structures:**

  sinus venarum cavarum
  tuberculum intervenosum
  crista/sulcus terminalis
  mm. pectinati
  auricula dextra
  fossa ovalis – limbus fossae ovalis

- **Orifices:**

  ostium v. cavae superioris
  ostium v. cavae inferioris
  (valvula Eustachii)
  ostium sinus coronarii
  (valvula Thebesii)
  ostia venarum minimarum
  ostia vv. ventriculi dx. anteriorum



Prenatal circulation

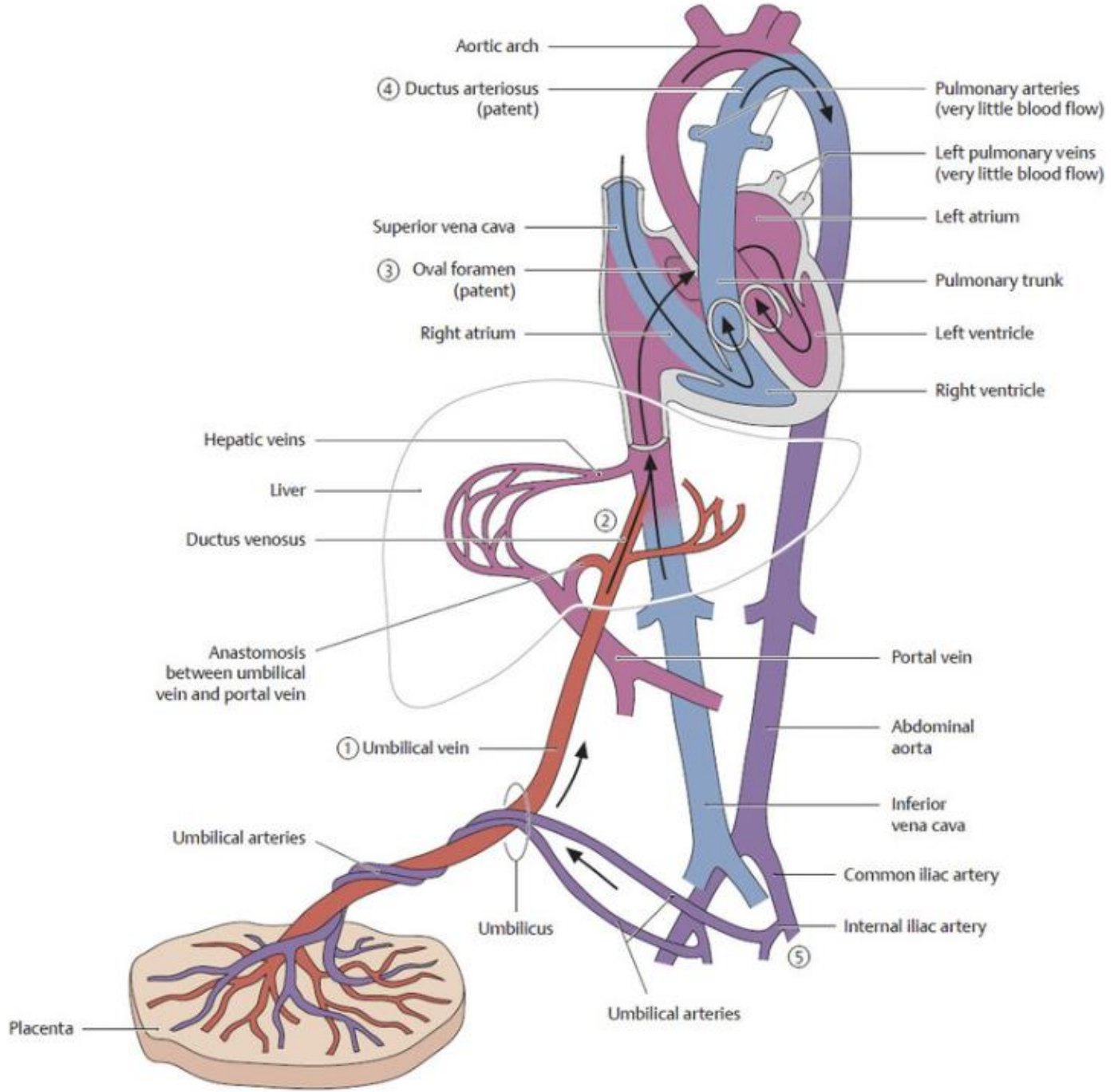
① Oxygenated and nutrient-rich fetal blood from the placenta passes to the fetus via the umbilical *vein*.

② Approximately half of this blood bypasses the liver (via the ductus venosus) and enters the inferior vena cava. The remainder enters the portal vein to supply the liver with nutrients and oxygen.

③ Blood entering the right atrium from the inferior vena cava bypasses the right ventricle (as the lungs are not yet functioning) to enter the left atrium via the oval foramen, a right-to-left shunt.

④ Blood from the superior vena cava enters the right atrium, passes to the right ventricle, and moves into the pulmonary trunk. Most of this blood enters the aorta via the ductus arteriosus, a right-to-left shunt.

⑤ The partially oxygenated blood in the aorta returns to the placenta via the paired umbilical arteries that arise from the internal iliac arteries.



