NCER
Module 2:
Cardiac Embryology

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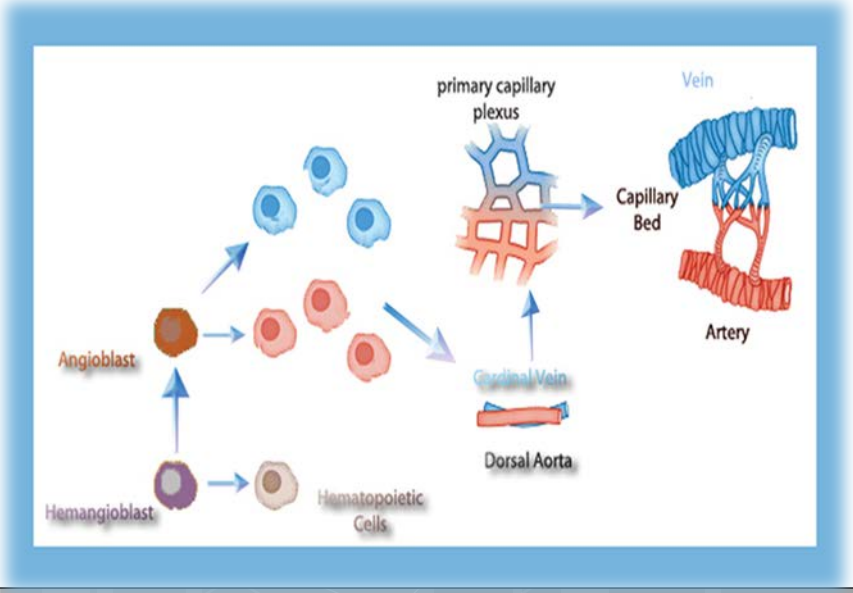
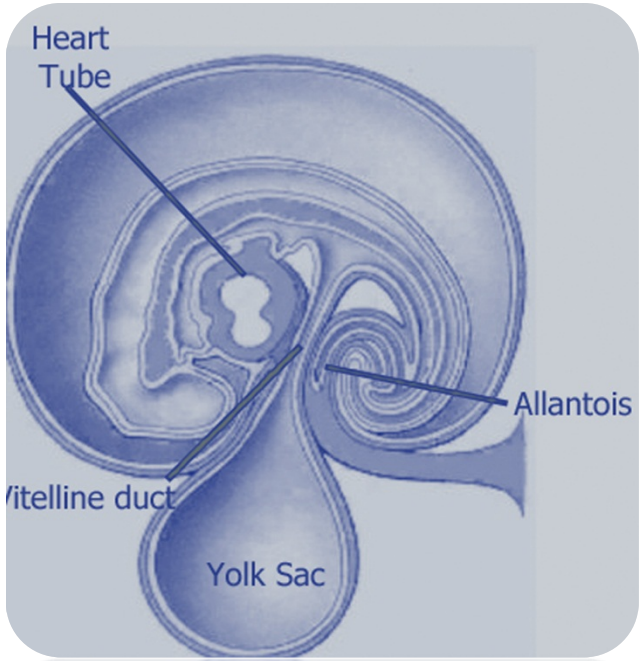
Objectives

- Define embryologic formation of the heart
- Identify normal fetal hart anatomy
- Describe fetal cardiac circulation
- Describe the timeline of fetal heart development

Cellular Terminology

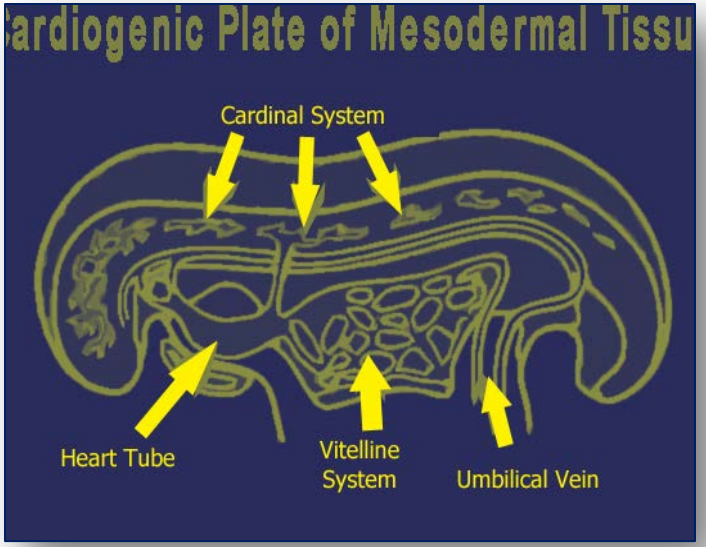
- Development of the Vascular System
- Hemangioblasts
  - Endothelial cells
  - Hematopoietic cells





