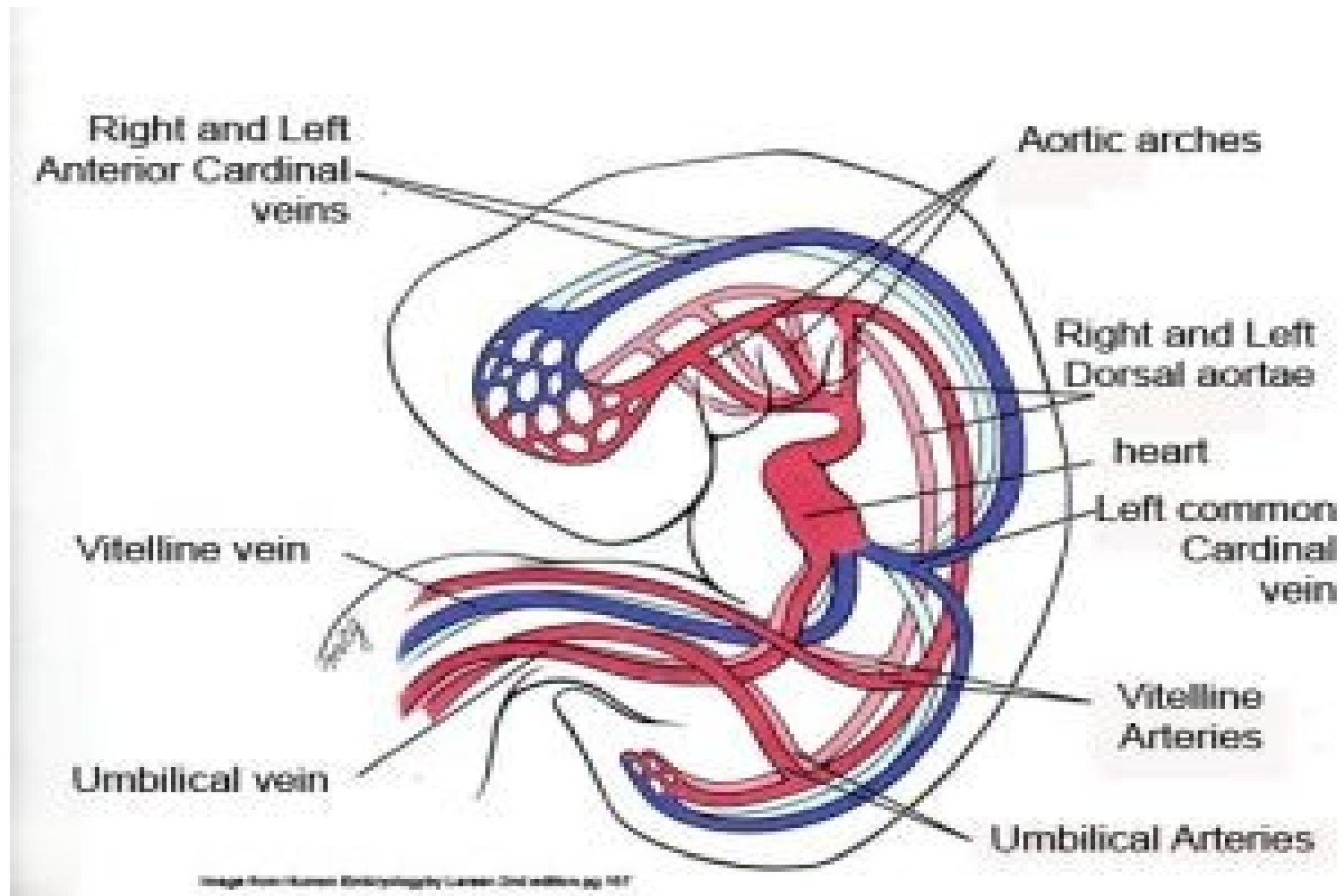


Development of cardiovascular system



- Primitive blood circulation.
- Heart development (dev. Of heart tube, septa and valves)
- Aortal arches and their derivatives.
- Fetal blood circulation.
- Cardiovascular system malformations.

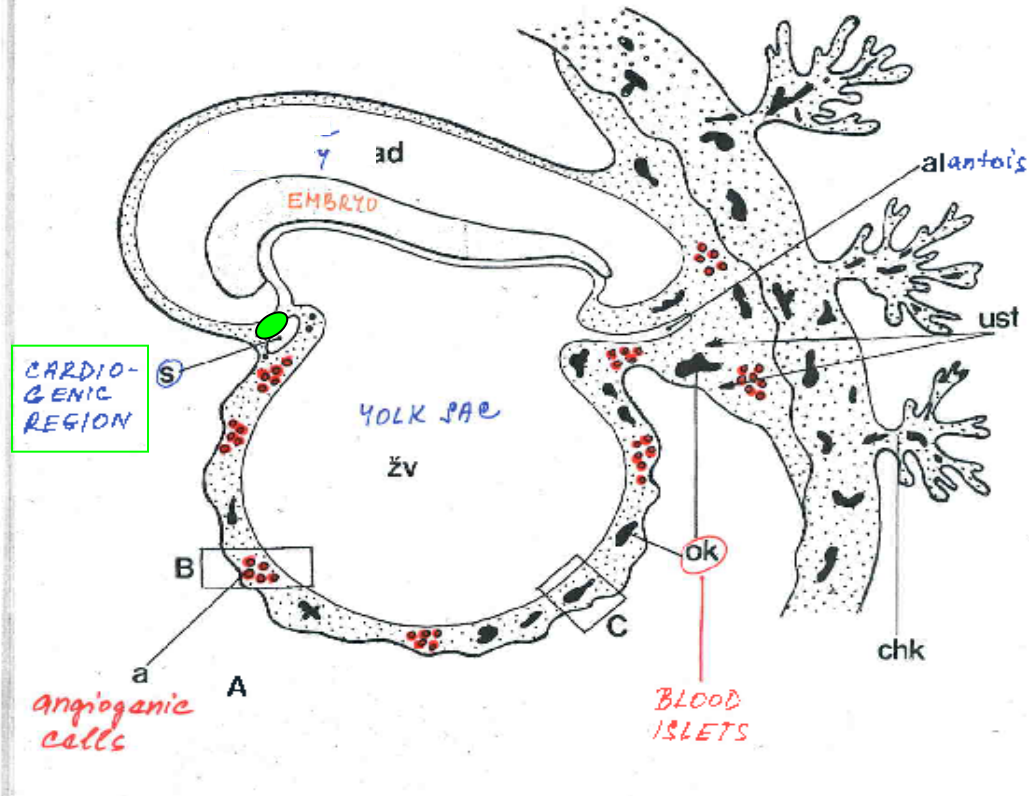
Vessels development:

(from week 3)

hemangiogenesis

- blood islands

(insulae sanguinae)



DAY 15 – 16

in **extraembryonic mesoderm** of

- yolk sac (*vasa omphalomesenterica /vitellina/*),
- connecting stalk and placenta (*vasa umbilicalia*)

DAY 17 – 18

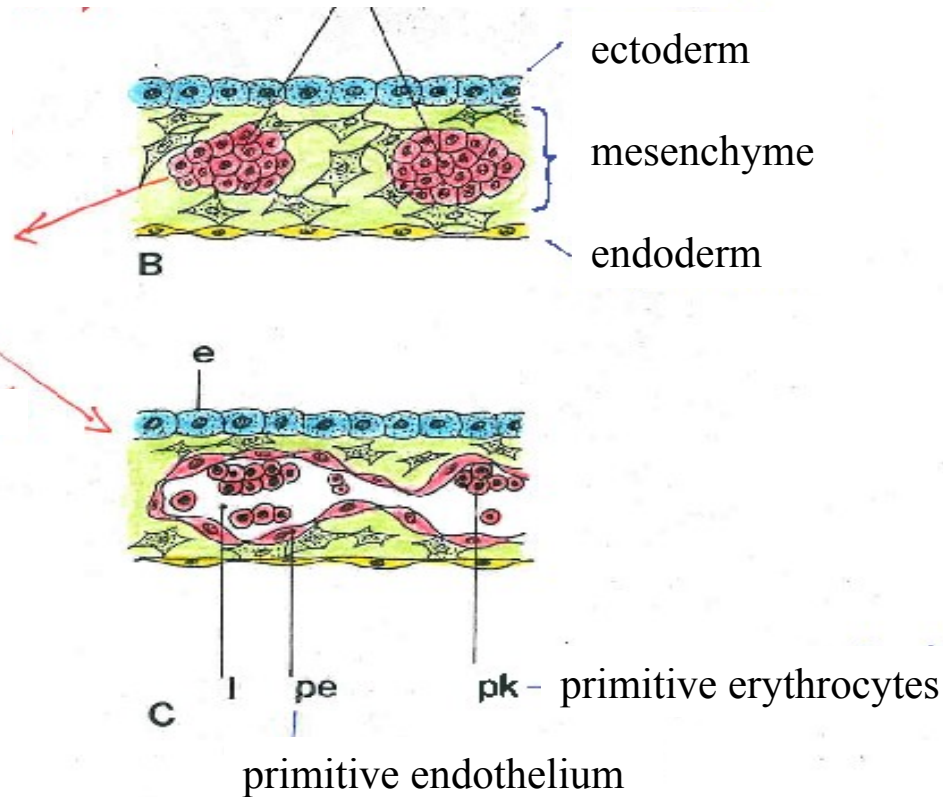
in **mesenchyme** of embryo

Groups of angiogenic cells in mesenchyma

Blood islet

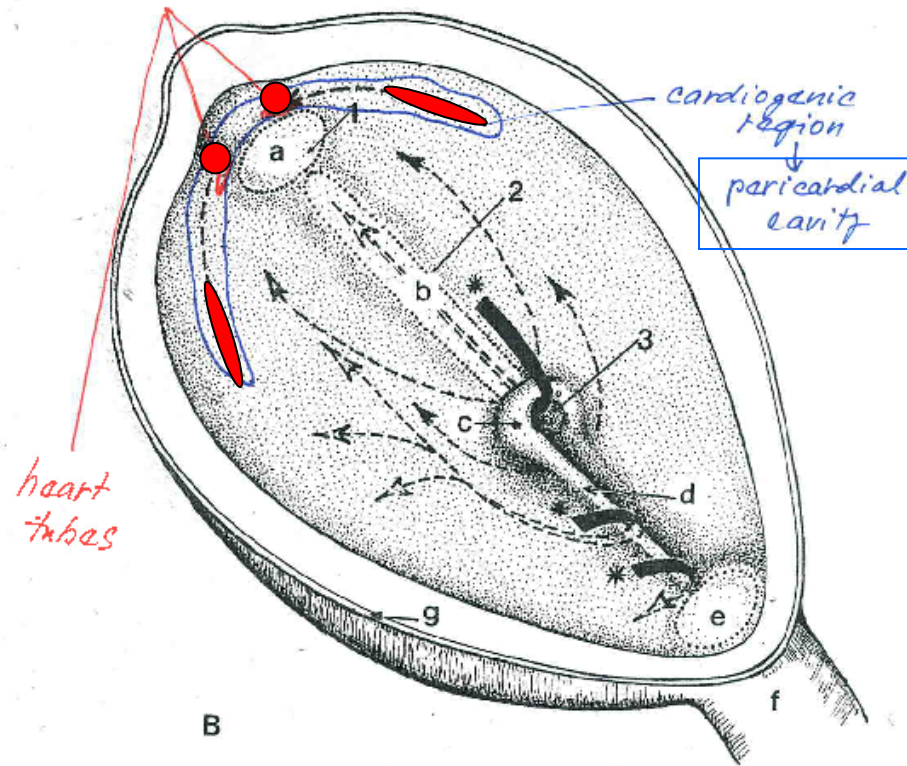
angioblasts

hemoblasts



Differentiation of mesenchymal cells \Rightarrow angiogenic cells:

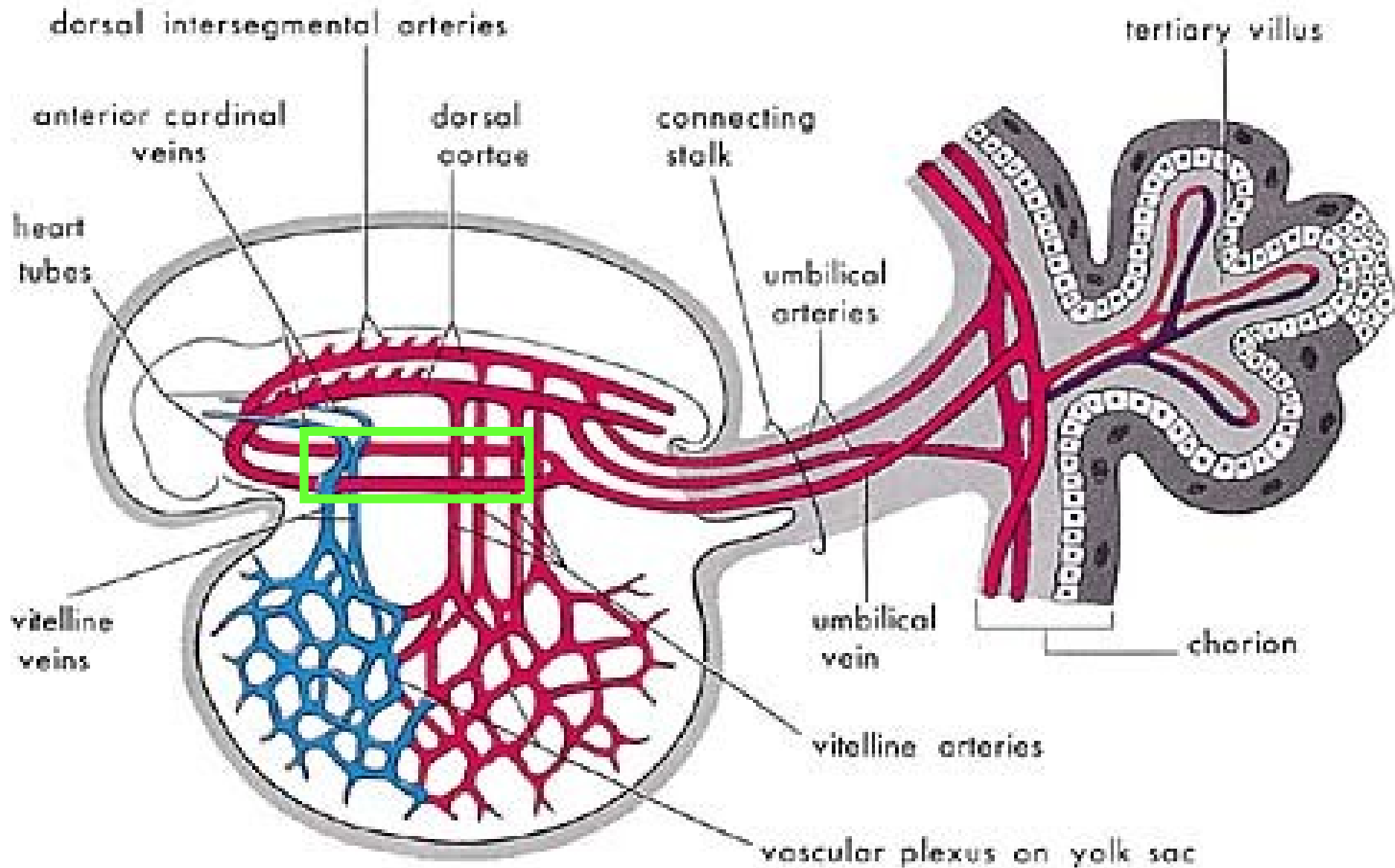
- angioblasts \Rightarrow endothelium (at the periphery of blood islets)
- hemoblasts \Rightarrow primitive erythrocytes (in the center of blood islets)

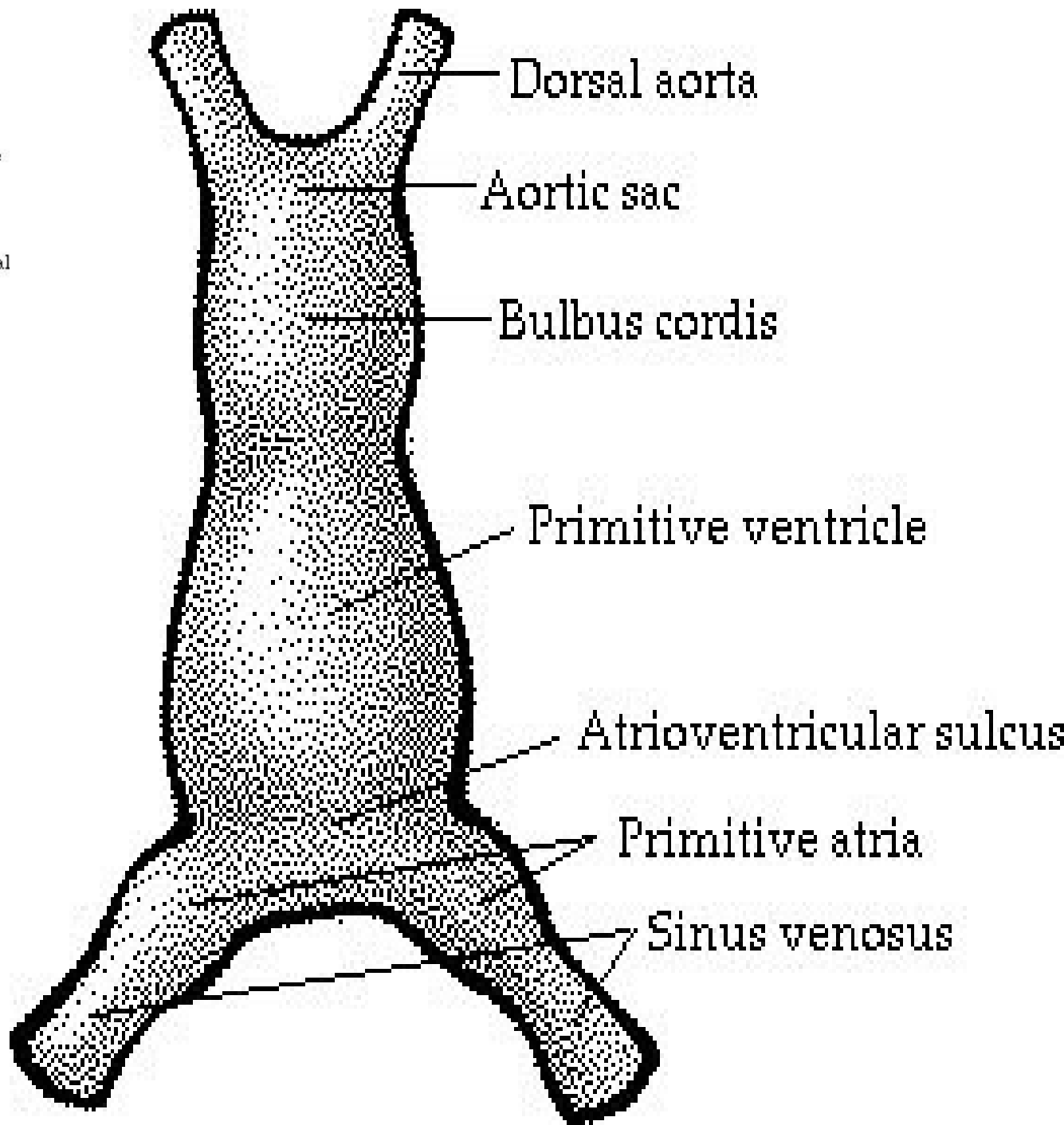
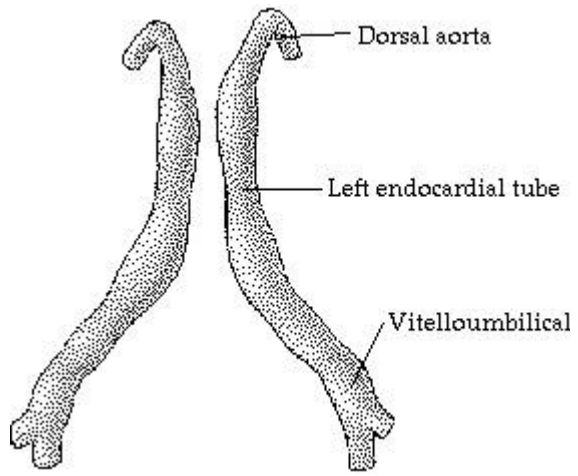


angiogenic cells form a "horseshoe-shaped" space between somatic and splanchnic layer of mesoderm = **pericardial cavity**.

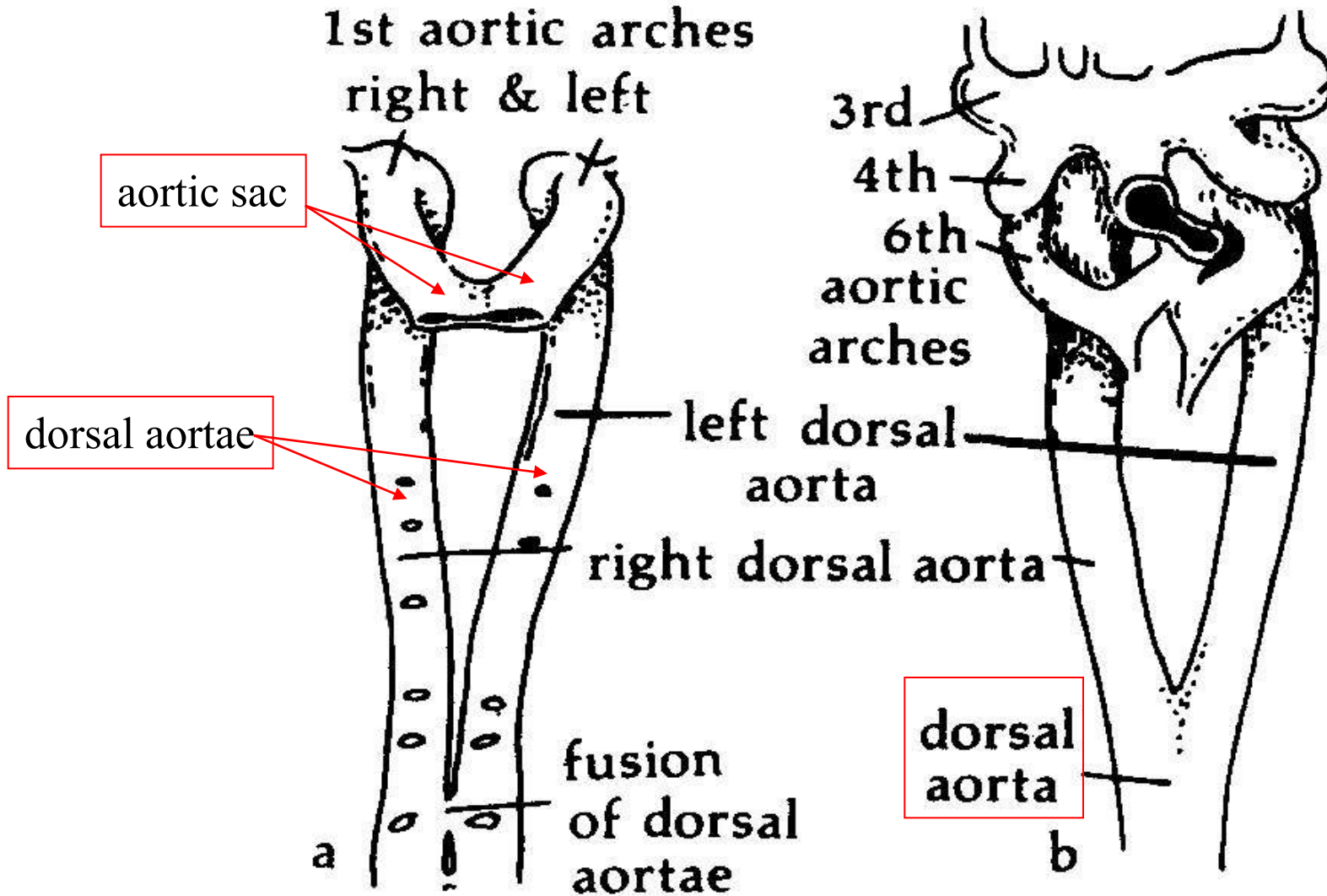
Two endothelial tubes arise in splanchnic mesoderm. The ventral portion with tubes forms the **cardiogenic area** ⇒ **two heart tubes**, while the lateral portions form the **dorsal aortae**.

Vitelline, umbilical and intraembryonic vessels fuse together and form primitive blood circulation (**NO** fetal blood circulation!)