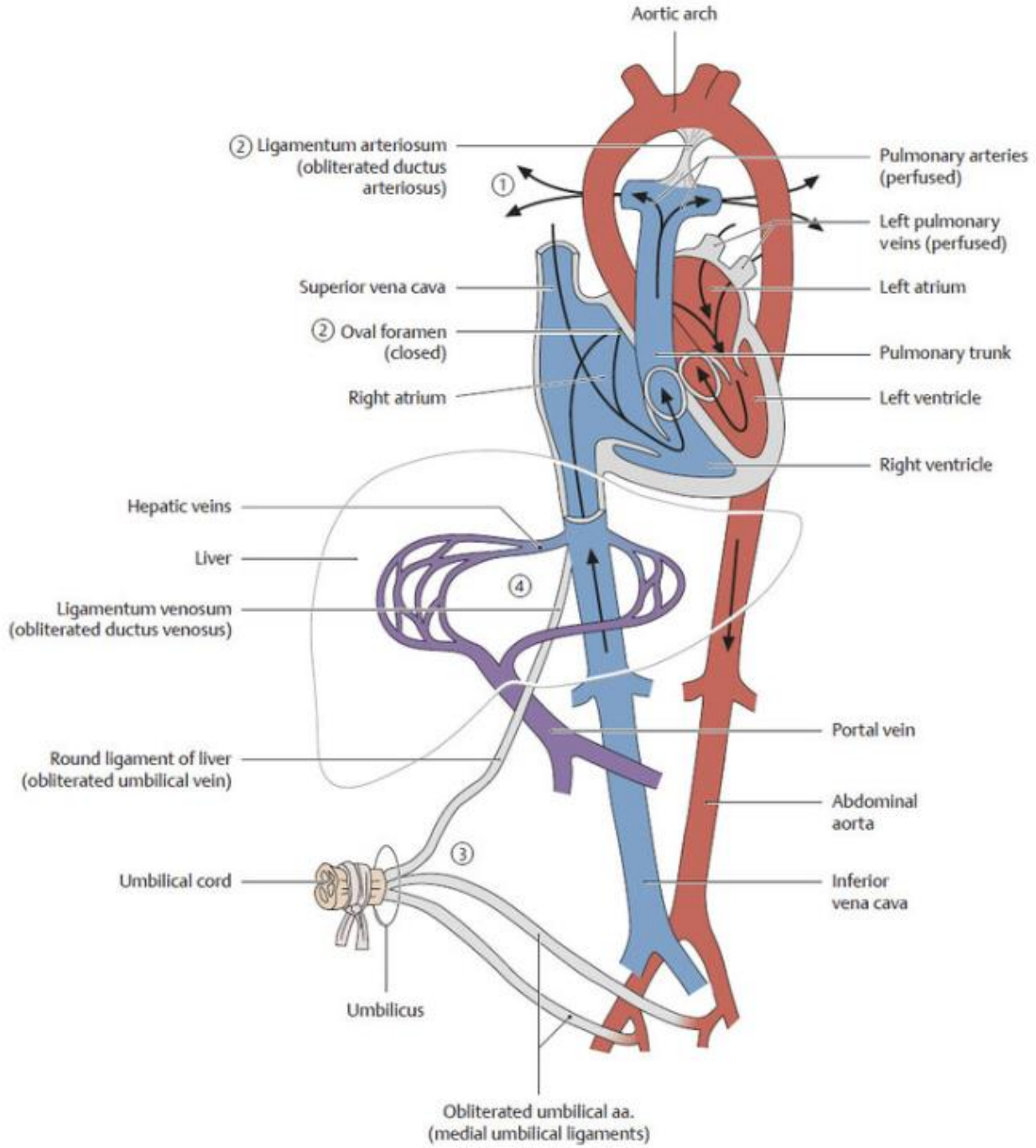
Postnatal circulation

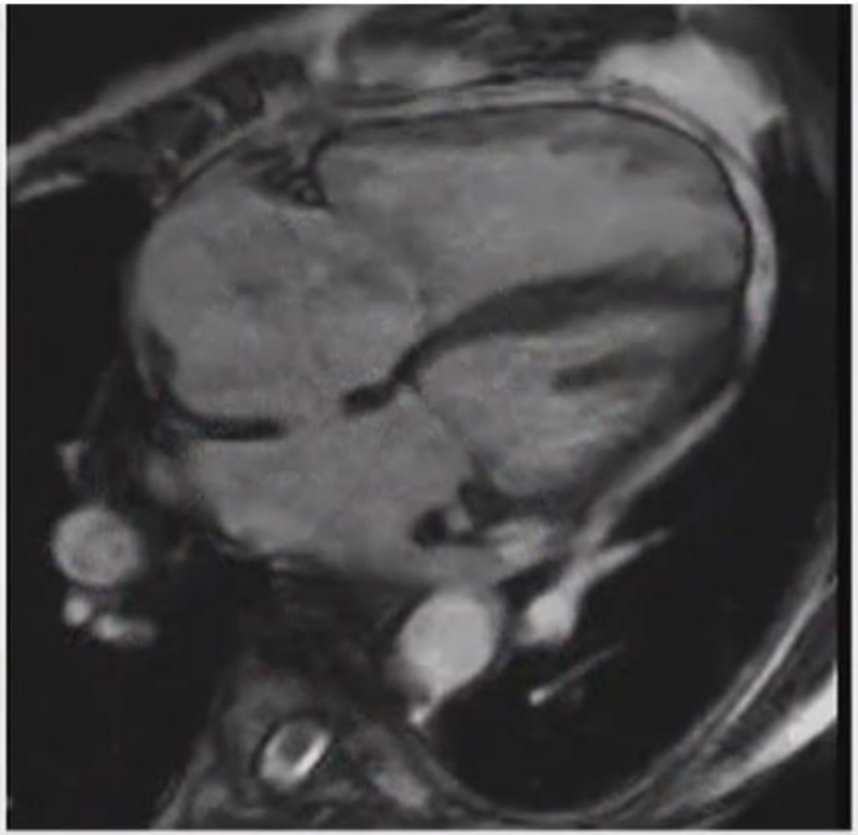
① As pulmonary respiration begins at birth, pulmonary blood pressure falls, causing blood from the pulmonary trunk to enter the pulmonary arteries.

