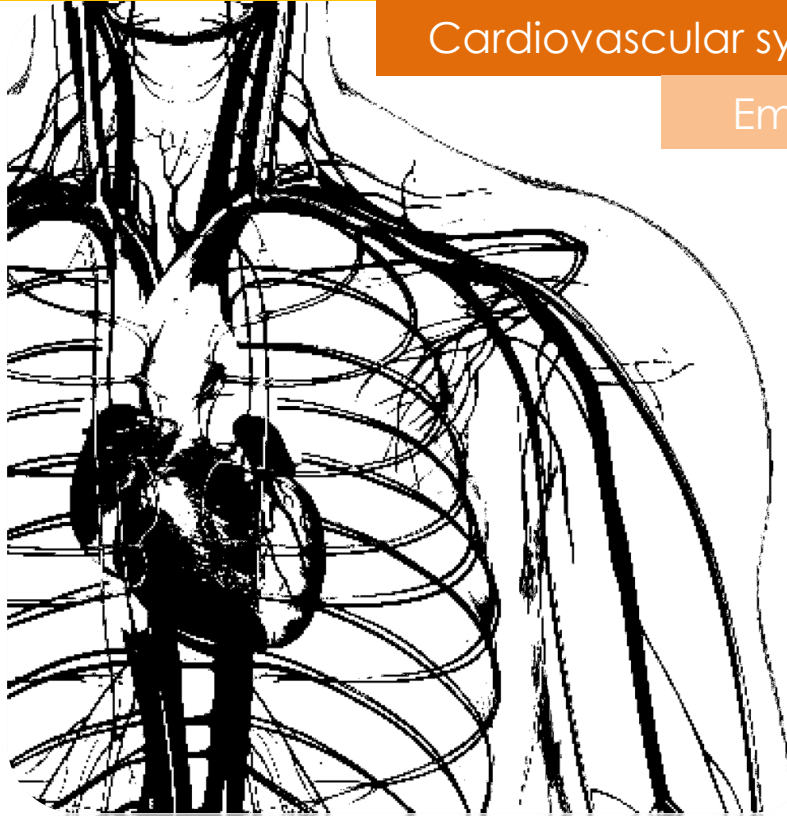


# Development of the HEART

Cardiovascular system

Embryology

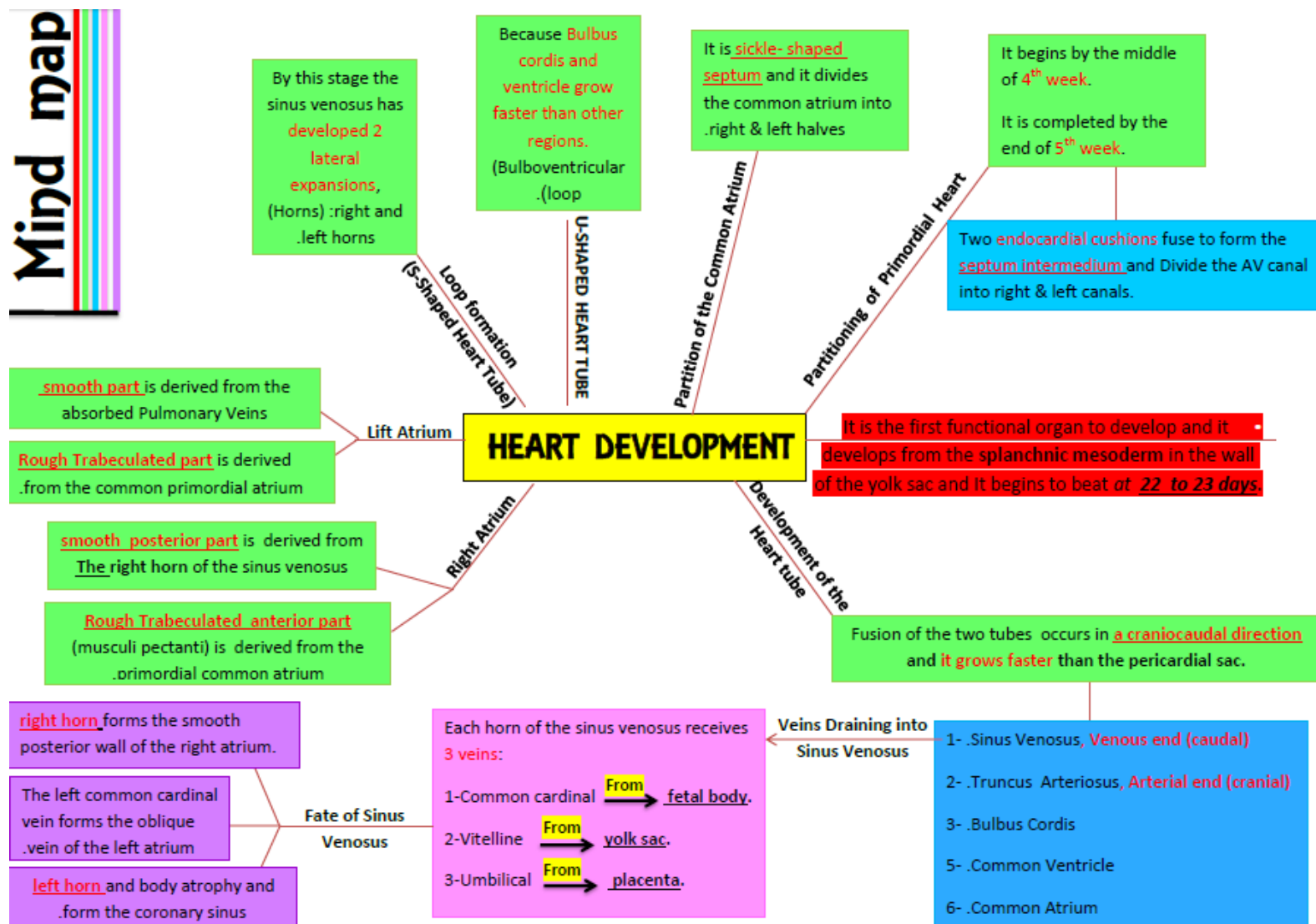


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# Objectives

## By the end of this lecture the student should be able to:

- Describe the formation, sit, union divisions of the of the heart tubes.
- Describe the formation and fate of the sinus venosus.
- Describe the partitioning of the common atrium and common ventricle.
- Describe the partitioning of the truncus arteriosus.
- List the most common cardiac anomalies.