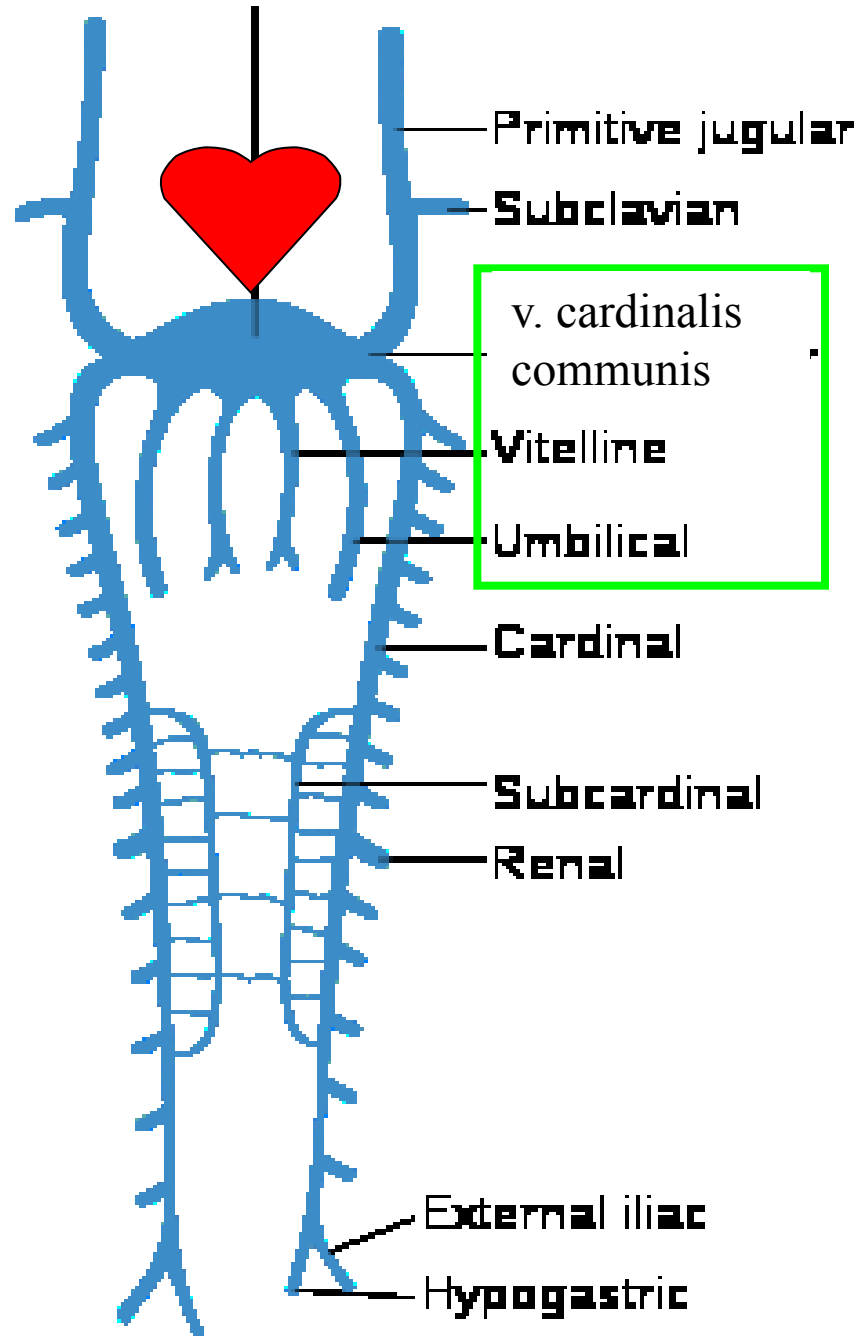




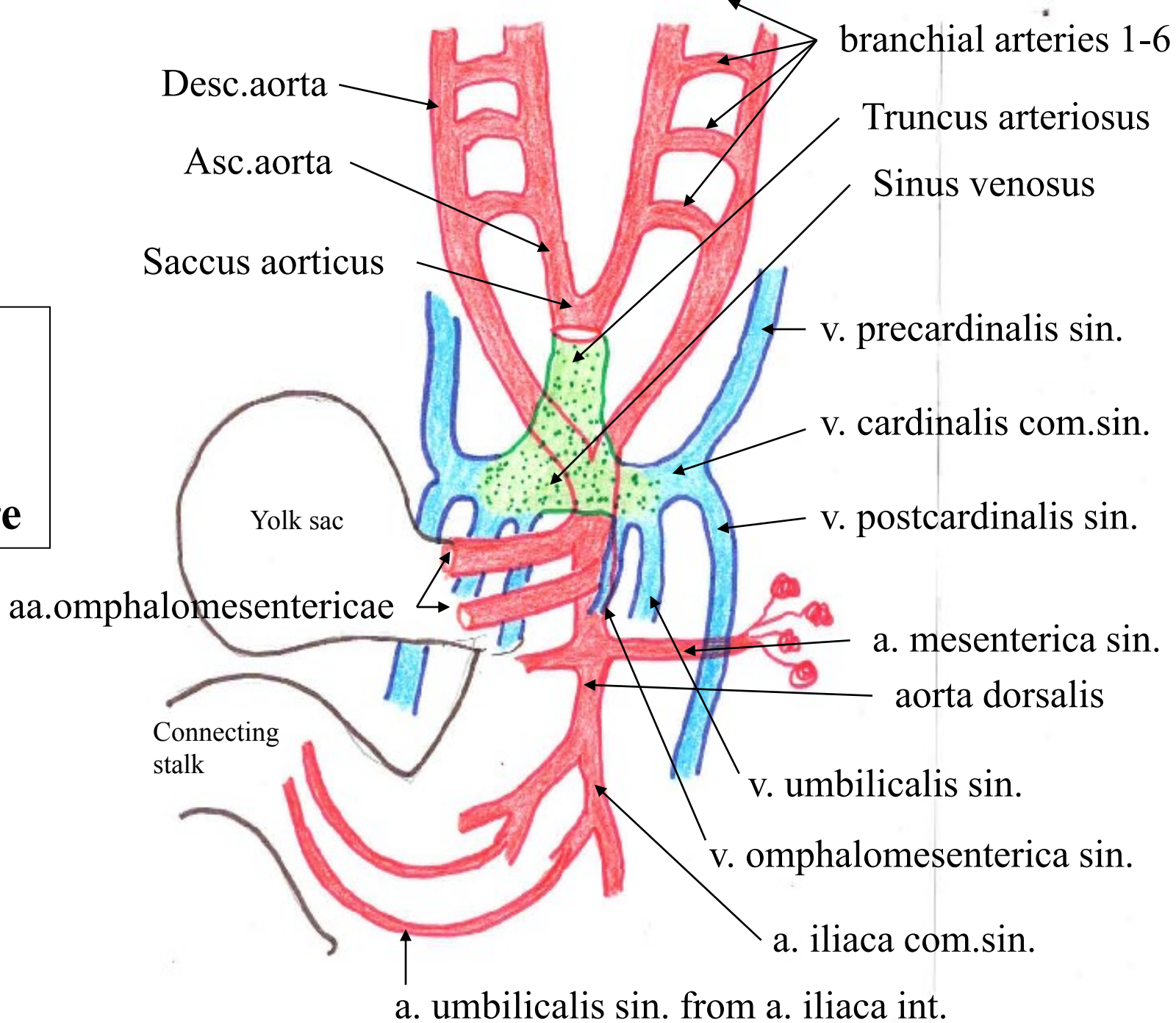
arterial end of heart tube



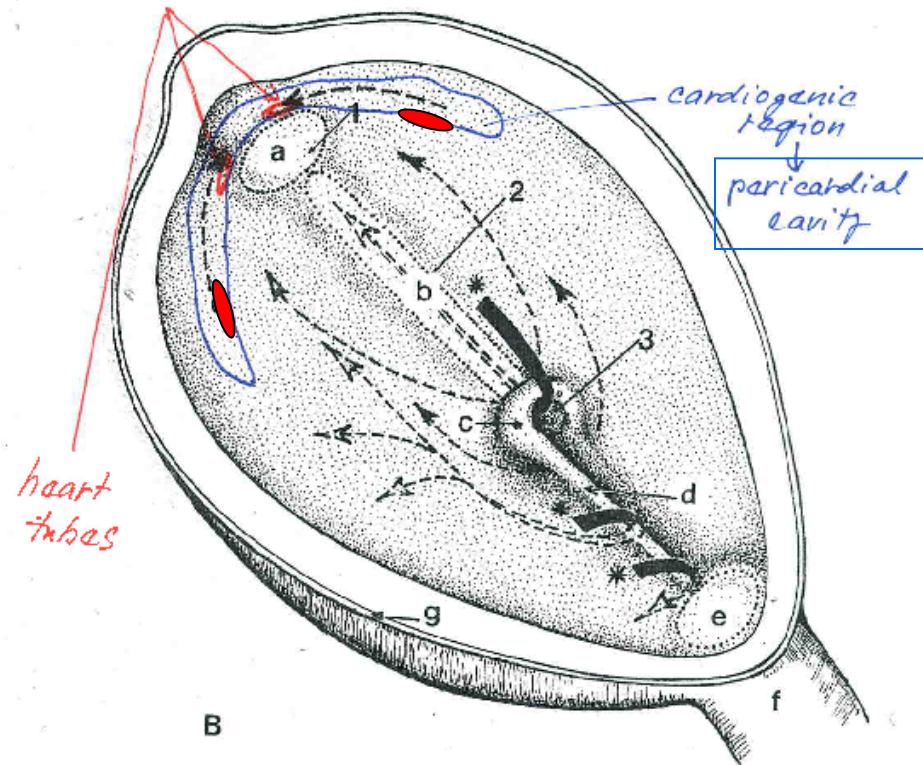
Veins entering venous end of herat tube:



**Vessels
+
cor
tubulare**



Heart development



Space between somatic (parietal) and splanchnic (visceral) mesoderm = **perikardial cavity** with
2 endothelial tubes in splanchnic mesoderm – **heart** (ventromedially)
2 endothelial tubes – **dorsal aortae** (ventrolaterally on arterial end of heart tubes).

Heart tubes

(day 18-19)

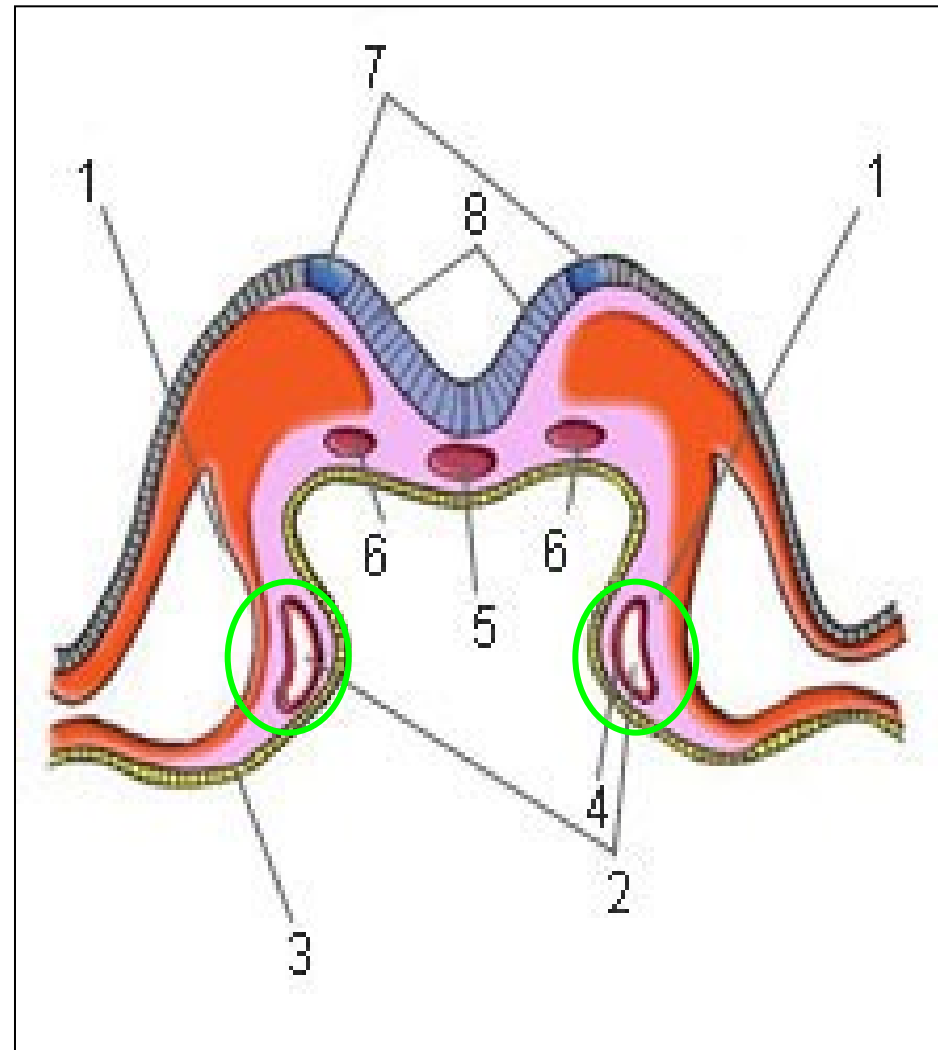
in mesenchyme of splanchnopleura
– 2 endothelial tubes

As a result of embryo flexion:

- separation of yolk sac
- heart tubes fusion ↓

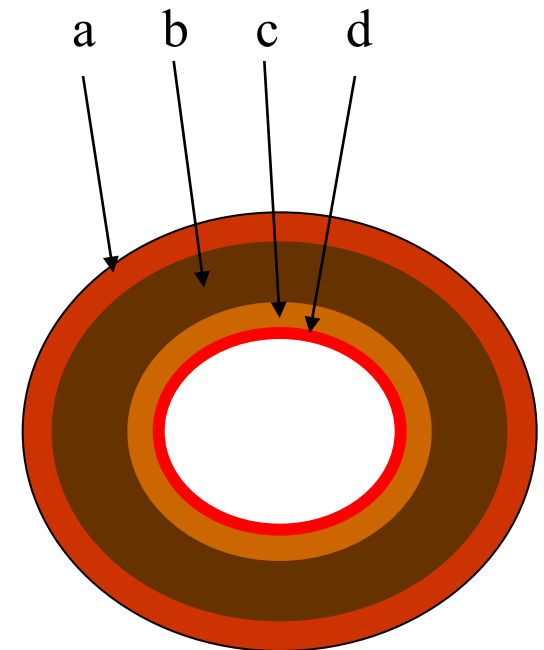
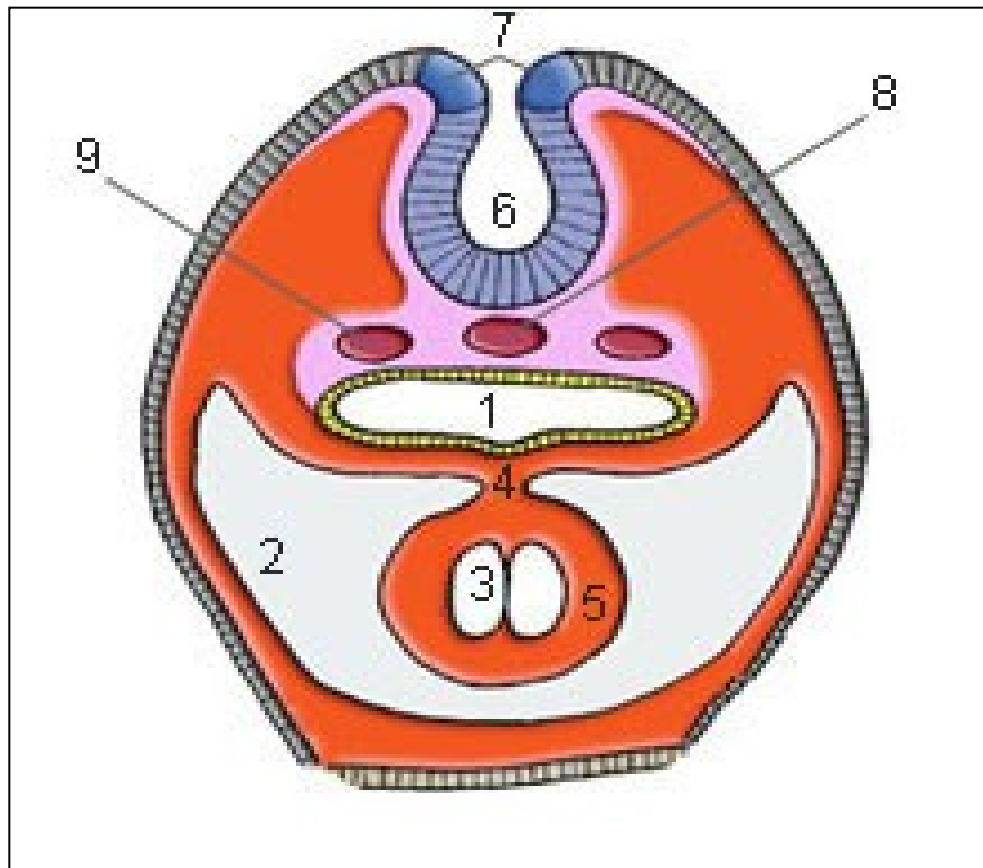
COR TUBULARE SIMPLEX

(contractions – day 23,
sono registration – week 4)

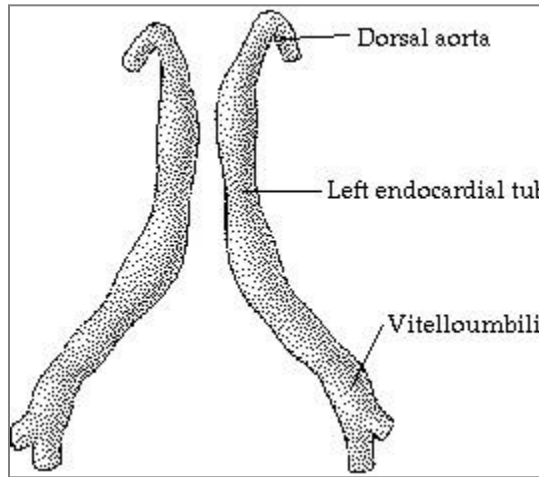


Histogenesis of heart tube wall

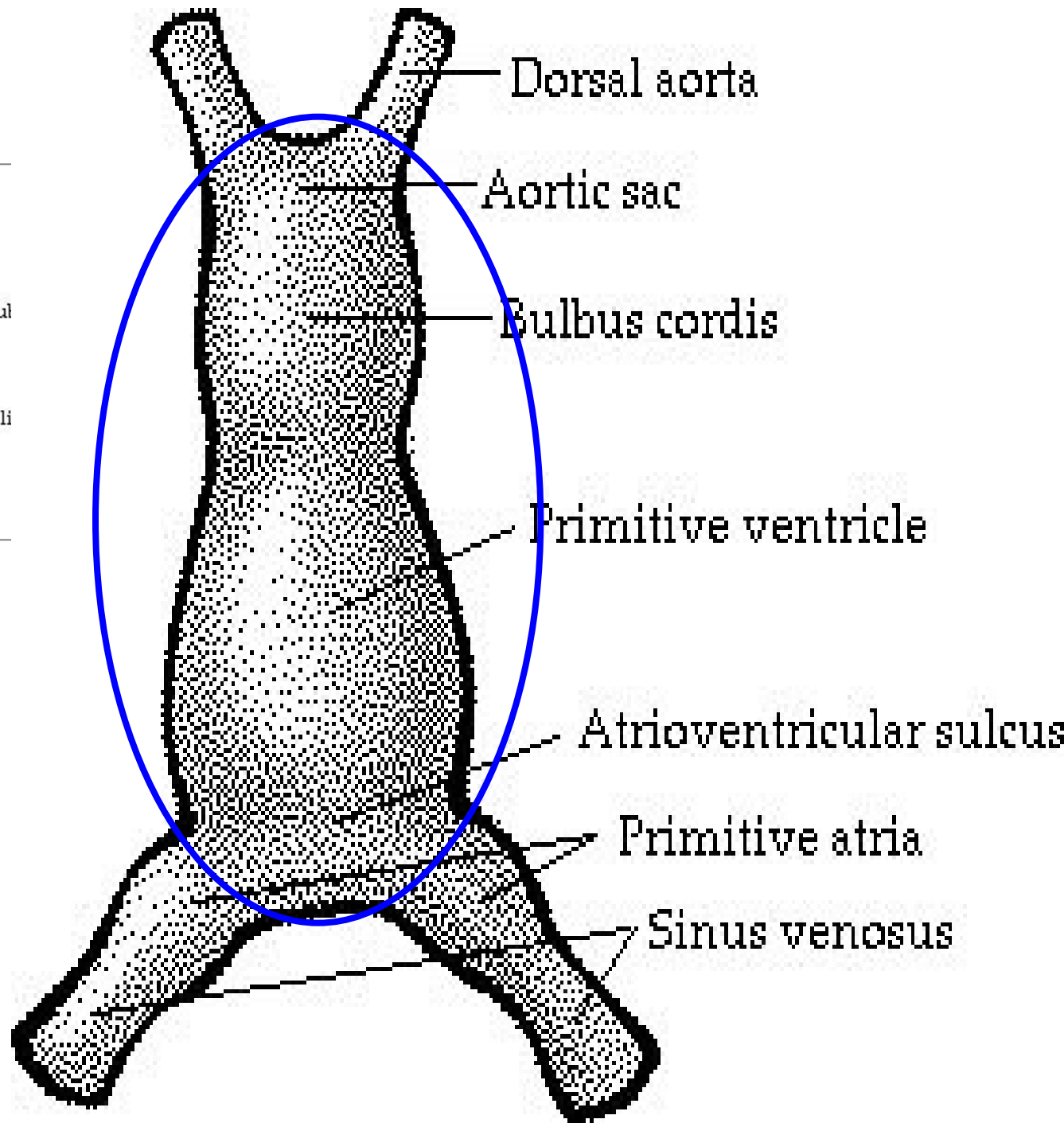
COR TUBULARE SIMPLEX – temporarily suspended on **mesocardium dorsale** (4). Visceral mesoderm (splanchnopleura, 5) propagates and forms myoepicardial coat \Rightarrow **myocardium (b)** + **epicardium (a)**. Below **endothelium (d)** – layer of cardiac jelly \Rightarrow **subendocardial connective tissue (c)**.



