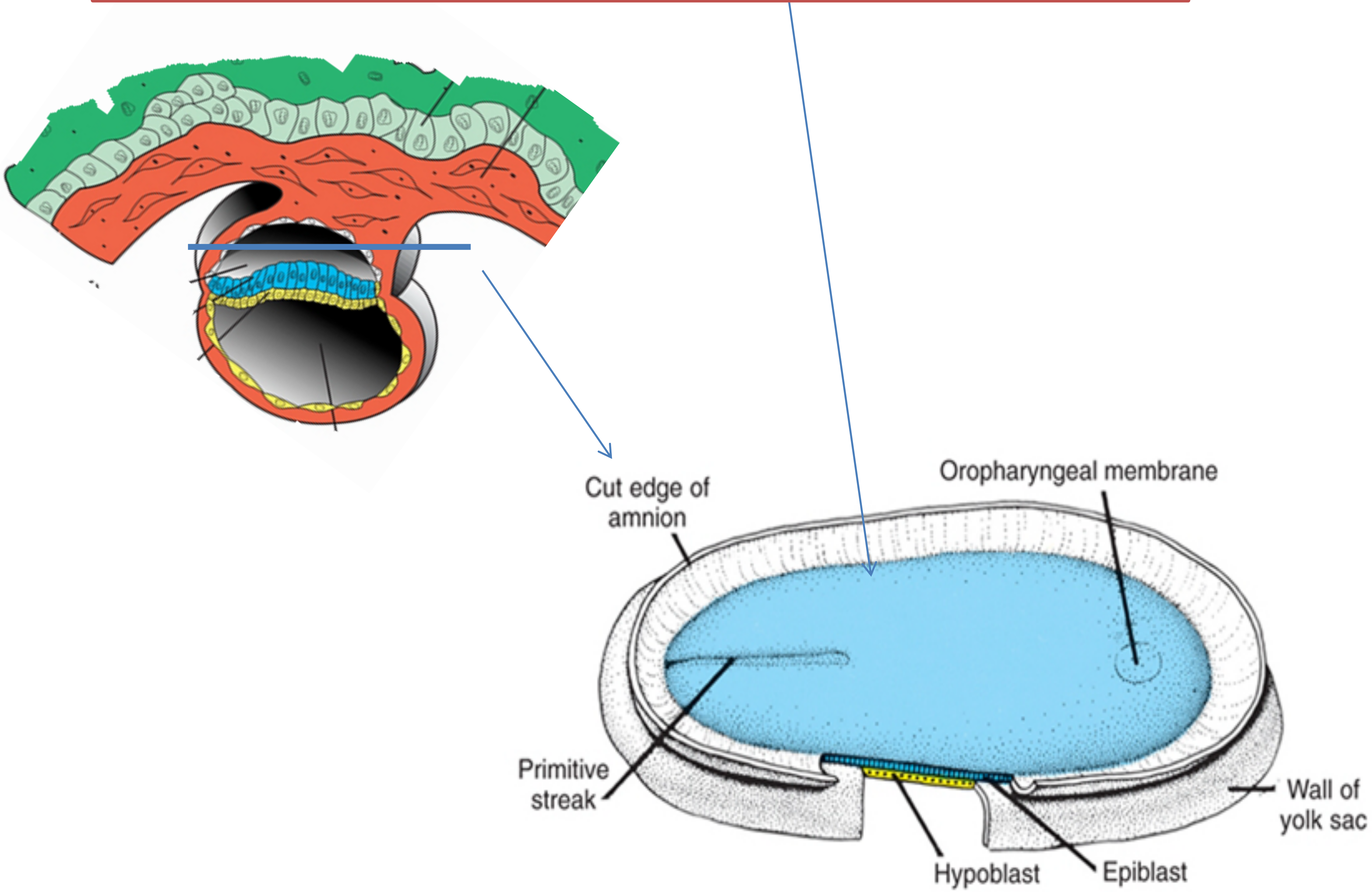
CVS Embryology-1

Dr. Amjad Shatatrat

When you see this diagram, remember that you are looking at the embryo **from above, through the amniotic cavity, where the epiblast appears as an oval disc**



DEVELOPMENT OF CARDIOVASCULAR SYSTEM

Why the embryo needs the vascular system?

because the embryo is no longer able to satisfy its nutritional requirements by diffusion alone.

When it appears?

The vascular system appears in the **<u>middle of the third week</u>**,
As the first major system to function in the embryo

Where it appears?

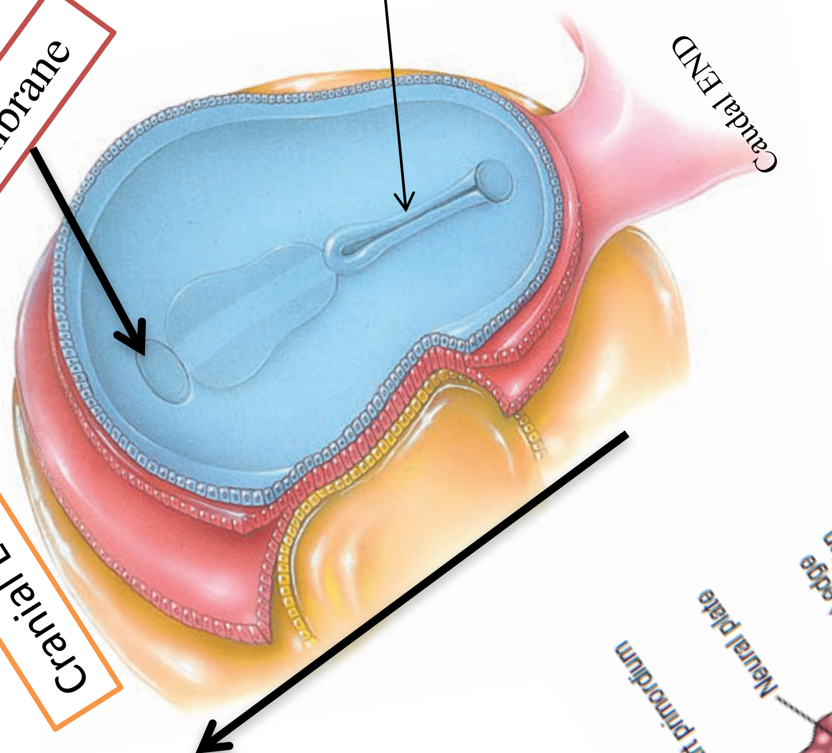
CARDIAC PROGENITOR CELLS LIE *<u>IN THE EPIBLAST</u>*

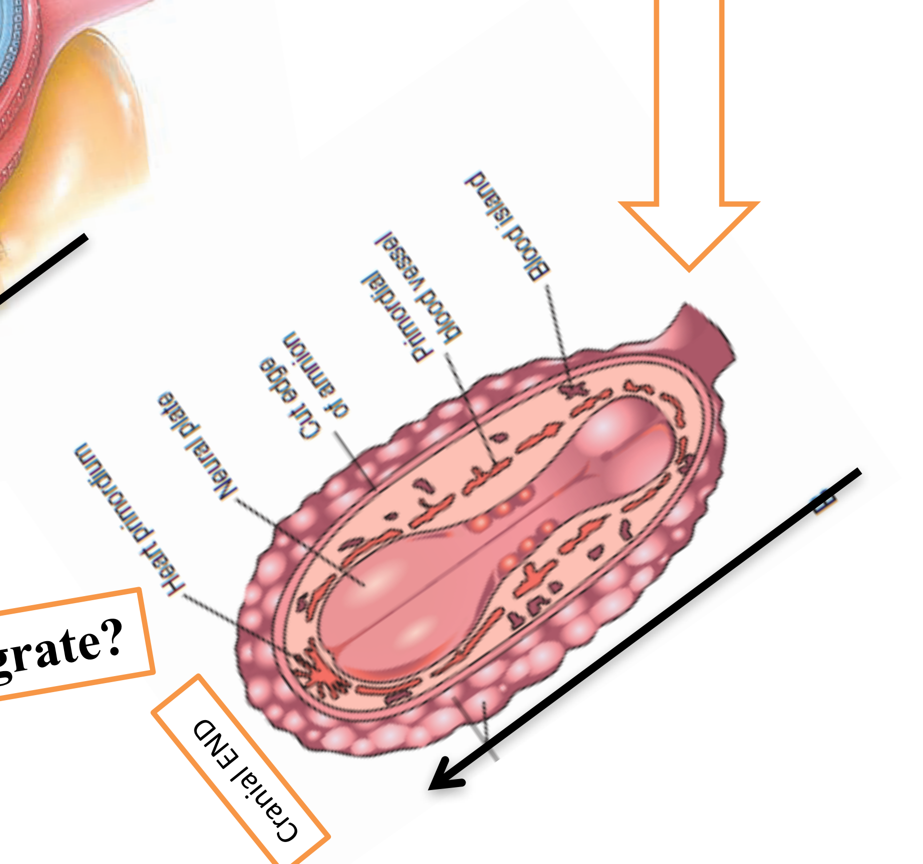
with later contributions from neural crest mesenchyme

The Cardiac progenitor cells migrate from the Epiblast

Through

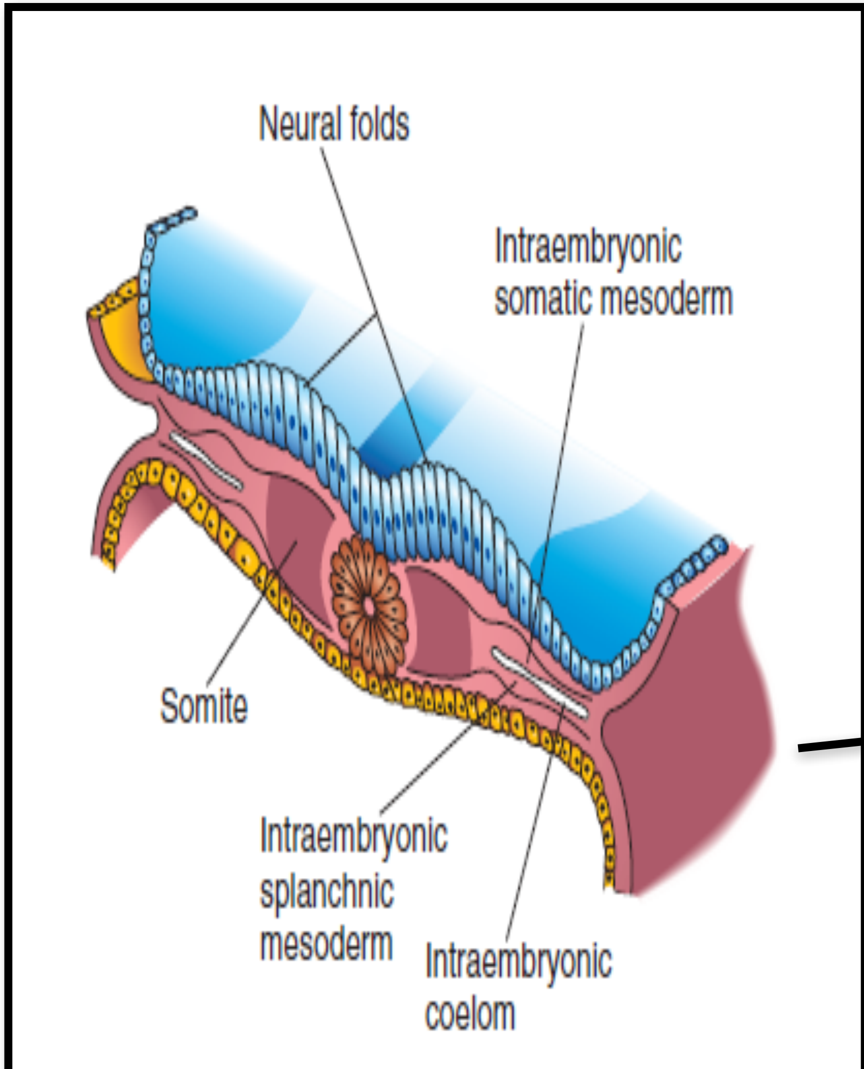
Primitive streak → In a → **Cranial direction on each side of the notochordal process and around the prechordal plate**