## Formation of the heart tube

#The heart is the first functional organ to develop.

#It develops from **splanchnic mesoderm** in the wall of the yolk sac.

**Cranial to** : the developing mouth & nervous system.

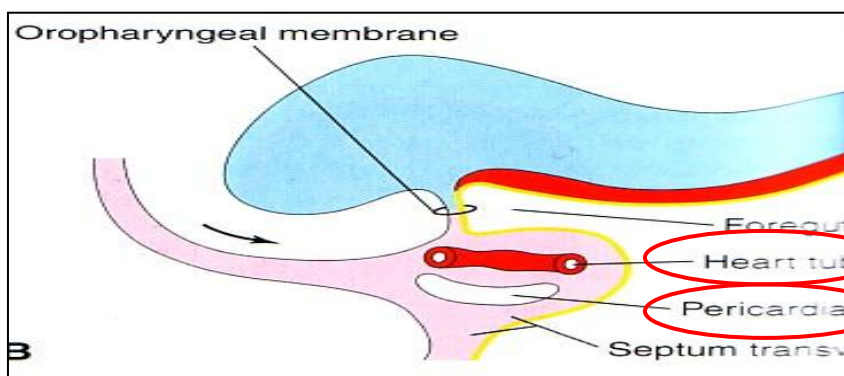
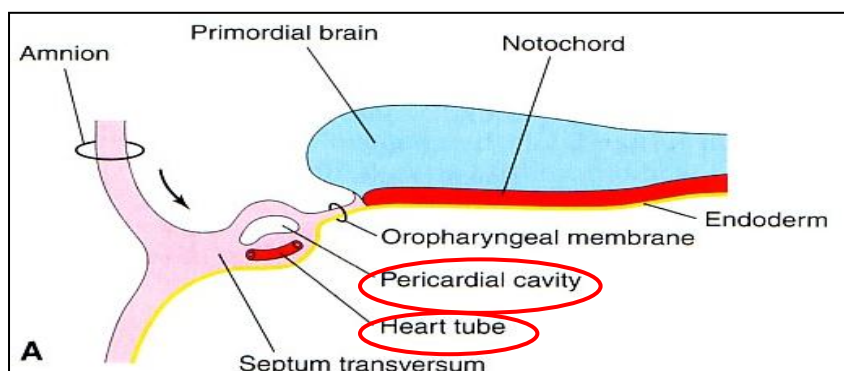
**Ventral to** : developing pericardial sac.

#The heart primordium is first evident **at 18 days** (as an angioplastic cords which soon canalize to form the 2 heart tubes)..

at this stage 2 folding are going to occur: ( Head folding & Lateral folding )

**First:** As the head folding complete : the developing heart tubes lie in the **ventral** aspect of the embryo **dorsal** to the developing pericardial sac (remember that it was on the ventral aspect before the folding ).

**Second :** After lateral folding of the embryo : the 2 heart tubes fuse together to form a single **endocardial heart tube** within the **pericardial sac**. This fusion occurs in a **craniocaudal** direction means from above to below.



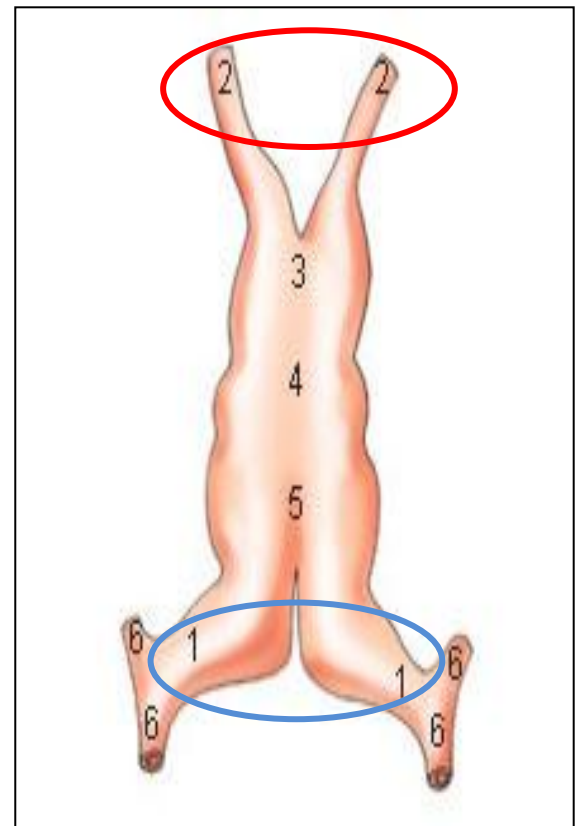
heart beats begin at	<b>22 to 23 days</b>
blood flow starts at the beginning of	<b>4<sup>th</sup> week.</b>
<b>( how can we visualize it ? By Ultrasound Doppler )</b>	

## What is the fate of the heart tube ?

The heart tube grows faster than the pericardial sac, so it shows **5 alternate dilations separated by constrictions.**

### These are:

<b>1-Sinus Venosus</b>	(most caudal – blood enter from it )
<b>2-Truncus Arteriosus</b>	(most cranial – blood flow out from it – in the future it will form the aorta and pulmonary trunk )
<b>3-Bulbus Cordis</b>	Chambers of heart
<b>4-Common Ventricle</b>	
<b>5-Common Atrium.</b>	Form rough atrium part