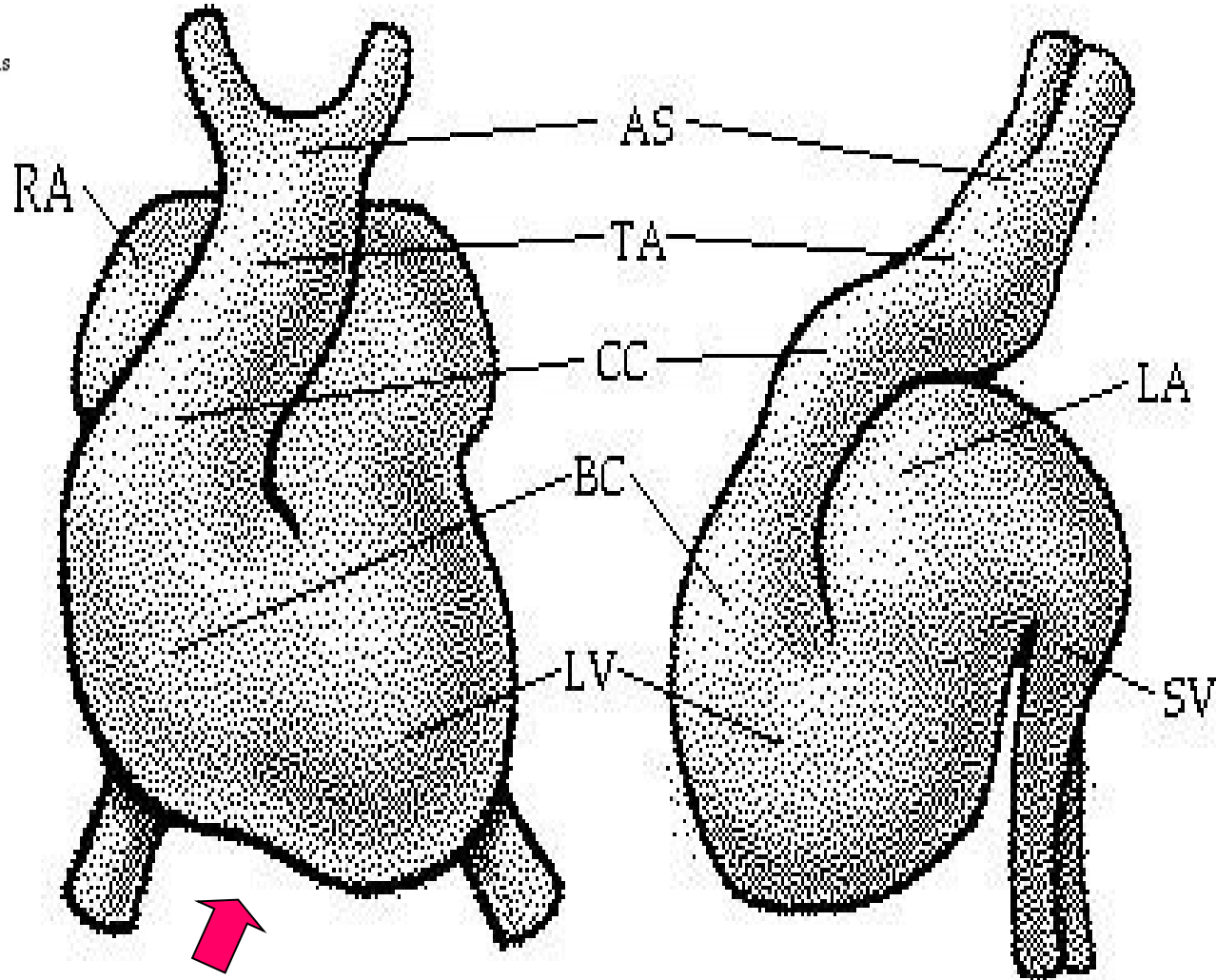
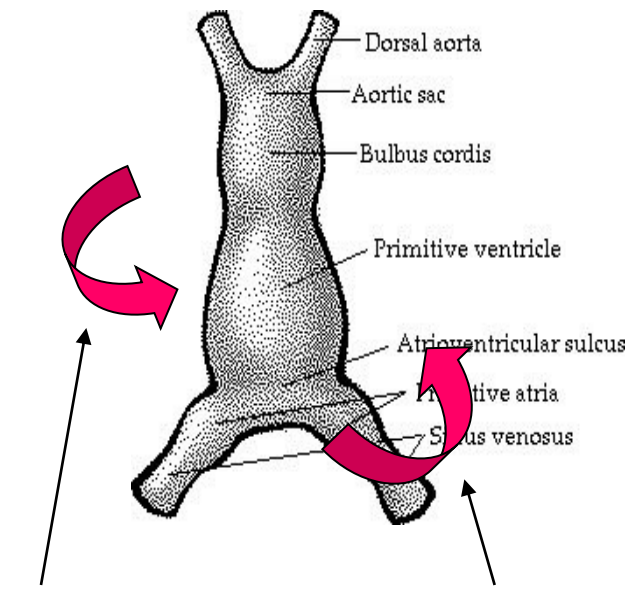
Heart tube(s)



Pericardial cavity



Bulboventricular loop



ventral view

lateral view

Heart tube

Truncus arteriosus
+ saccus aorticus

Bulbus cordis

Ventriculus

Atrium

Sinus venosus

vv. cardinales
communes

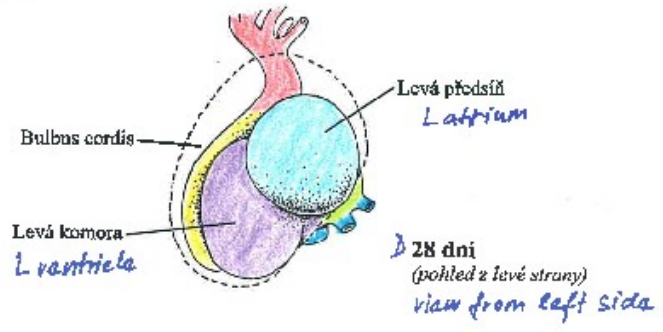
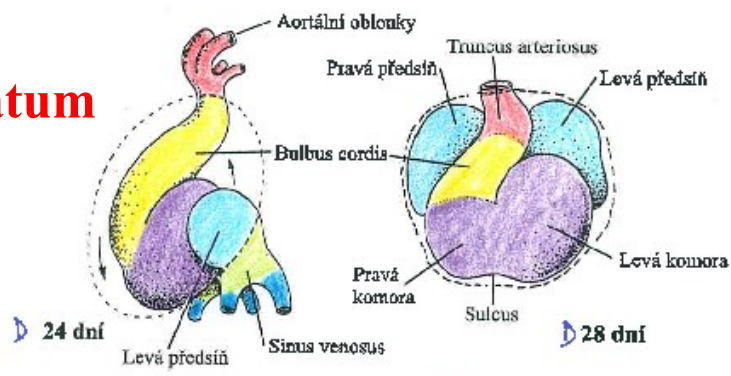
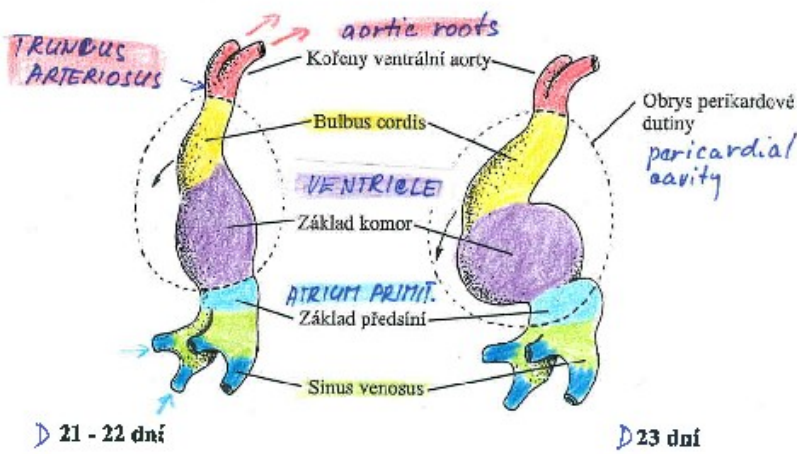
vv. umbilicales

vv. vitellinae

Cor
tubulare
simplex

Cor
sigmoideum
uniloculare

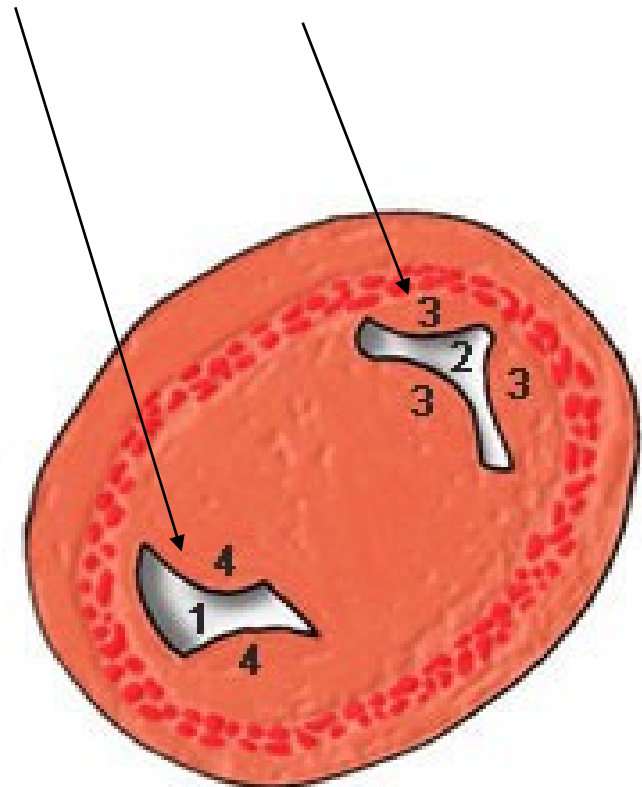
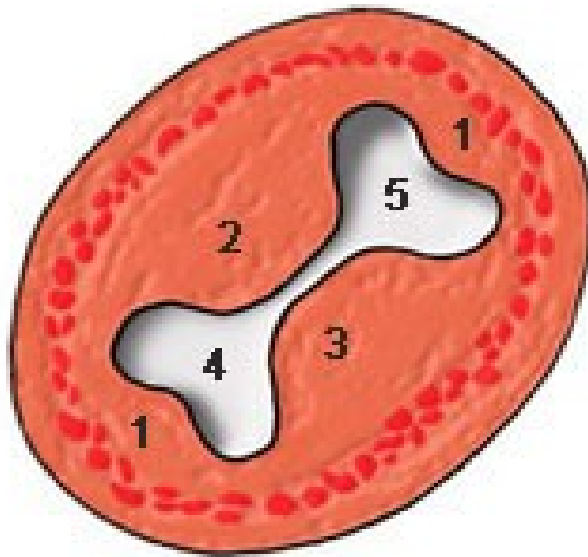
Cor
quadricameratum

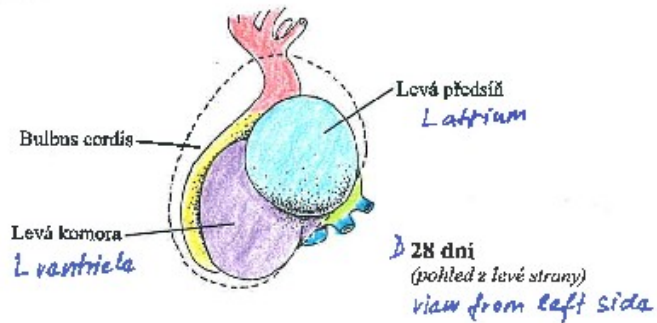
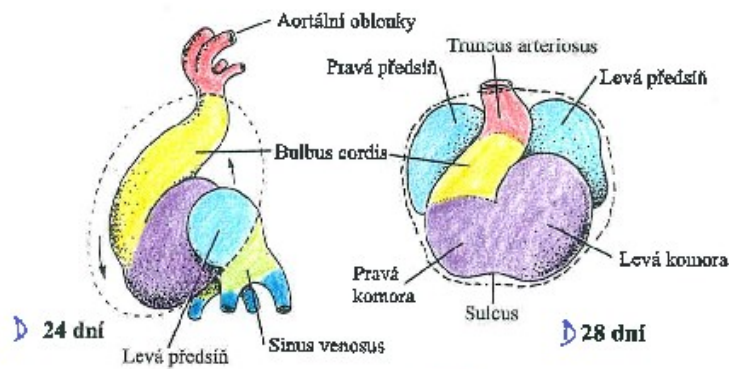
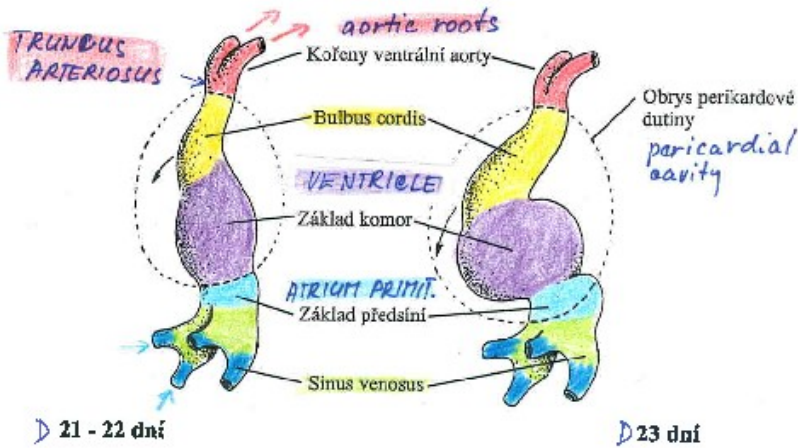


Septum atrioventriculare

A/ **Endocardial cushions** – from dorsal (3) and ventral (2) wall of atrioventrikular canal. Grow against each other and separate right and left AV canal (4, 5).

B/ Lateral interventricular cushions – **bicuspid + tricuspid AV valve**.

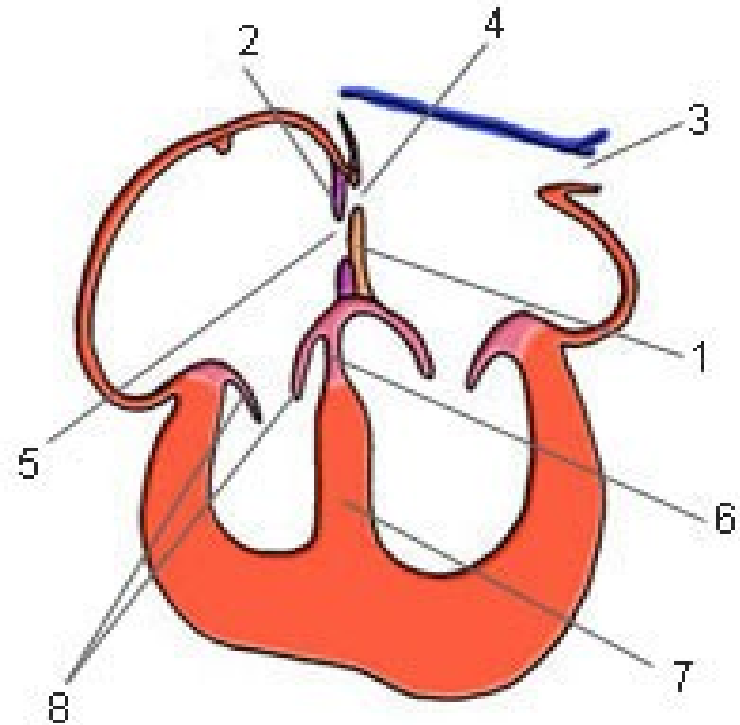




Ventriculus

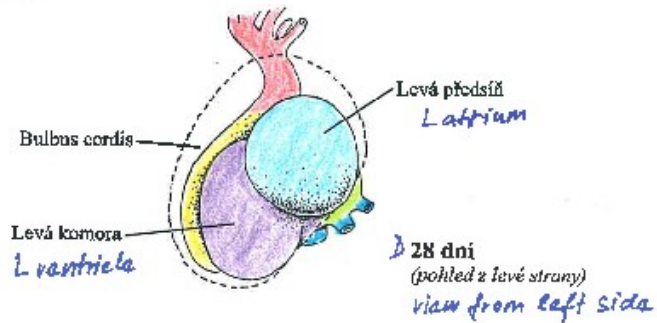
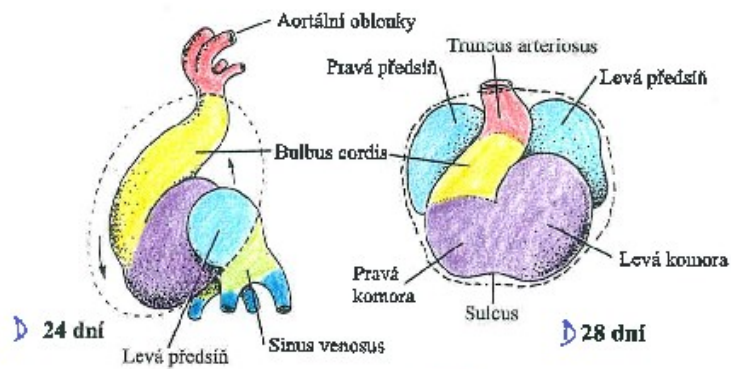
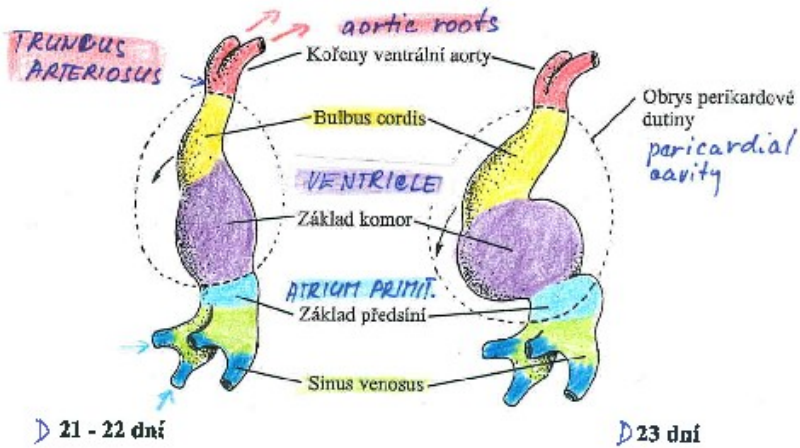
Septum interventriculare

Grows from apex cordis cranially to AV septum



6 - membranózní část septa

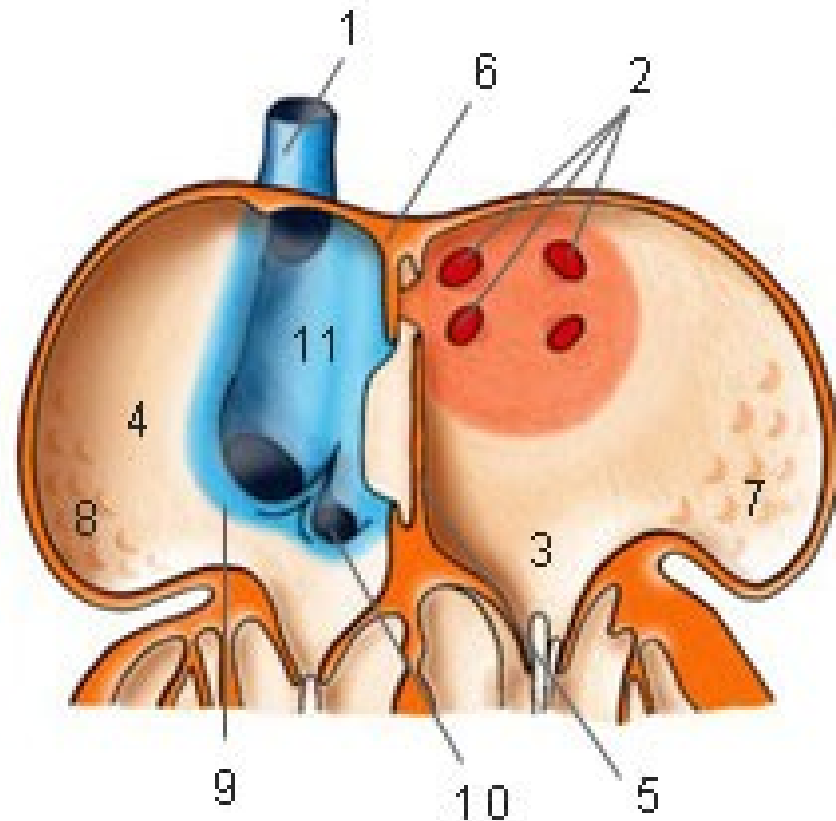
7 - IV septum



Atrium

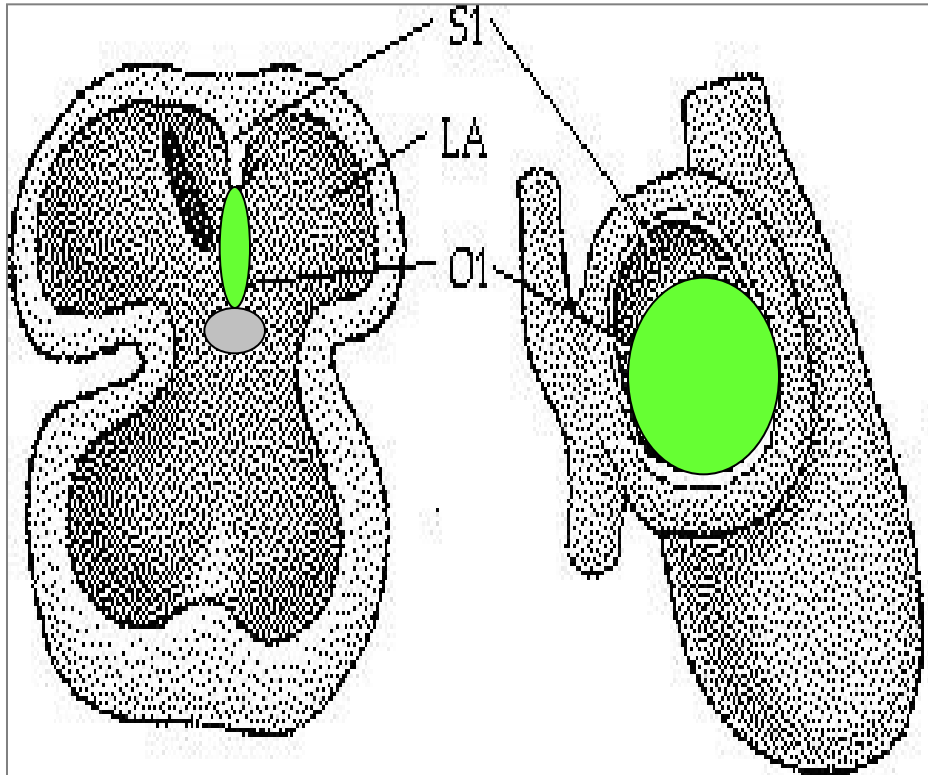
Septum atriorum

-septum primum s ostium primum (obliteration); ostium secundum
 -septum secundum with foramen ovale



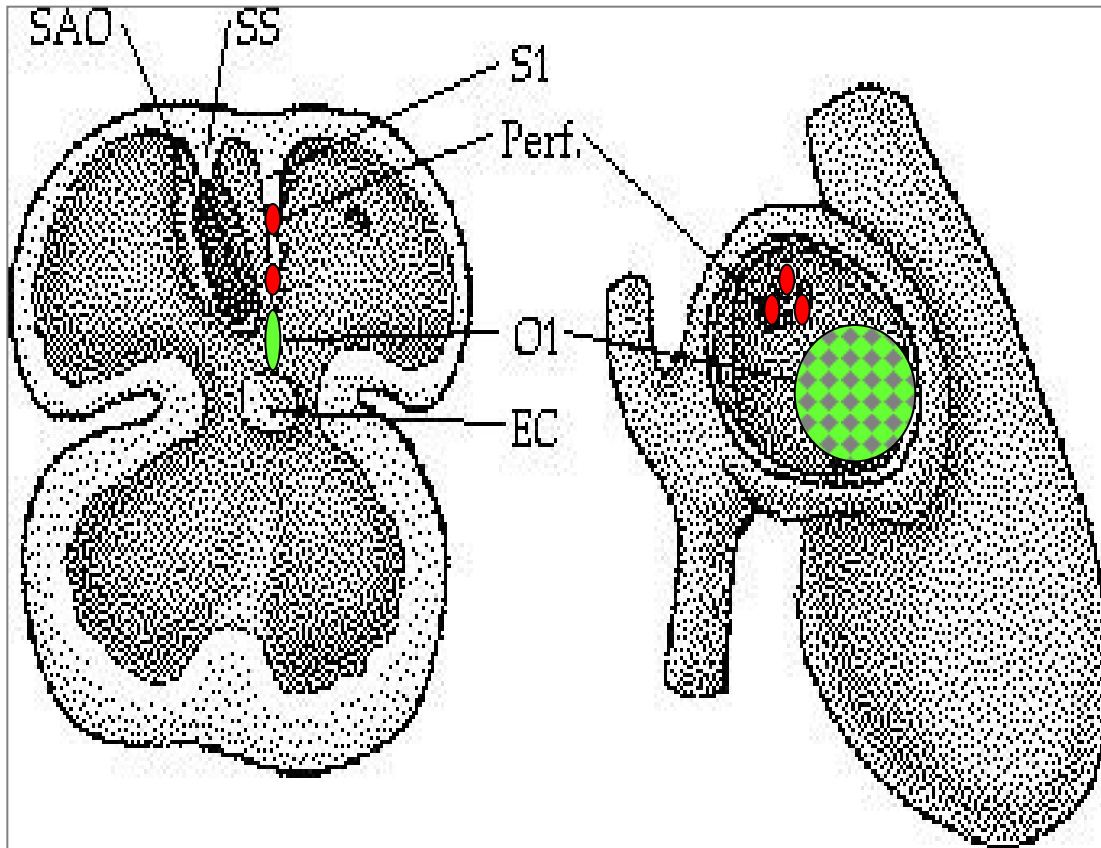
Septum primum

Grows from dorsocranial wall – foramen primum (caudally), closes later, and foramen secundum (above) appears by cell apoptosis



S1 – septum primum, O1 – foramen secundum

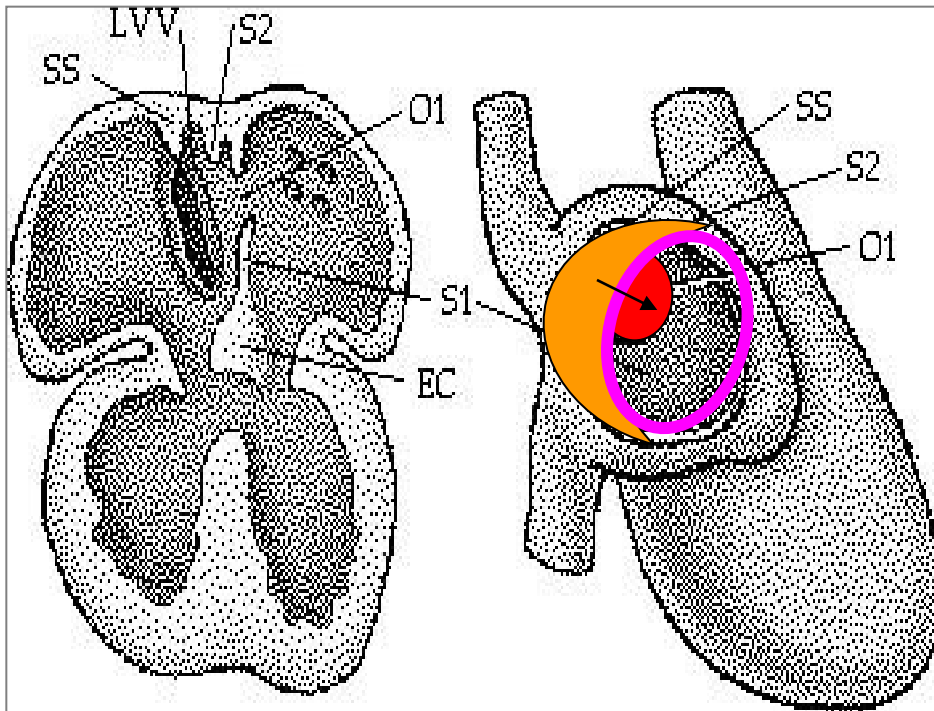
In septum primum by cell apoptosis **foramen secundum** will arise