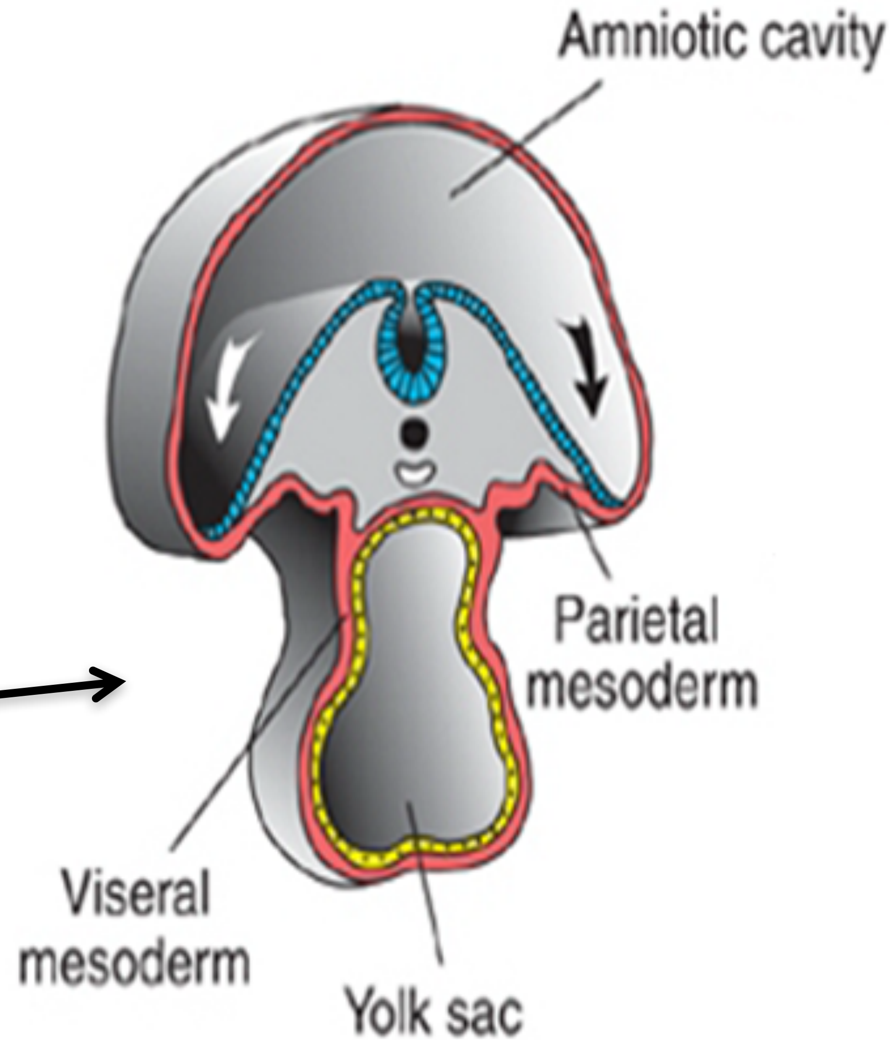




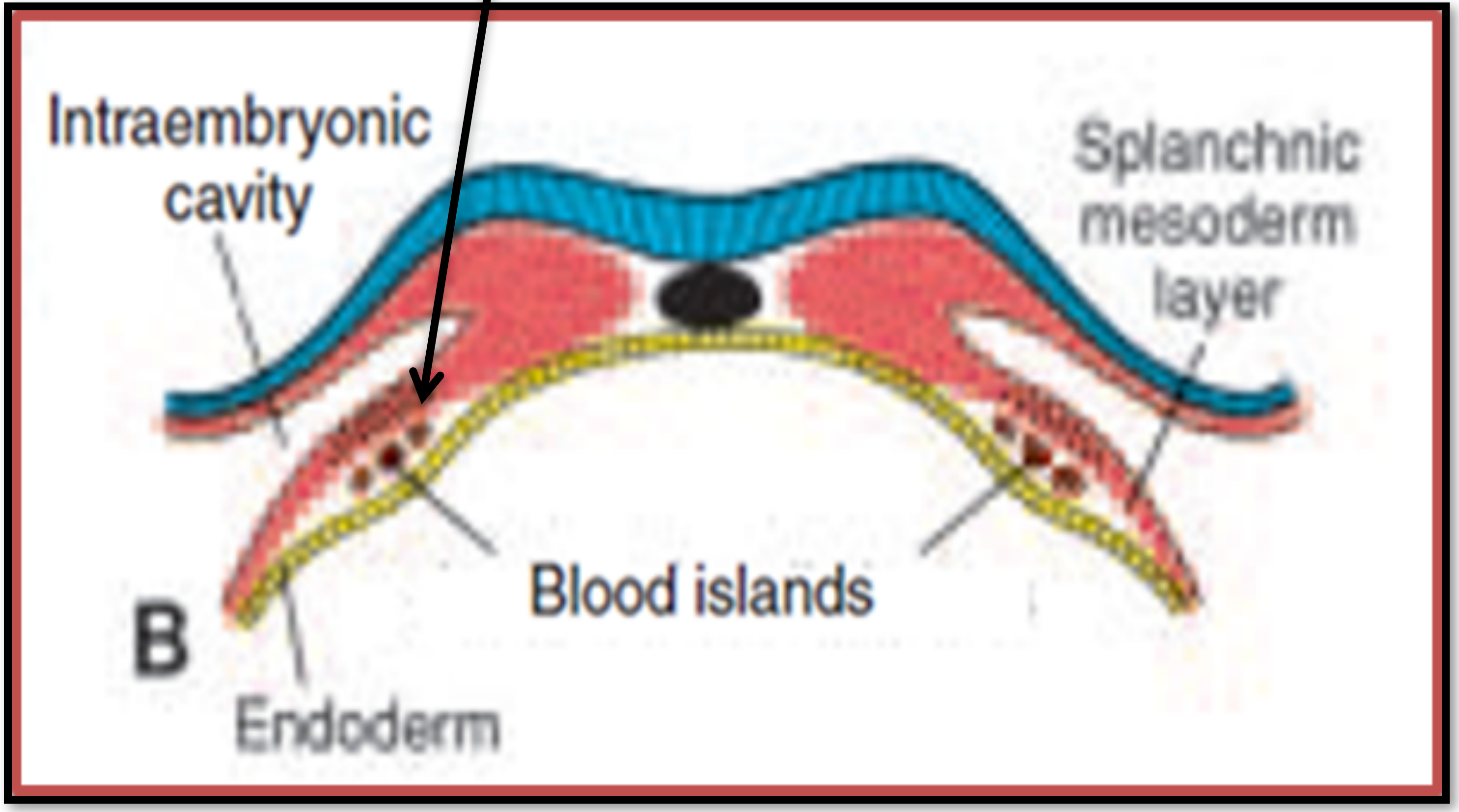
Where do the Cardiac progenitor cells migrate?

into the **splanchnic layer** of the lateral plate mesoderm





into the **splanchnic layer** of the lateral plate mesoderm



The cells from both sides meet cranially to form the

Primary Heart Field (PHF)

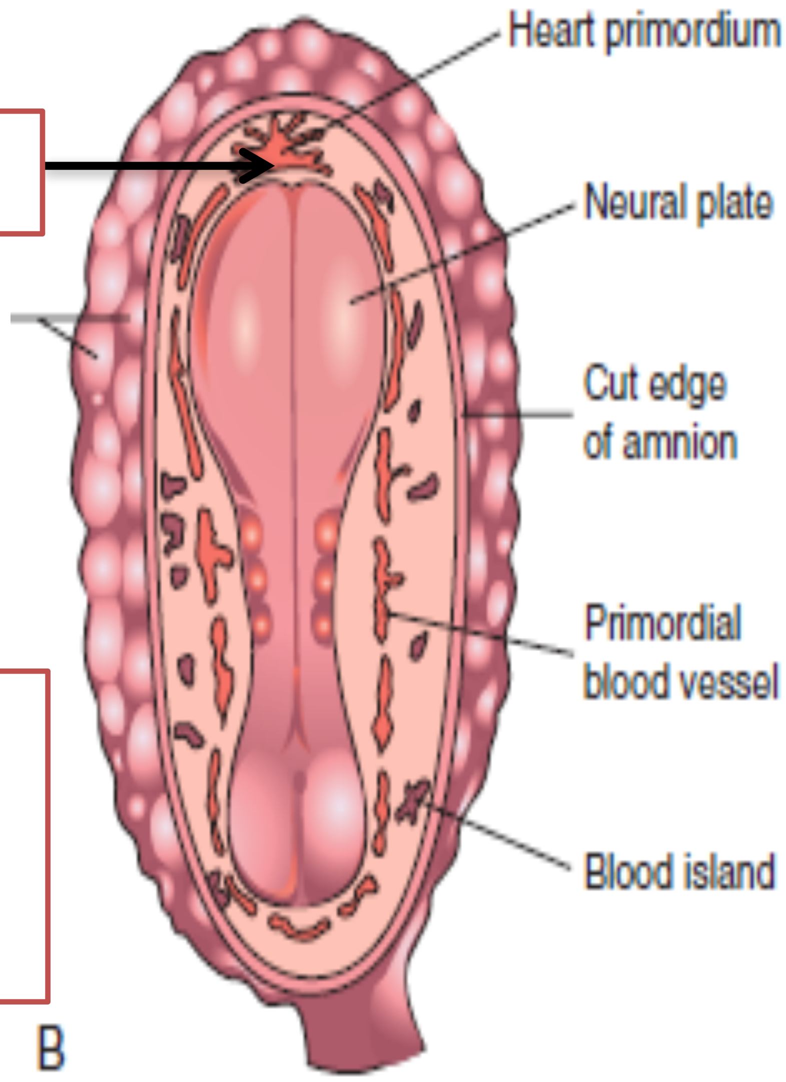
These cells will form :

- The atria
- Left ventricle
- Part of right ventricle

- The remainder of the right ventricle
- outflow tract (conus cordis and truncus arteriosus)

Are derived from the

Secondary Heart Field (SHF)



Formation Of the Heart Tube

ONE-SOMITE AND TWO-SOMITE STAGES

Induction

After migration, the Cardiac progenitor cells are influenced (induced) by the underlying pharyngeal endoderm to form