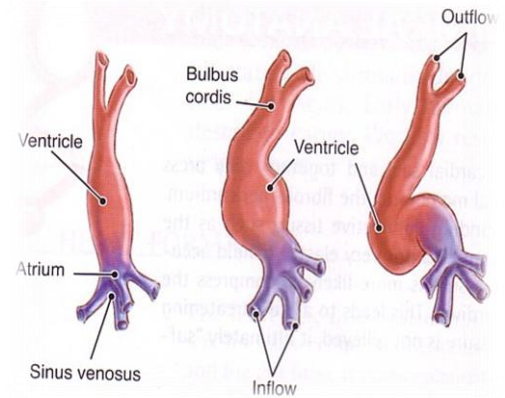
As mentioned before, The endocardial heart tube has 2 ends:

- 1. Venous end (caudal) → Sinus Venosus.**
- 2. Arterial end (cranial) → Truncus arteriosus.**

## U & S shape heart tubes

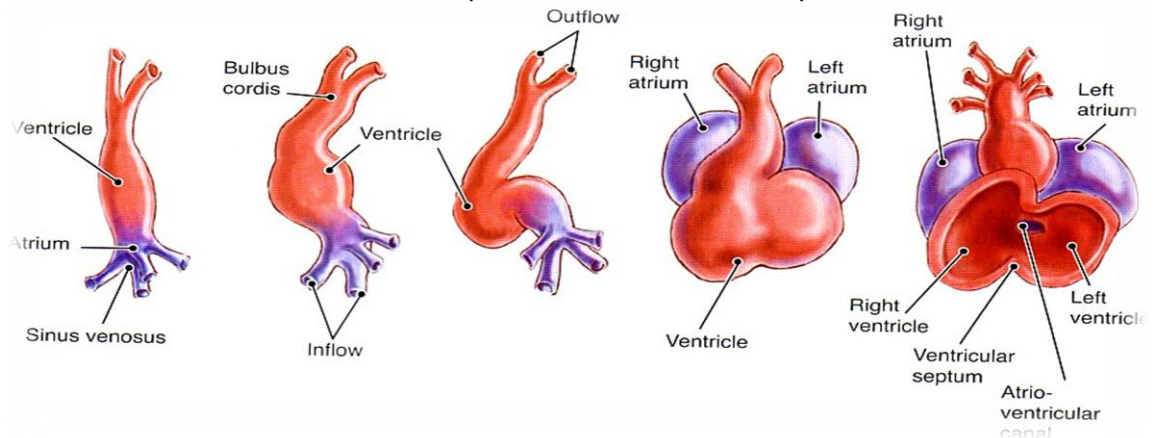
### First: U shaped heart tube

The cause of the U shape tube formation is the rapid growth of **Bulbus cordis** and **ventricle** ( number 3 & 4 ) than the other regions, So the heart Fold upon itself, forming The U-shaped heart tube (**Bulboventricular loop**)



### Second: S shaped heart tube

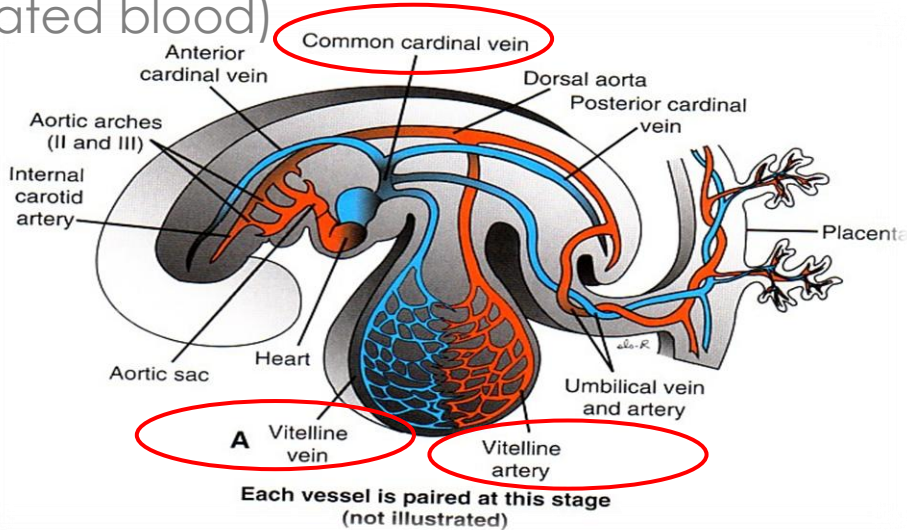
Because of the U shaped tube the the atrium and sinus venosus (number 1 & 5 ) become cranial in position & dorsal to the truncus arteriosus, bulbus cordis, and ventricle.



By this stage the sinus venosus has developed 2 lateral expansions, (Horns) : right and left horns (each horn will receive 3 veins )

#The three veins are :

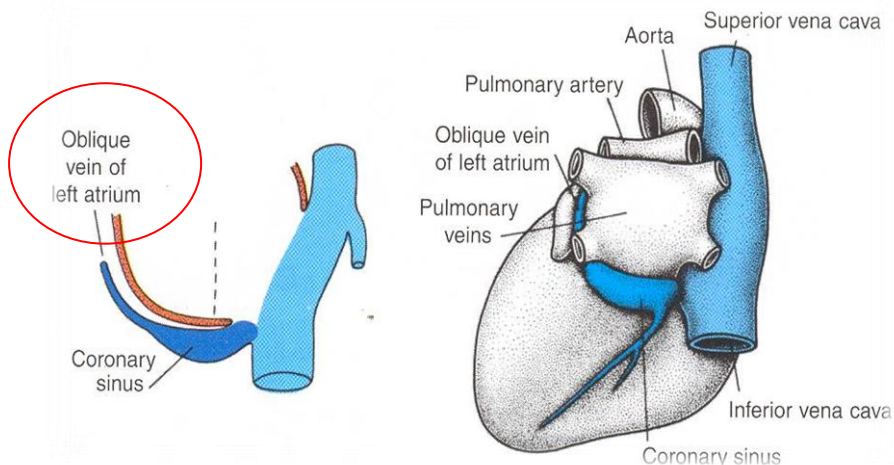
1. **Common cardinal vein** from the fetal body.
2. **Vitelline** from the yolk sac
3. **Umbilical** from the placenta. (the only vein have oxygenated blood)