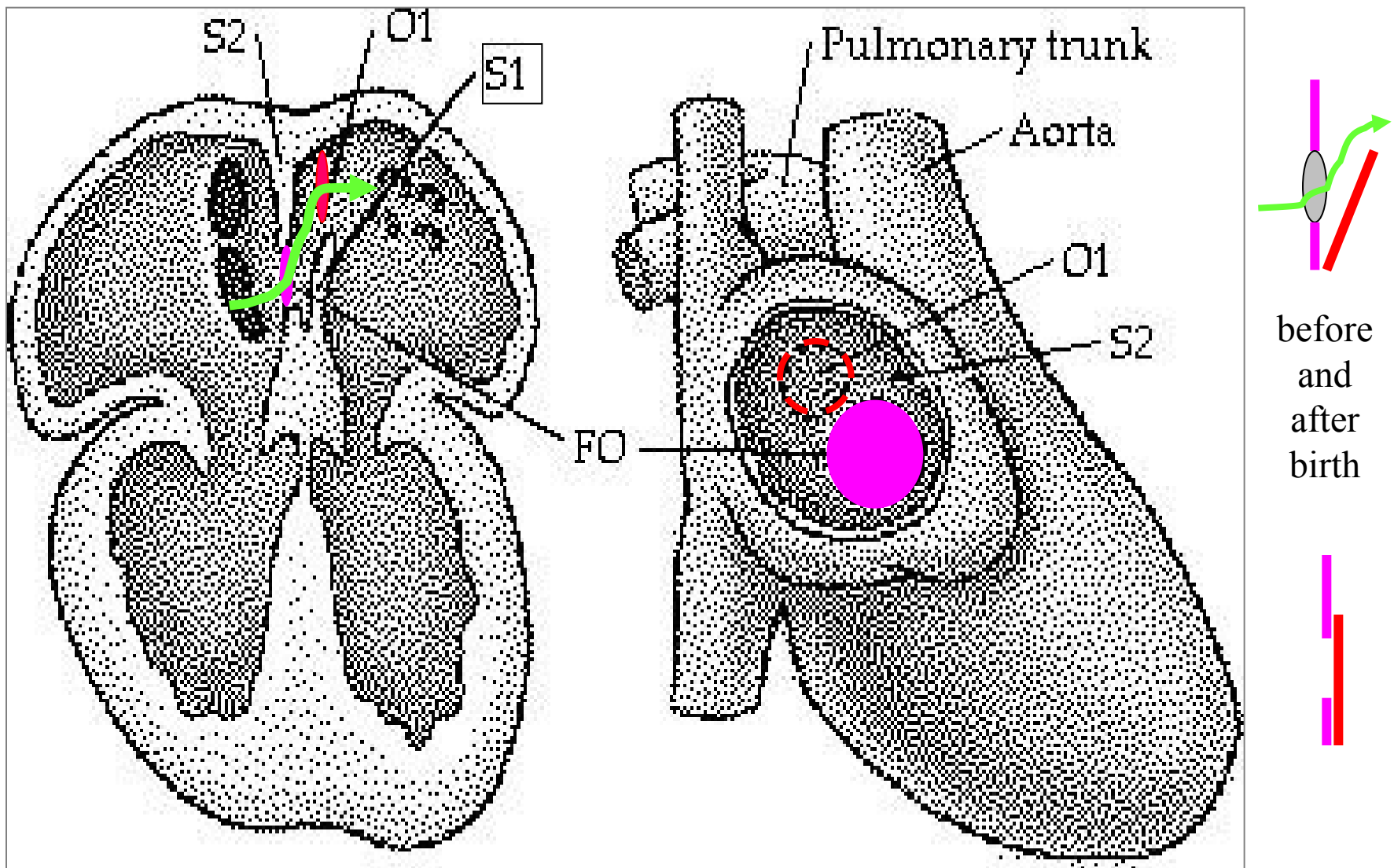
S1 – septum primum, SS – septum spurium,
O1 – foramen primum, EC – endocard. cushion,
Perf – perforation of foramen secundum,
SAO – sinoatrial orifice,

Septum secundum

- semicircular fold, does not reach endocardial cushions;
- covers foramen secundum in septum primum and by its free lower margin surrounds foramen ovale

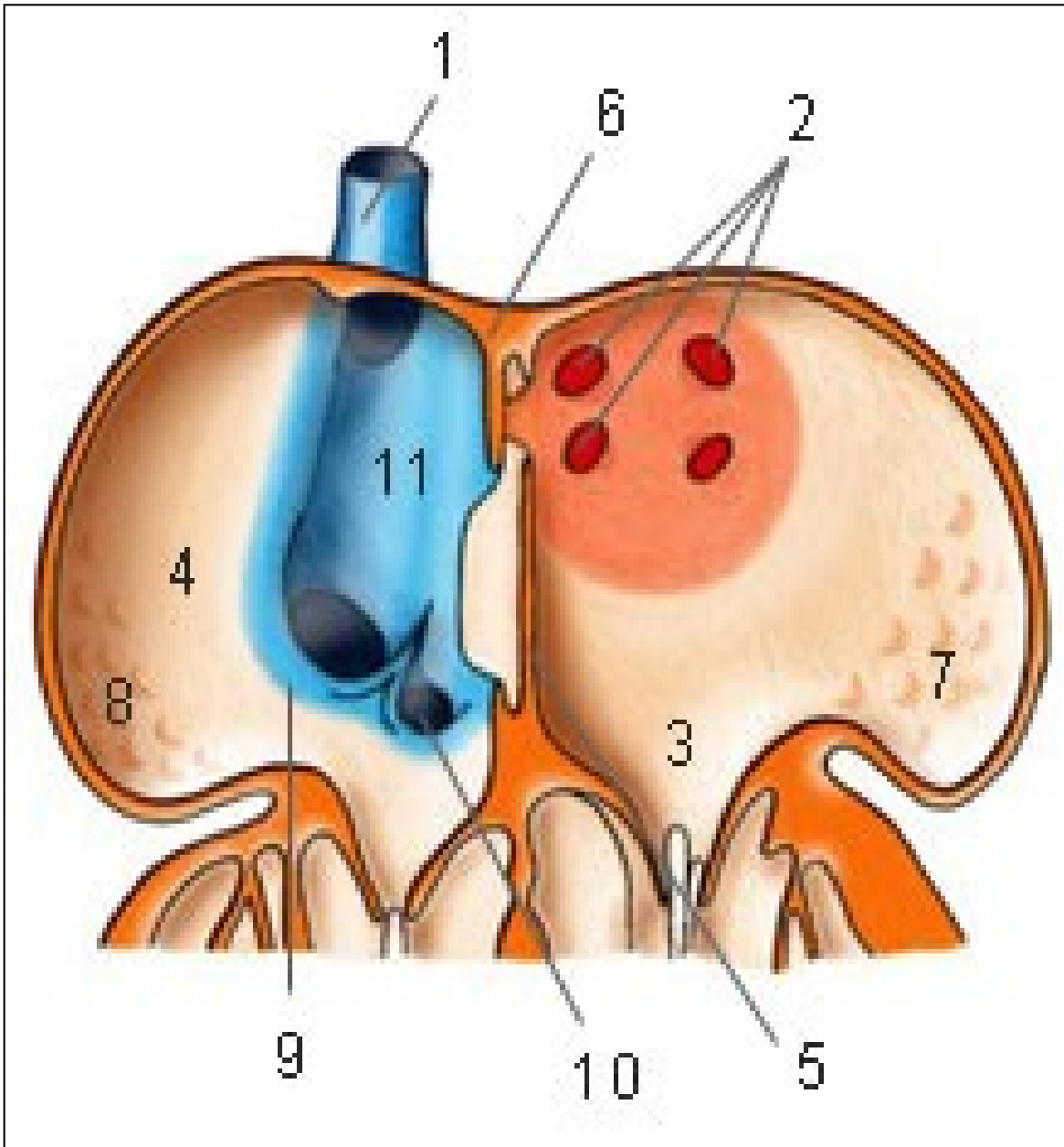


S1 – septum primum, S2 – septum secundum, SS – septum spurium,
O1 – foramen secundum, FO – foramen ovale,
EC – endocard. cushion,
LVV – left venous valve

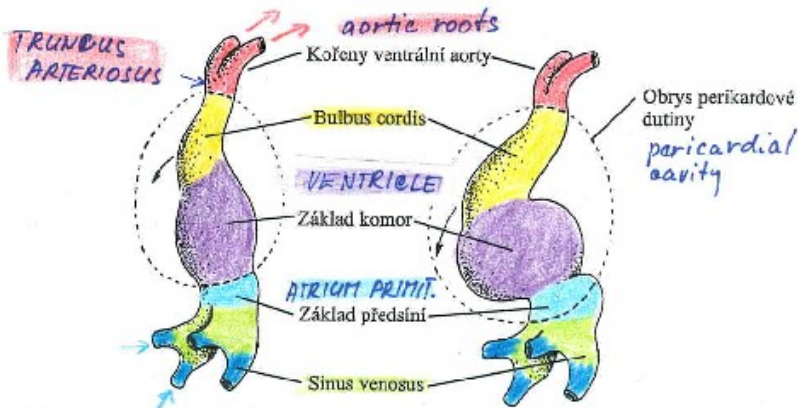


S1 – septum primum (valvula foraminis ovalis), S2 – septum secundum, SS – septum spurium, O1 – foramen secundum, FO – foramen ovale, EC – endokardový polštářek, Perf – perforace, SAO – sinoatriální orificium, LVV – levá venózní chlopeč

Blood from v. cava under pressure flows from the right atrium into the left.

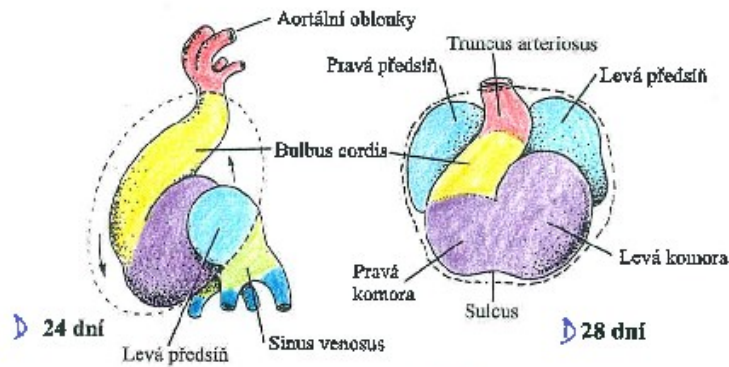


1. Vena cava superior
2. Venae pulmonales
3. Atrium sin.
4. Atrium dx.
5. Septum primum
6. Septum secundum
7. Primitive left atrium
8. Primitive right atrium
9. Valve of vena cava inferior
10. Valve of sinus coronarius
11. Sinus venosus



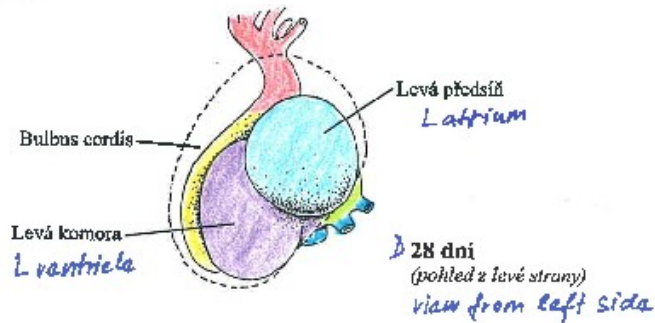
▷ 21 - 22 dní

▷ 23 dní



▷ 24 dní

▷ 28 dní



Sinus venosus

vv. cardinales
communes

vv. umbilicales

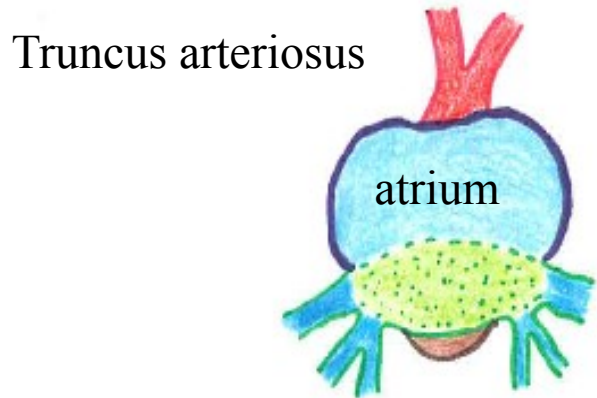
vv. vitellinae

Left veins obliterate and

- left part of sinus venosus ⇒ sinus coronarius

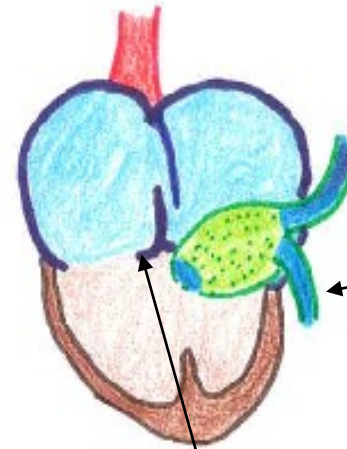
- right part of sinus venosus ⇒ part of right atrium wall

Sinus venosus + atria



Sinus venosus:
-transvesal part
-R + L horns:

- v. cardinalis comm.
- v. umbilicalis
- v. omphalomesenterica



On the right side:

v. cava sup.

from v. cardin. comm.
dx.+ v. precardin. dx.

v. cava inf.

(posthepatic part)
from v. omphalomes. dx.

On the left side:

veins obliterate and give
rise to
sinus coronarius

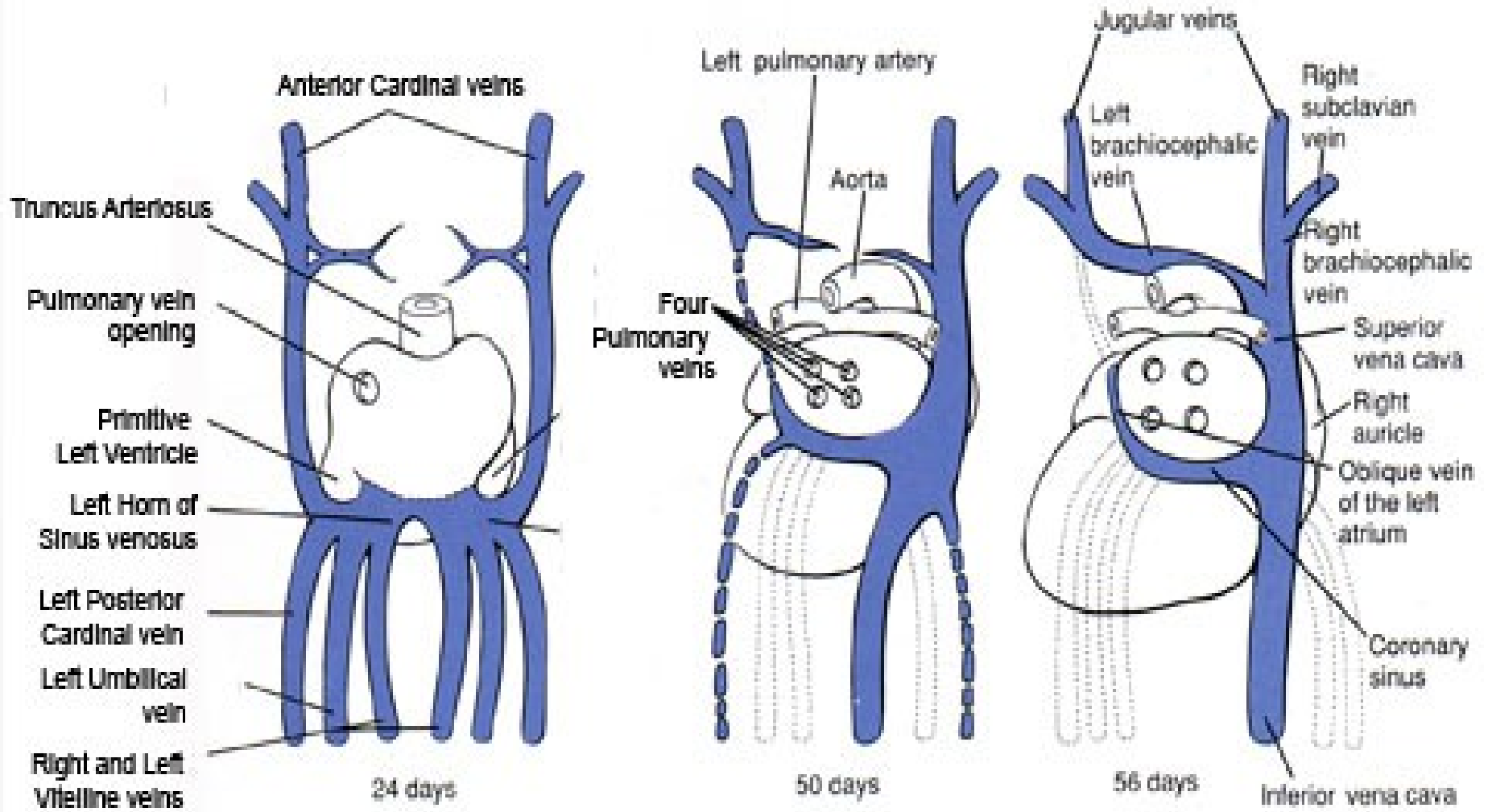
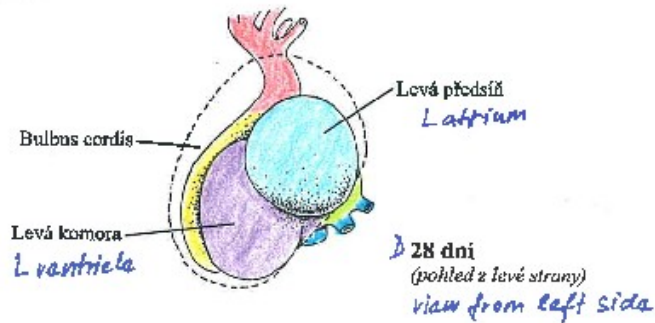
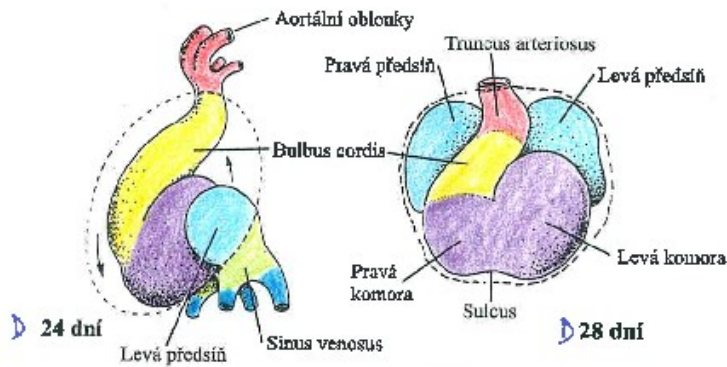
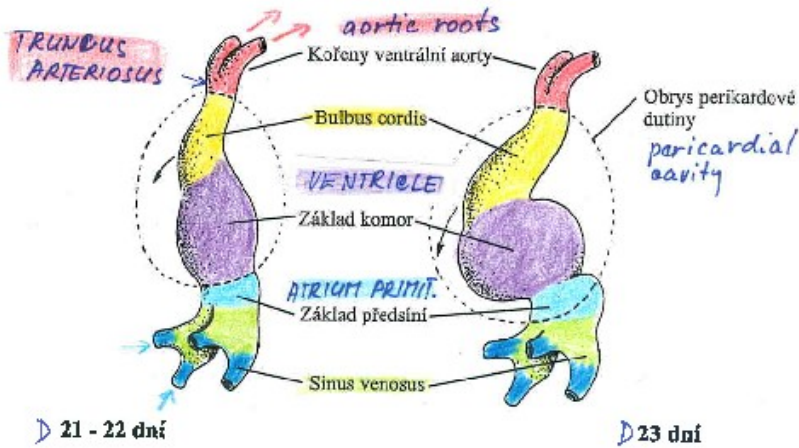
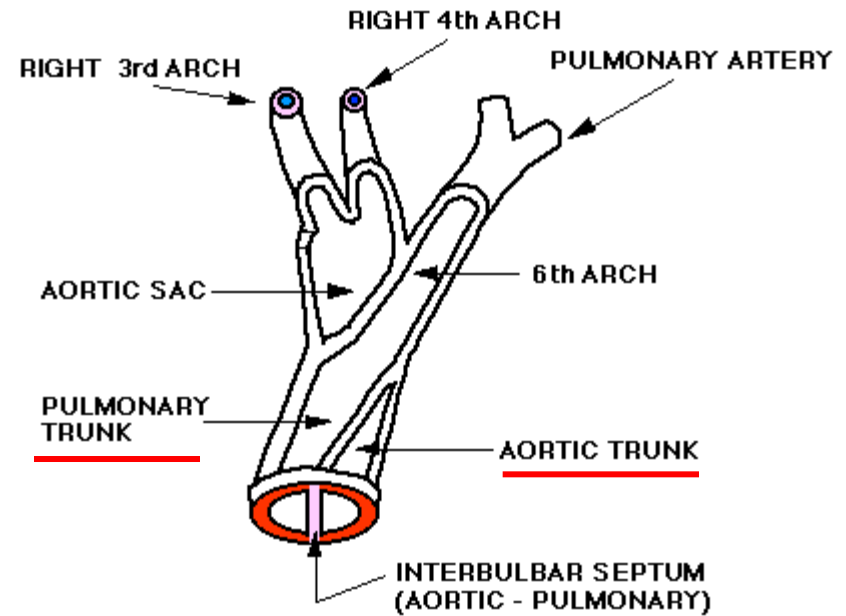


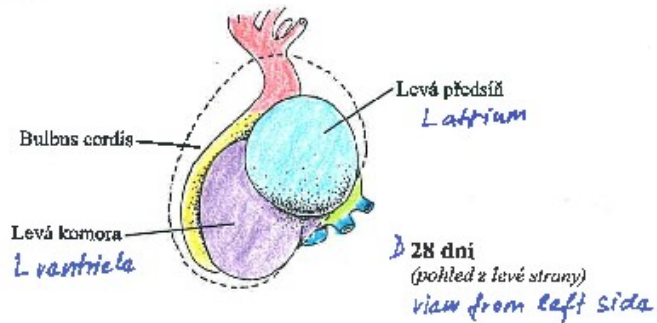
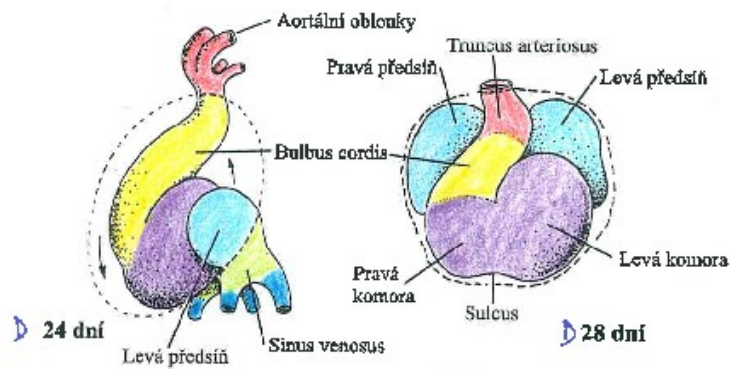
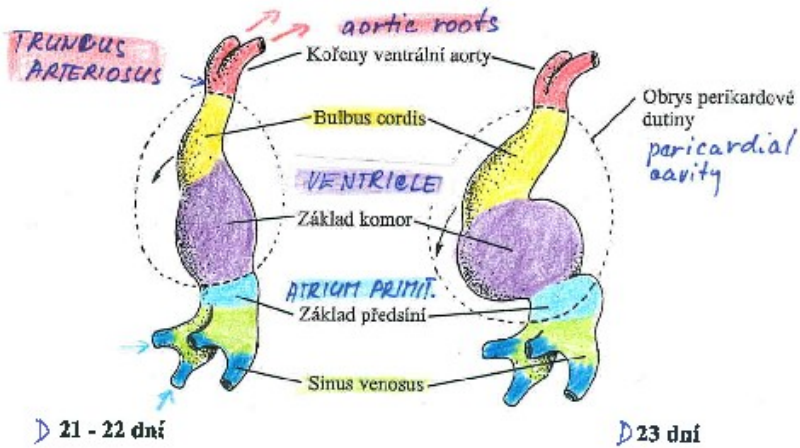
Image from Human Embryology by Larsen 2nd edition. pg. 161