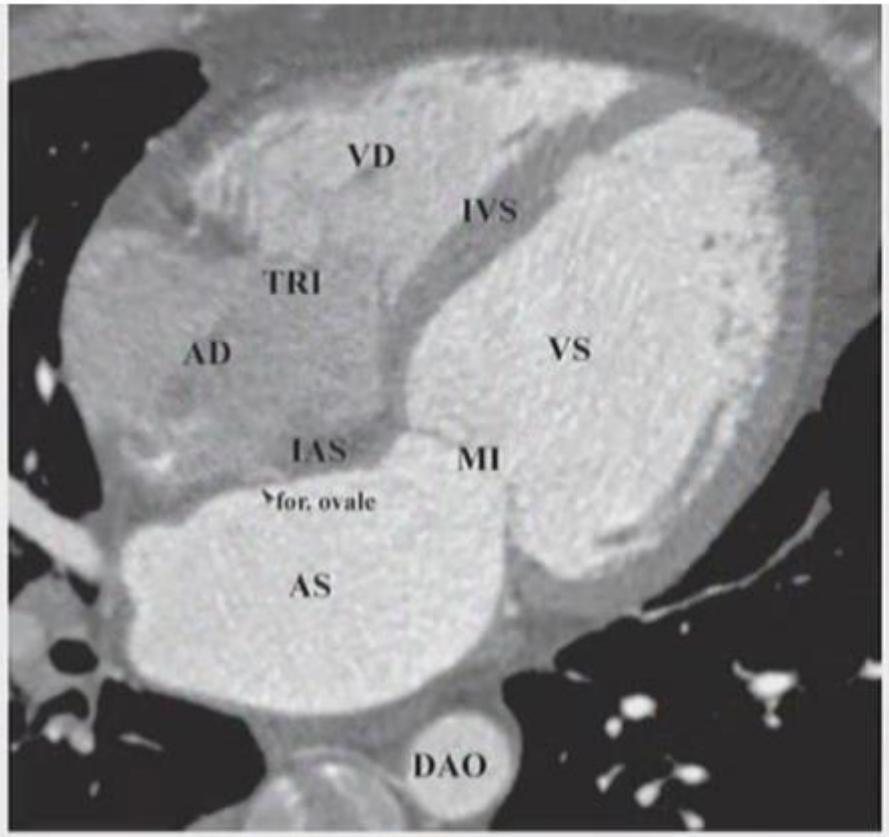
② The oval foramen and ductus arteriosus close, eliminating the fetal right-to-left shunts. The pulmonary and systemic circulations in the heart are now separate.

③ As the infant is separated from the placenta, the umbilical arteries occlude (except for the proximal portions), along with the umbilical vein and ductus venosus.

④ Blood to be metabolized now passes through the liver.