Cellular Terminology

- Erythrocytes
  - Produced in the yolk sac
    - Enter blood stream before the heart tube is formed

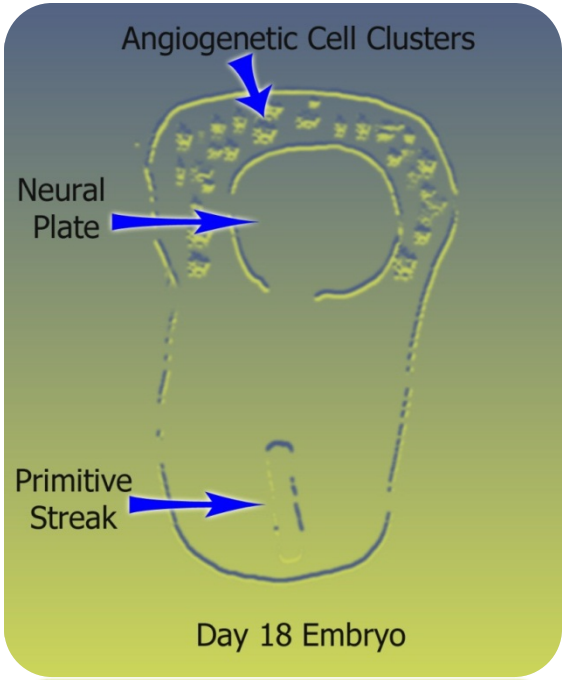


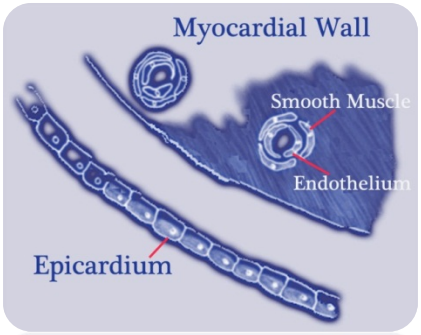
Embryonic Crests

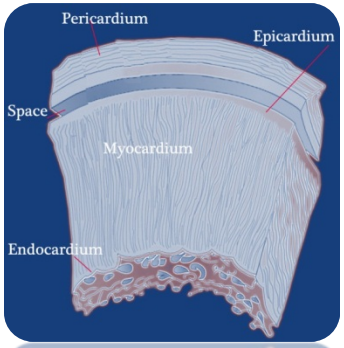
- Clusters of angiogenic cells
  - Form heart tubes
    - Eventually merge to form one heart tube

Primitive Vascular Tube

- Angioblastic cords
  - Consists of three layers:
    - Epicardium
    - Myocardium
    - Endocardium