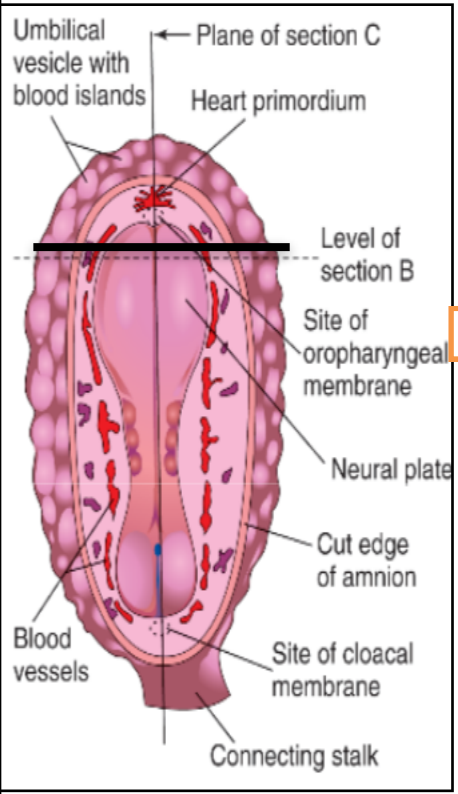
CARDIAC MYOBLASTS

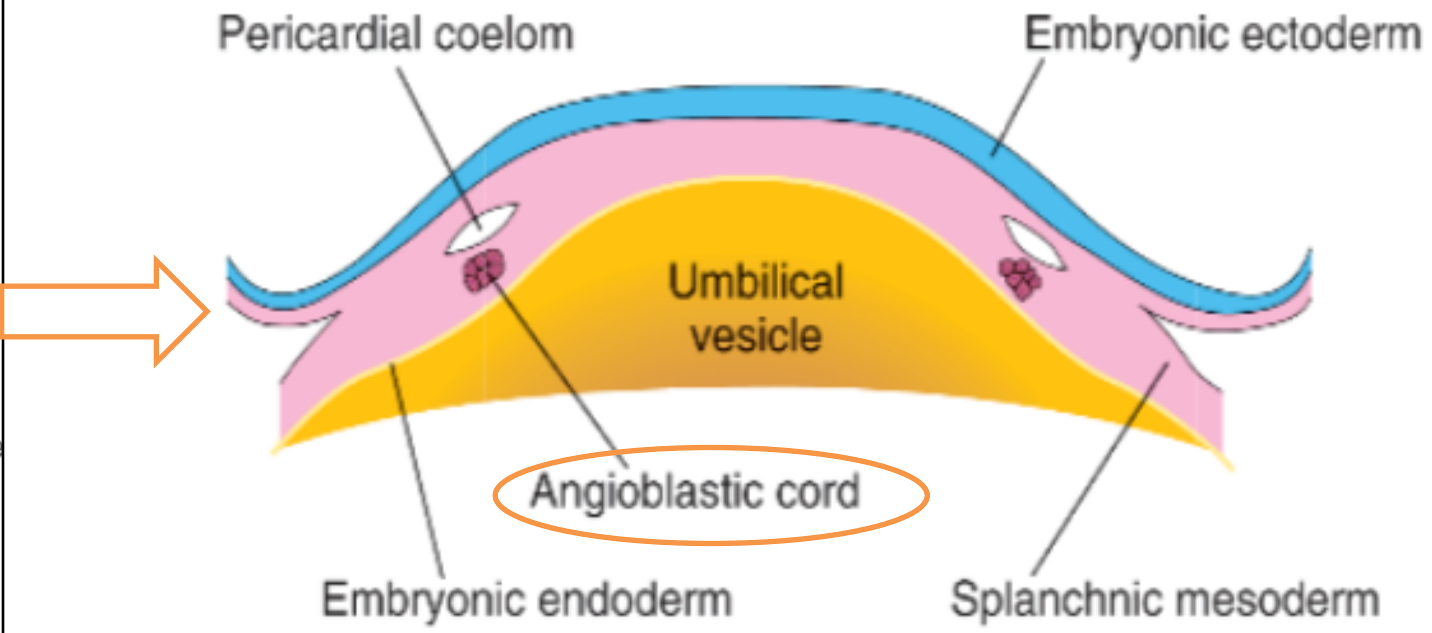
They form

Paired endothelial strands

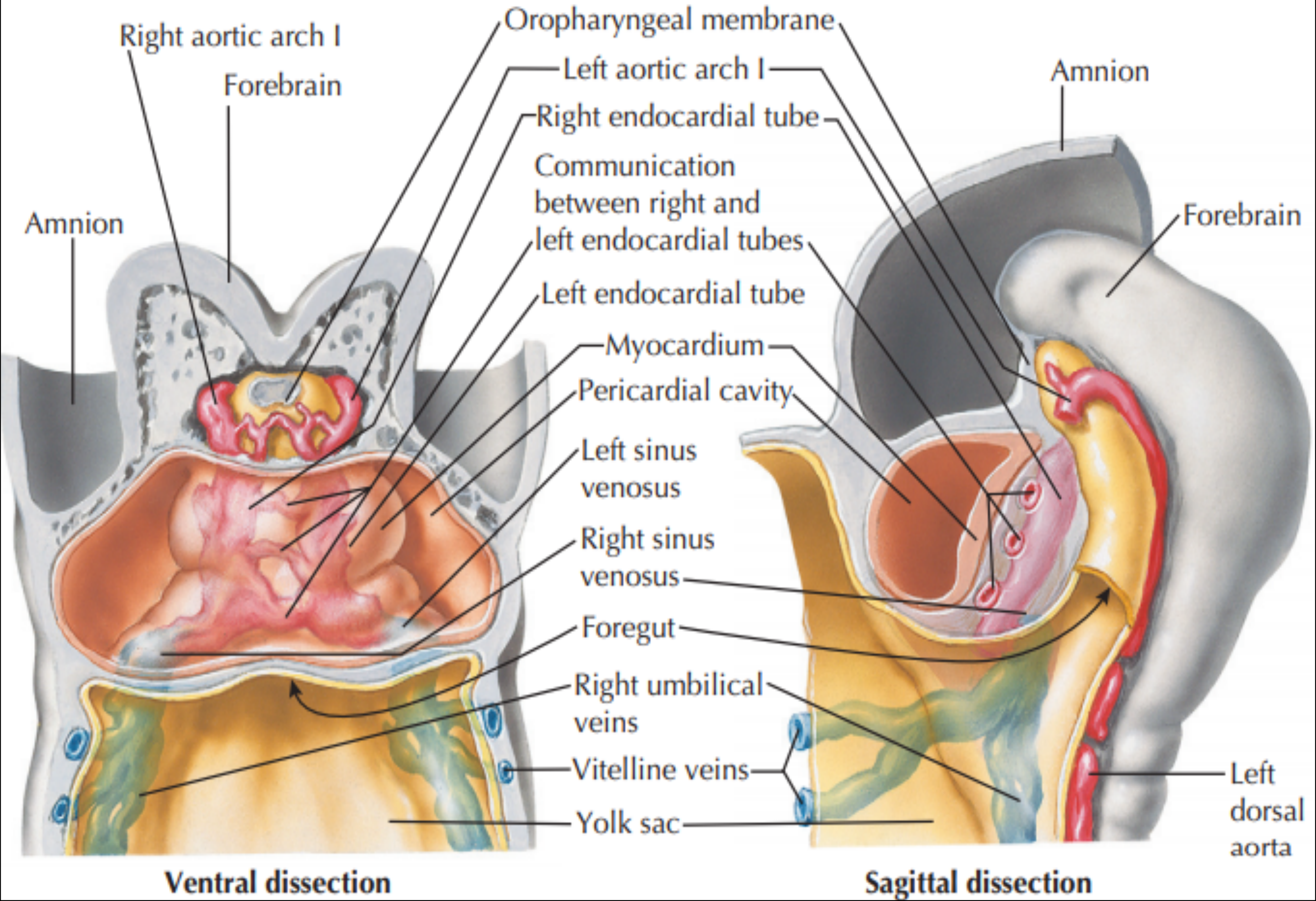
ANGIOBLASTIC CORDS

appear in the cardiogenic mesoderm during the third week of development





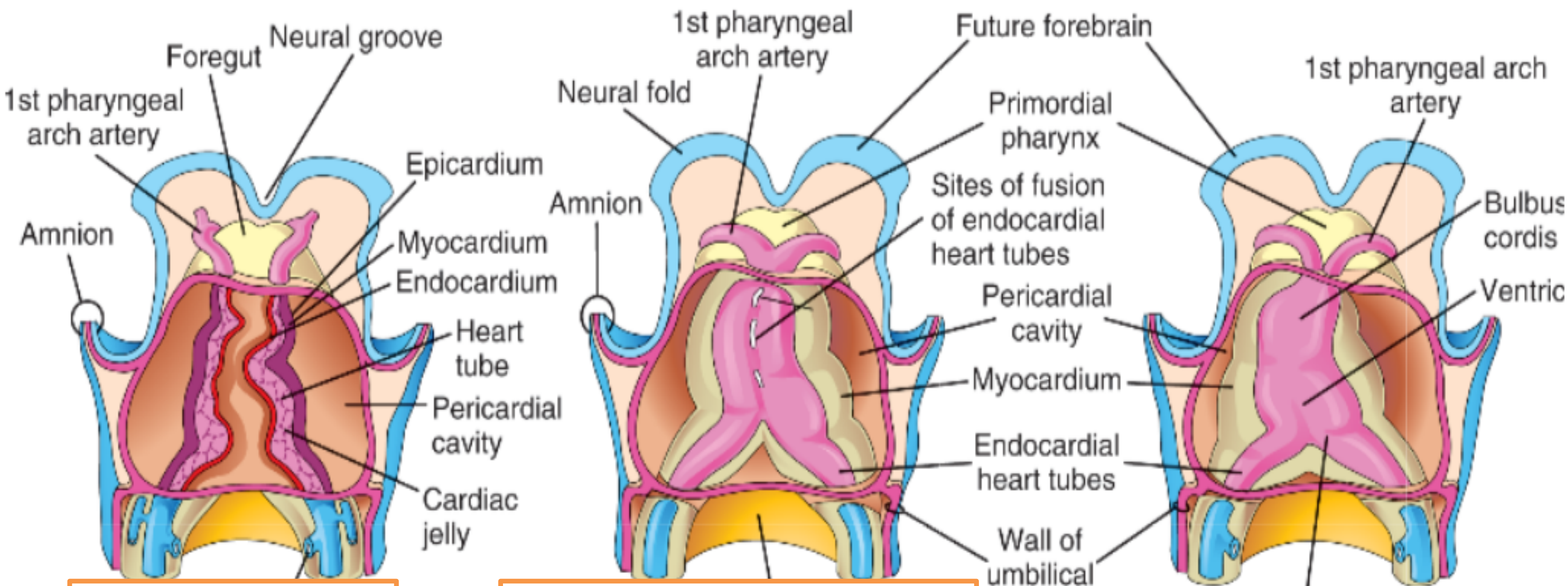
Four-somite stage (2.0 mm) at approximately 22 days



These cords canalize to form two **heart tubes** that soon fuse as embryo

<u>folds laterally</u>

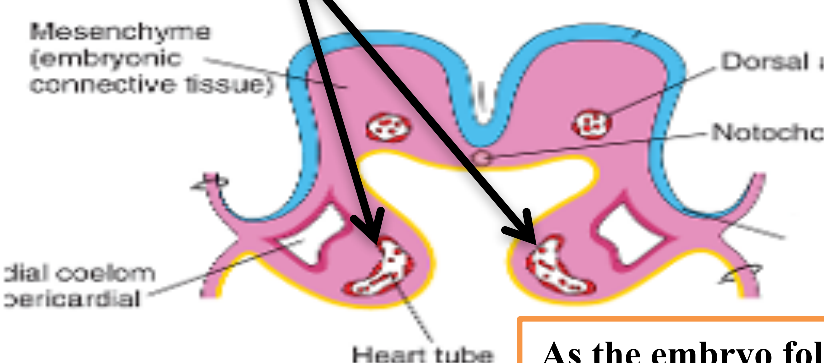
to form a single **heart tube** late in the third week



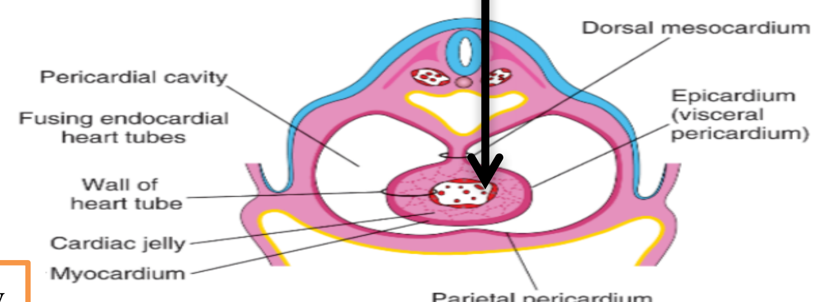
Two hearts tubs

The two tubs are Fused

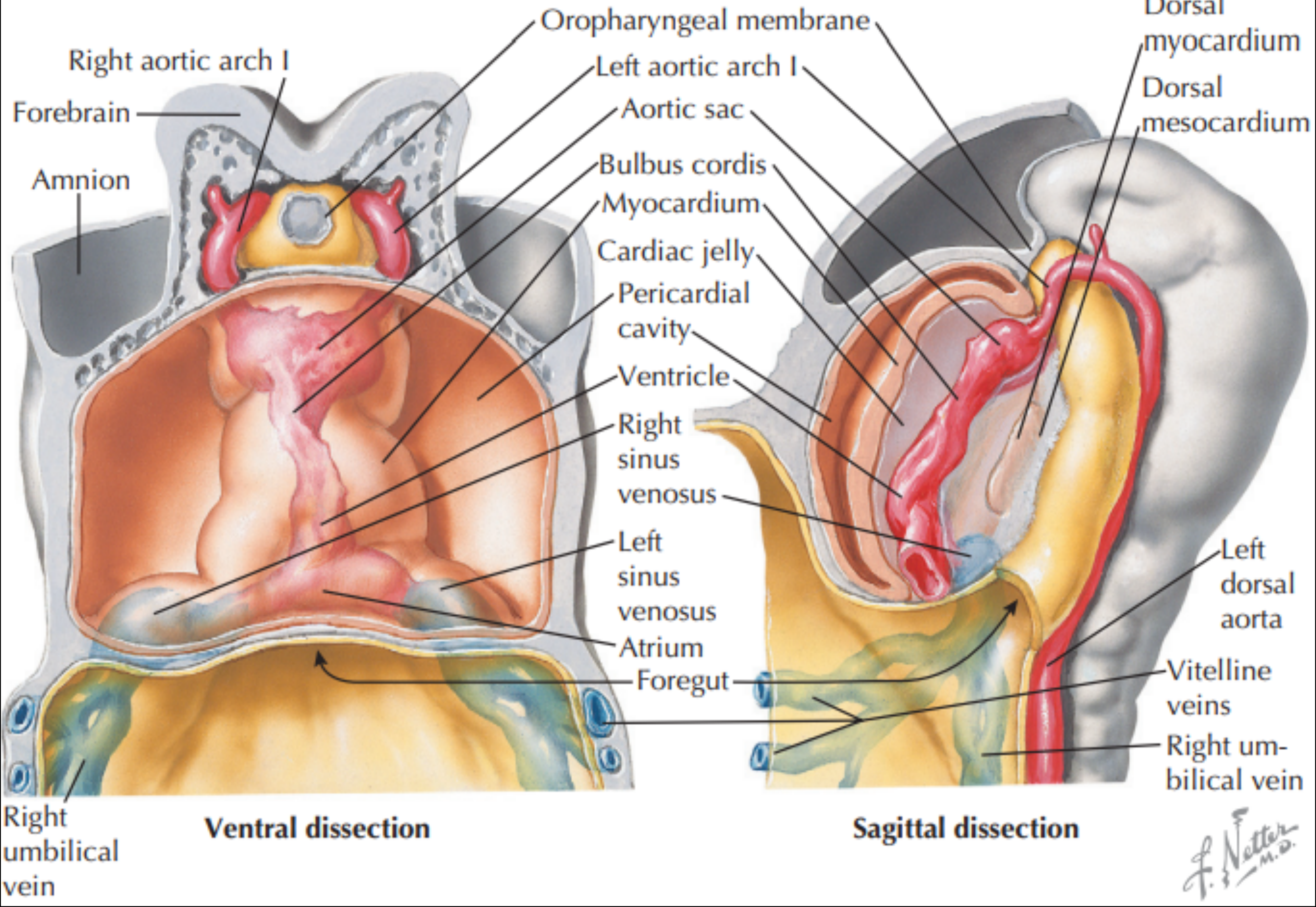
Single heart tube is formed



<u>As the embryo folds laterally</u>



Seven-somite stage (2.2 mm) at approximately 23 days



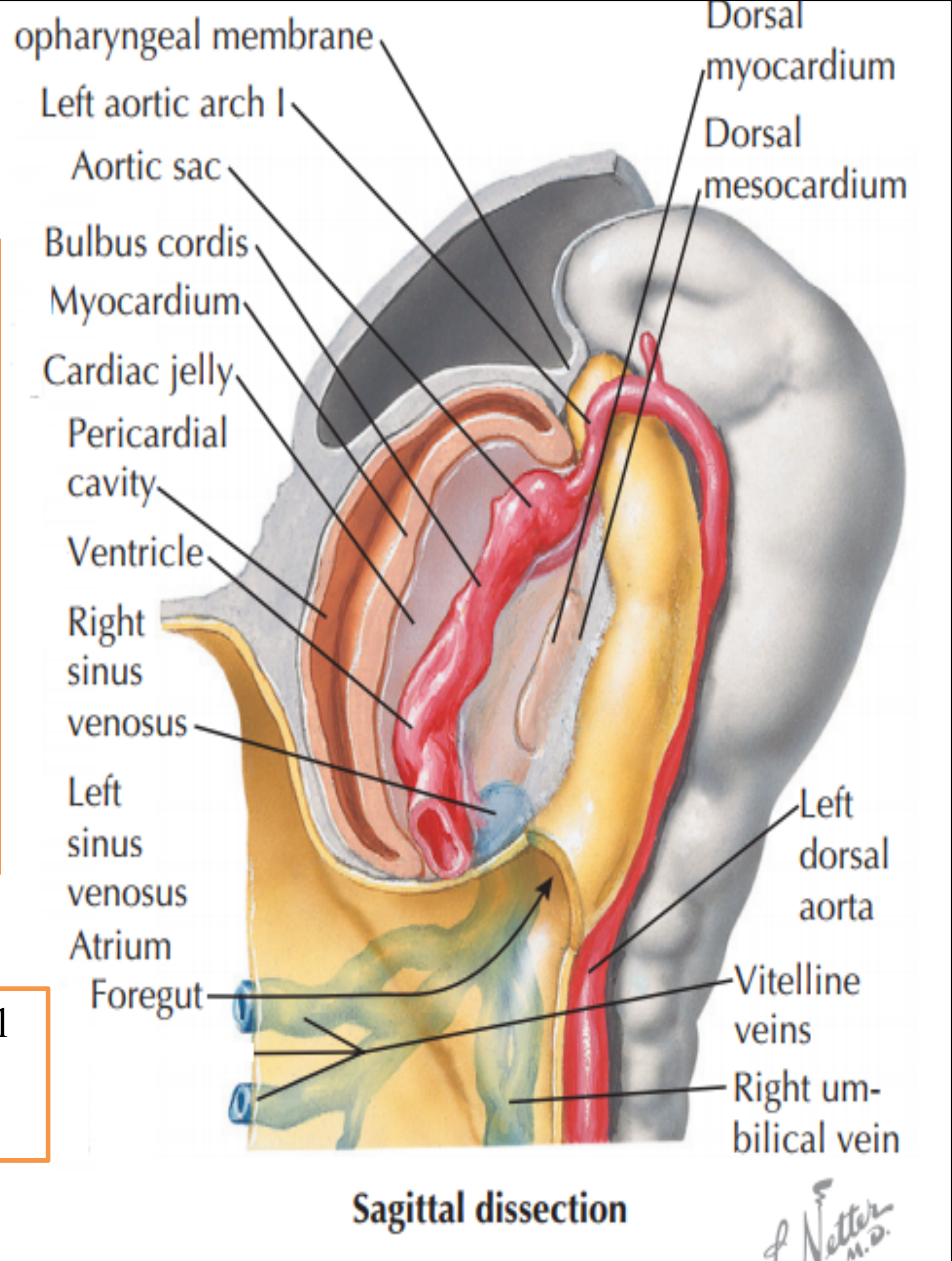
Ventral dissection

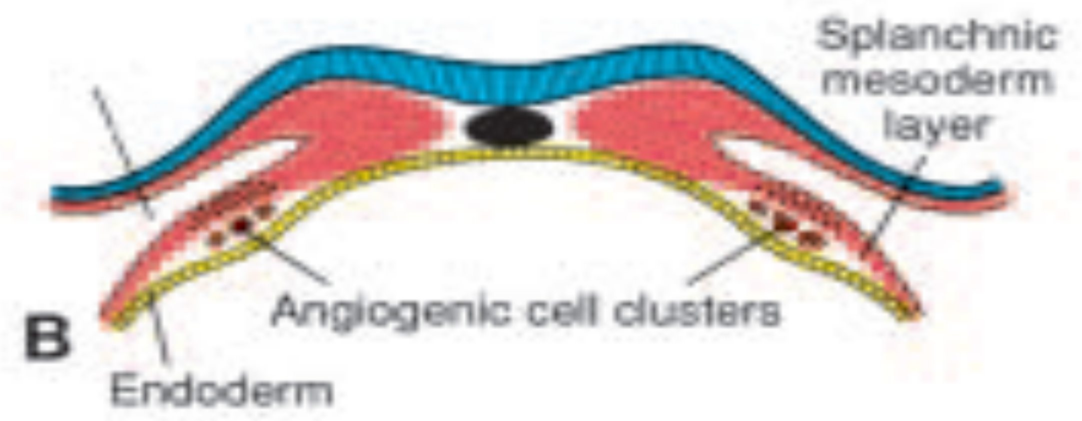
Sagittal dissection

The mesodermal tissue surrounding the endothelial heart (endocardial) tube, has differentiated into three layers

1-The inner layer immediately around the endothelium is initially thick, gelatinous connective tissue called the cardiac jelly.
(The cardiac jelly disappears later)
2-The next layer is the cellular primitive myocardium. (elaborates and matures to become the muscular wall of the heart, the myocardium)
3- The third (outer) layer consists of flat mesothelial cells that also line the remaining pericardial cavity.