## Fate of Sinus Venosus :

Each part will give rise to different structure :

right horn	<b>forms the smooth posterior wall of the right atrium.</b>
left horn and body	<b>atrophy and form the coronary sinus.</b>
left common cardinal vein	<b>forms the oblique vein of the left atrium.</b>

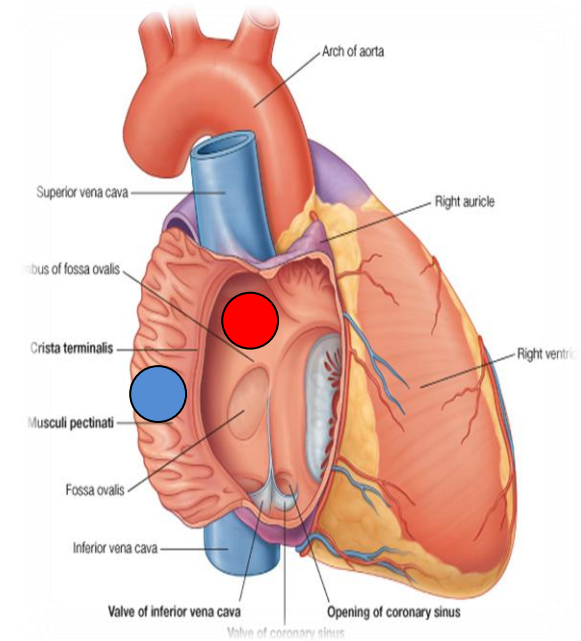


## #Right Atrium

Different parts derived from different

Previous structures :

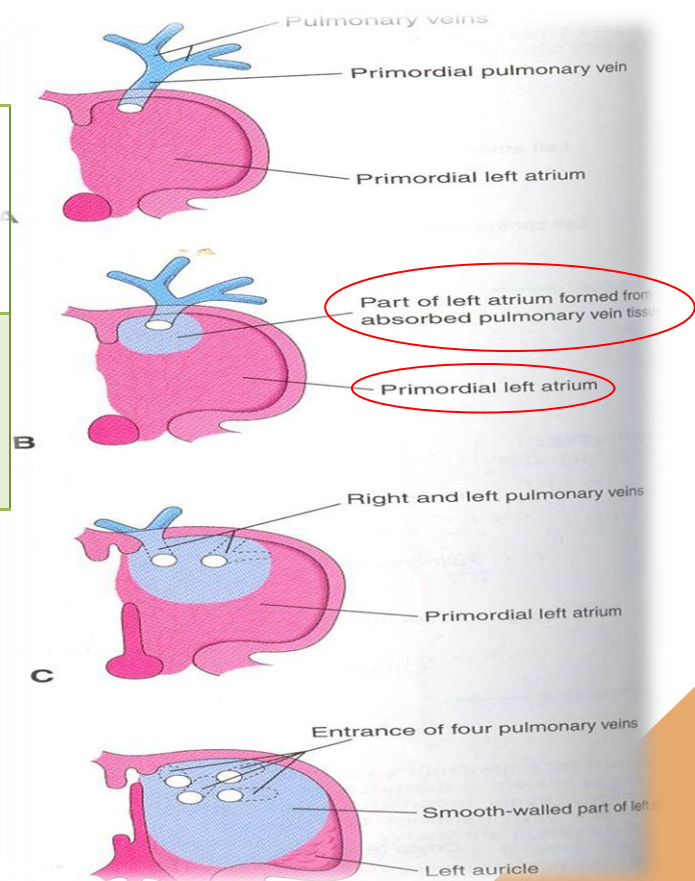
smooth posterior part of the right atrium <b>(RED CIRCLE)</b>	From the right horn of the sinus venosus
Rough Trabeculated anterior part (musculi pectanti) <b>(BLUE CIRCLE)</b>	derived from the primordial common atrium.



(These two parts are demarcated by the crista terminalis internally and sulcus terminalis externally)

## #Left Atrium

smooth part	derived from the absorbed Pulmonary Veins
Rough Trabeculated part	derived from the common primordial atrium



## #Partitioning of Primordial Heart:

The partitioning begins by the middle of **4<sup>th</sup> week**. It is completed by the end of **5<sup>th</sup> week**.

It occurs to 4 different structures :

1-Atrioventricular canal.

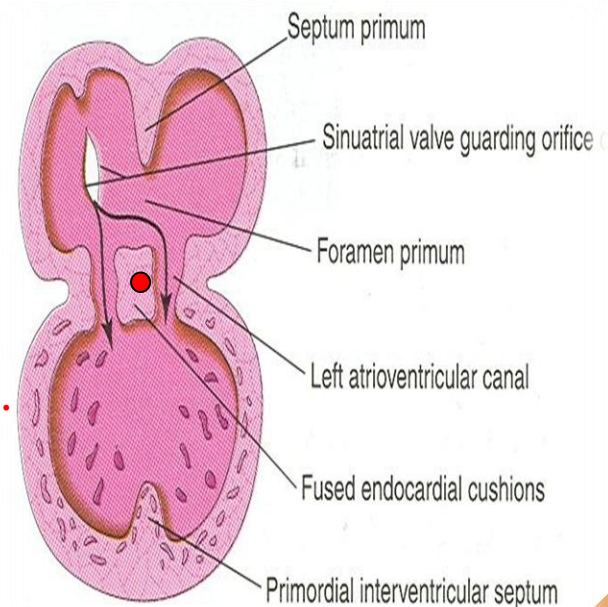
3-Common ventricle.

2-Common atrium.

4-Truncus arteriosus & Bulbus cordis.

### First : Partitioning of Atrioventricular canal :

- Two endocardial cushions are formed on the dorsal and ventral walls of the AV canal.
- The AV endocardial cushions approach each other and fuse to form the **septum intermedium (RED CIRCLE)**. Dividing the AV canal into **right & left canals (2 Arrows)**.
- These canals partially separate the primordial atrium from the ventricle.