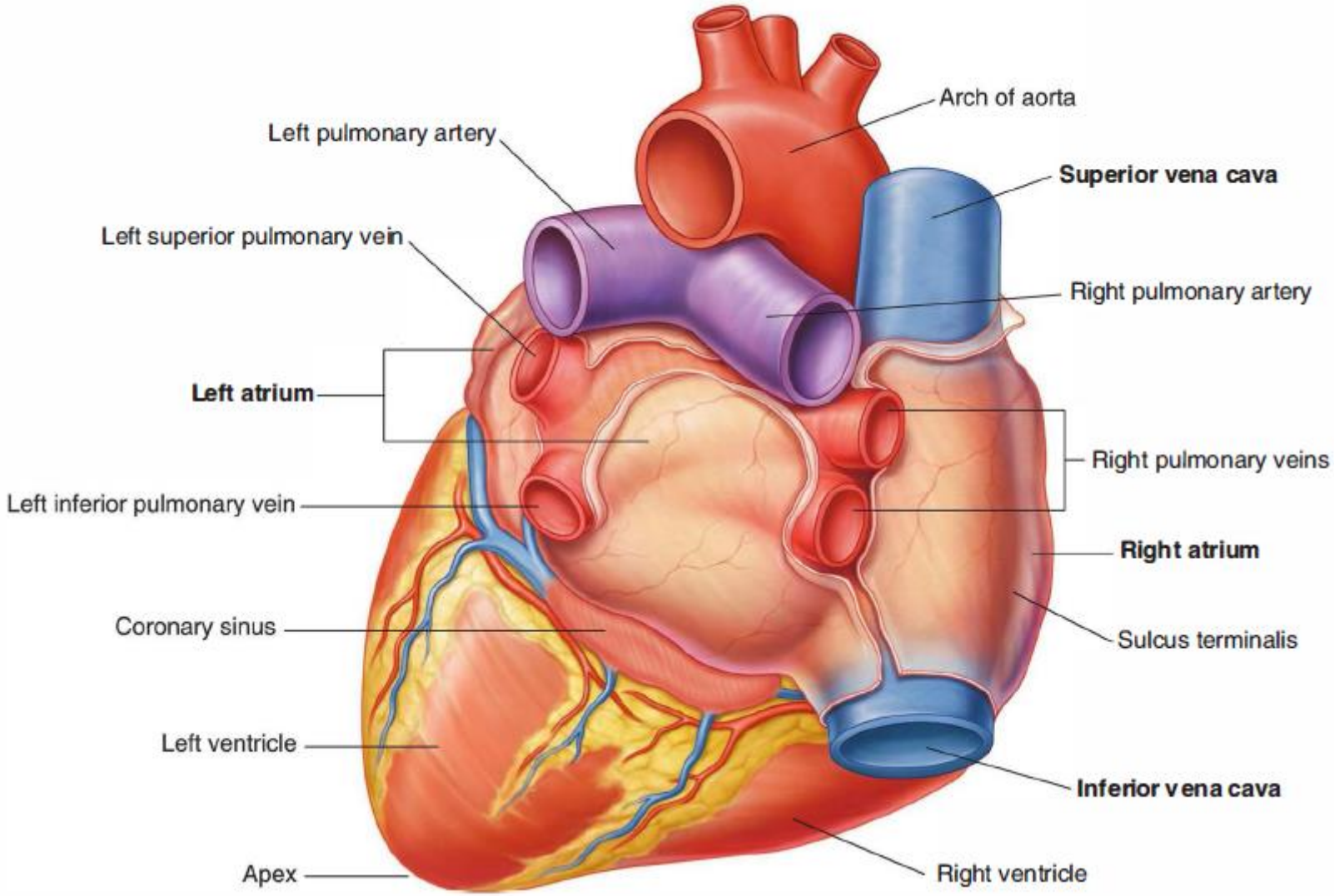


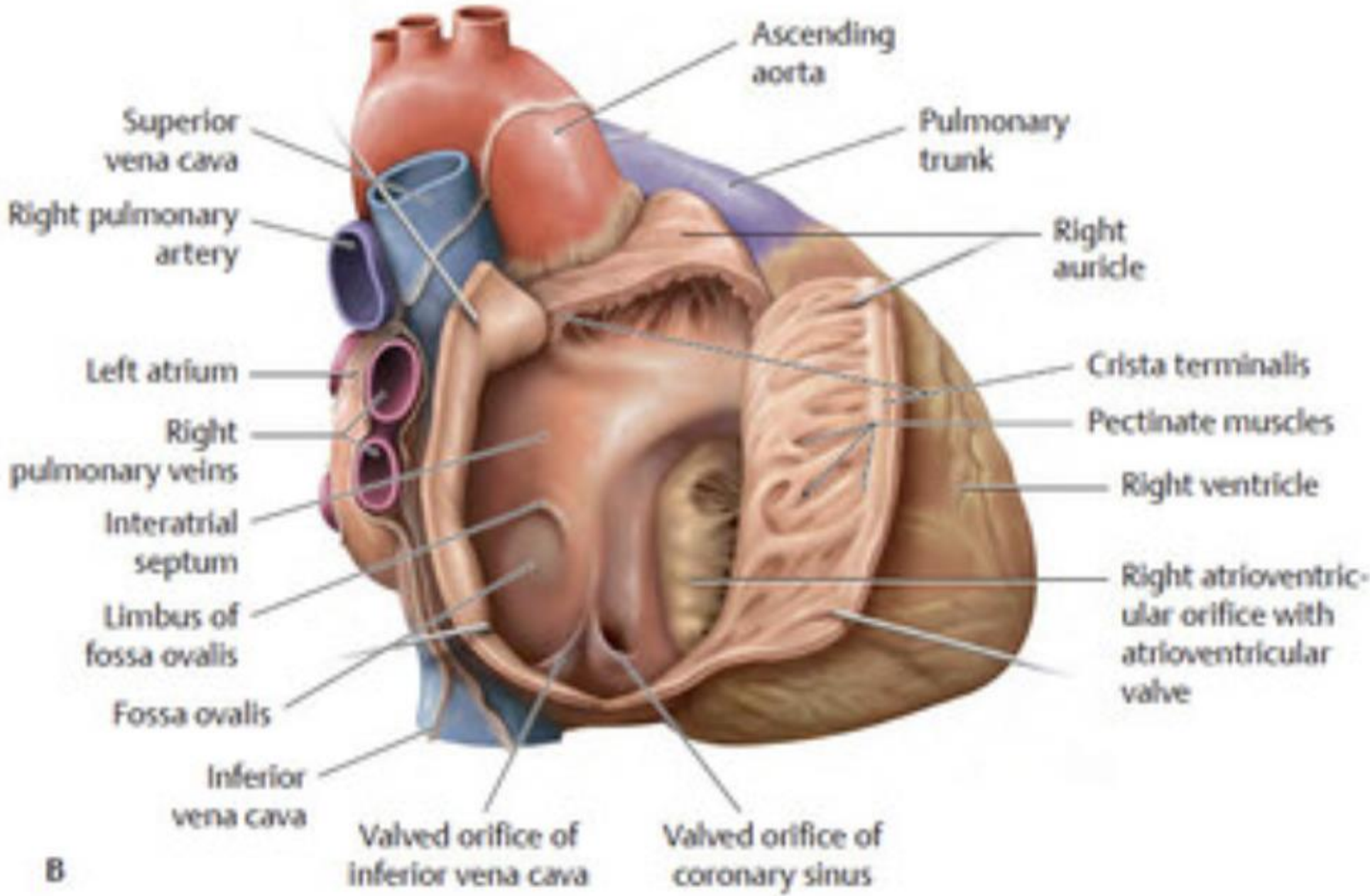




- Foramen ovale patens x foramen ovale apertum
- Paradoxical embolism
- Eisenmenger syndrome

FORAMEN OVALE


Arch of aorta
Left pulmonary artery
Superior vena cava
Left superior pulmonary vein
Right pulmonary artery
Left atrium
Right pulmonary veins
Left inferior pulmonary vein
Right atrium
Coronary sinus
Sulcus terminalis
Left ventricle
Inferior vena cava
Apex
Right ventricle