The endothelial tube becomes the internal endothelial lining of the heart
the **Endocardium**



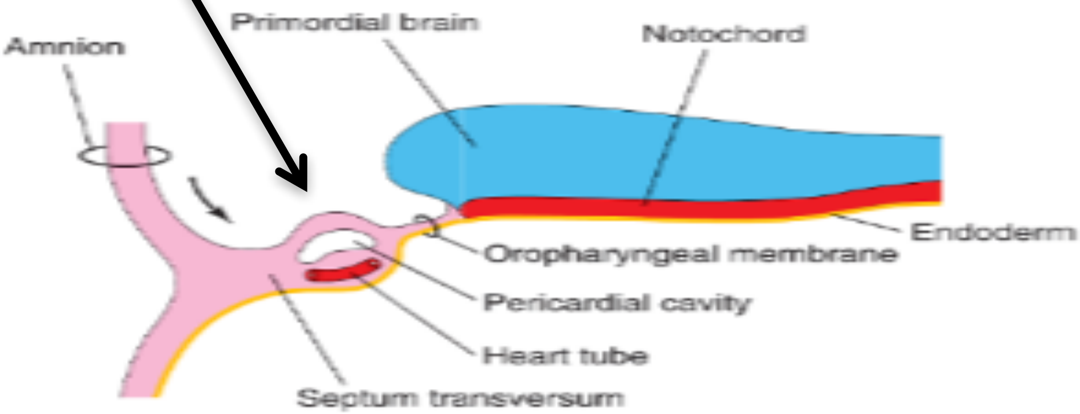


note

In addition to the cardiogenic region, other blood islands appear bilaterally, parallel and close to the midline of the embryonic shield. These islands form a pair of longitudinal vessels, the **dorsal aortae.**

Position of the heart

AS you can see , the cells that will form the heart are located in a cranial position !!!!!!!



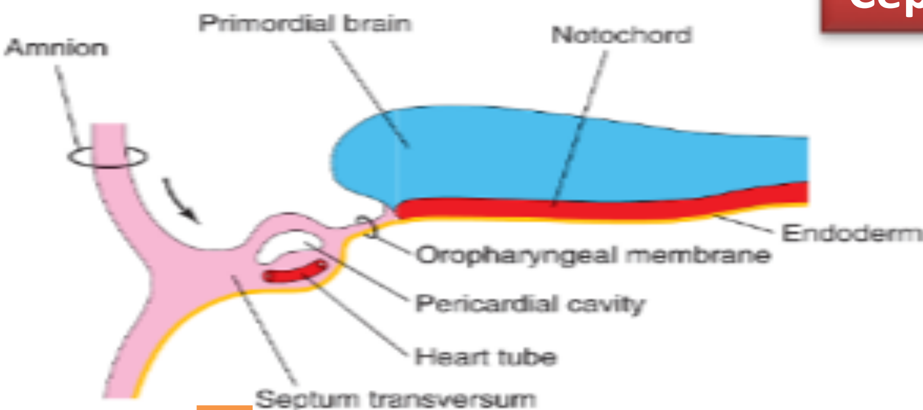
<u>From cranial to caudal before folding</u>

1- Septum transversum
2- Pericardium and ventral to it the Heart tube
4- oropharyngeal membrane.

How will the heart move to its normal position in the thorax?????

Cephalocaudal folding

1



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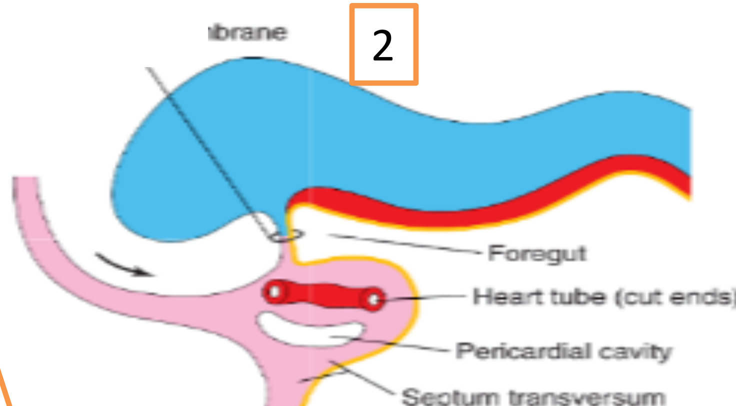

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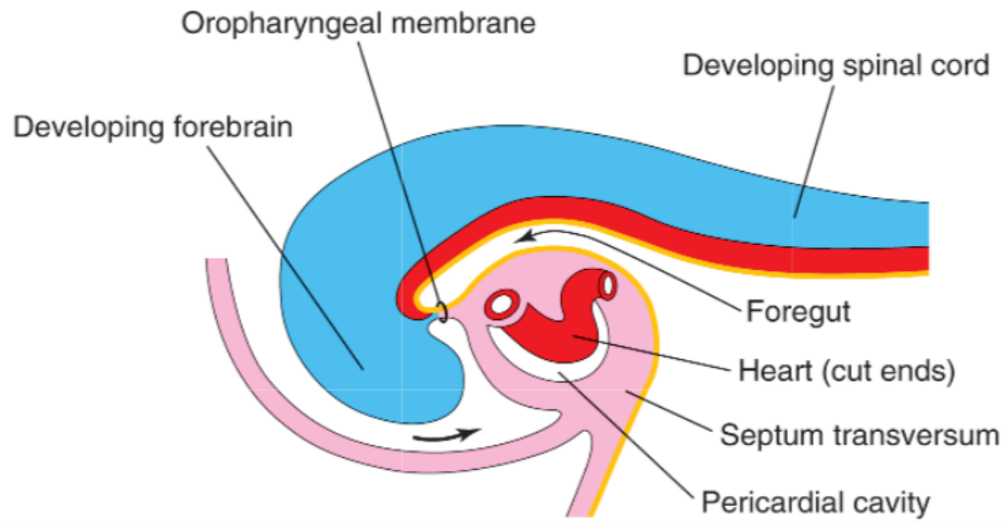
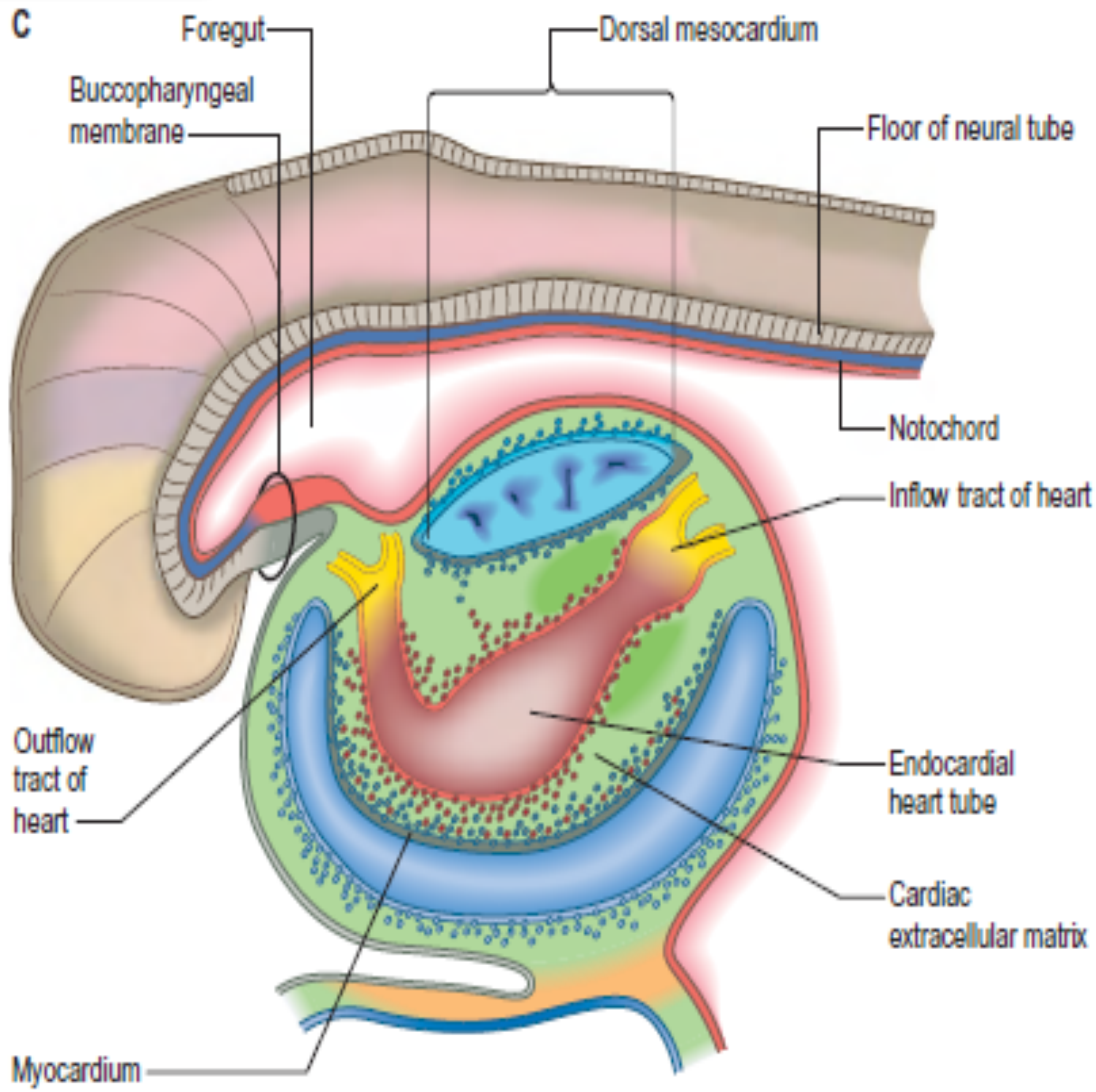


As folding of the head region occurs, the heart and the pericardial cavity appear ventral to the foregut and caudal to the oropharyngeal membrane

The result of cephalocaudal folding

From cranial to caudal:

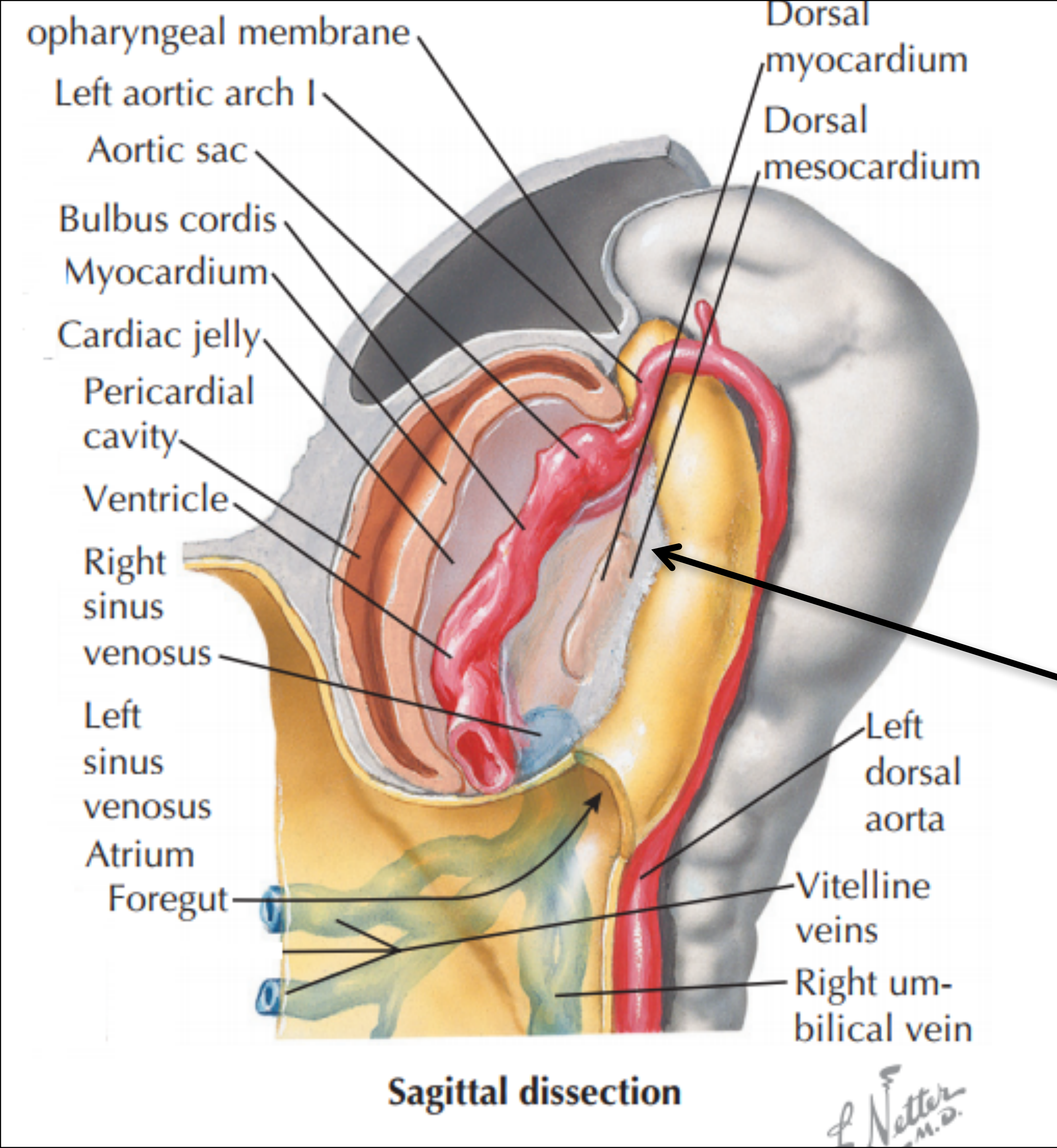
1- Buccopharyngeal membrane.
2- Pericardium.
3- **Heart tube becomes dorsal to paricardial Cavity and ventral to foregut and invaginates the pericardial cavity**
4- Septum transversum.