Truncus arteriosus + saccus aorticus



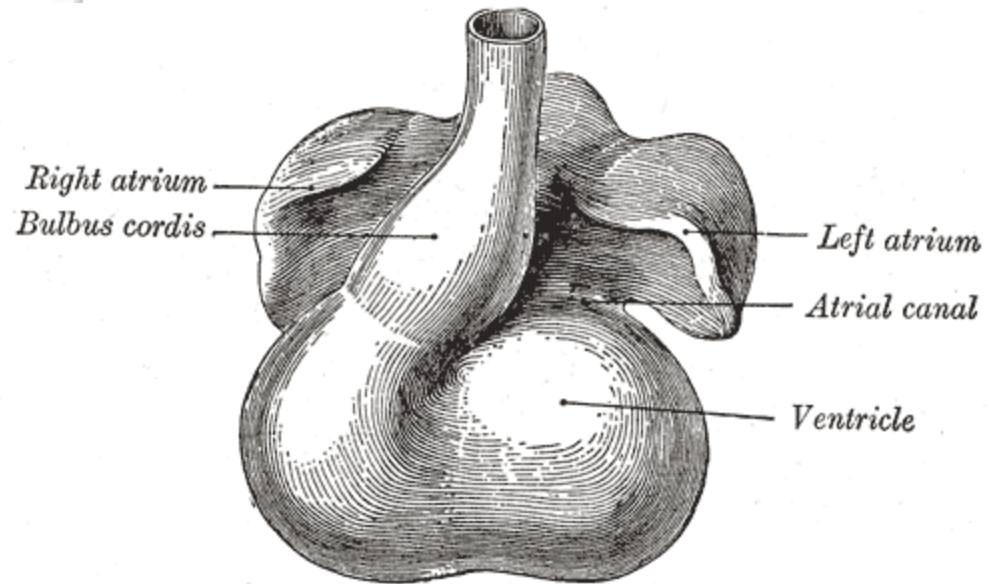
cranial part of bulbus cordis separates into:
-2 aortic roots with 6 pairs of aortic arches

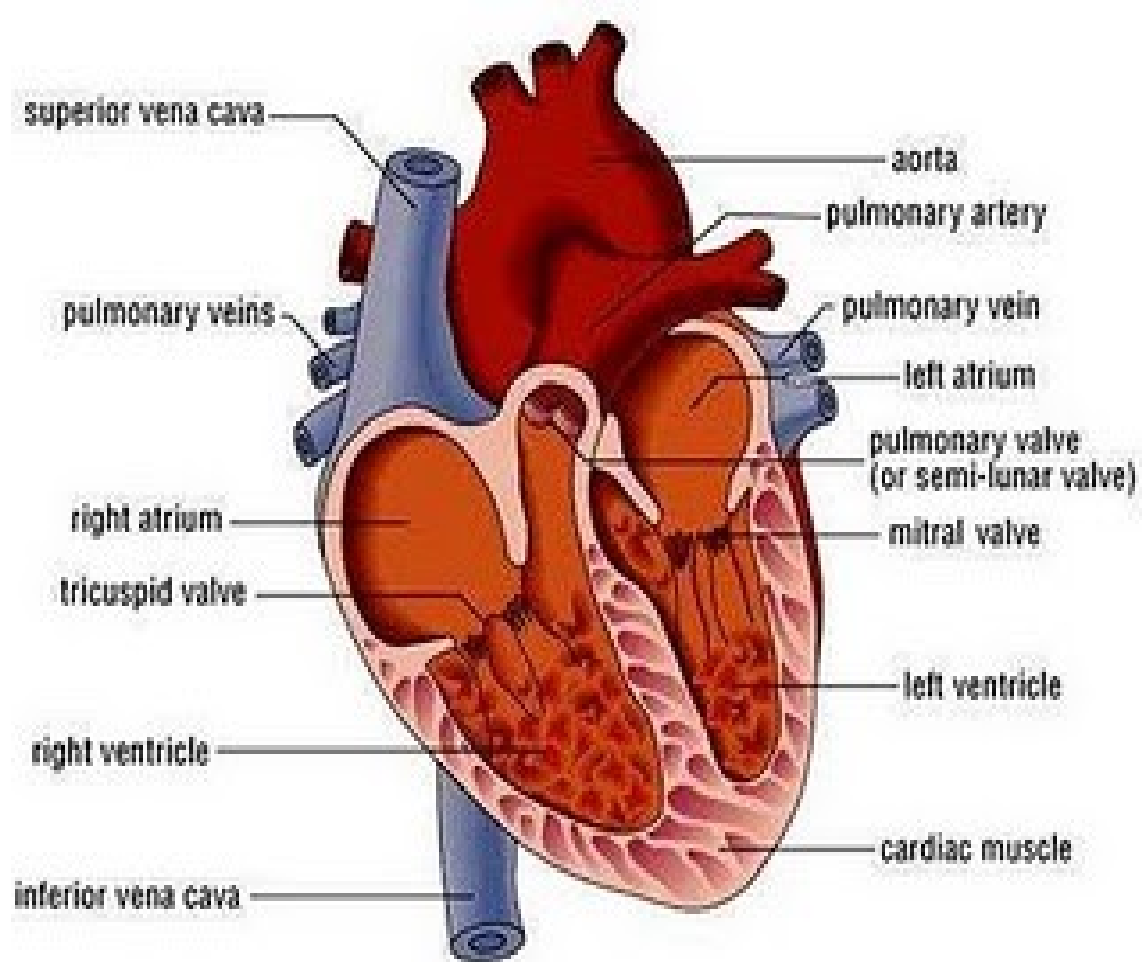
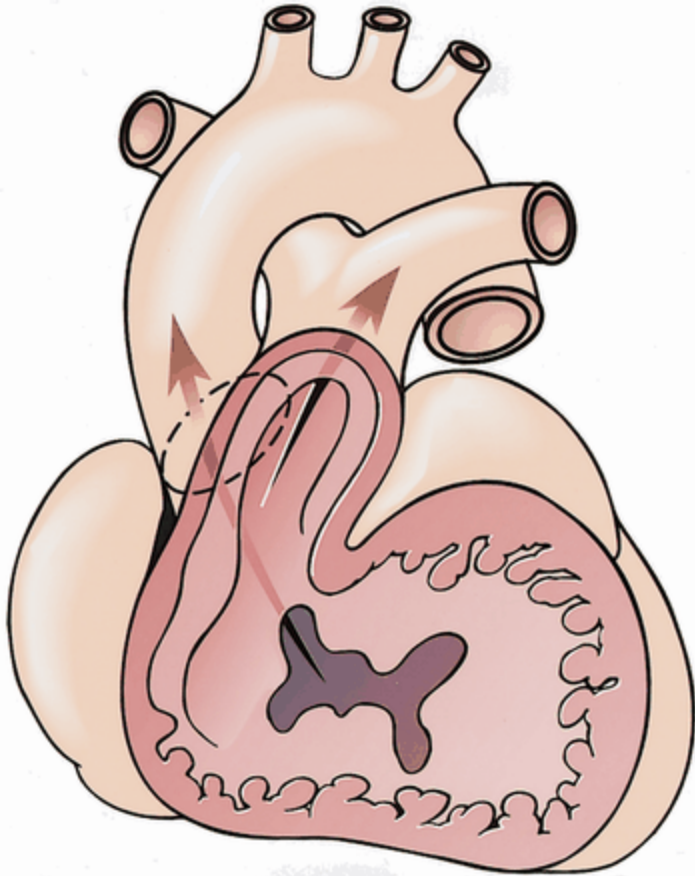




Bulbus cordis

- cranial – truncus arteriosus
- middle – conus arteriosus
- caudal – part of ventricle wall

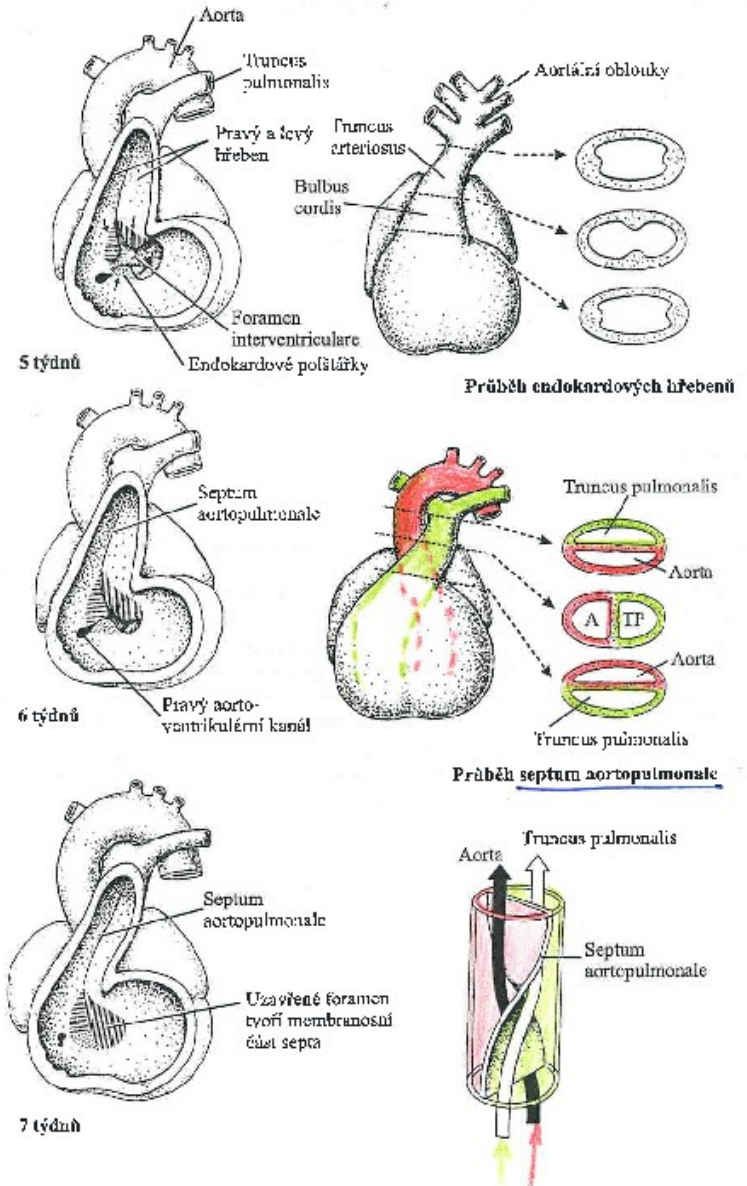




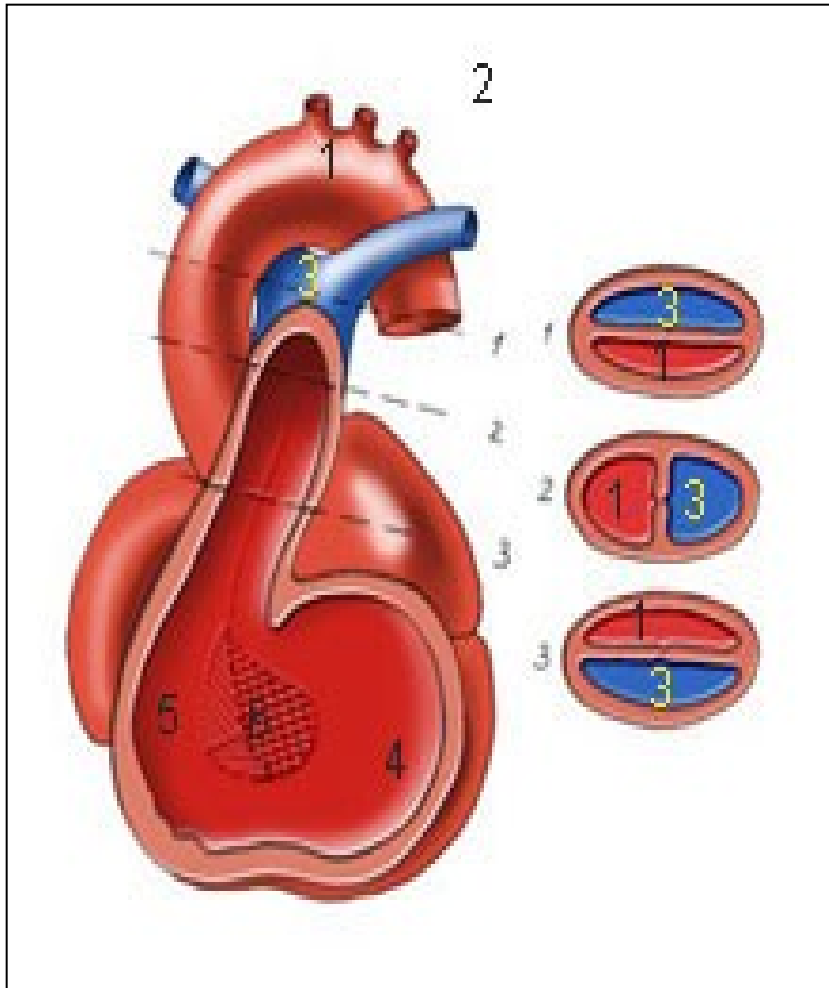
**Bulbus cordis – participate in ventricle wall;
in RV - conus arteriosus, in LV – sinus aortae.**

Bulbus cordis a truncus arteriosus

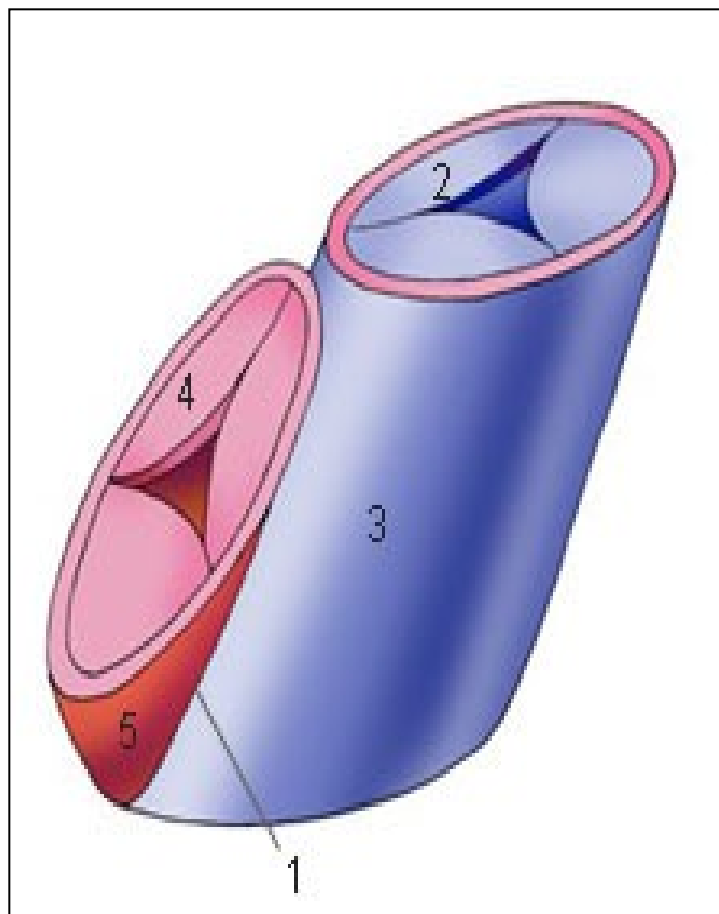
a pair of opposing ridges appear in the walls of the bulbus cordis and truncus arteriosus. These ridges twist around each other, forming a spiral course of the **aortico-pulmonary septum**. This septum divides the bulbus cordis and truncus arteriosus into two channels, the **aorta** and the **pulmonary artery**. It also participates in the closure of the interventricular foramen



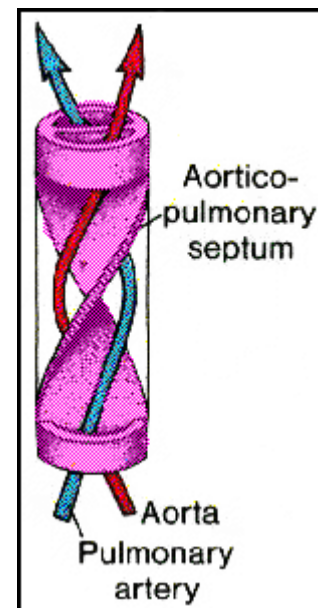
Septum aortopulmonale

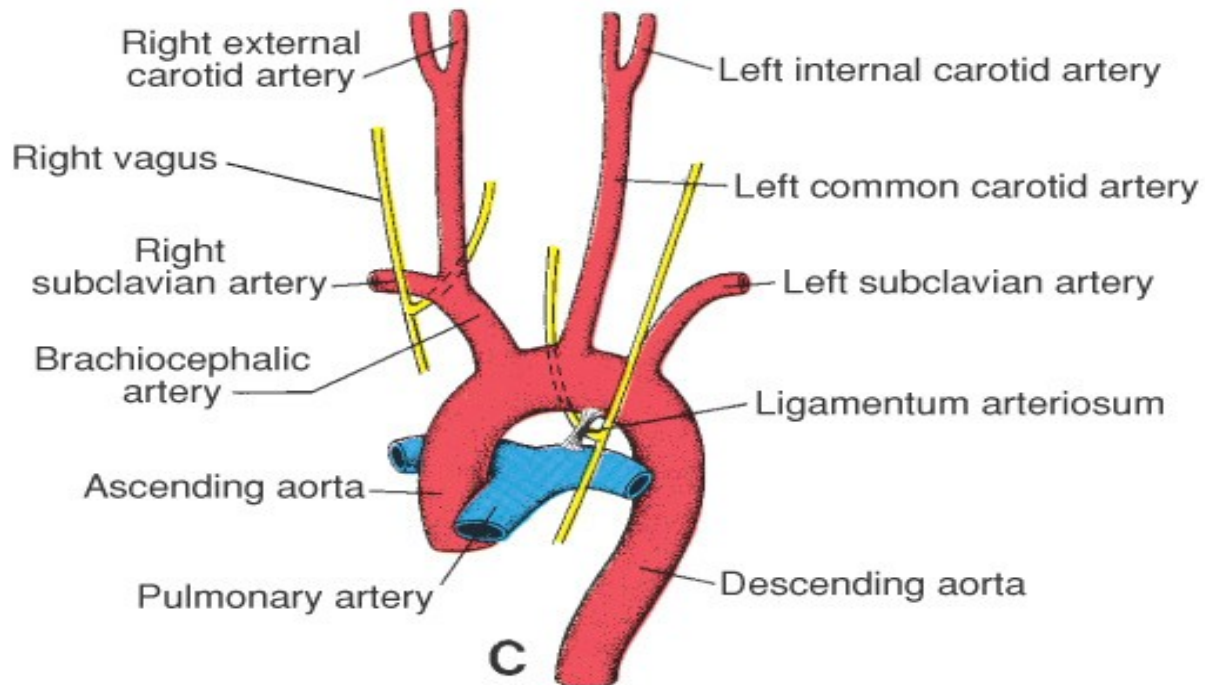
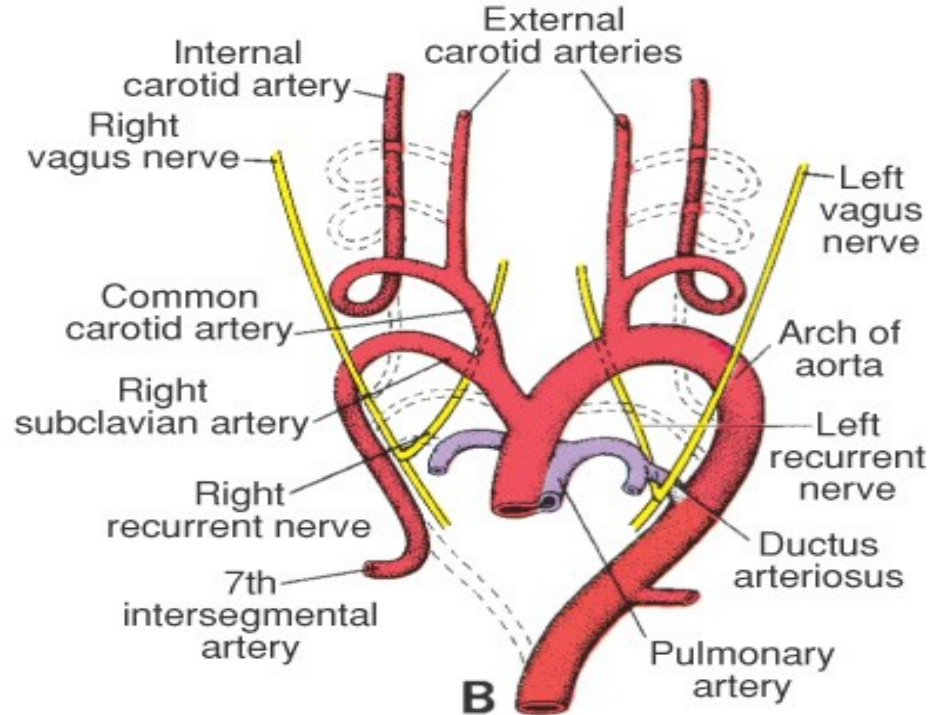
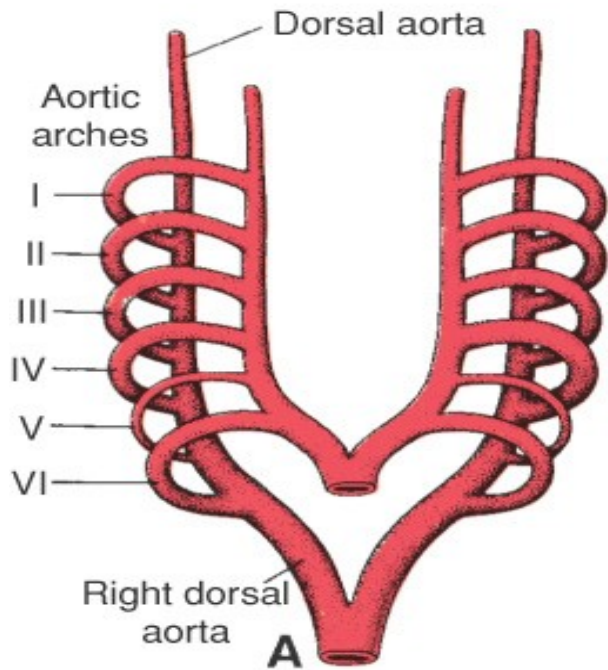


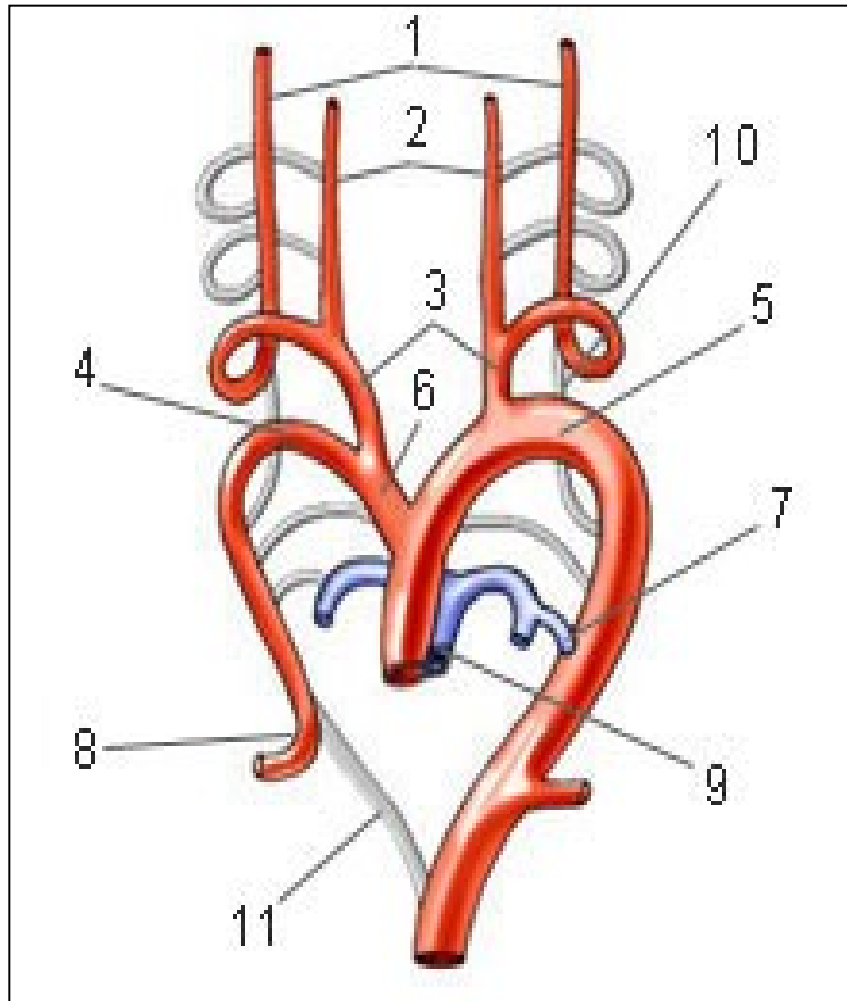
1. Aorta
2. a. pulmonalis sin.
3. Truncus pulmonalis
4. Septum interventriculare (svalová část)
5. pravá komora
6. membranózní část septum interventriculare