Ascending aorta
Superior vena cava
Pulmonary trunk
Right pulmonary artery
Right auricle
Left atrium
Crista terminalis
Right pulmonary veins
Pectinate muscles
Right ventricle
Interatrial septum
Right atrioventricular orifice with atrioventricular valve
Limbus of fossa ovalis
Fossa ovalis
Inferior vena cava
Valved orifice of inferior vena cava
Valved orifice of coronary sinus

B

Ventriculus dexter

- **Structures:**

  trabeculae carneae

  trabecula septomarginalis

  mm. papillares (ant., post., septalis) – chordae tendineae

  crista supraventricularis

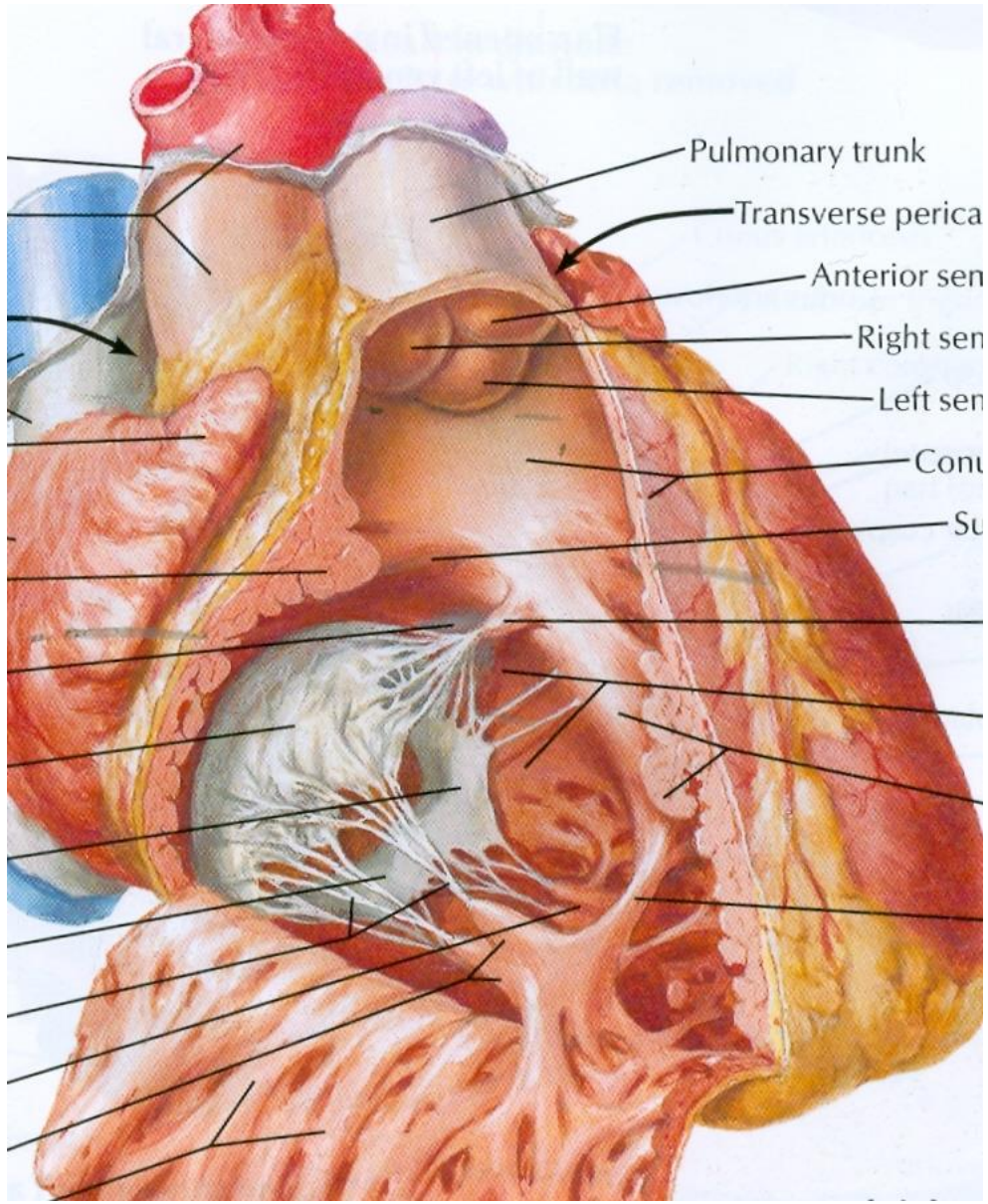
  infundibulum/conus arteriosus (trunci pulmonalis)

  Chordae tendinae

- **Orifices:**

- **ostium atrioventriculare dextrum – valva tricuspidalis (cuspis ant., post., septalis)**

  ostium trunci pulmonalis - valva trunci pulmonalis (valvula semilunaris ant., dx., sin.