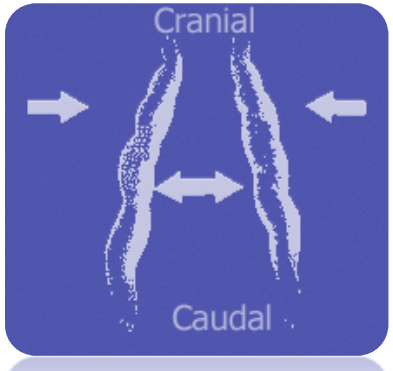


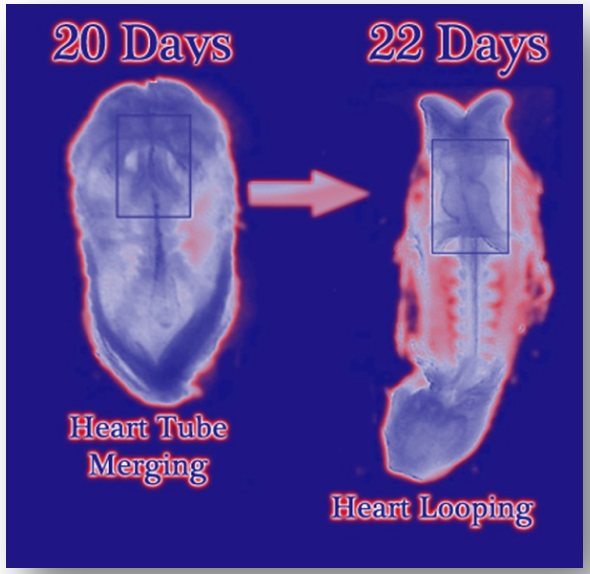




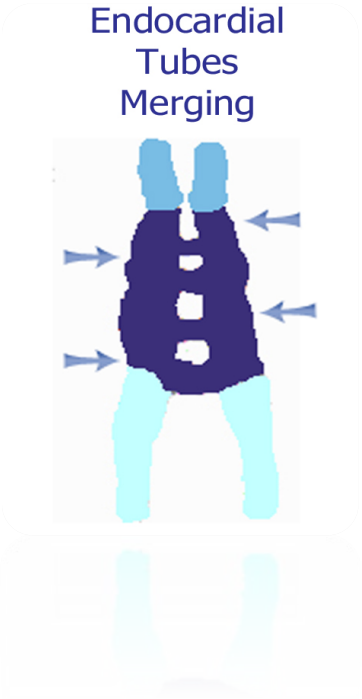
Primitive Vascular Tube

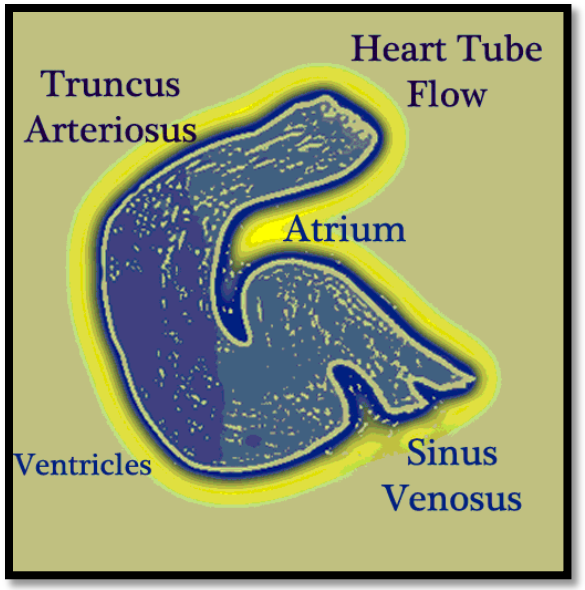
- Angioblastic cords
  - Paired tubes formed by the end of the 22nd day
- Fuse together to become Heart Tube