1. Septum aorticopulmonale
2. Pulmonální chlopeň
3. A. pulmonalis
4. Aortální chlopeň
5. Aorta

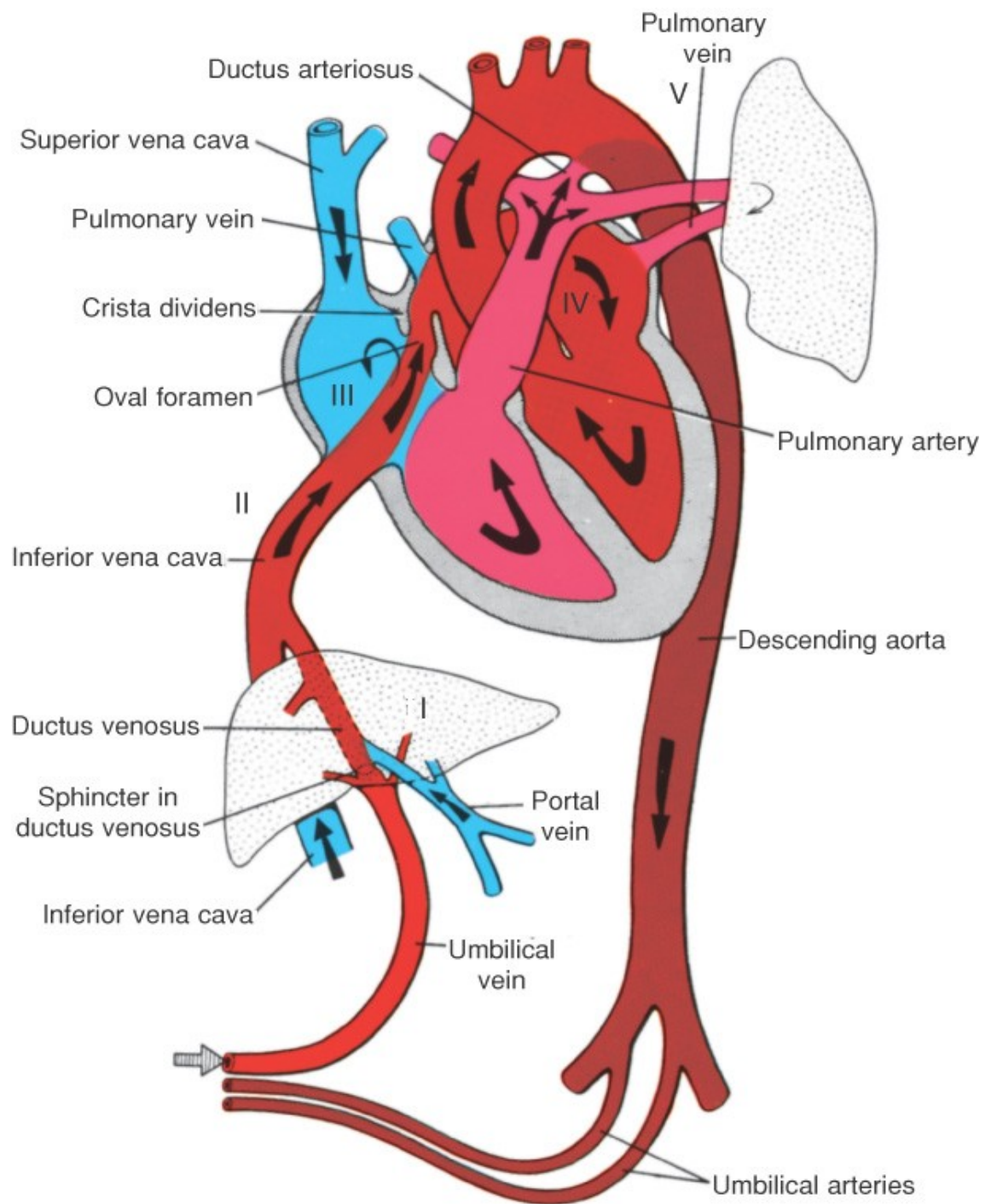




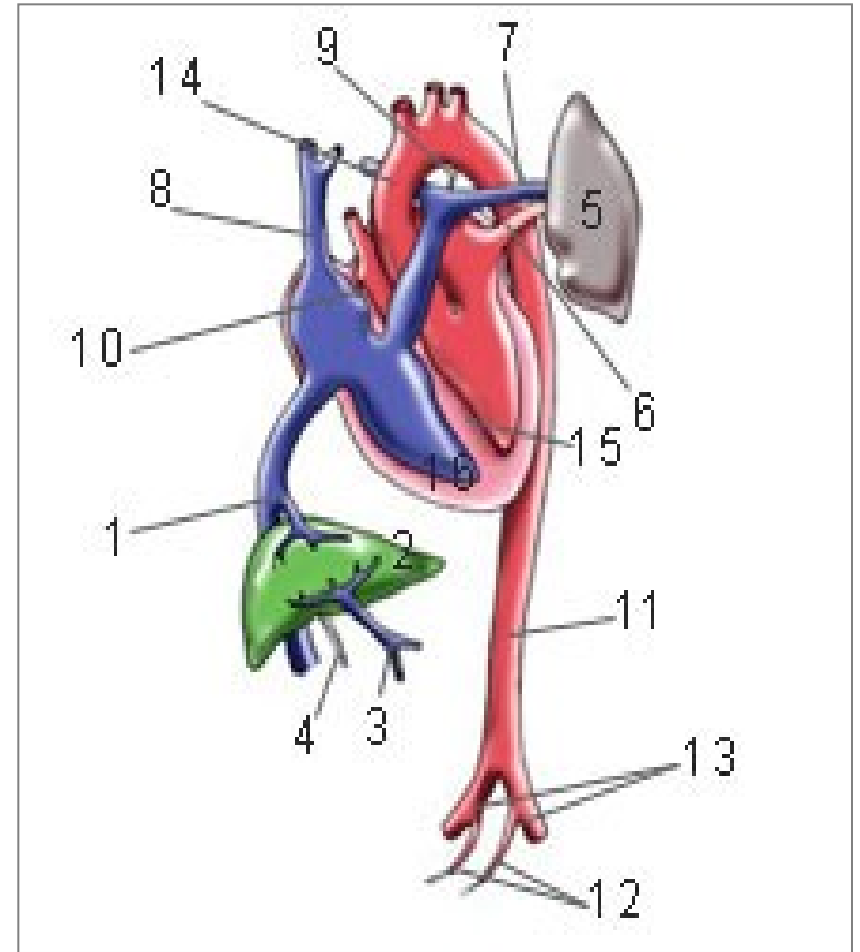
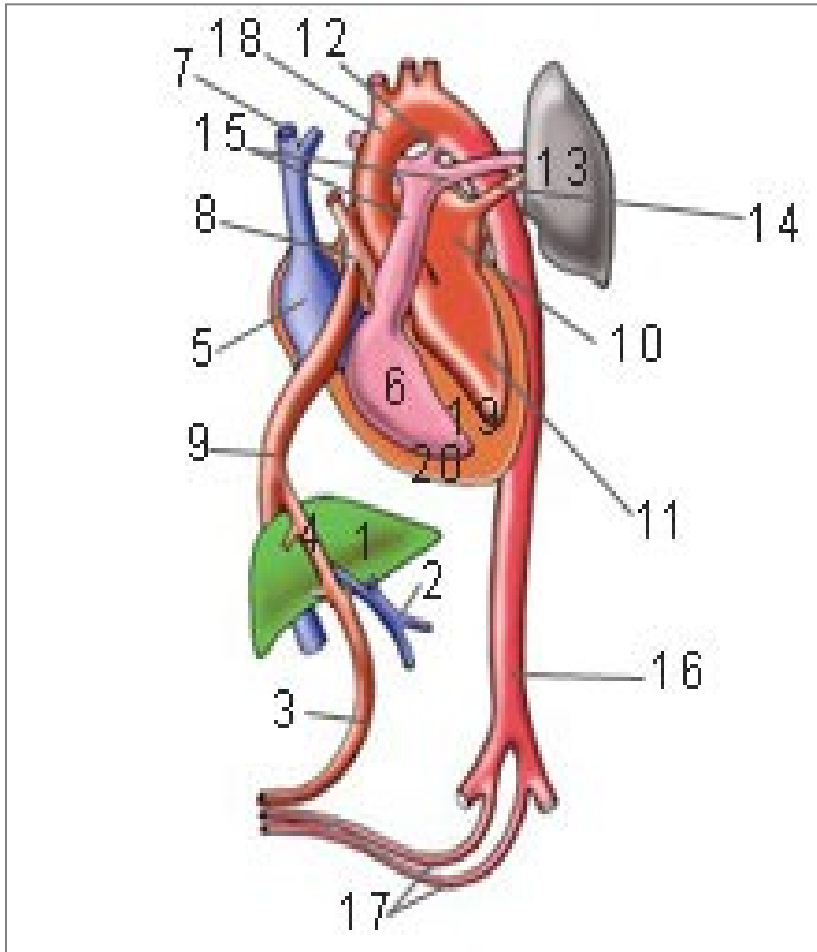


1. Internal carotid artery
2. External carotid artery
3. Common carotid artery
4. Right subclavian artery
5. Arch of aorta
6. Brachiocephalic artery
7. Ductus arteriosus
8. 7th intersegmental artery
9. Pulmonary artery
10. Carotid duct
11. Obliterated right dorsal aorta

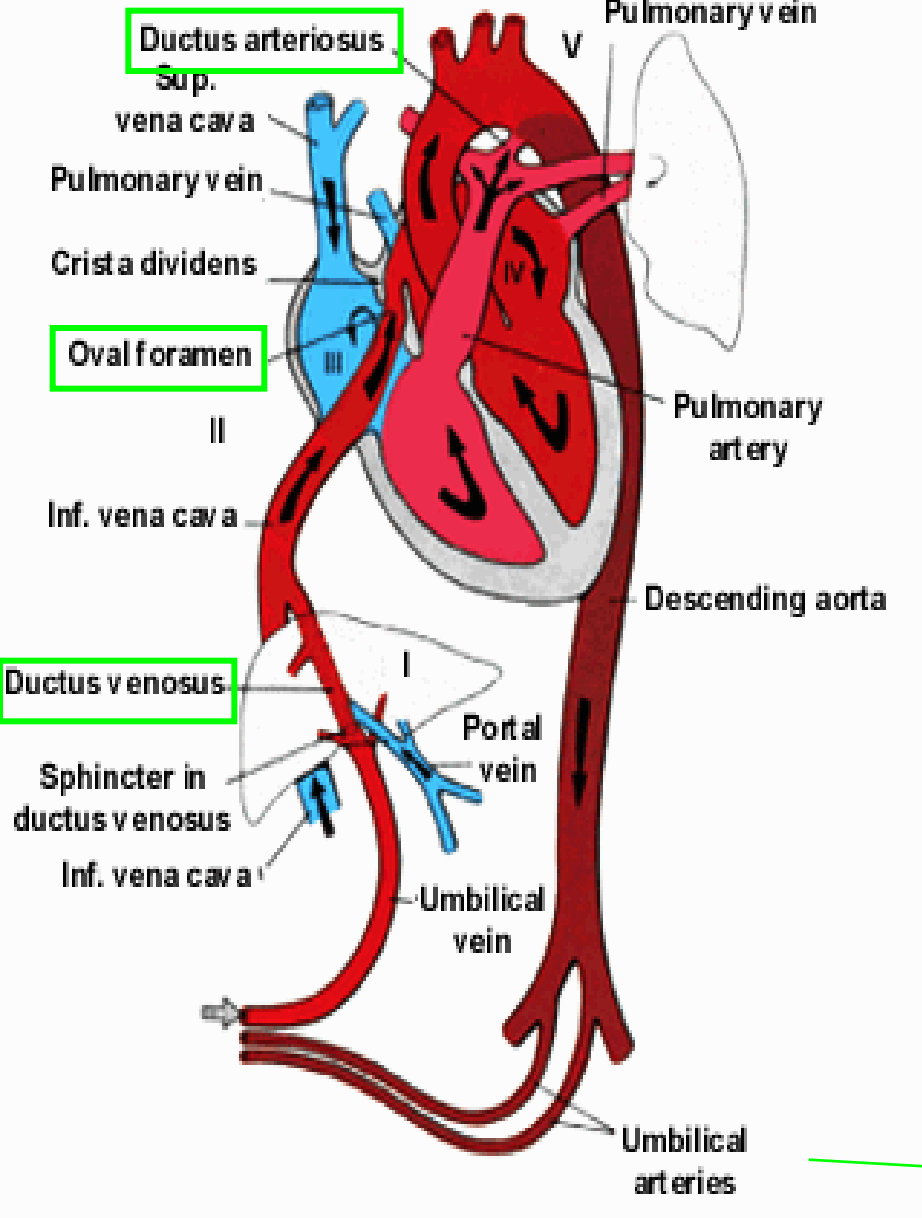
The fetal circulation



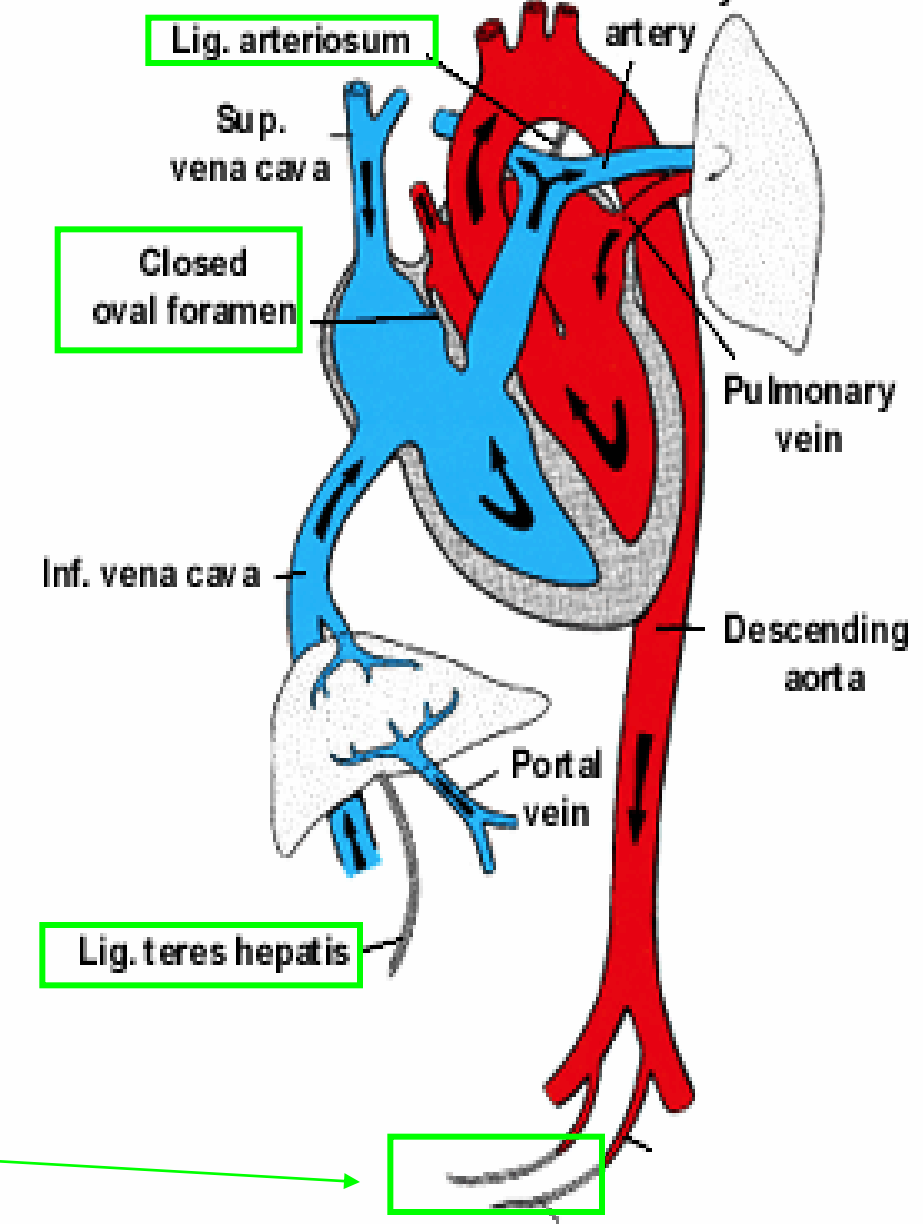
At birth, the circulation of the fetal blood through the placenta is stopped and the lungs begin to function. The foramen ovale, ductus arteriosus, ductus venosus and umbilical vessels subsequently obliterate and transform into corresponding ligaments.