As the primitive, bilaterally symmetric cardiovascular system appears, shaping of the embryo during the fourth week profoundly influences the relative position of the cardiac portion of this system.

The trilaminar embryonic disc folds into a cylinder, and the amnion tucks around the embryo on each side. The amnion also envelops the head end of the embryo as the ectodermal tube of the forebrain rapidly increases in size in a cranial and ventral direction.

The result is a 180-degree sagittal plane rotation of the cardiogenic mesoderm and oropharyngeal membrane, which were originally cranial to the neural plate and the developing neural tube. The heart is now caudal to the oropharyngeal membrane rather than cranial, and the heart locates dorsal to the developing pericardial cavity



- As indicated earlier, the heart tube is dorsal to the developing pericardial cavity
- As the tube enlarges and bends, it bugles into the underlying coelom
- As the heart tube comes to rest entirely within the pericardial cavity, it is suspended by the two opposing epithelial layers of the pericardial sac,

The dorsal mesocardium.

A ventral mesocardium never develops

important

No known cardiac anomaly can be attributed to the developmental phases described thus far

Formation of the cardiac loop

What we have by now

The heart is essentially

- a straight tube with **a caudal venosus end and cranial arterial end**
- *It lies within the pericardial cavity*
- *is attached posteriorly only by the dorsal mesocardium*

The embryo now
has seven somites
is about 2.2 mm long
is approximately 23 days old
begins to beat

About 3 days have elapsed between the appearance of intraembryonic vasculogenesis and the formation of the **endocardial tube**

Differential growth defines five segments of the heart tube: (from caudal to cephalic or according to direction of blood flow)

1- Sinus venosus
2- Primitive atrium.
3- primitive ventricle.
4- Bulbus cordis (conus).
5- truncus arteriosus.

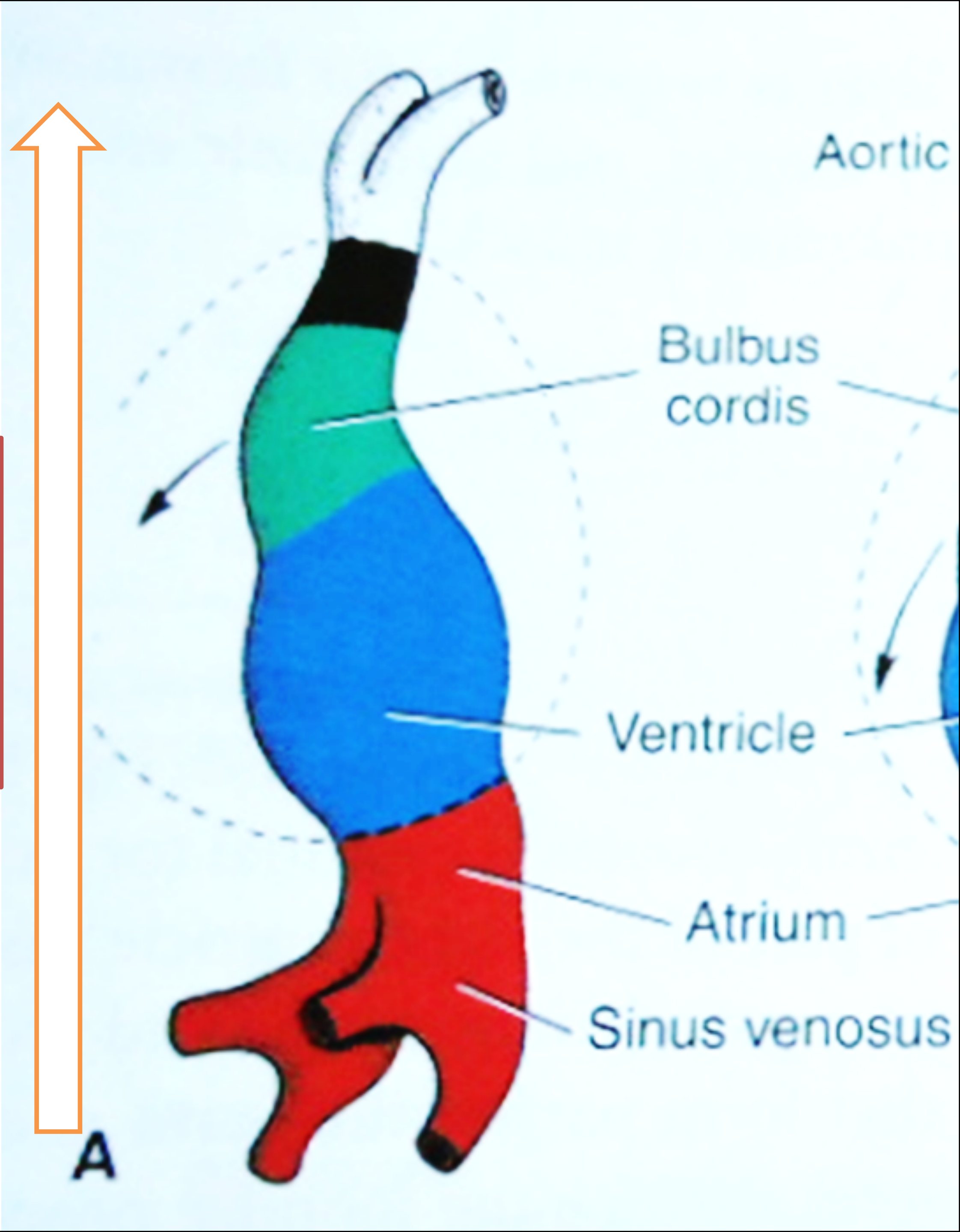


Table III-2-1. Adult Structures Derived From the Dilatations of the Primitive Heart

Embryonic Dilatation	Adult Structure
Truncus arteriosus (neural crest)	Aorta; Pulmonary trunk; Semilunar values
Bulbus cordis	Smooth part of right ventricle **(conus arteriosus)** Smooth part of left ventricle **(aortic vestibule)**
Primitive ventricle	Trabeculated part of right ventricle Trabeculated part of left ventricle
Primitive atrium*	Trabeculated part of right atrium (pectinate muscles) Trabeculated part of left atrium (pectinate muscles)
Sinus venosus (the only dilation that does not become subdivided by a septum)	Right–Smooth part of right atrium **(sinus venarum)** Left–Coronary sinus and oblique vein of left atrium

*The **smooth-walled part** of the **left atrium** is formed by incorporation of parts of the **pulmonary veins** into its wall. The **smooth-walled part** of the **right atrium** is formed by the incorporation of the **right sinus venosus**.

From the venous end

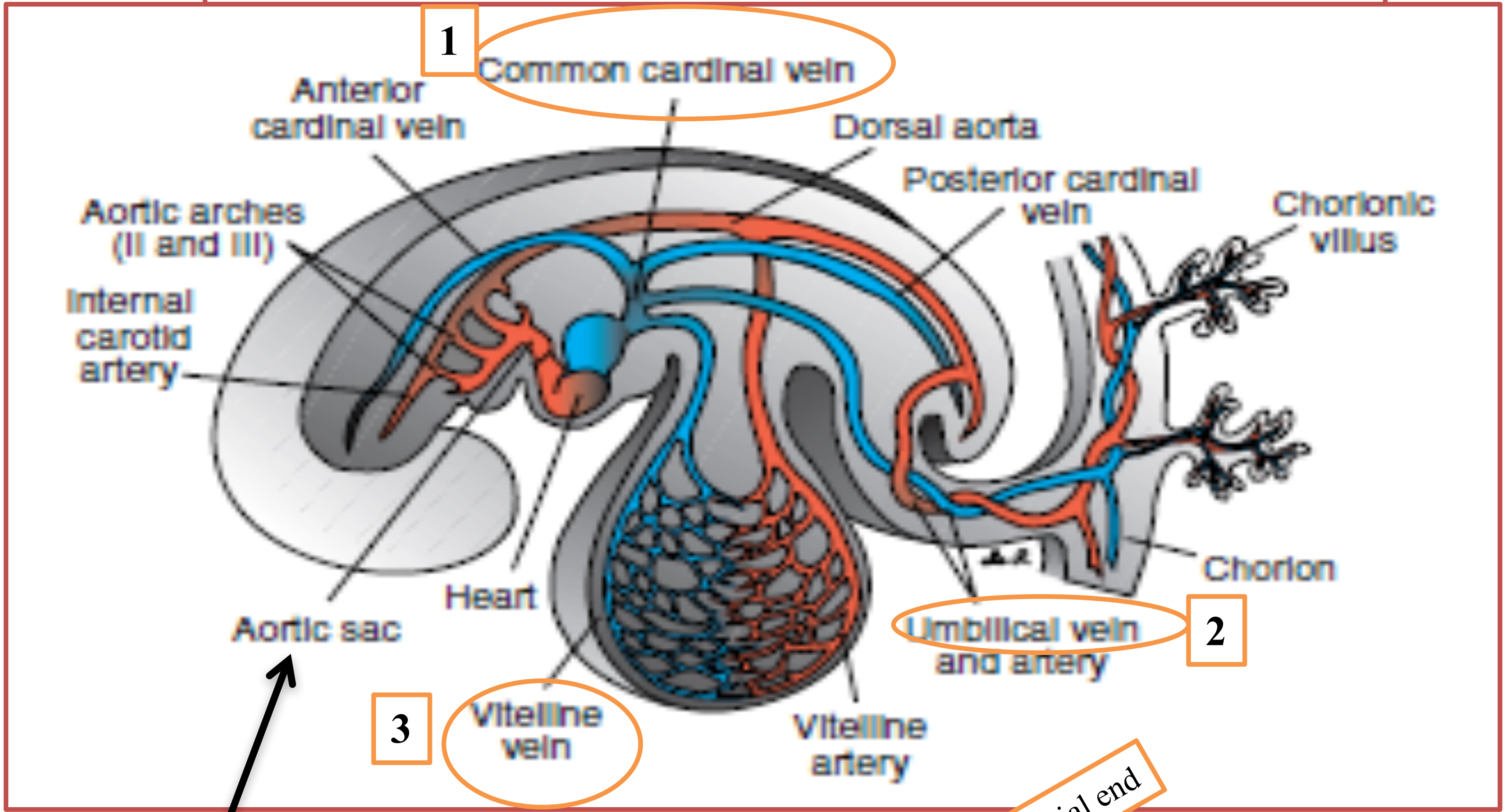
<u>The sinus venosus represent the venous end</u> of the heart

It receives 3 veins:

1- Common cardinal vein → body wall

2- Umbilical vein → from placenta

3- Vitelline vein → from yolk sac

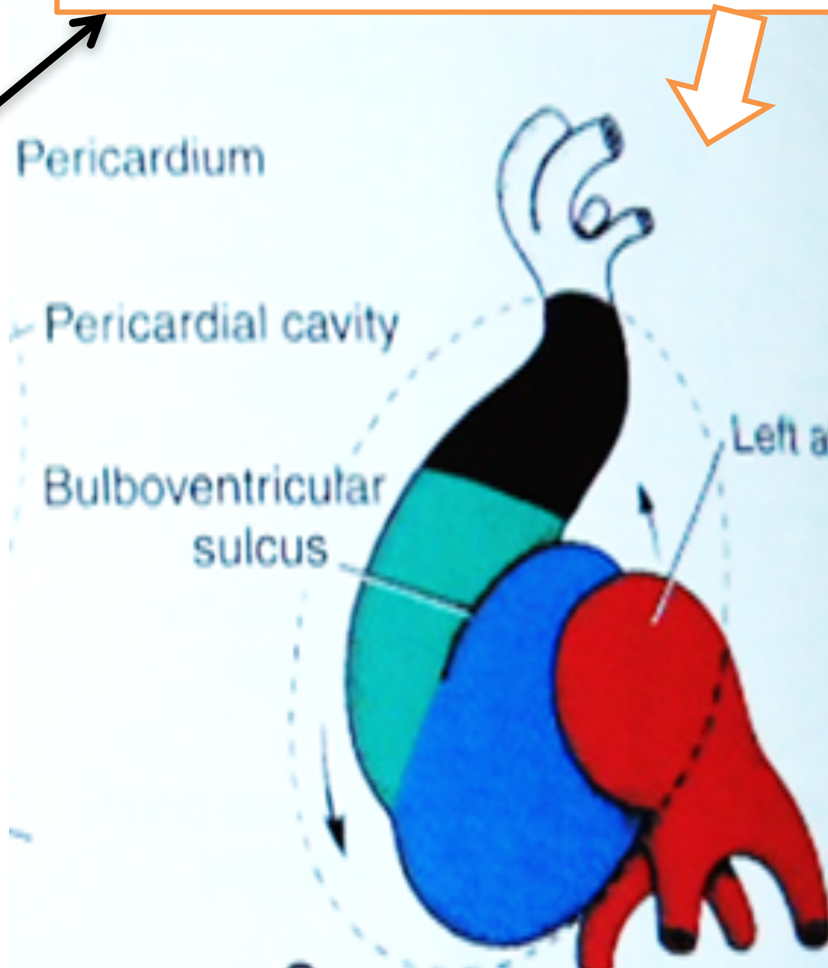


The tubular truncus arteriosus (TA) is continuous cranially with the aortic sac

From the arterial end

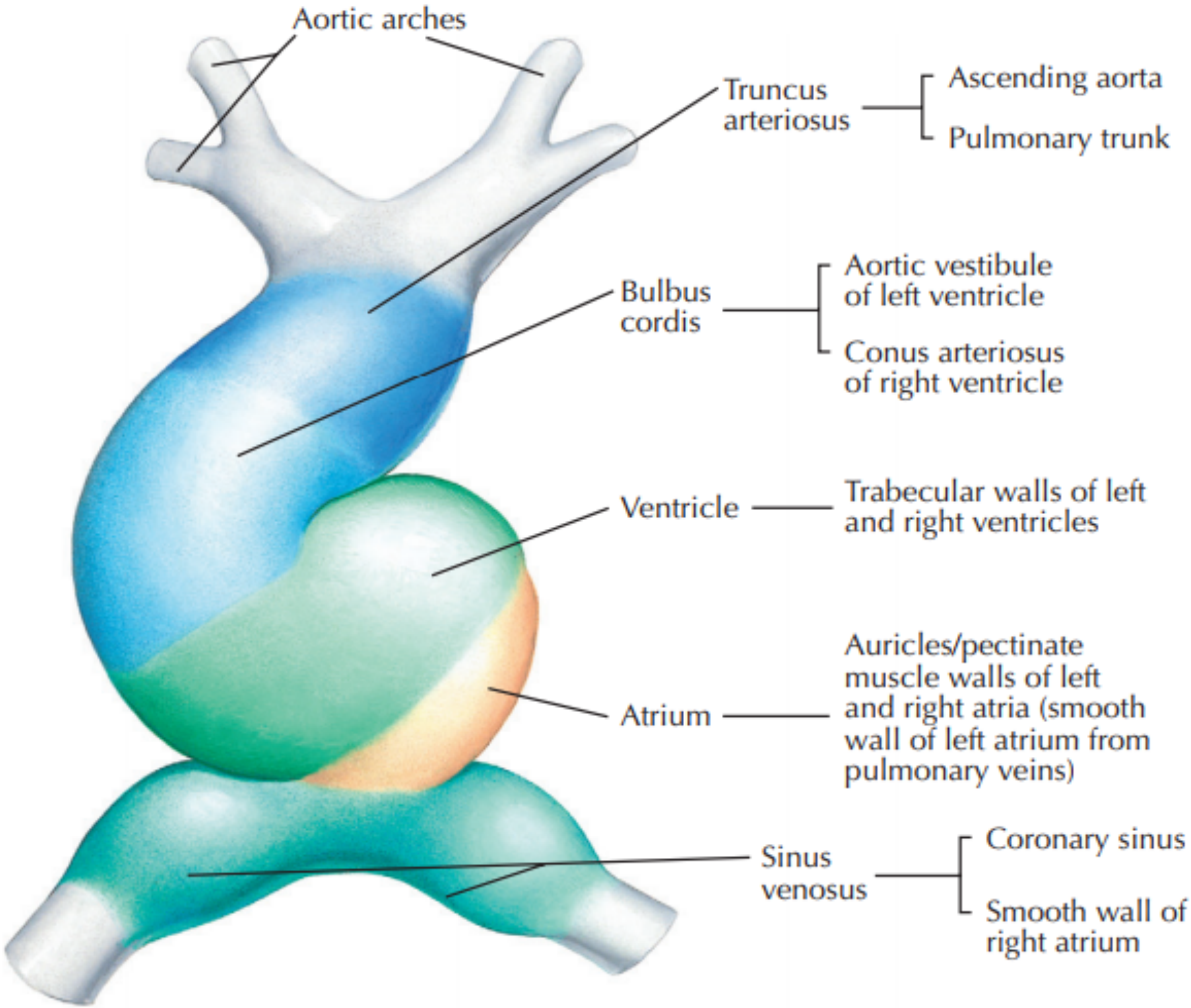
The arterial end of the heart is fixed by the pharyngeal arches

Remember that at this stage of development



The venous end of the heart is fixed by the septum transversum

Heart Tube Derivatives



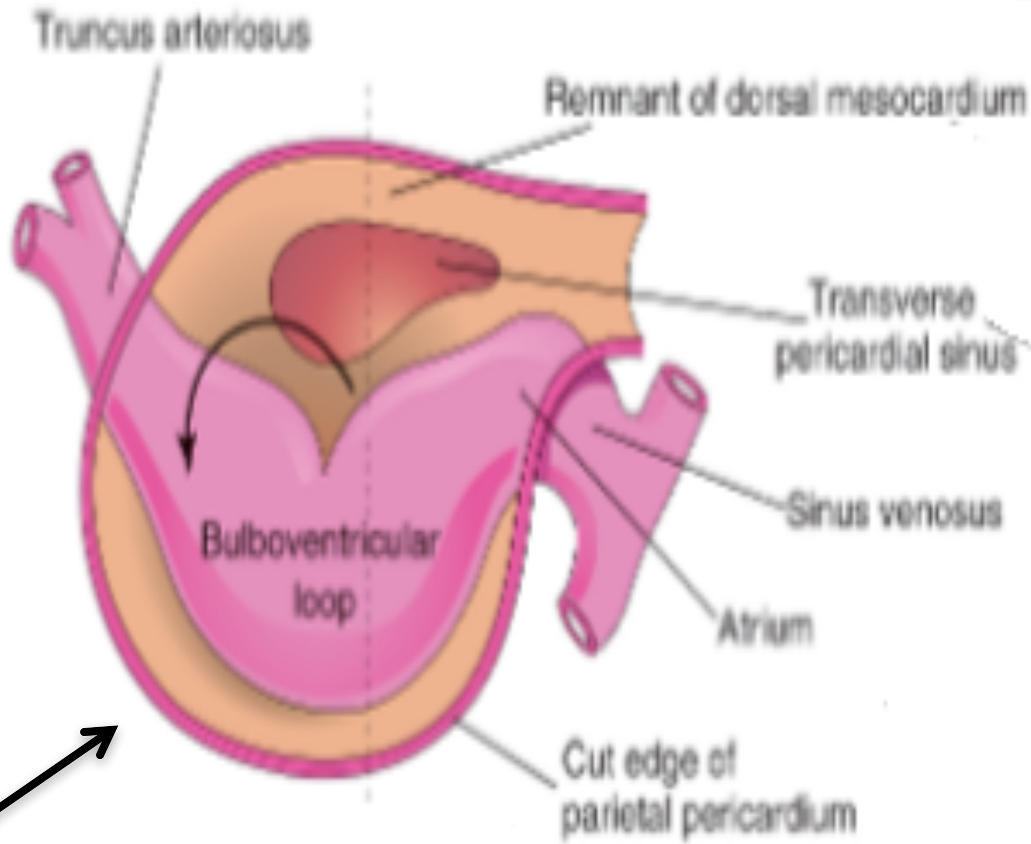
Heart tube derivatives

The part of the tube lying within the pericardial cavity is made up of bulbus cordis and ventricle

Because the **bulbus cordis** and **ventricle** grow **faster** that the other regions

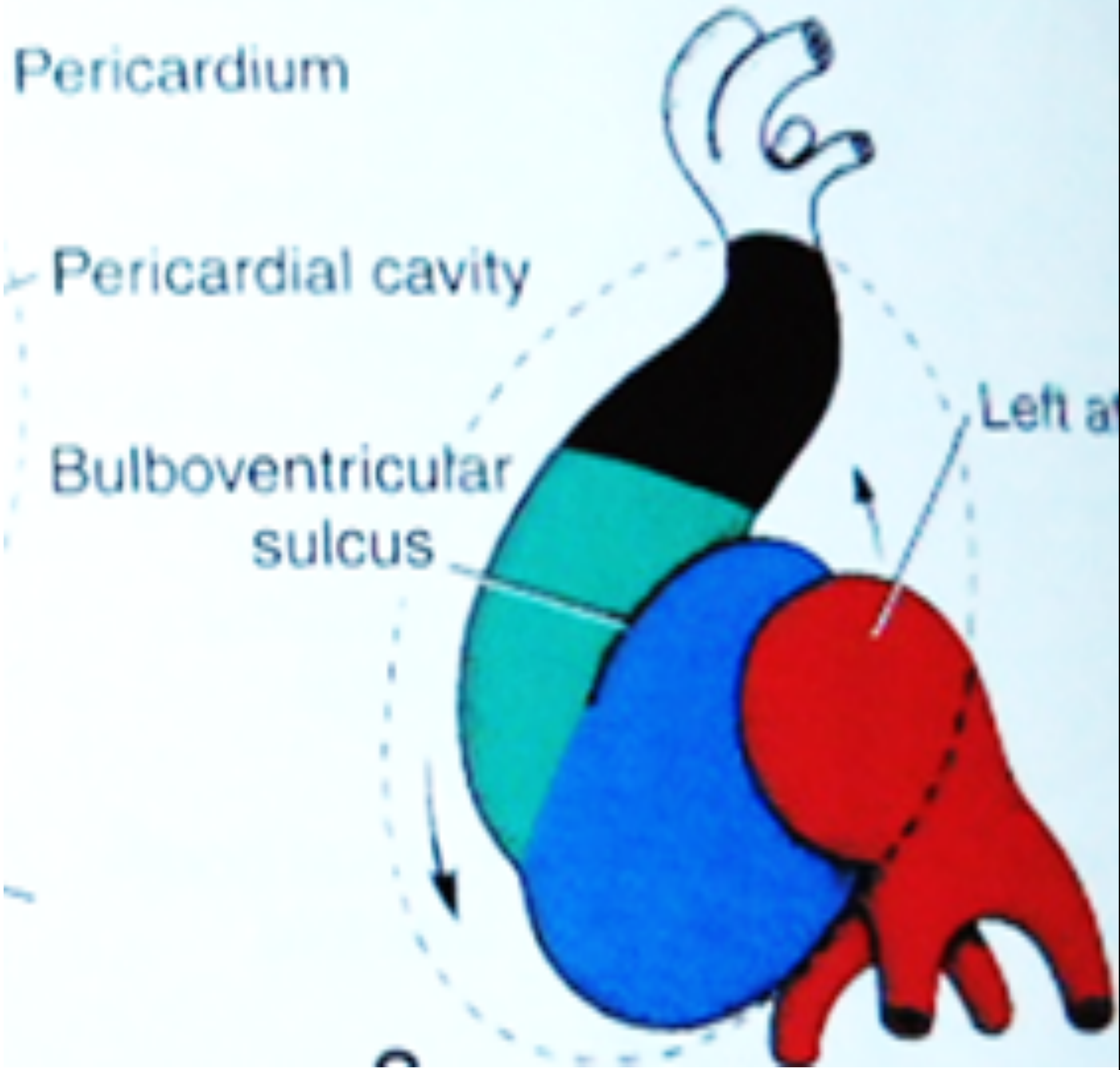
the heart bends on itself (usually bends to the right, thus the proximal bulbus cordis (RV) lying anterior and to the right of the primitive ventricle) forming