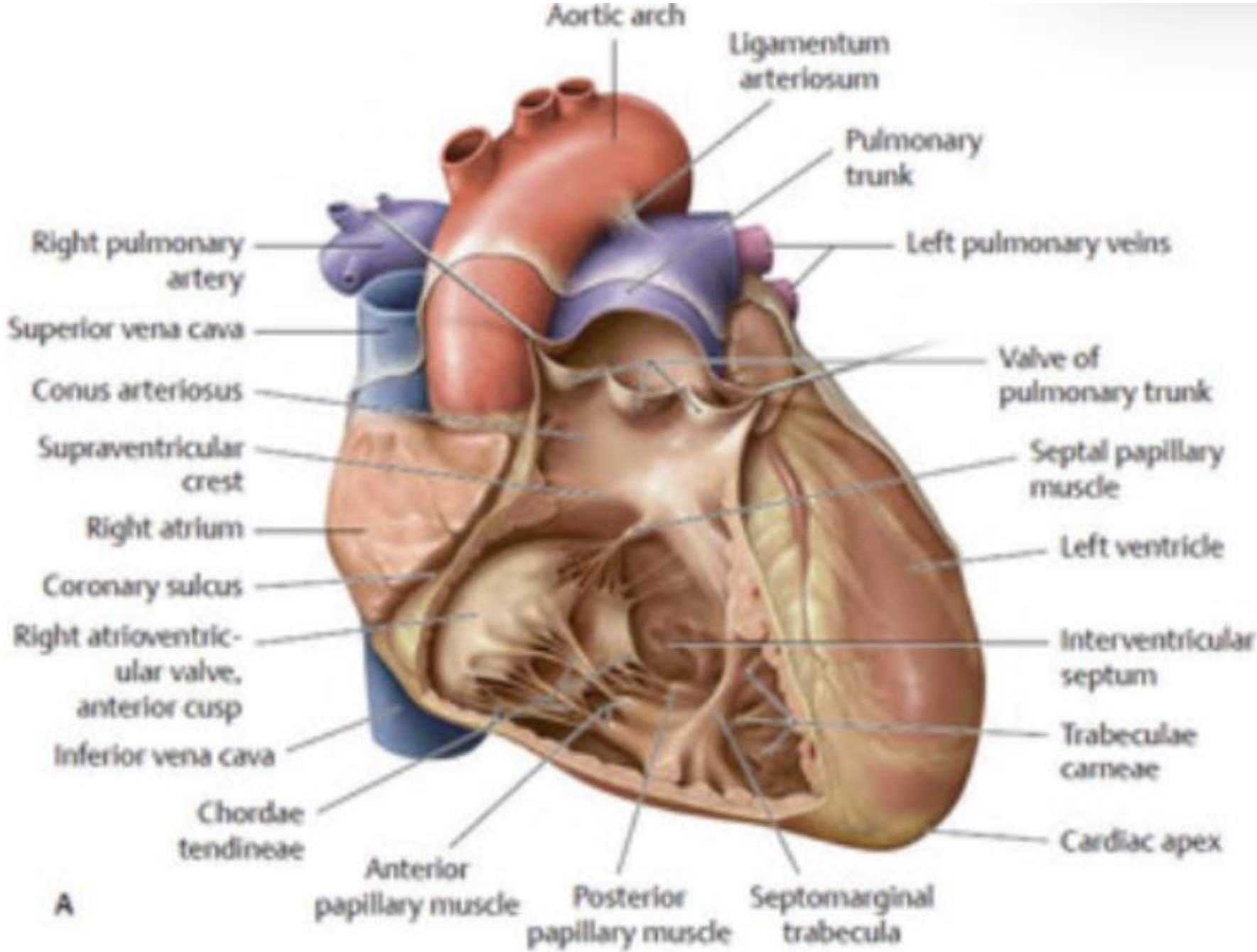
The medial wall is formed by the septum interventriculare

The right ventricular cavity can be divided into:

The inflow portion: (pars trabecularis) with the trabeculae carneae, from the ostium atrioventriculare dextrum to the apex cordis

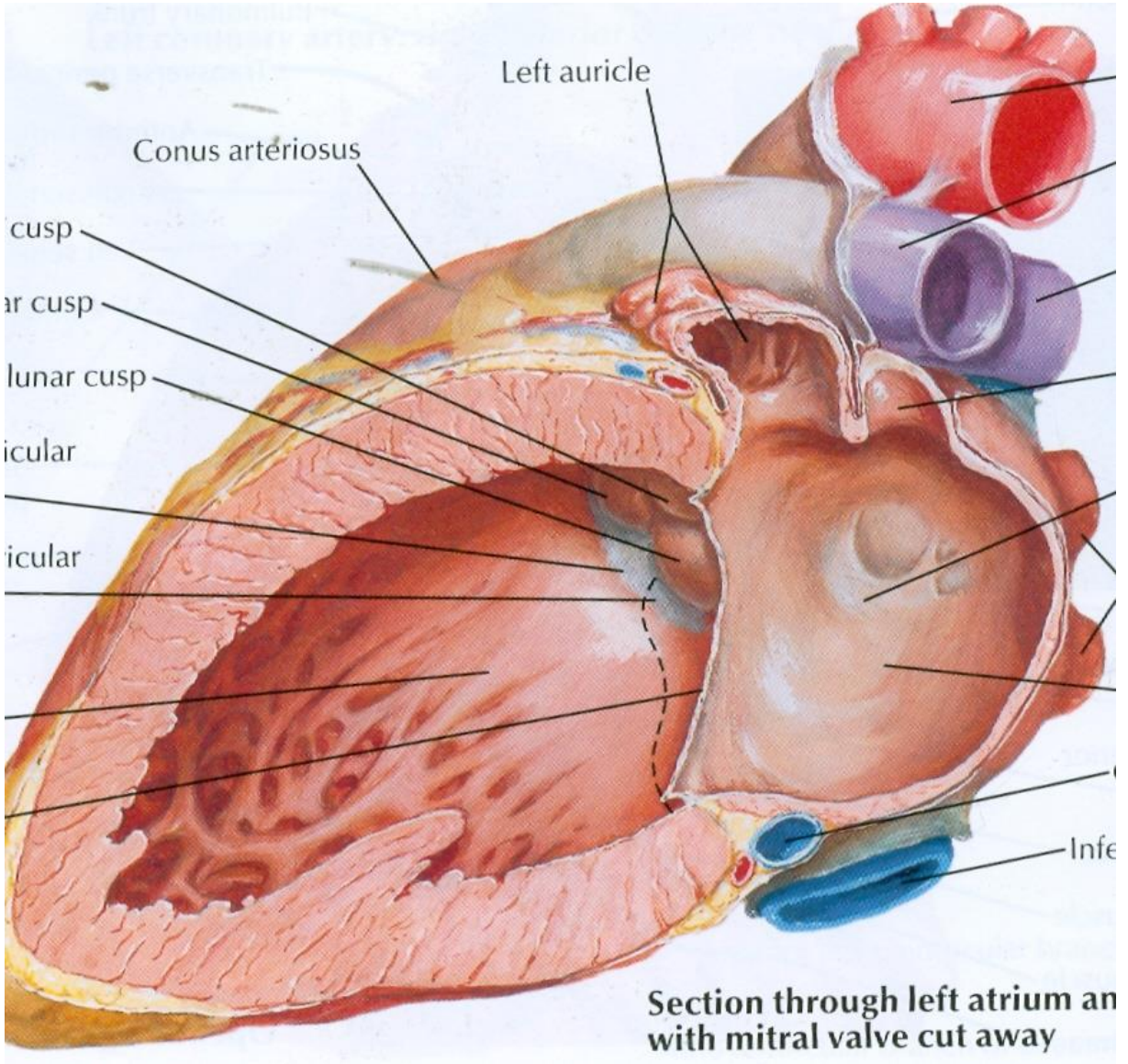
The outlet part: (pars glabra) is the smooth wall, from the cardiac apex upwards and forwards towards the truncus pulmonalis (infundibulum/conus arteriosus)