Pre-Birth



Post-Birth



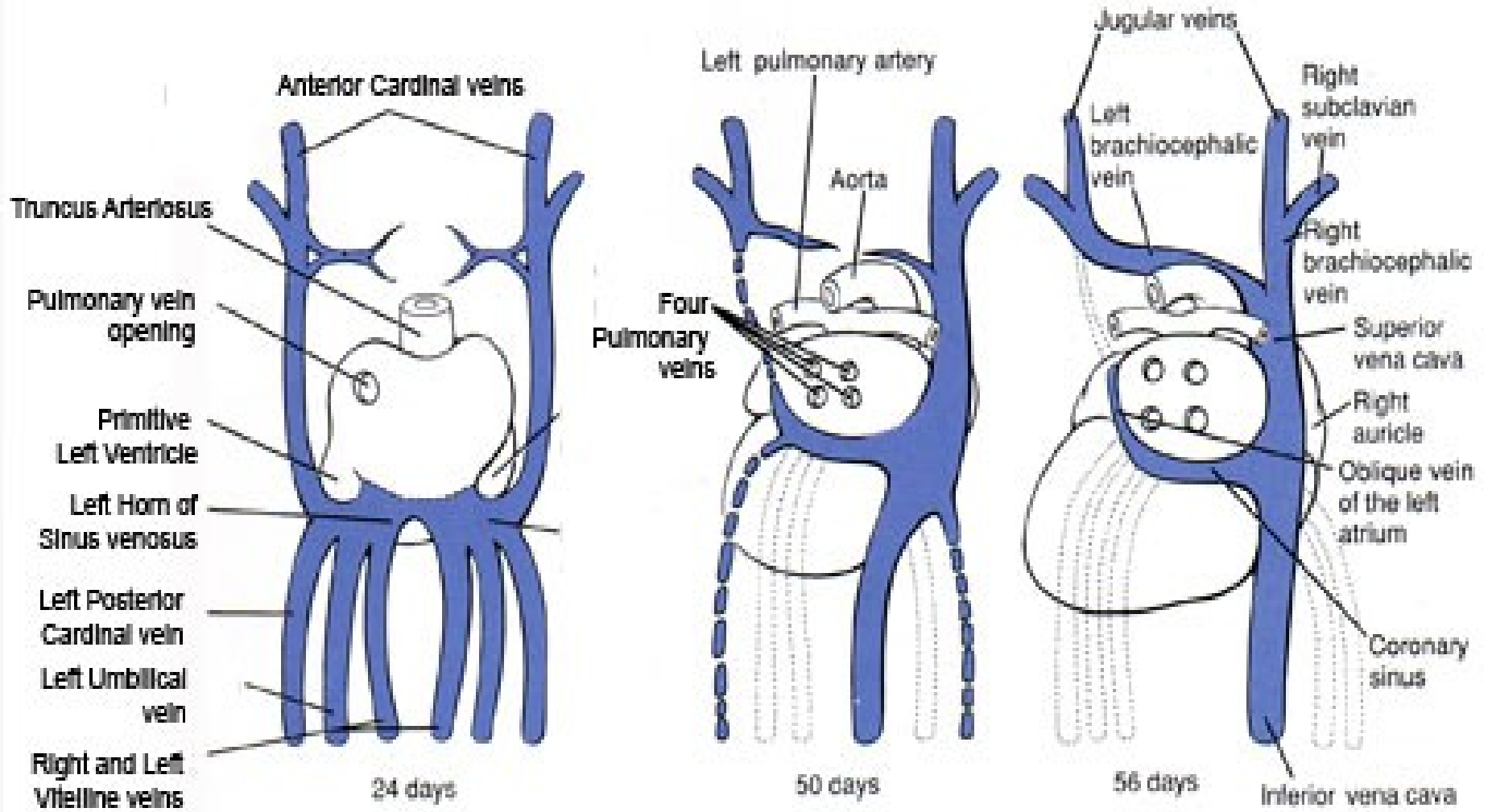
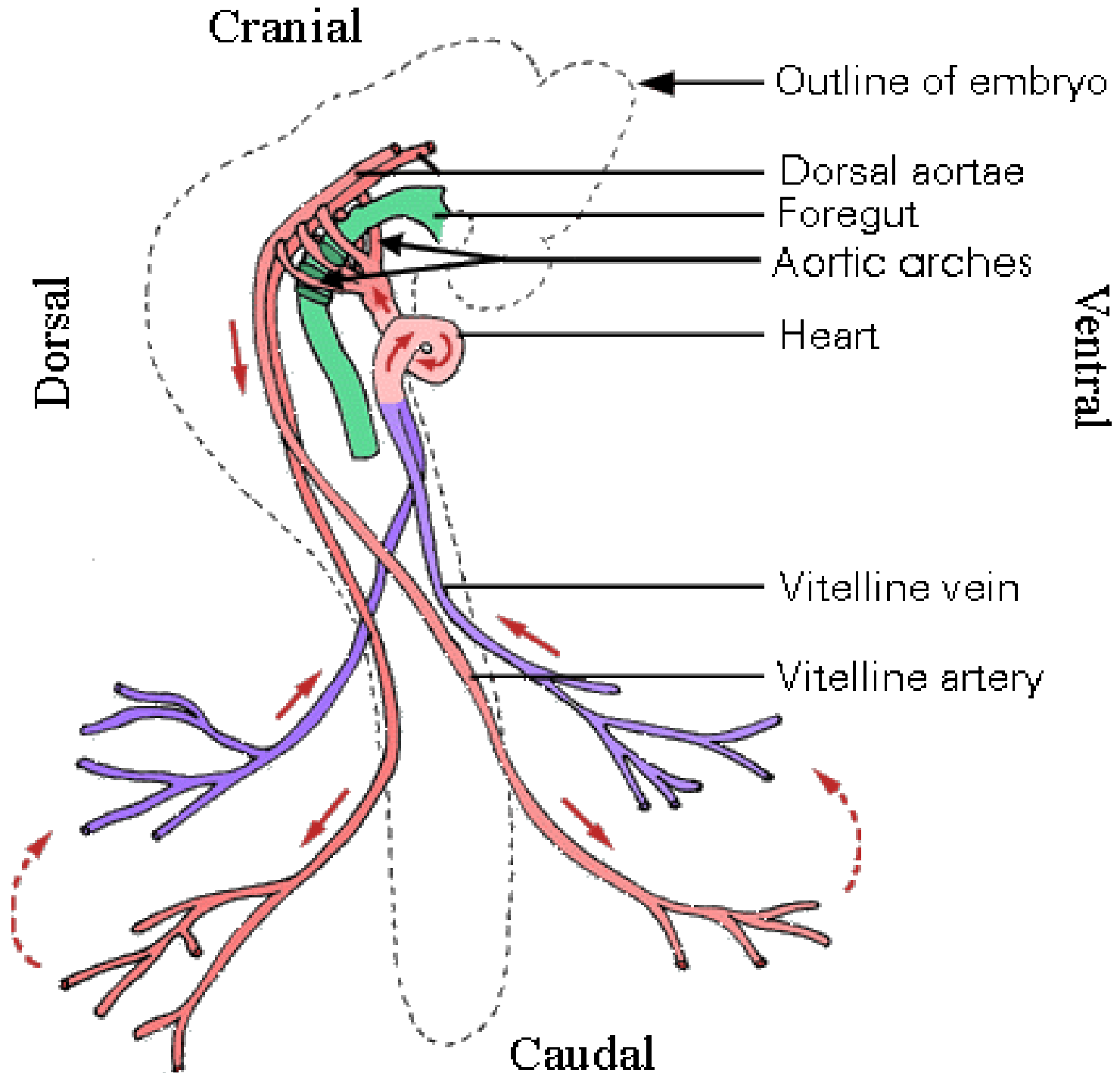
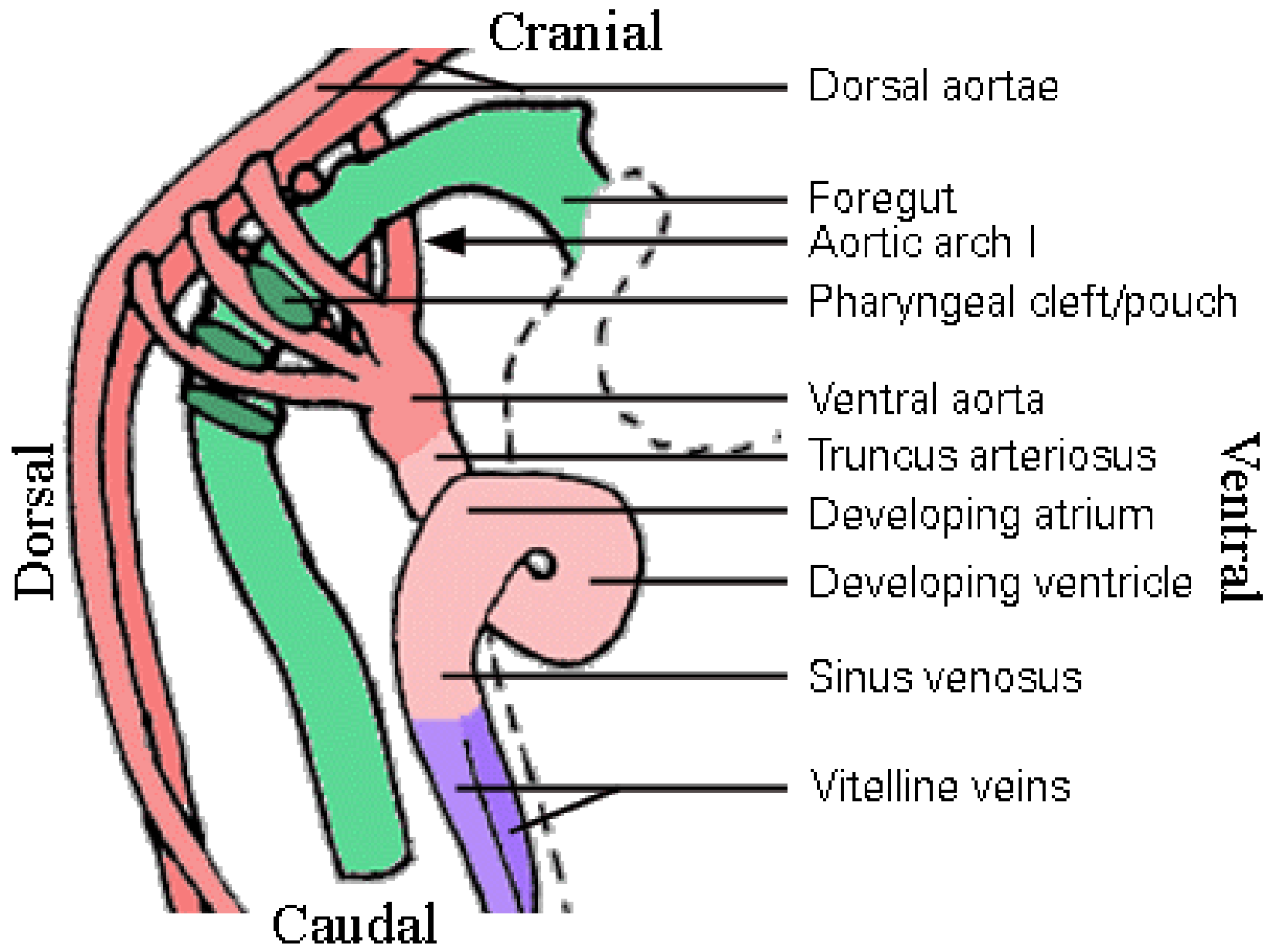
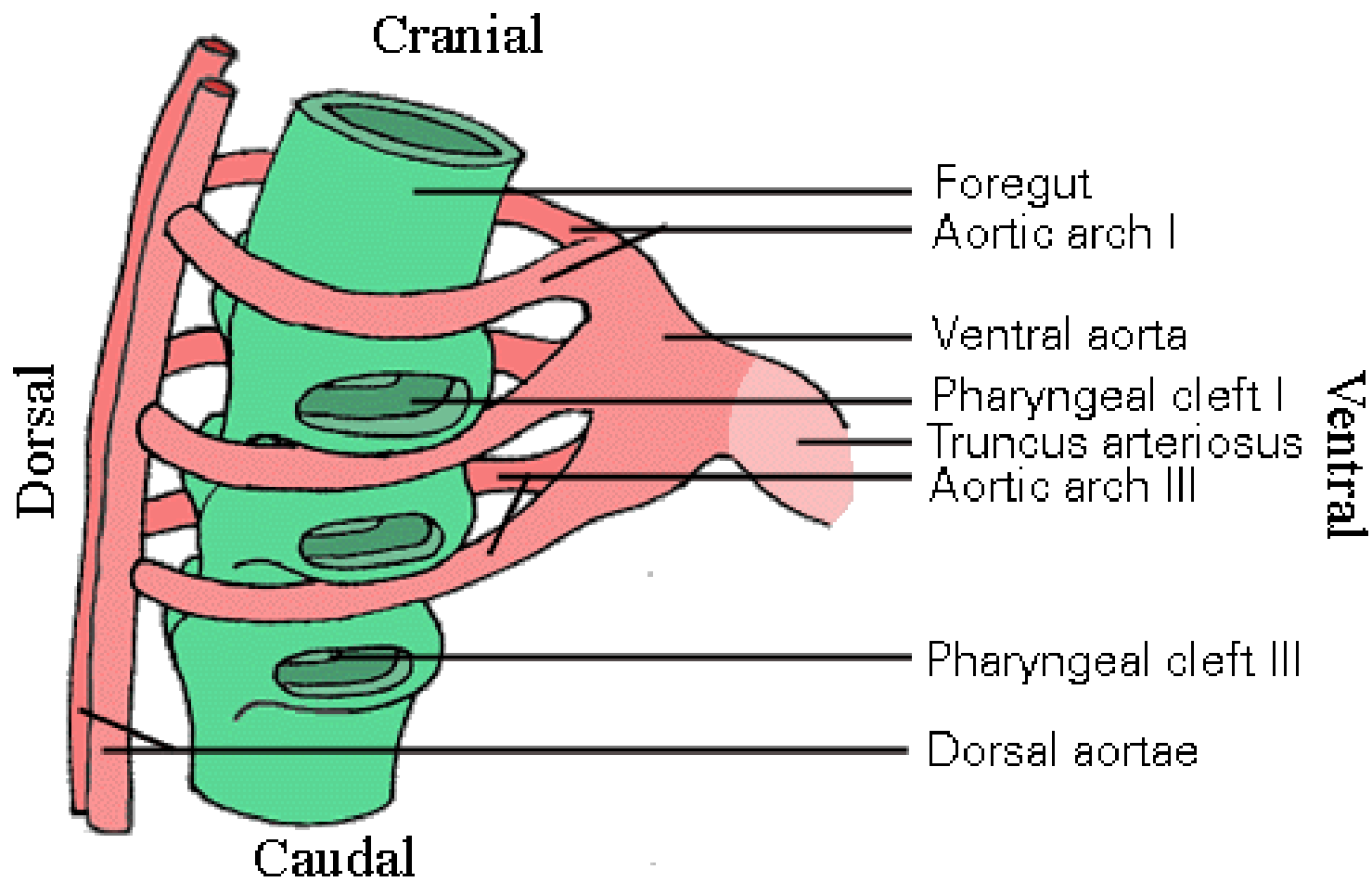


Image from Human Embryology by Larsen 2nd edition. pg. 161

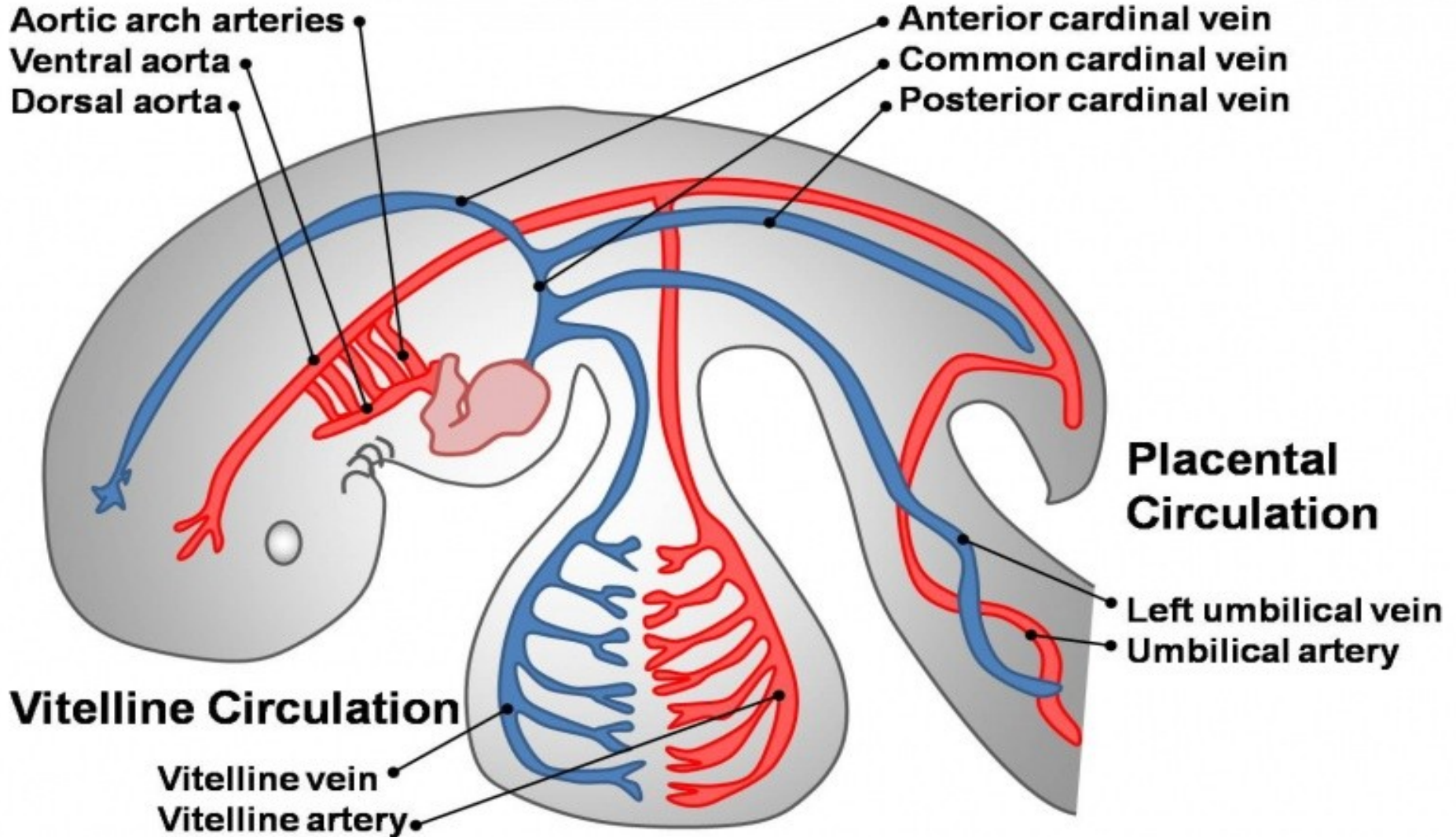






Primitive blood circulation

Embryonic Circulation



Congenital malformations in CVS

(the most frequent)

- **With left – right shunt (without cyanosis)**

atrial septum defect

ventricular septum defect

ductus arteriosus apertus (= patens, = persistens)

- **With right – left shunt (with cyanosis)**

Fallot tetralogy

transposition of great vessels

truncus arteriosus (common aortopulmonary canal)

tricuspid valve atresia

- **Without shunt**

coarctation of aorta

aortic stenosis

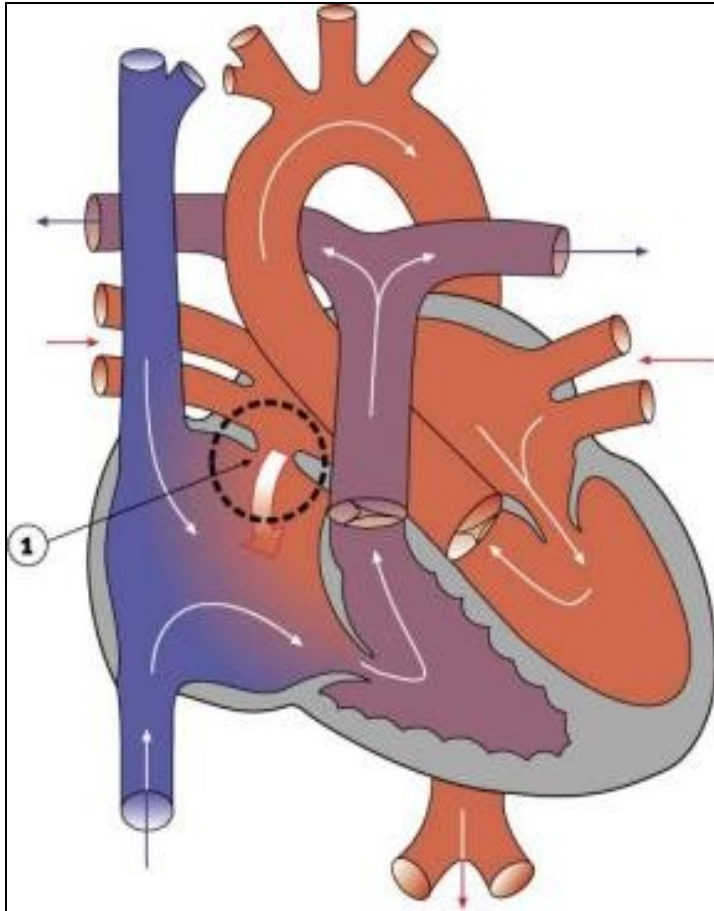
pulmonary stenosis

dextrocardia (+situs inversus)

ectopia cordis

Atrial Septal Defects

a group of common congenital anomalies defects occurring in a number of different forms and more often in females.

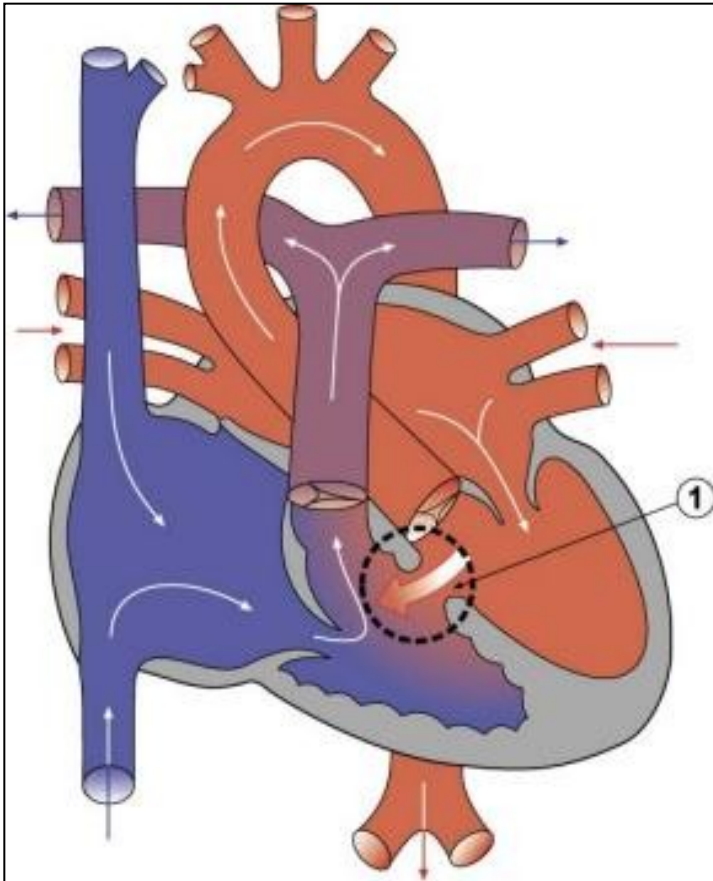


patent foramen ovale

left-right shunting

Ventricular Septal Defect

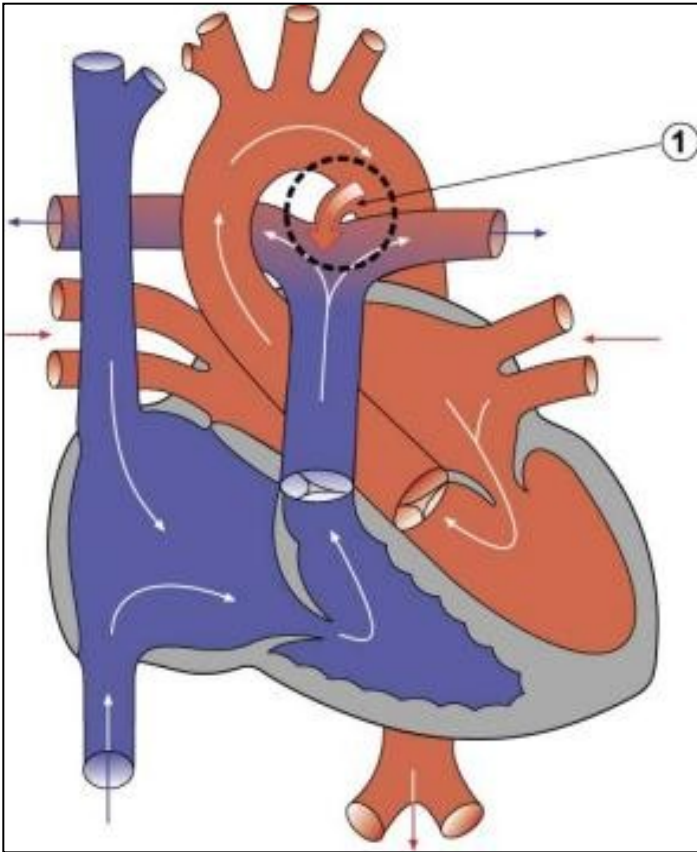
The Ventricular Septal Defect occurs in the interventricular septum, and is more frequent in males than females.



left-right shunting

Patent Ductus Arteriosus

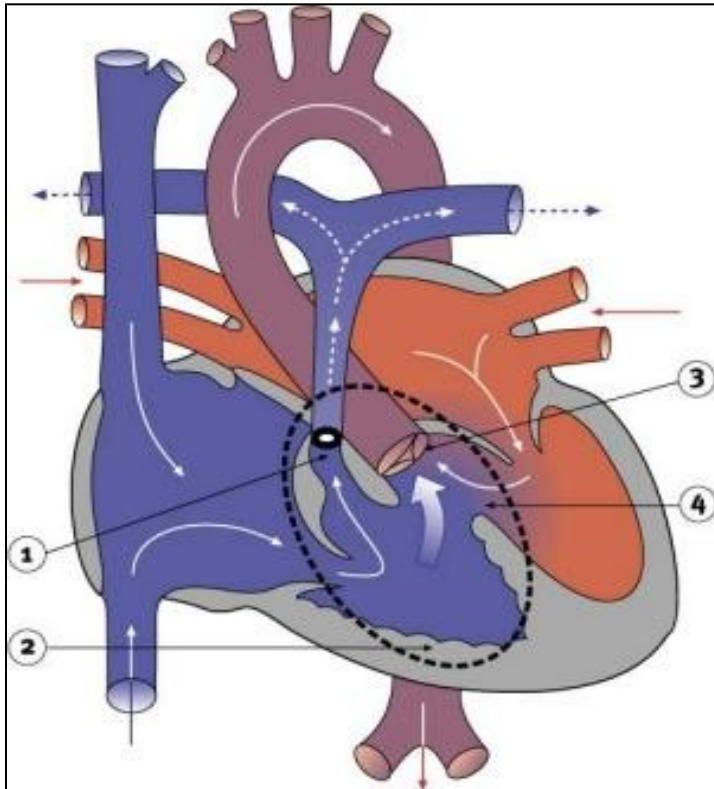
occurs commonly in preterm infants, can close spontaneously (by day three in 60% of normal term neonates) the remainder are ligated simply and with little risk.



left-right shunting

Tetralogy of Fallot

Named after Etienne-Louis Arthur Fallot (1888) who described it as "*la maladie blue*" and is a common developmental cardiac defect. The syndrome consists of a number of cardiac defects *possibly stemming from abnormal neural crest migration*.



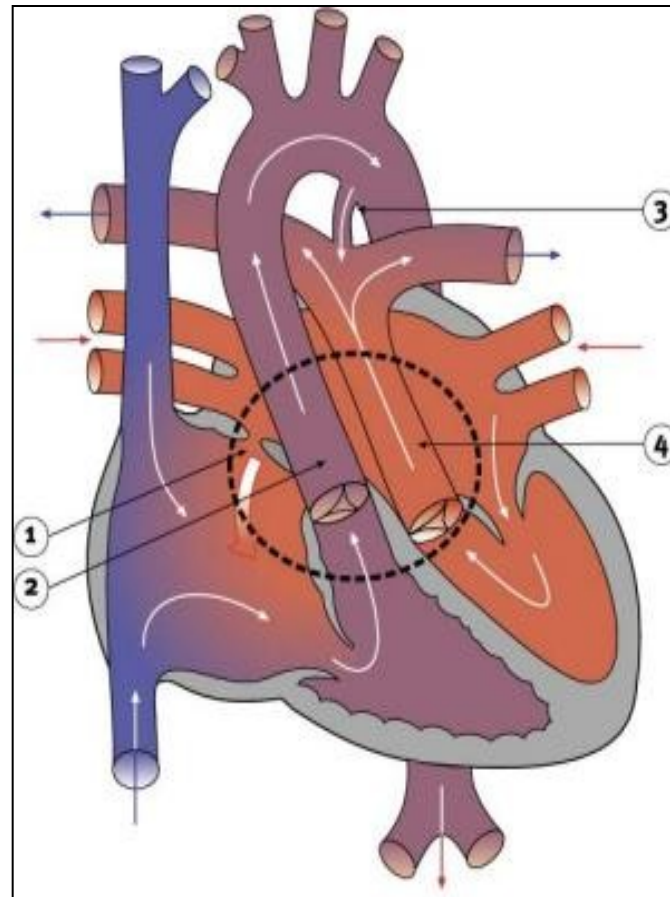
consists of:

1. ventricular septal defect
2. pulmonary stenosis (valvular or infundibular)
3. results in an overriding aorta
4. right ventricular hypertrophy

right-left shunting

Transposition of Great Vessels

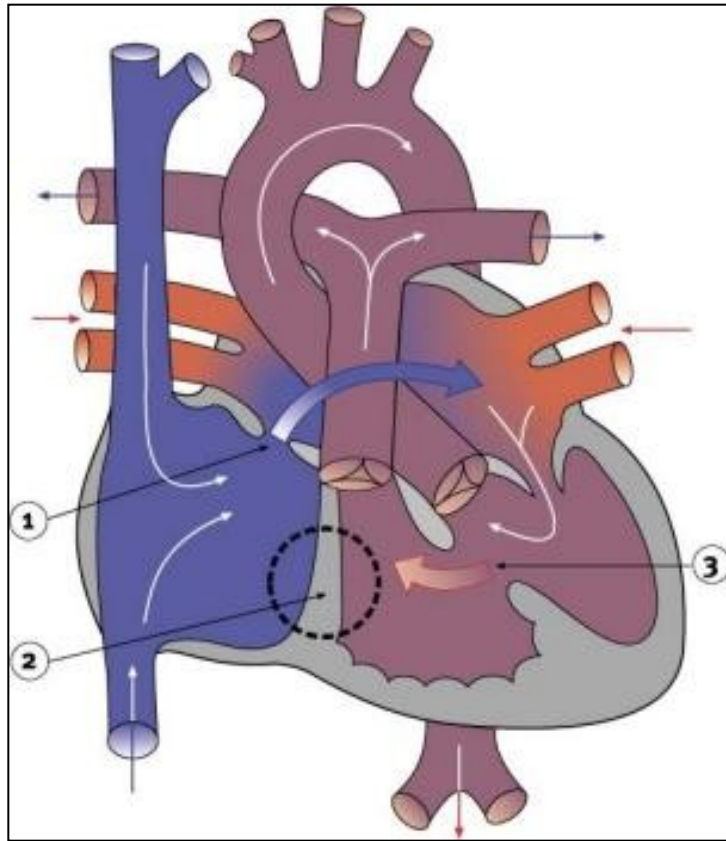
Characterized by aorta arising from right ventricle and pulmonary artery from the left ventricle and often associated with other cardiac abnormalities (e.g. ventricular septal defect).



right-left shunting

Tricuspid Atresia

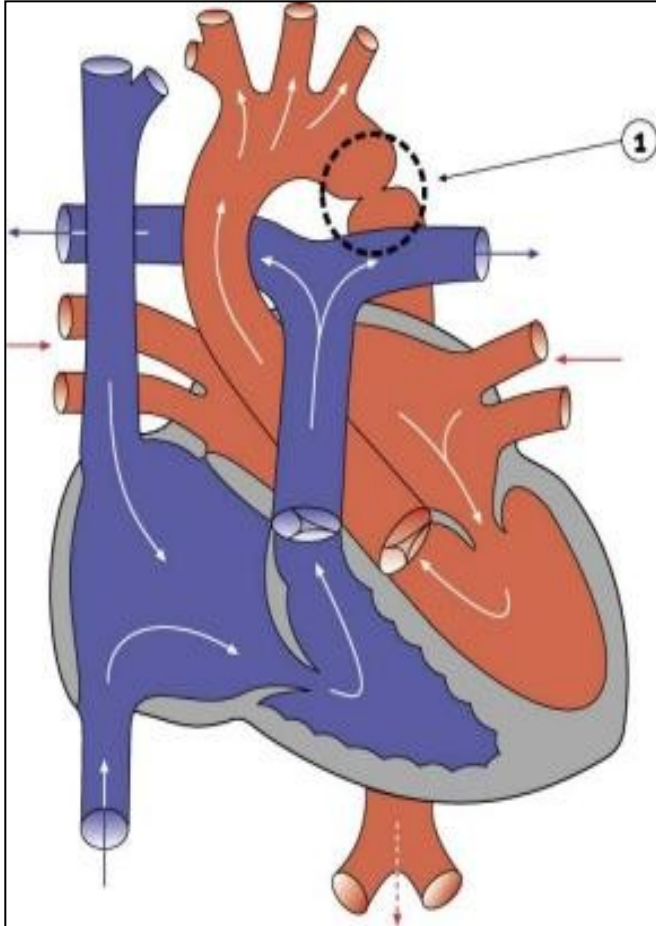
Blood is shunted through an atrial septal defect to the left atrium and through the ventricular septal defect to the pulmonary artery. The shaded arrows indicate mixing of the blood.