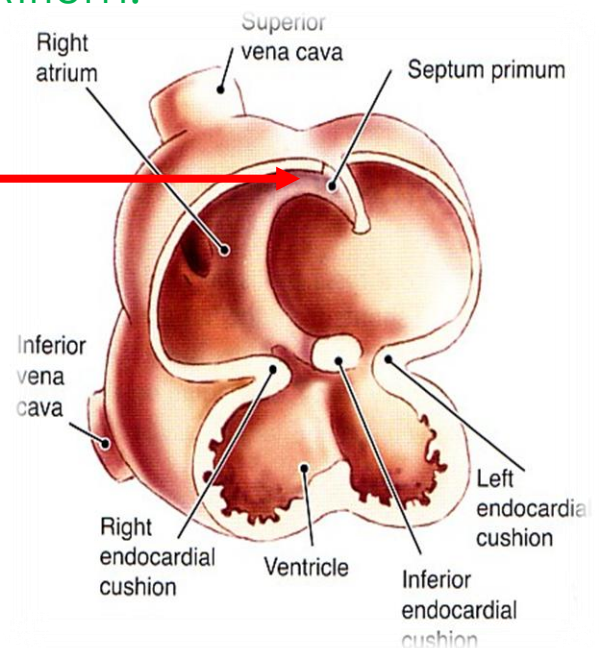




## Second: Partition of the Common Atrium:

### #Septum Primum

It is sickle-shaped septum that grows from the roof of the common atrium towards the fusing endocardial cushions (septum intermedium). So, it divides the common atrium into right & left halves.



### #Ostium Primum

- The two ends of septum primum reach to the growing endocardial cushions before its central part.
- Now the septum primum bounds (surrounds) a foramen called ostium primum.

### \*What is the function of this foramen ?

It serves as a shunt, enabling the oxygenated blood to pass from right to left atrium. \*Because the lung is not developed yet, So the pressure in the right atrium is higher than the left\*

- The ostium primum become smaller and disappears as the septum primum fuses completely with the septum intermedium to form the AV septum.

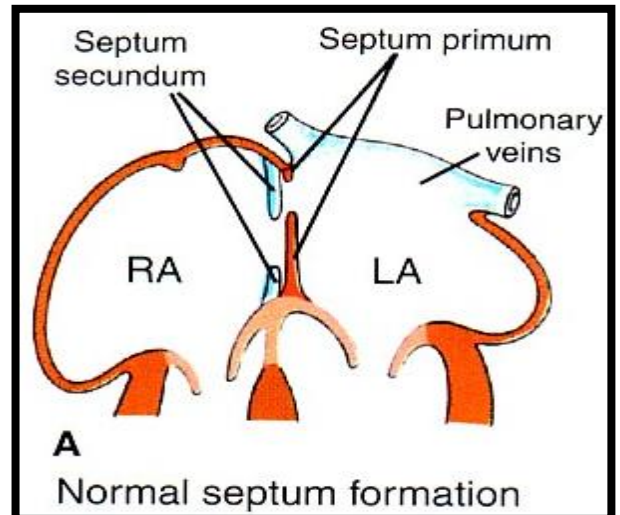
Note : THE PARTITION = SEPTUM PRIMUM,  
THE FORAMEN = OSTIUM PRIMUM.

## #Septum Secundum

On the upper part of **septum primum** ( The previous partition ) a small openings are

seen and fuse together to form an opening called **Ostium**

**secundum**. This foramen has a specific septum called **septum secundum** ( it descends to the right side of septum primum).



-It forms an **incomplete** partition between the two atria.

- Consequently a valvular oval foramen forms, (**foramen ovale**).

### What is the fate of this Foramen ovale ?

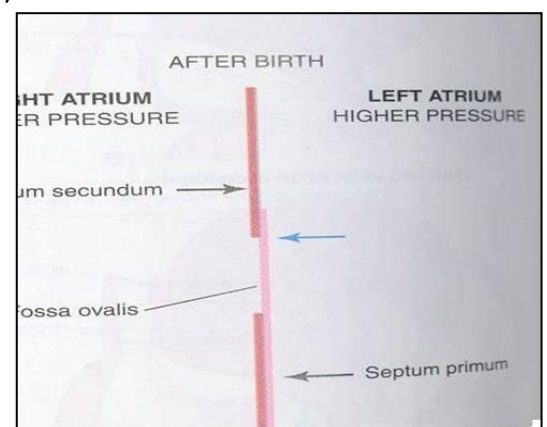
-At birth when the lung circulation begins, **the pressure in the left atrium increases.**

-The valve of the foramen ovale is pressed against the septum secundum and obliterates the foramen ovale.

-Its site is represented by the **Fossa Ovalis**

-Its **floor** represents the persistent part of the septum primum.

-Its **limbus** (anulus) is the lower edge of the septum secundum.



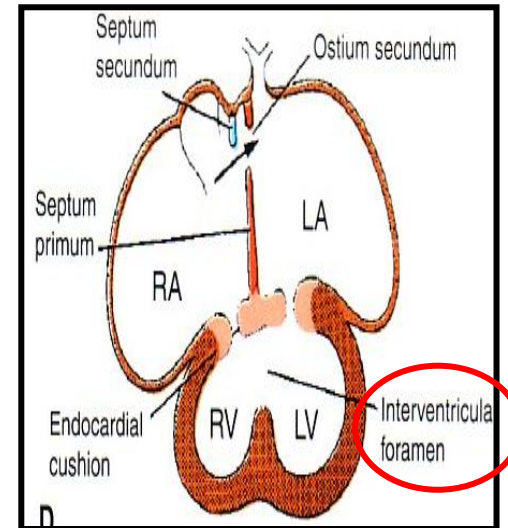
### Third: Partitioning of Primordial Ventricle

The interventricular is divided into (muscular part and membranous part).