The boundary between the two compartments being the transversely oriented muscular crest (crista supraventricularis).


Aortic arch
Ligamentum arteriosum
Pulmonary trunk
Right pulmonary artery
Left pulmonary veins
Superior vena cava
Valve of pulmonary trunk
Conus arteriosus
Supraventricular crest
Septal papillary muscle
Right atrium
Left ventricle
Coronary sulcus
Right atrioventricular valve, anterior cusp
Interventricular septum
Trabeculae carneae
Inferior vena cava
Chordae tendineae
Cardiac apex
Anterior papillary muscle
Posterior papillary muscle
Septomarginal trabecula
A

Atrium sinistrum

- **Structures:**
  - mm. pectinati
  - auricula sinistra
  - valvula foraminis ovalis
- **Orifices:**
  - ostia venarum pulmonalium



Ventriculus sinister

- **Structures:**

  trabeculae carneae

  m. papillaris anterior

  posterior

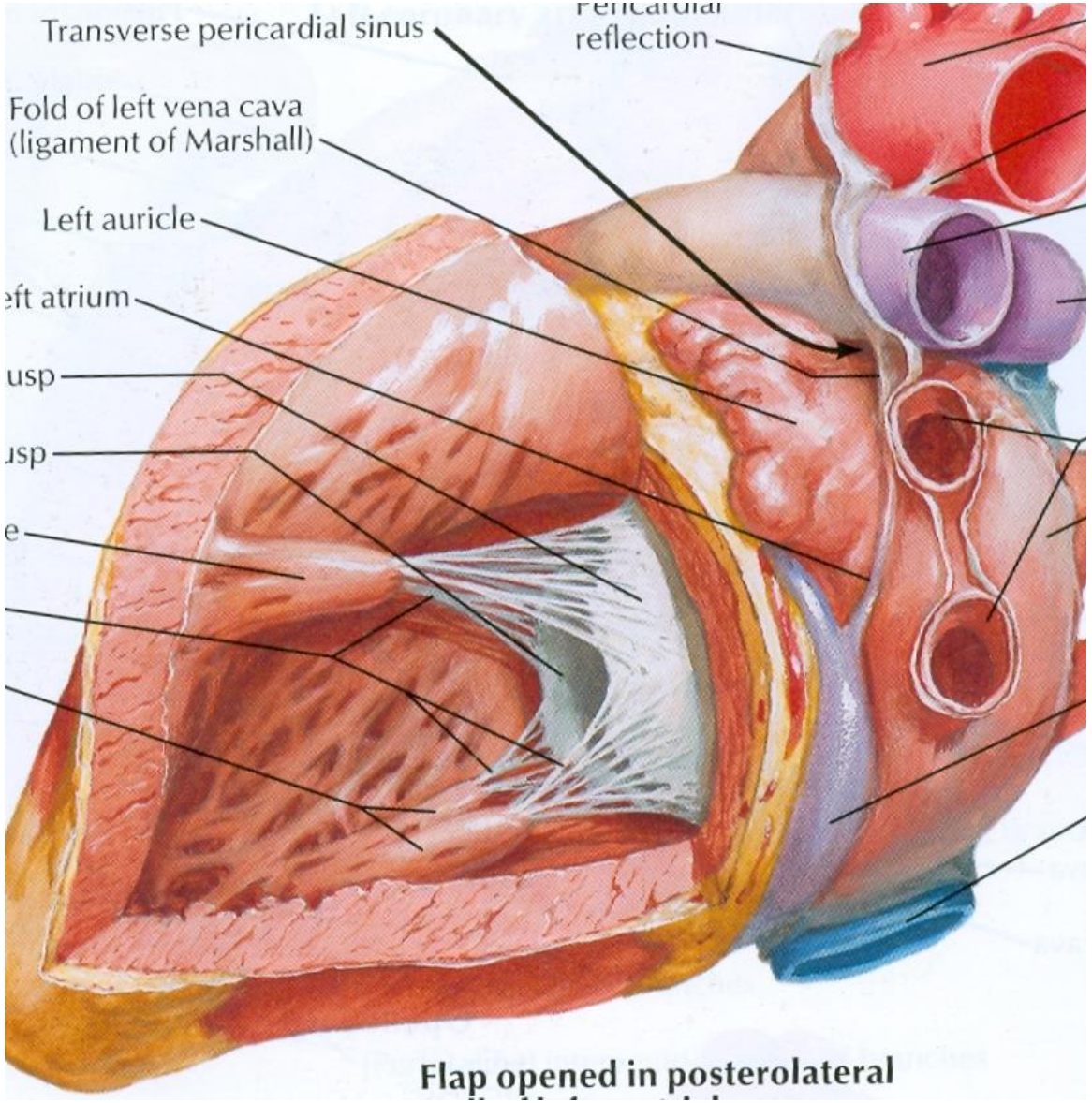
  chordae tendineae

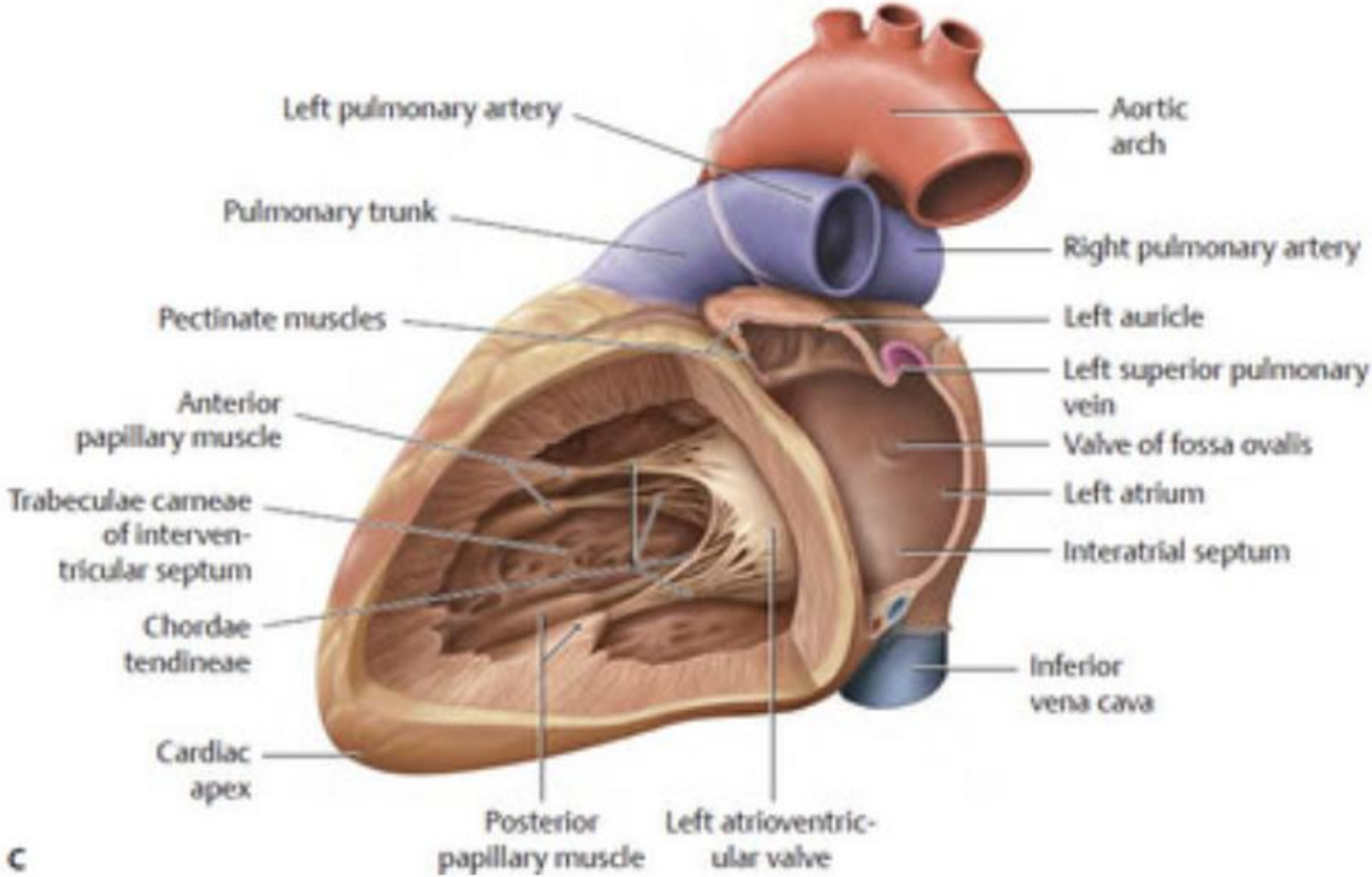
  vestibulum aortae

- **Orifices:**

- **ostium atrioventriculare sinistrum – valva bicuspidalis/mitralis (cuspis ant., post., cuspides commissurales)**

  ostium aortae – valva aortae (valvula semilunaris dx., sin., post.)




Left pulmonary artery
Aortic arch
Pulmonary trunk
Right pulmonary artery
Pectinate muscles
Left auricle
Left superior pulmonary vein
Anterior papillary muscle
Valve of fossa ovalis
Left atrium
Trabeculae carneae of interventricular septum
Interatrial septum
Chordae tendineae
Inferior vena cava
Cardiac apex
Posterior papillary muscle
Left atrioventricular valve

C

Thank you for your attention