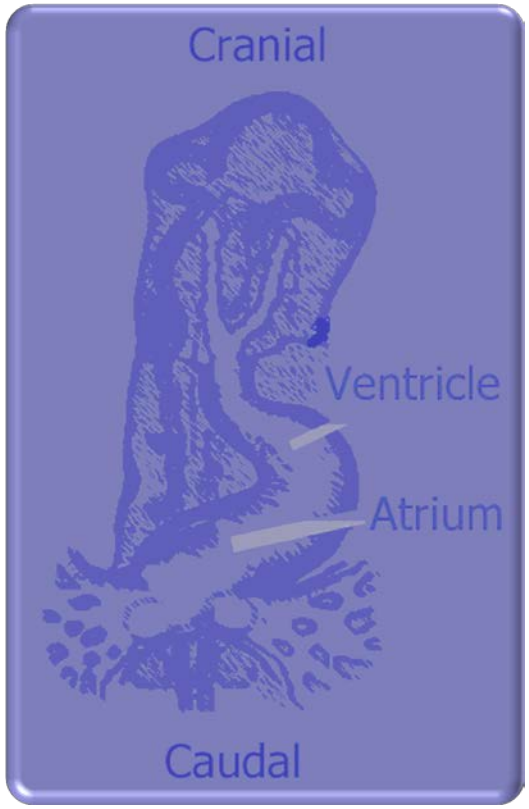




Angiogenic Cords=Heart Tube





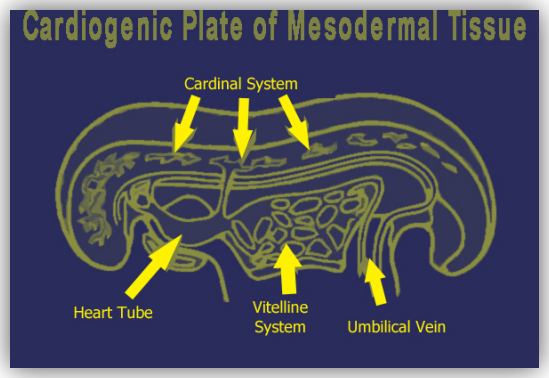


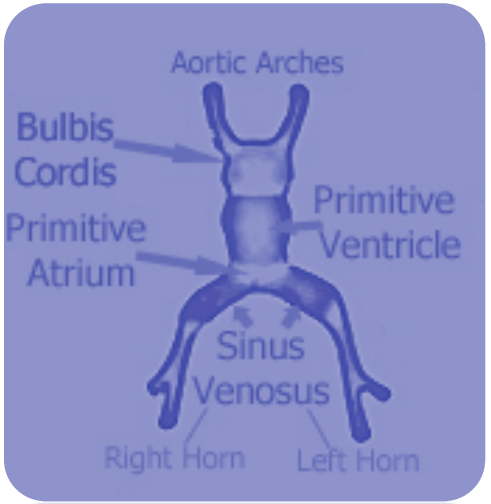
Original Arterial Supply

Inflow into the tube

Outflow through the primitive aortic arches

Venous Drainage

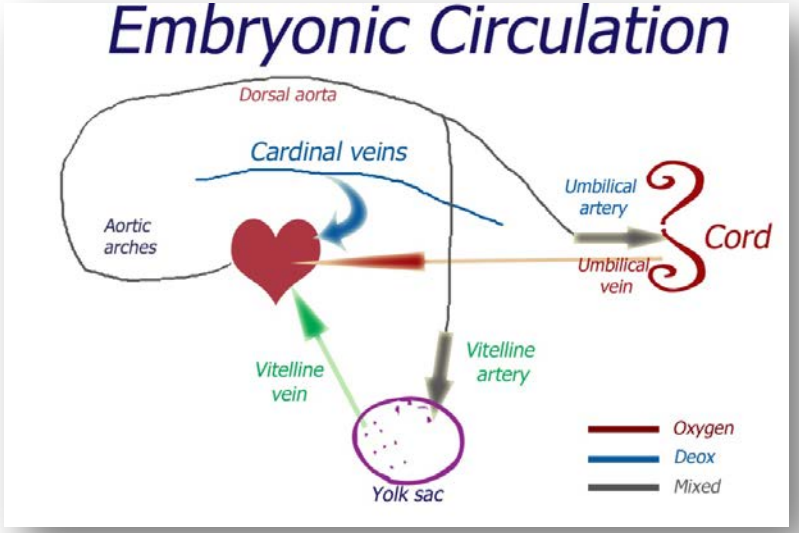


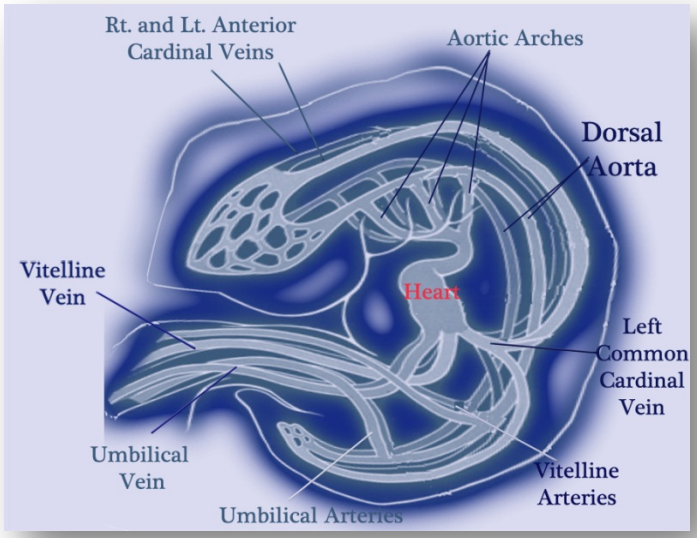


- Sinus venosus
  - Confluence of veins draining the yolk sac, chorion and embryo
    - Umbilical veins
    - Vitelline veins
    - Cardinal veins