#### #The Muscular part :

-Division of the primordial ventricle is first indicated by a median muscular ridge, the primordial interventricular septum.

-It is a thick crescentic fold which has a concave upper free edge.



-This septum bounds a temporary connection between the two ventricles called **Interventricular foramen** (Because the muscular part can't reach to the cushions).

#### #The Membranous part

It is derived from 3 parts :

- 1- A tissue extension from the right side of the endocardial cushion.
- 2- Aorticopulmonary septum.
- 3- Thick muscular part of the IV septum.

### Fourth: Spiral Aorticopulmonary Septum

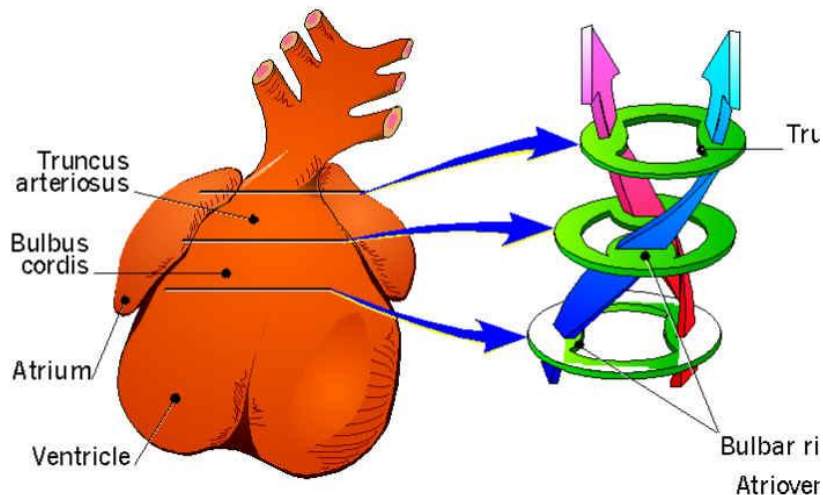
A spiral septum develops in the **truncus arteriosus** (number 2 before) dividing it into **aorta and pulmonary trunk** \*that's why it is called Aorticopulmonary septum\*

- The septum deviates in the **lower part** of the T A to **Right**
- It deviates in the **middle part Horizontally** (dividing TA into anterior & posterior parts).
- It deviates in the **upper part** of the TA into **Left**

This explains the origin of pulmonary trunk from right ventricle and aorta from left ventricle.

To summarize the course of this septum we can say the it divides the upper and lower part vertically (Right & Left)

And the middle part horizontally ( Anterior and posterior).



## #BULBUS CORDIS

The bulbus cordis forms **the smooth upper part of the two ventricles.**

### Right Ventricle:

Conus Arteriosus or (Infundibulum) which leads to the pulmonary trunk.

### Left ventricle:

Aortic Vestibule leading to ascending aorta.

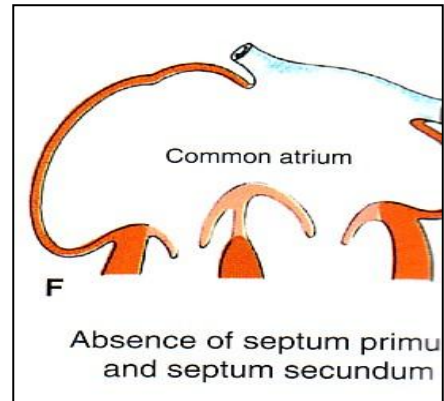
## ~~~ MAJOR CARDIAC ANOMALIES ~~~

We will study 5 anomalies :

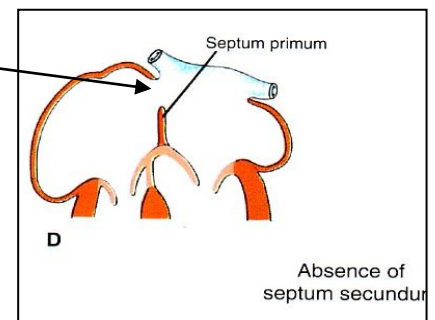
### # First anomaly : ( ASD ) Atrial Septal Defects :-

It has 4 types :

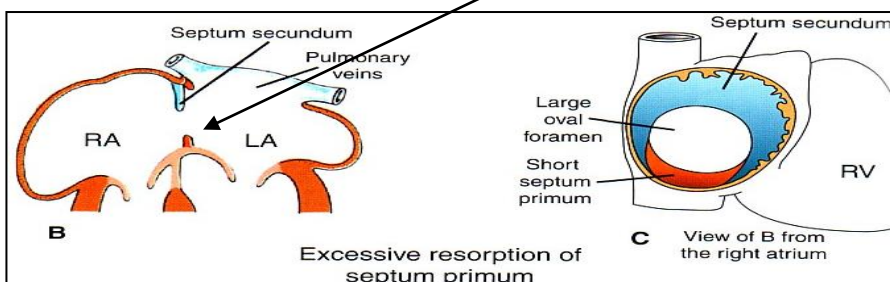
1 : common atrium : which is Absence of both **septum primum** and **septum secundum** .



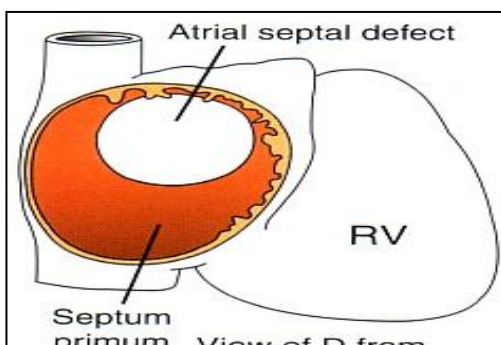
2 : Absence of Septum **Secundum** •



3 : Large foramen ovale : caused by **Excessive resorption** of **septum primum** .