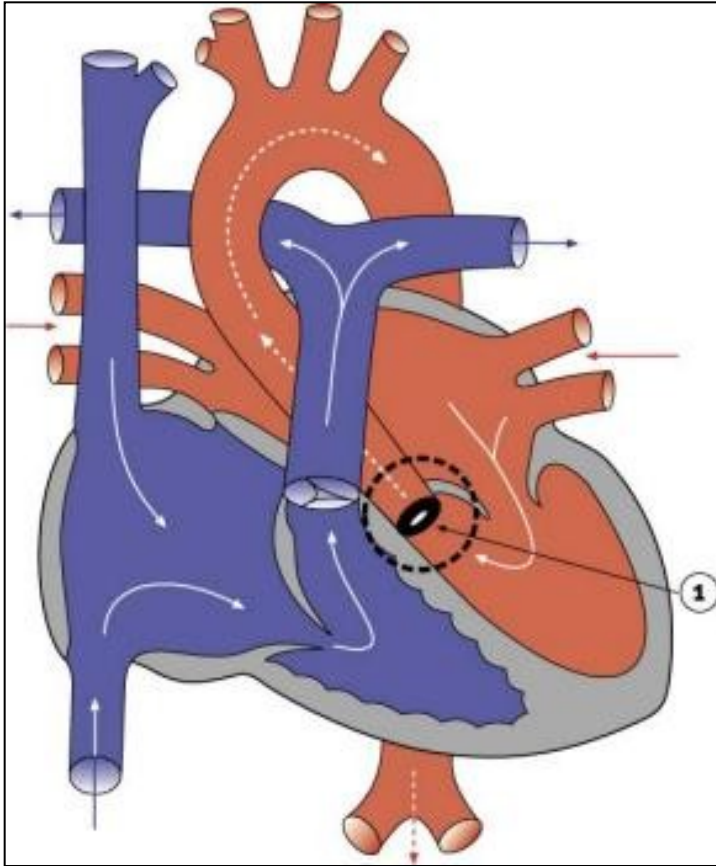
right-left shunting

Coarctation of Aorta (preductal or postductal)

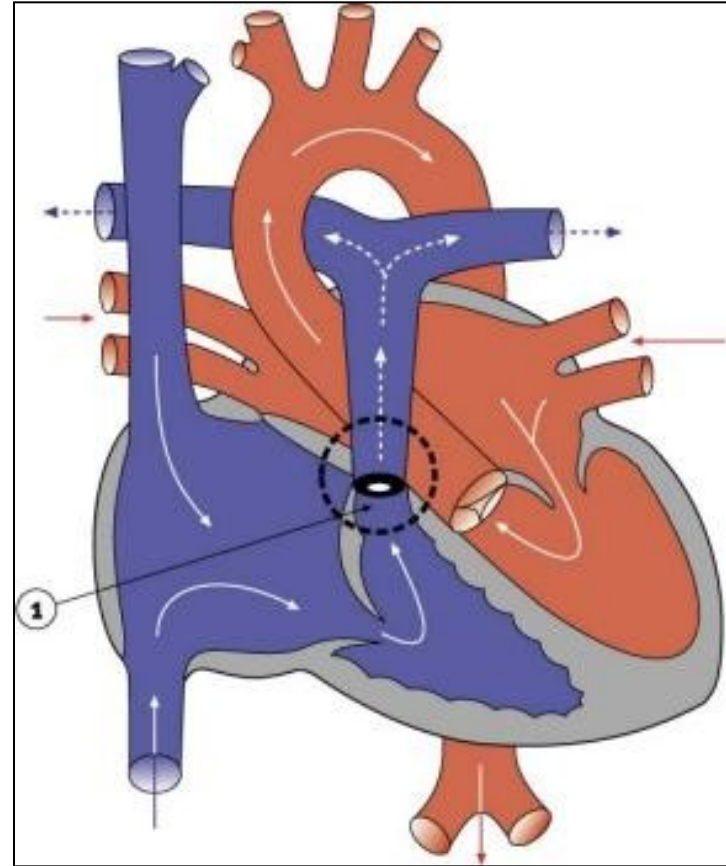
before or behind ductus arteriosus



Aortic Stenosis

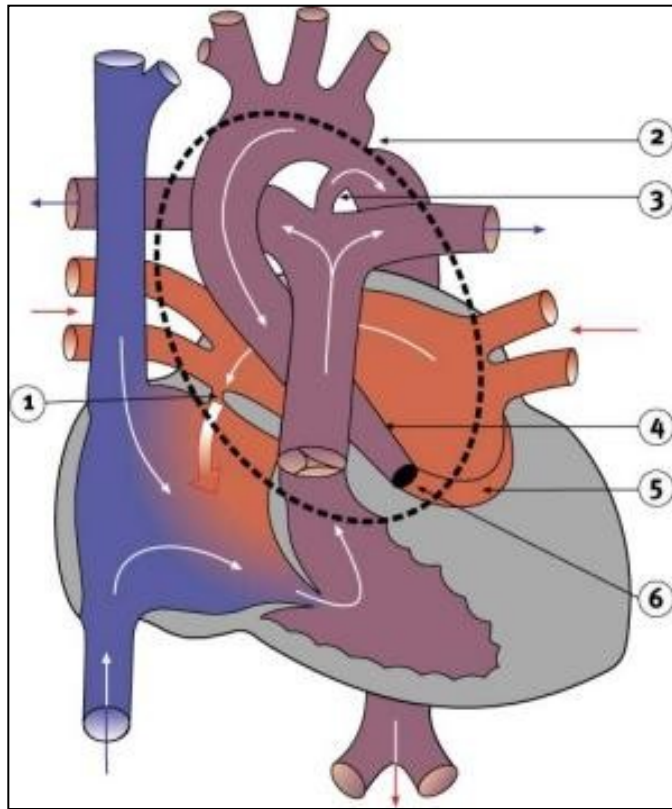


Pulmonary Stenosis

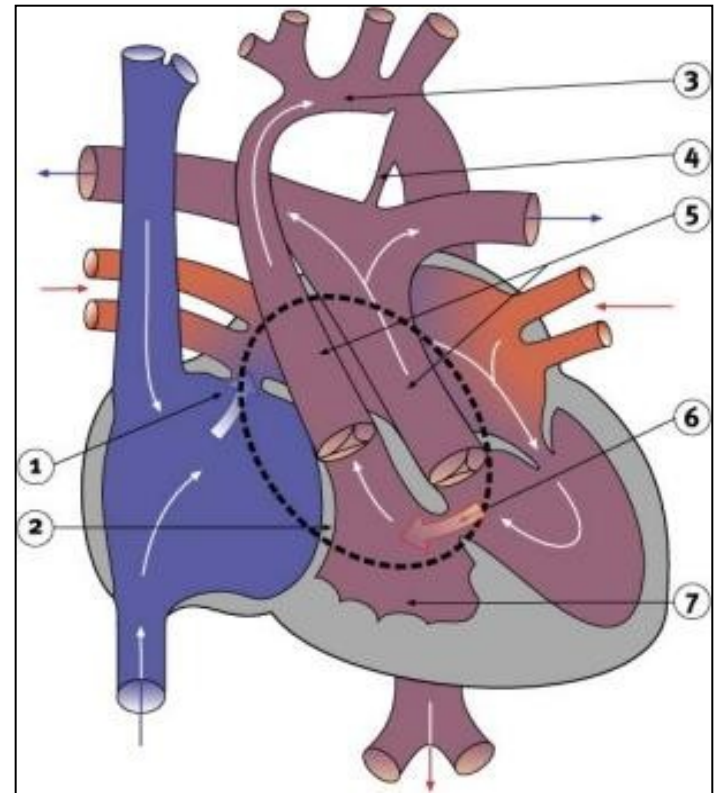


Hypoplastic Left Heart

Characterized by hypoplasia (underdevelopment or absence) of the left ventricle obstructive valvular and vascular lesion of the left side of the heart.



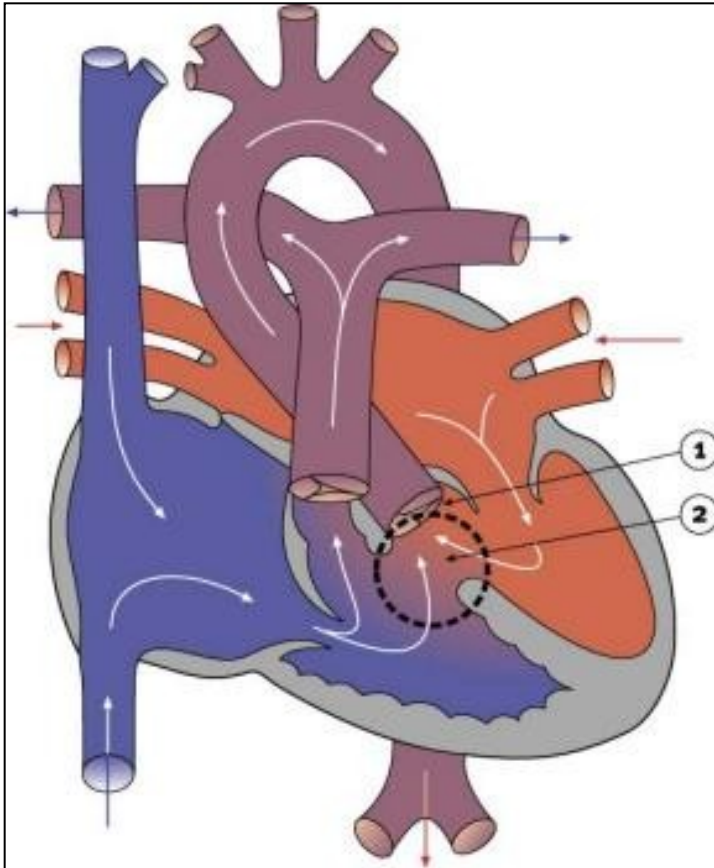
hypoplastic left hear



functional hypoplastic left heart

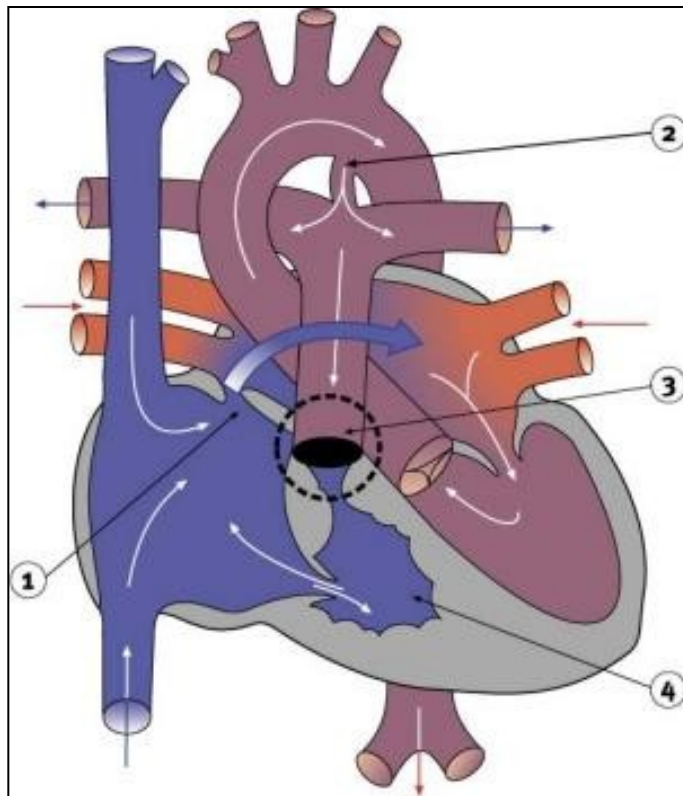
Double Outlet Right Ventricle

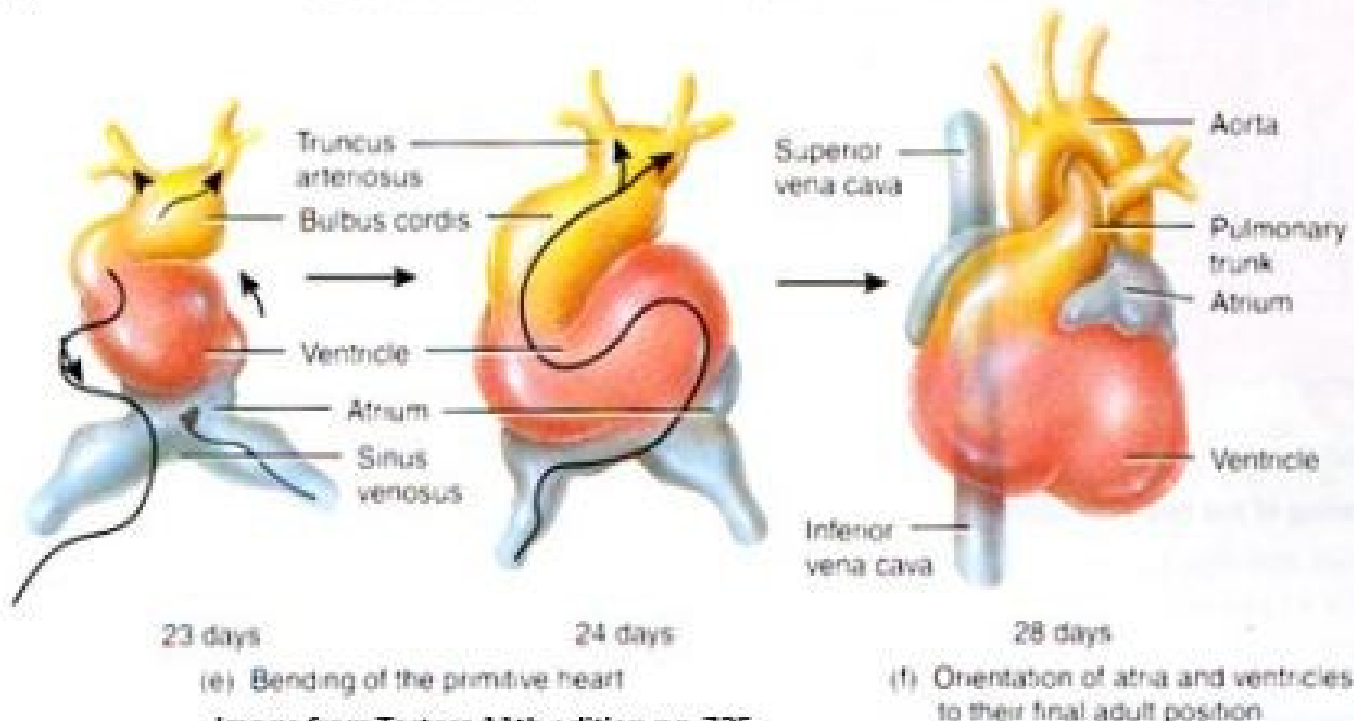
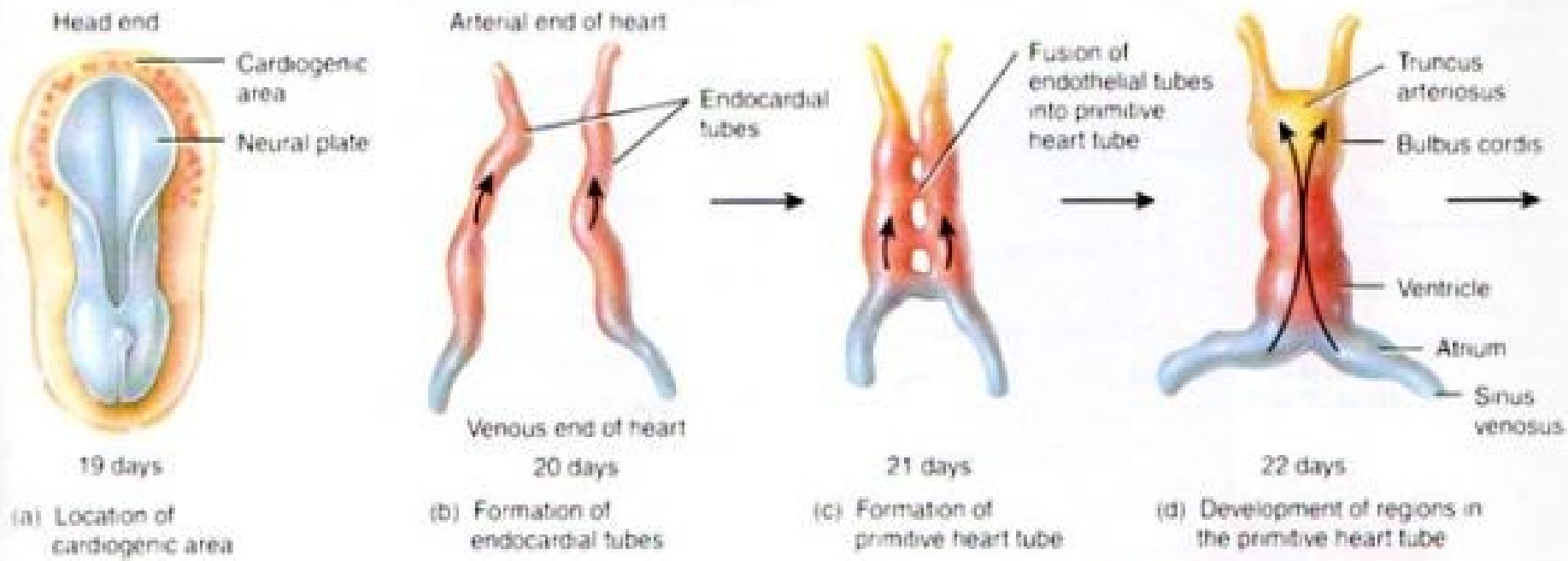
De-oxygenated blood enters the aorta from the right ventricle and is returned to the body.



Pulmonary Atresia

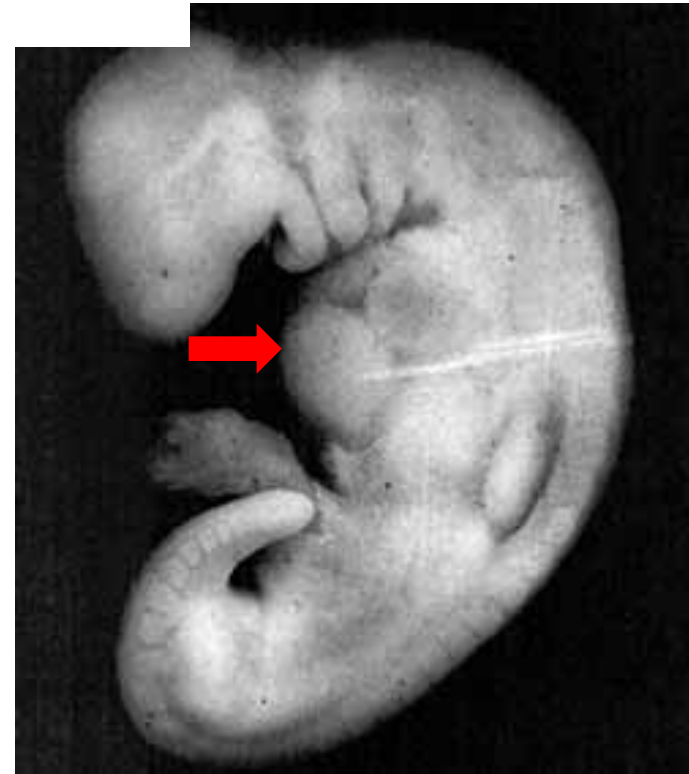
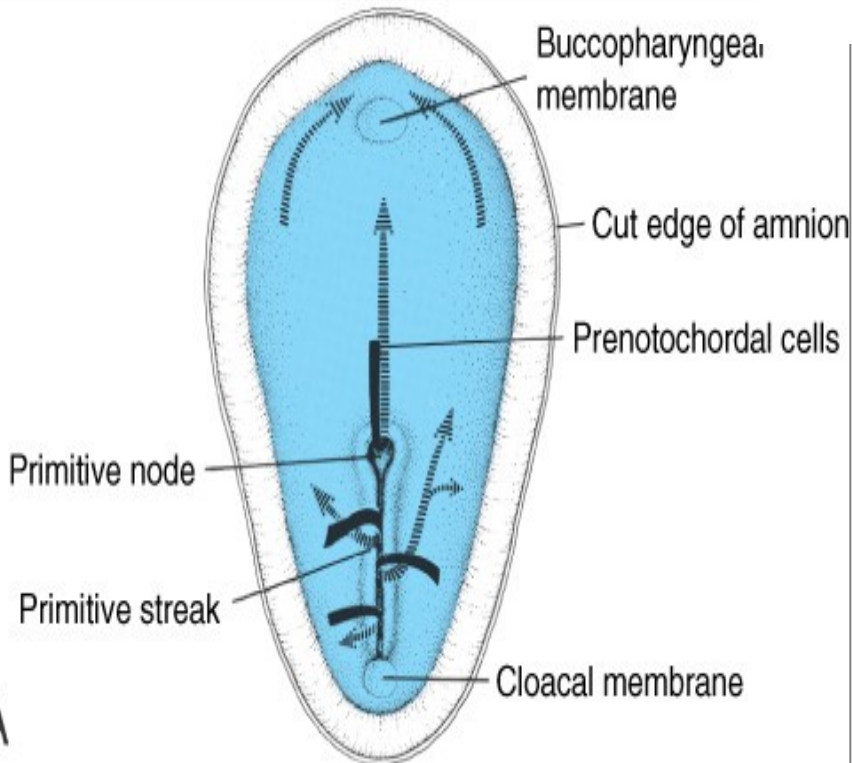
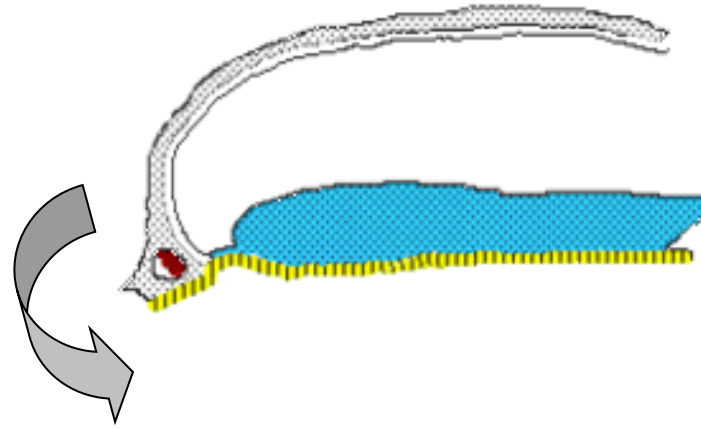
Abnormal blood flow (as indicated by the shaded blue arrow) is from the right atrium and right ventricle through an atrial septal defect to the left side of the heart. Blood can reach the pulmonary arteries only through a patent ductus arteriosus.





At the beginning, cardiogenic plate . After flexion of germ situated ventrocaudally.

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