Original Vascular Circuit

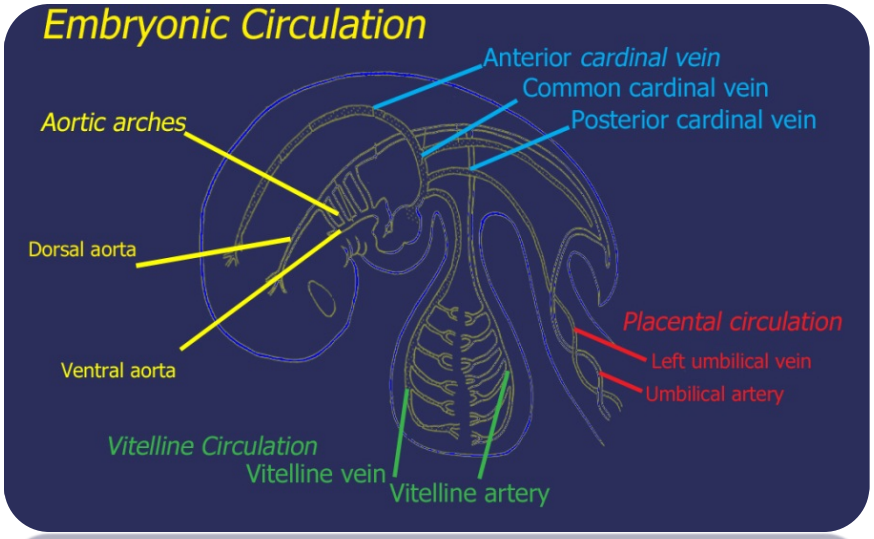
- Embryonic
  - Dorsal aorta
  - Cardinal veins
- Two extraembryonic
  - Vitelline
  - Umbilical

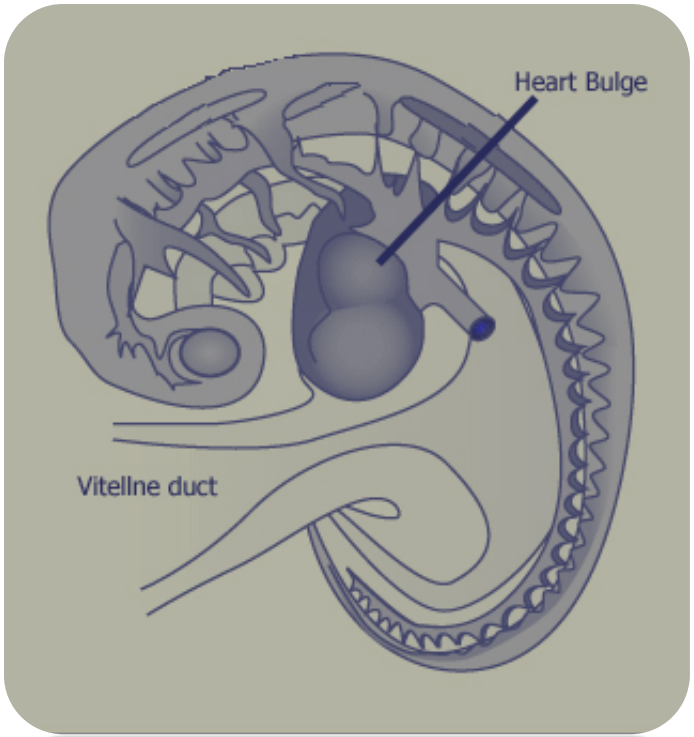




Venous Drainage

- Cardinal veins
  - Main venous drainage
  - Superior and anterior
    - Head region
  - Inferior and posterior
    - Lower half of body
- Empty into sinus venosus