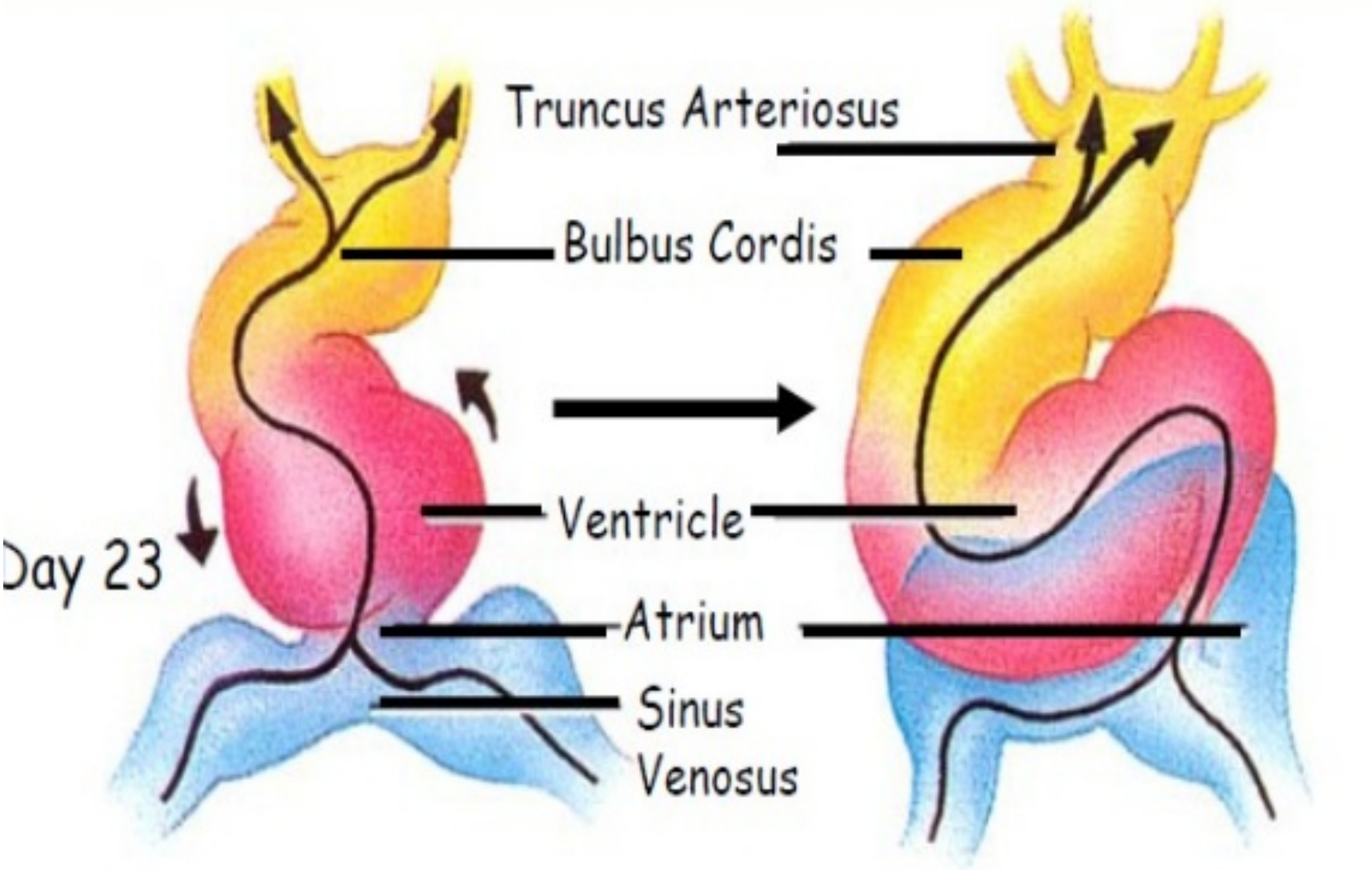
a U-shaped **bulboventricular loop**

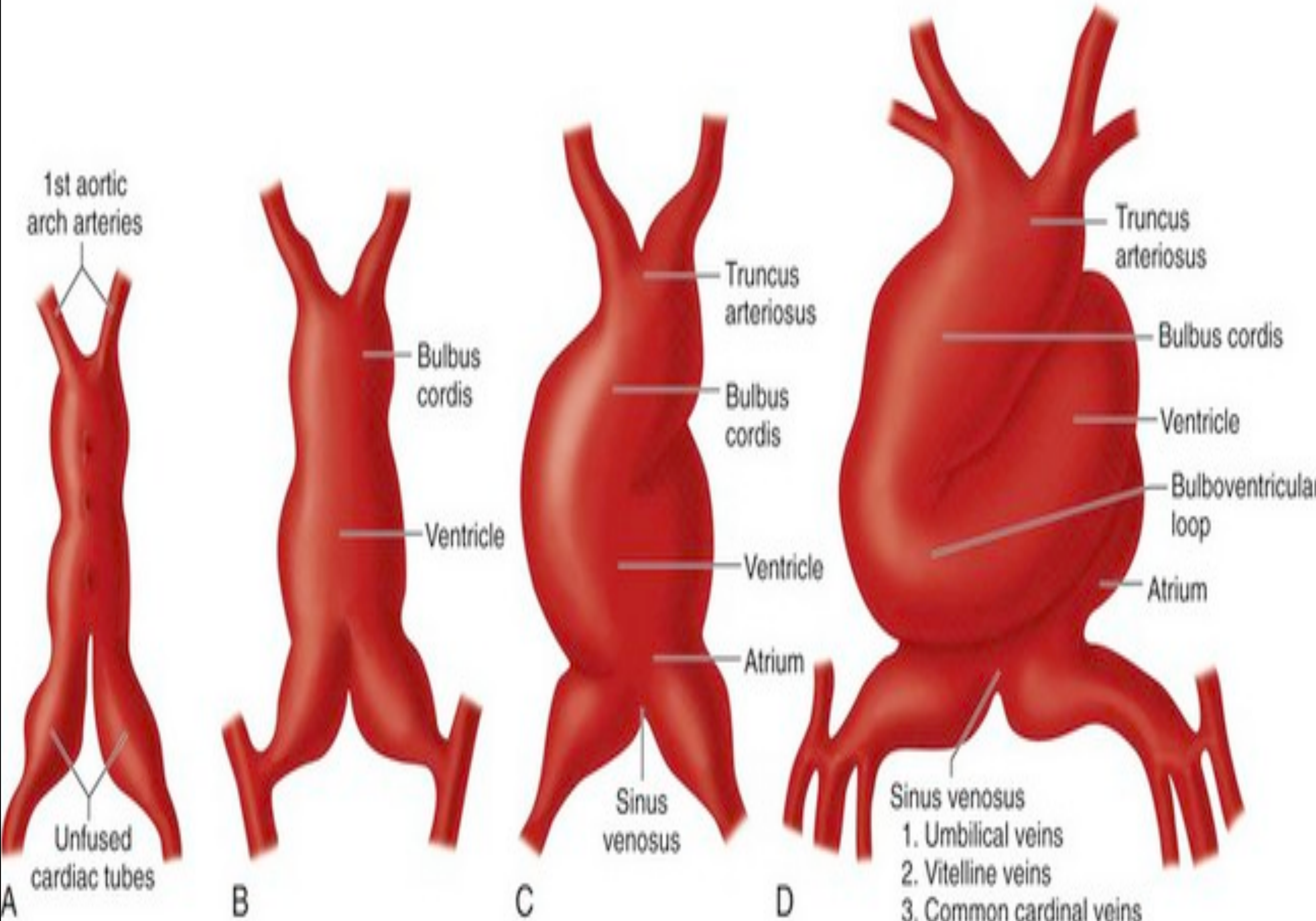


As the atrium and sinus venosus are freed from **the septum transverum** they come to lie behind and above the ventricle and the heart tube is now

S-shaped



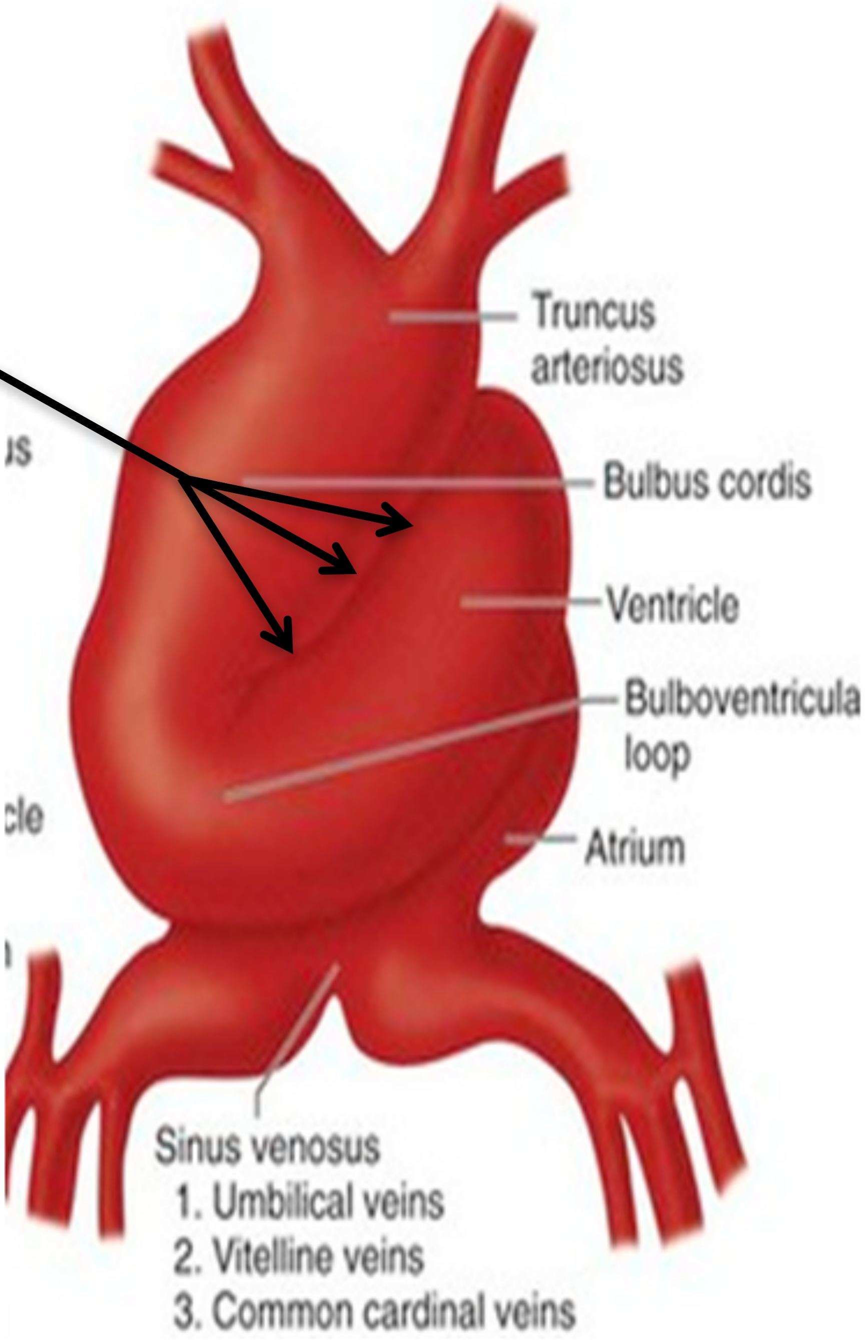

Truncus Arteriosus
Bulbus Cordis
Ventricle
Day 23
Atrium
Sinus
Venosus


1st aortic
arch arteries
Unfused
cardiac tubes
A
Bulbus
cordis
Ventricle
B
Truncus
arteriosus
Bulbus
cordis
Ventricle
Atrium
Sinus
venosus
C
Truncus
arteriosus
Bulbus cordis
Ventricle
Bulboventricular
loop
Atrium
Sinus venosus
1. Umbilical veins
2. Vitelline veins
3. Common cardinal veins
D

At this stage

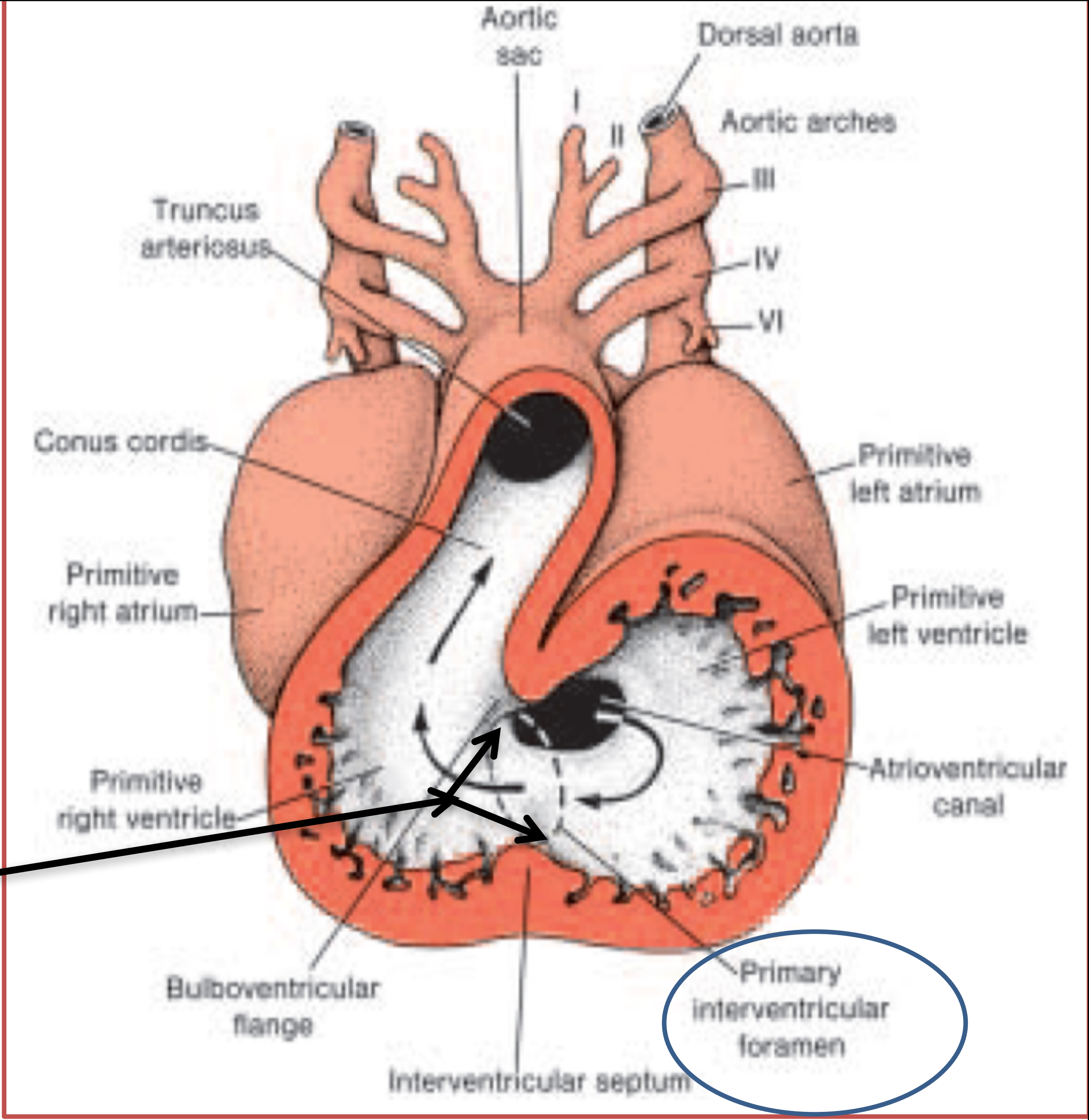
The embryo is now about 3.2 mm long and approximately 25 days old, and it possesses 20 somites

- At this stage the bulbus cordis and ventricle are separated by a deep bulbo-ventricular sulcus.