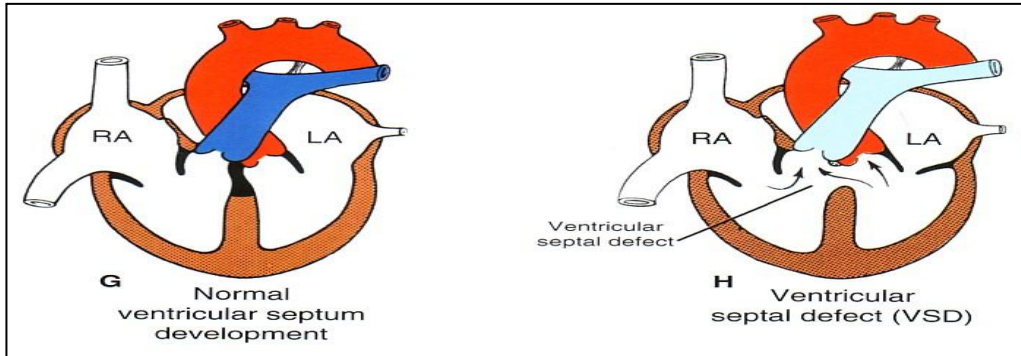
4 : Patent foramen ovale : (NO CLOSING OF FORAMEN OVALE ... COULD BE ASYMPTOMATIC )



## #SECOND anomaly: **(VSD) VENTRICULAR SEPTAL DEFECT** :-

**Roger's Disease** : It is **absence** of the **membranous** part of intraventricular septum ( this mean **persistent IV foramen** )

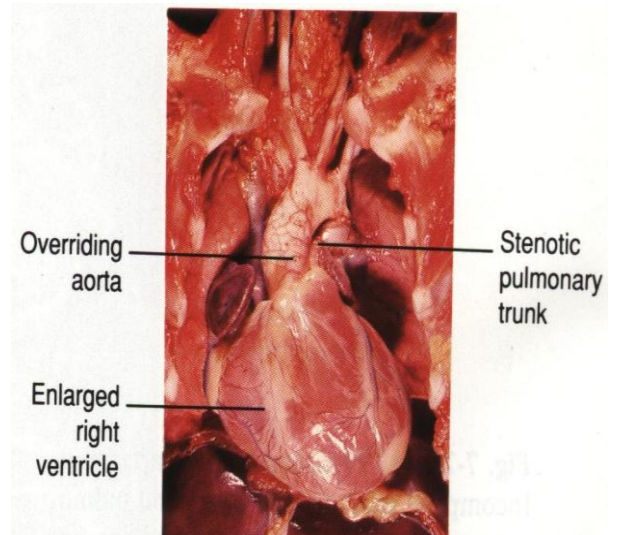
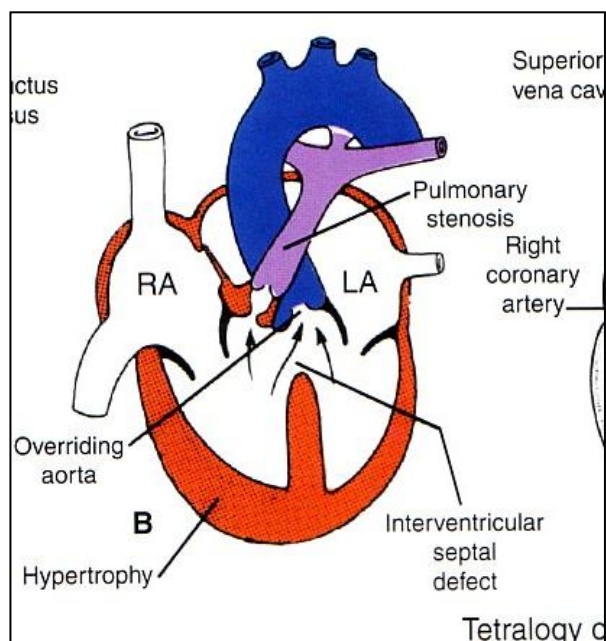
~ usually accompanied with other cardiac defects .



## #Third anomaly : **TETRALOGY OF FALLOT** :- (tetralogy : complex of four symptoms ) **((Blue Baby ))**.

The four symptoms are :

- 1-VSD
- 2- Pulmonary stenosis .
- 3-Overriding of the aorta
- 4- Right ventricular hypertrophy.

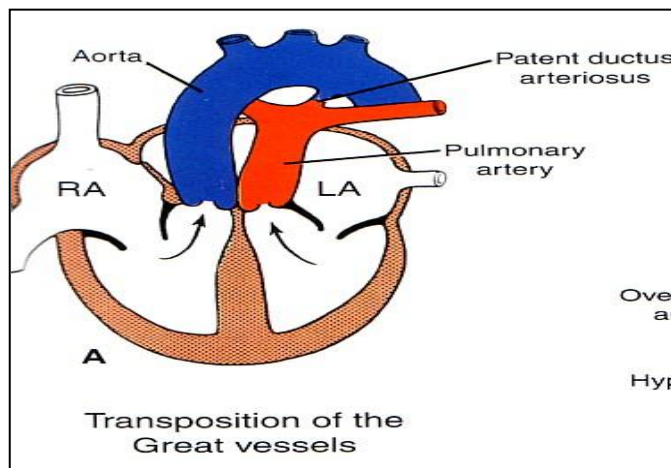


## # Fourth anomaly : (TGA) TRANSPOSITION OF GREAT ARTERIES((Blue Baby )) .

TGA is due to **abnormal rotation** or **malformation** of the **aorticopulmonary septum**, so the **right** ventricle joins the **aorta**, while the **left** ventricle joins the pulmonary **artery** .