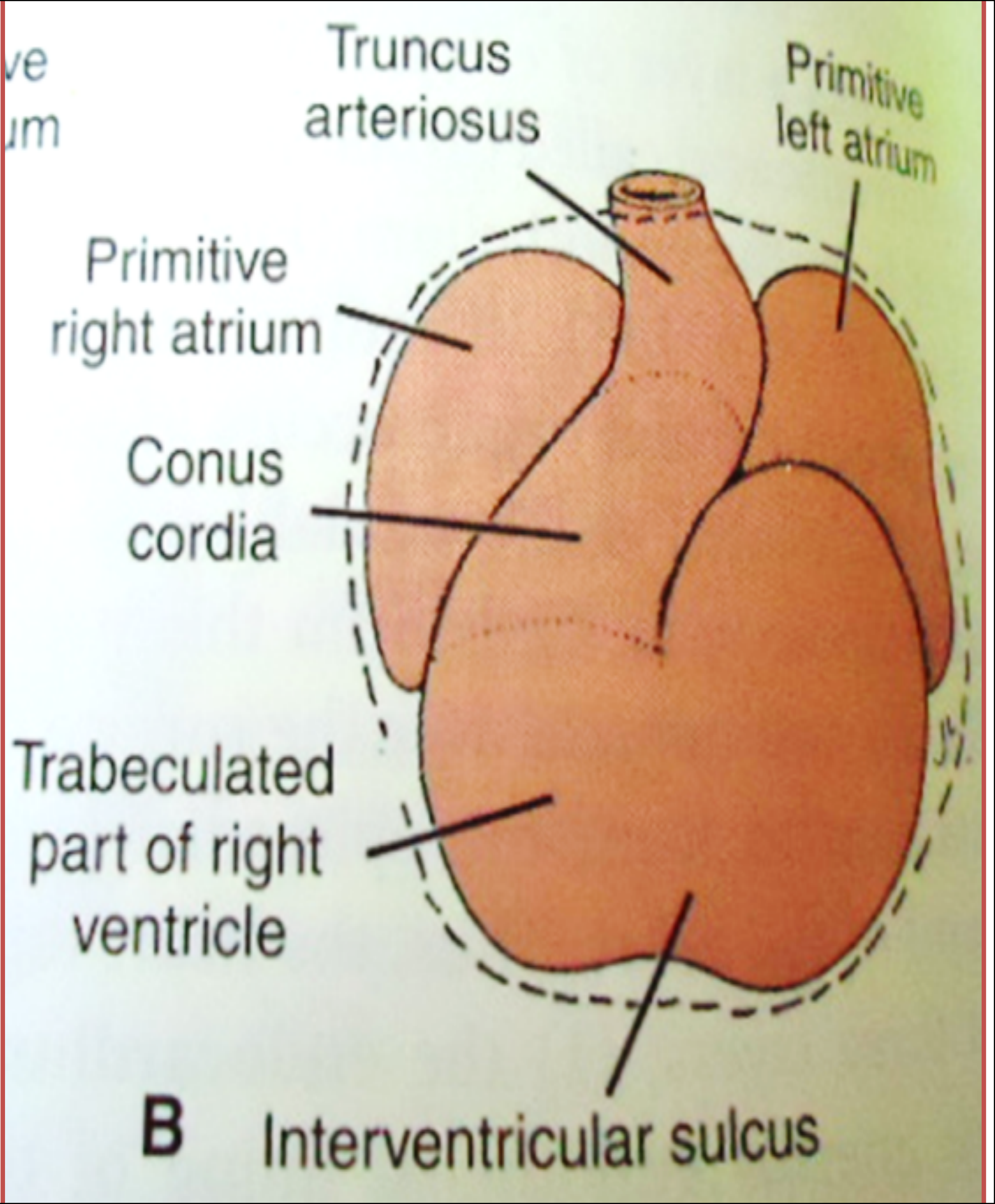


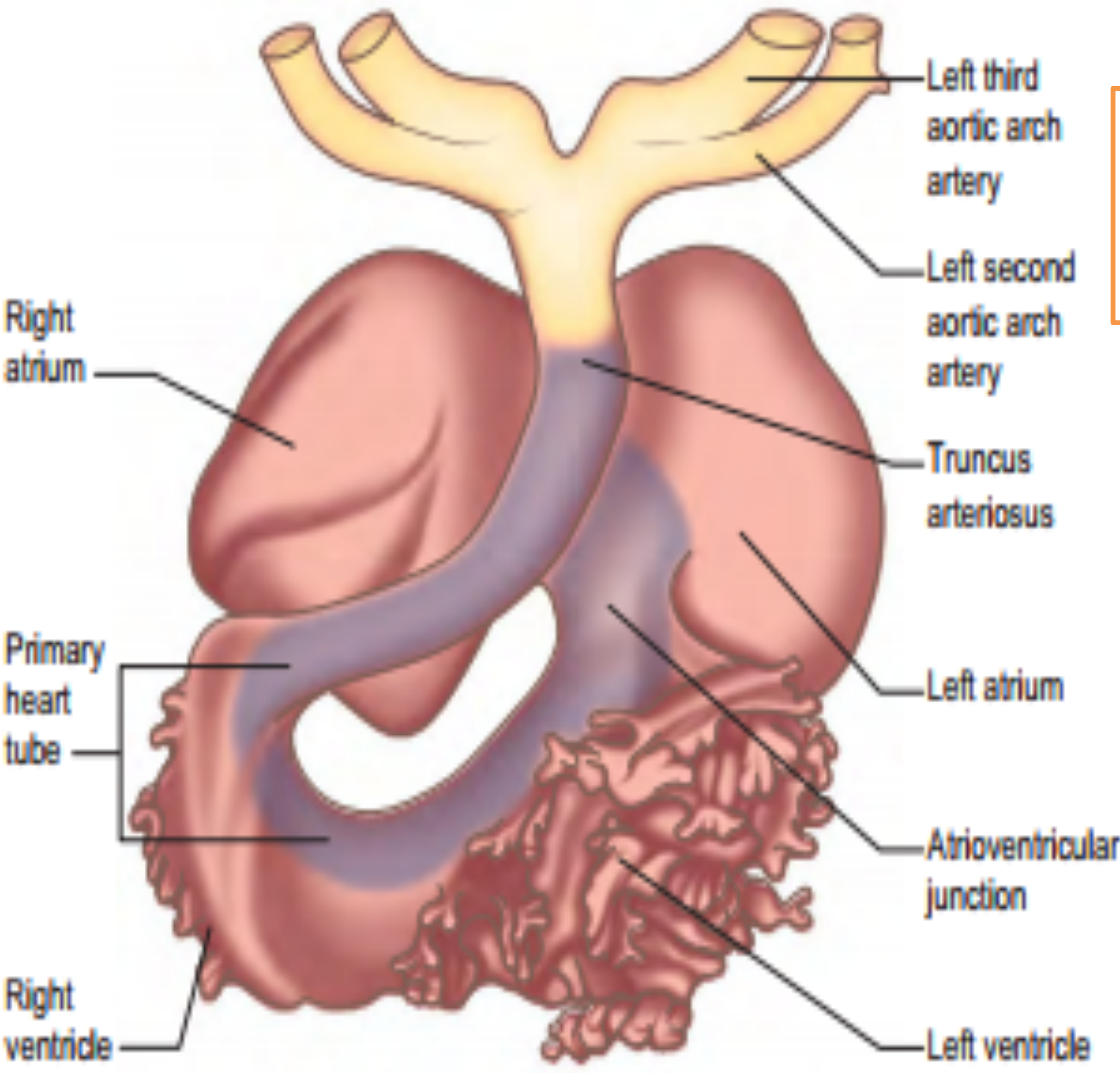
- This sulcus gradually becomes shallower so that the bulbus cordis and the ventricle come to form **one chamber** which communicates with the truncus arteriosus.

The **<u>primary interventricular foramen</u>**



- The atrial chamber expands so that parts of it come to project forwards on either side of the truncus

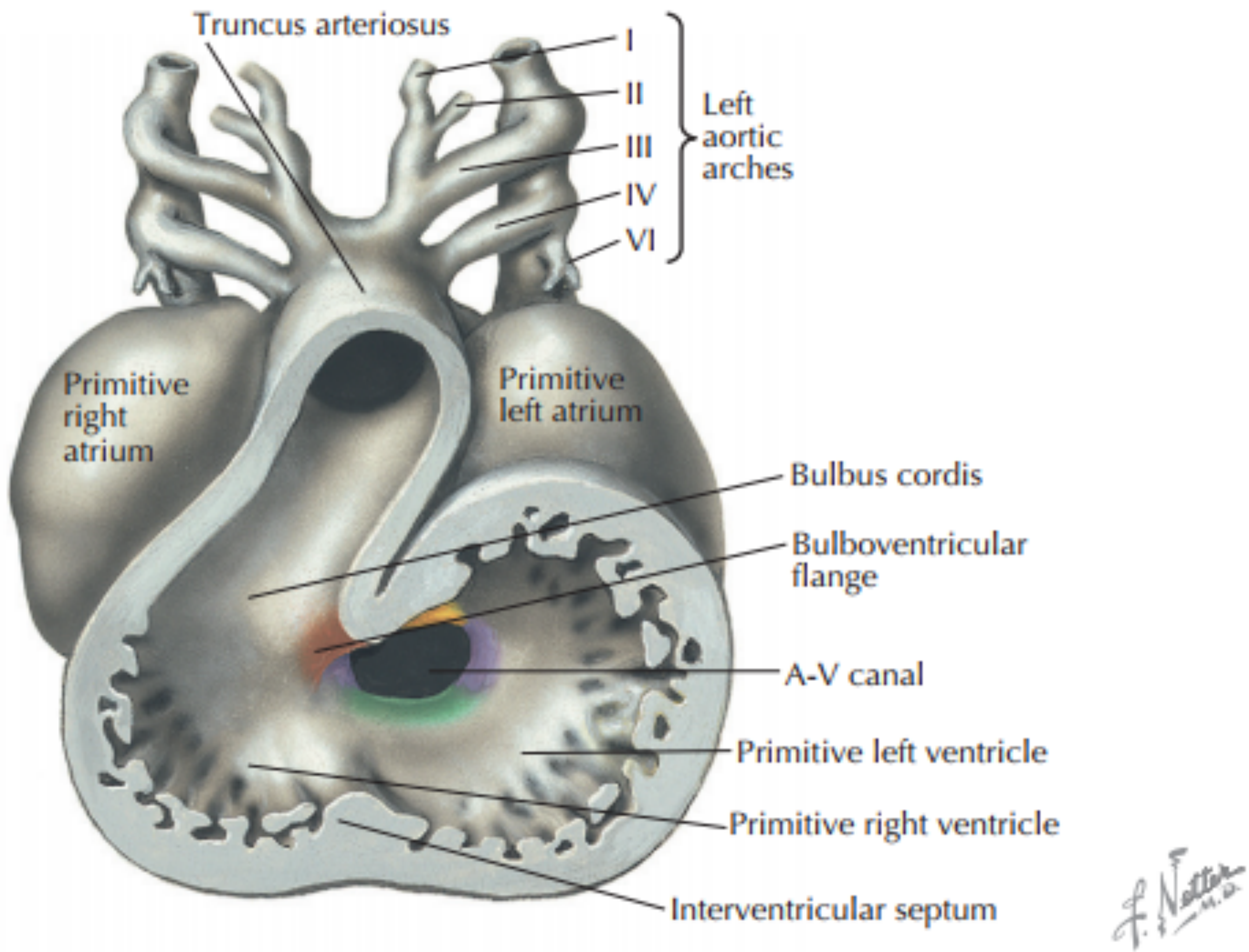




The atrial chamber expands so that parts of it come to project forwards on either side of the truncus

As a result of these changes the exterior of the heart assumes its definitive shape

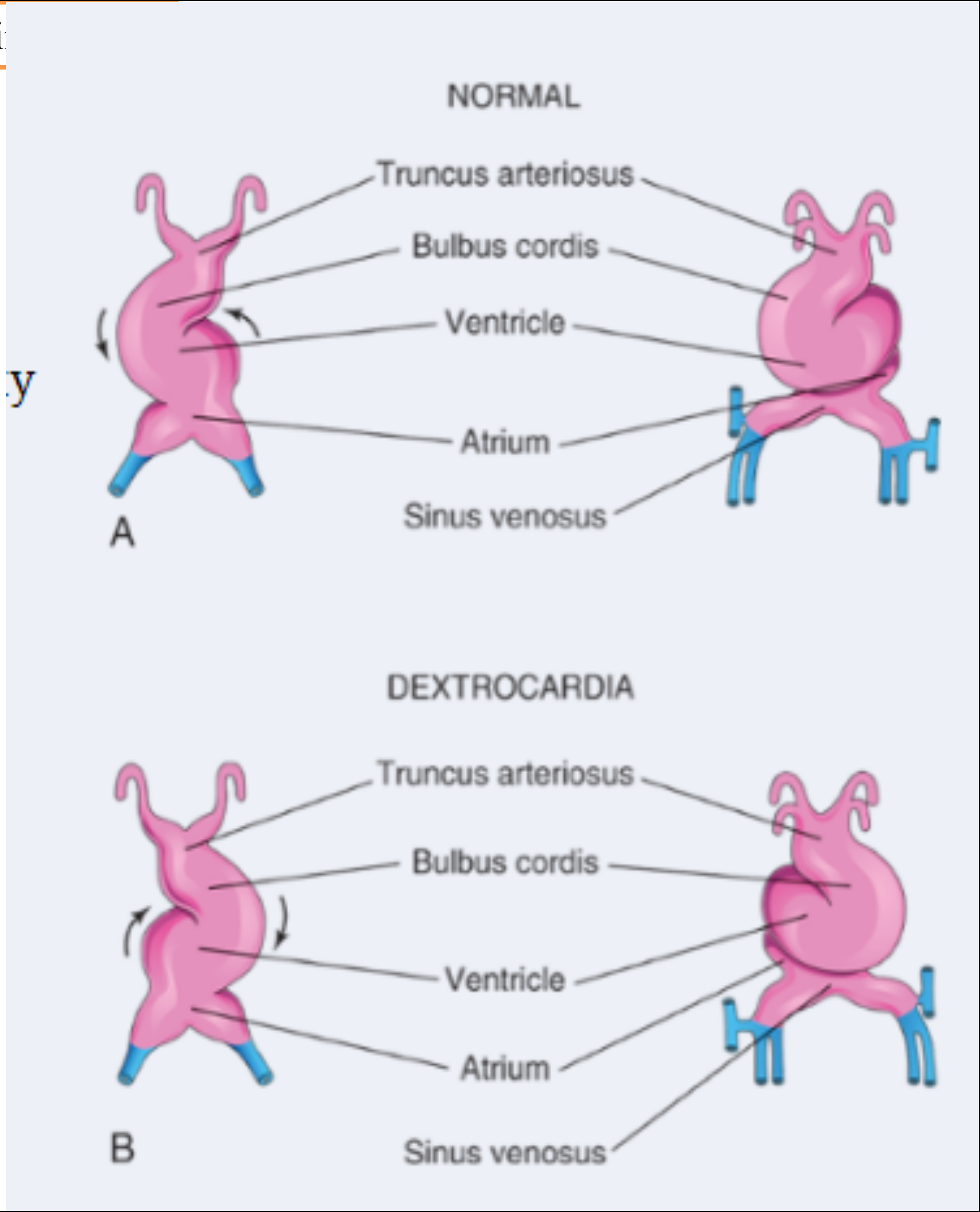
4 to 5 mm (approximately 27 days)



Abnormalities of Cardiac Loopi

Dextrocardia, in which the heart lies on the right side of the thorax instead of the left, is caused because the heart loops to the left instead of the right.

Dextrocardia may coincide with situs inversus, a complete reversal of asymmetry in all organs. Situs inversus, which occurs in 1/7000 individuals, usually is associated with normal physiology, although there is a slight risk of heart defects. In other cases sidedness is random, such that some organs are reversed and others are not; this is



Read only

It is often stated that looping of the tube is the first visual evidence of asymmetry in the embryo, although careful examination reveals that the atrioventricular canal has become asymmetric prior to the start of looping. Although the sense of laterality of the developing organs of the body, including the atrial appendages, develops during gastrulation, the pathway of signalling that governs rightward looping of the heart tube remains unknown

. However, it is now well established that signalling pathways ***including Pitx2, nodal, lefty, and cited-2,*** determine the formation of the morphologically left-sided or right-sided features seen in organs such as the lungs, the bronchial tree, the liver and spleen, and the atrial appendages