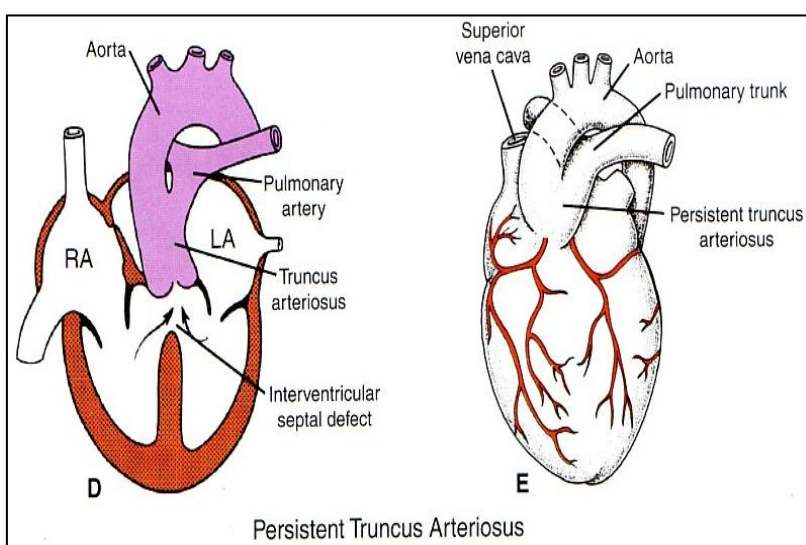
~ It is One of the most common causes of cyanotic heart disease in the newborn.

~ Often associated with **ASD** or **VSD**. If not ... baby will die . ( here **ASD** and **VSD** useful for baby why ? because it help in mixing oxygenated blood with non oxygenated )



## # Fifth anomaly : Persistent Truncus Arteriosus :-

- It is due to **failure** of the development of **aorticopulmonary (spiral) septum** .
- It is usually accompanied with **VSD** .



## Summary

EVENT	DATE
Heart primordium	<u>18 days</u>
Heart start to beat	<u>22-23 days</u>
Blood flow	during the <u>beginning of the_ fourth week</u>
<p><u>Partitioning of:</u></p> <ol style="list-style-type: none"> <li>1- Atrioventricular canal.</li> <li>2- Common atrium.</li> <li>3- Common ventricle.</li> <li>4- Truncus arteriosus &amp; Bulbus cordis</li> </ol>	<p>It begins by the <u>middle of 4th week.</u> It is completed by <u>the end of 5th week.</u></p>
The ostium primum become smaller and disappears	When the <u>septum primum fuses completely with the septum intermedium</u> to form the AV septum.
Fate of foramen Ovale	<u>At birth</u> when the lung circulation begins and the pressure in the left atrium increases.



- The heart is the first functional organ to develop. It develops from splanchnic mesoderm.
- After lateral folding of the embryo the **2 heart tubes** fuse together to form a single endocardial heart tube.
- The endocardial heart tube has 2 ends: Venous end (Sinus Venosus) and Arterial end (Truncus arteriosus).
- **S-Shaped Heart Tube:**
  - \* The atrium and sinus venosus become cranial in position.
  - \* The sinus venosus has developed 2 lateral expansions, (Horns): right and left horns.
- The **right horn** forms the **smooth posterior wall** of the right atrium.
- The **left horn and body** atrophy and form the **coronary sinus**.
- The **atrioventricular canals** partially separate the **primordial atrium from the ventricle**.
- The Septum Primum divides the **common atrium into right & left halves**.
- The **two atria** are separated by incomplete two septums: Septum Primum and Septum Secundum. They form an incomplete partition between the atria, this result in the formation of Foramen Ovale
- Before birth, foramen ovale allows the blood to pass from **the right to the left atrium**.
- At birth when the lung circulation begins, the pressure in the **left atrium increases resulting in closure of the foramen ovale**.
- There is five major anomalies : 1- ASD . 2-VSD. 3- tetralogy of fallot. 4- TGA. 5-presistent truncus artriosus .

## MCQs :

1\*The heart primordium is first evident at:

- A.17 days    B.18 days    C.22-23 days    D.24 days

2\*Blood flow begins during:

- A. beginning of the 4'th week    B.End of the 4'th week  
C.Middle of the 4'th week

3\* Fusion of the two heart tubes occurs in ..... direction :

- A. ventrolateral    B. Bilateral    C. craniocaudal

4\*the Vitelline vien drain into Sinus Venosus from .....?

- A. fetal body    B.placenta    C.yolk sac

5\*(musculi pectanti) of the right atrium is derived from:

- A. primordial common atrium.    B. The right horn of the sinus venosus    C. Pulmonary Veins

6\*The AV endocardial cushions approach each other and fuse to form:

- A. Septum Primum    B. septum intermedium    C. ostium

7\*.....forms an incomplete partition between the two atria:

- A. Septum Secundum    B. ostium secundum    C. foramen ovale

8\* which one forms the smooth posterior wall of right atrium.

- A. left horn    B. right horn    C. left common cardinal

9\*the smooth part of left atrium derived from :

- A. common primordial atrium B. pulmonary artery C. absorbed part of pulmonary vein .

10\*In what anomaly you can find absence of septum primum and secundum :

- A. patent foramen oval B. large foramen oval C. common atrium

11\*In case of large foramen oval you find :

- A. absence of septum primum B. excessive resorption of septum primum C. excessive resorption of septum secundum

12\*which one of the following anomalies can be Asymptomatic :

- A. patent foramen oval B. large foramen oval C.TGA

13\*In case of VSD (Roger's disease) Mostly absence of :

- A. muscular part of IV septum B. membranous part of IV septum C. both A and B

14\*the fallot's tetralogy is formed of pulmonary stenosis +overriding of aorta and:

- A. VSD + ASD B. right atrium hypertrophy +VSD C. right ventricular hypertrophy + VSD

15\* TGA is due to aorticopulmonary septum :

- A. failure of development    B. abnormal rotation and formation  
C. hypertrophy

Ans.

1.B 2.A 3.C 4.C 5.A 6.B 7.A 8.B  
9.C 10.C 11.B 12.A 13.B 14.C 15.B

YouTube Videos :

<http://www.youtube.com/watch?v=5DIUk9IXUal>

<http://www.youtube.com/watch?v=OArR67aFze0>

This work is done by :

Abdulhameed Saeed Alghamdi

Rawan Alotaibi

Sara Alseneidi

Amani Alotaibi

Baraah Alqarni

Noura Alnajashi