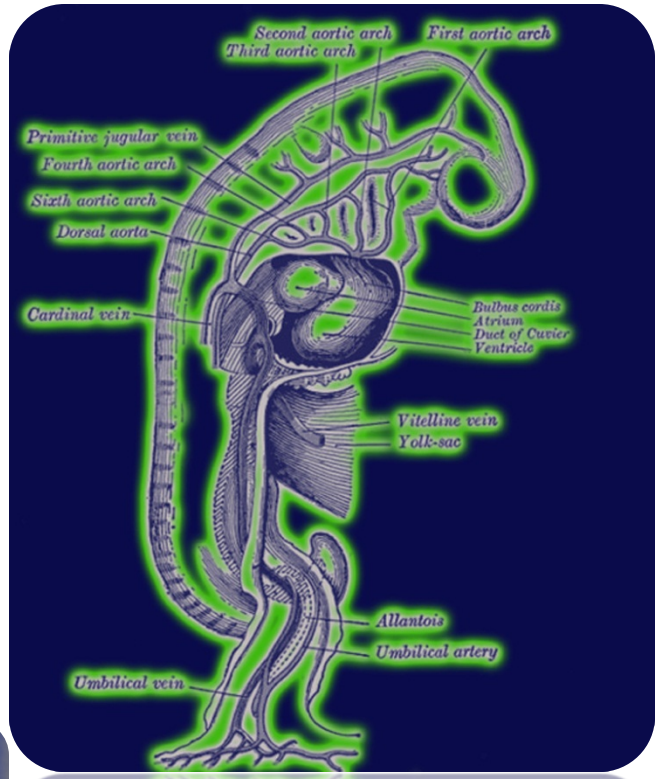


- Vitelline veins
  - Drains deoxygenated blood back to the yolk sac
  - Develop into portal system

Venous Drainage

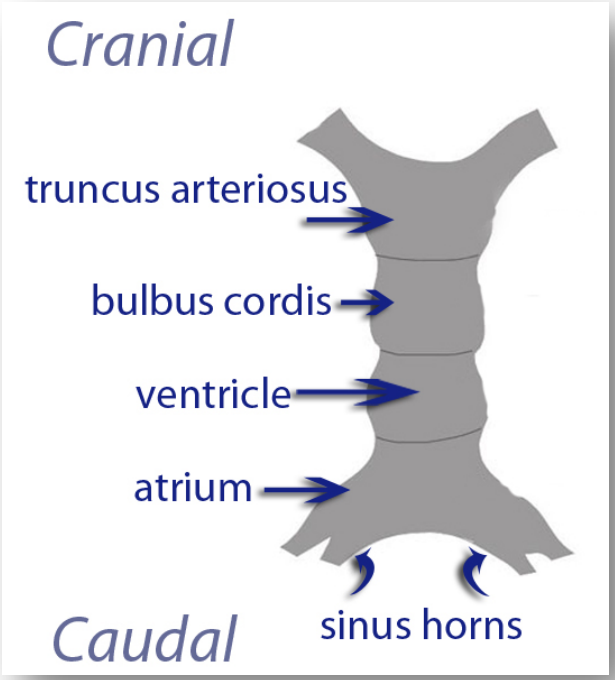
Venous Drainage

- Umbilical veins
  - Right umbilical vein regresses
  - Left carries highly oxygenated blood to the liver
  - Ductus venosus
    - Bypasses sinusoids of liver to allow oxygenated blood to enter right atrium



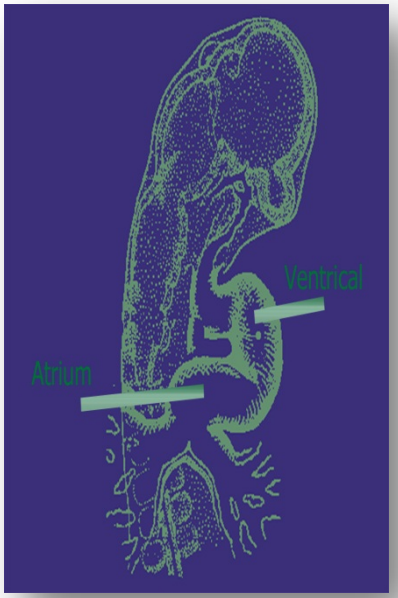
Regions of the Heart Tube

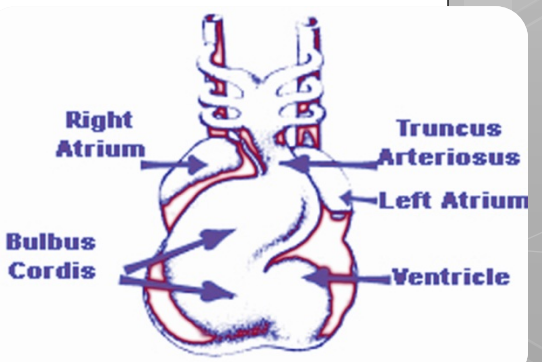
- Five distinct regions present:
  - Sinus Venosus
  - Primitive atrium
  - Primitive ventricle
  - Bulbus cordis
  - Truncus arteriosus



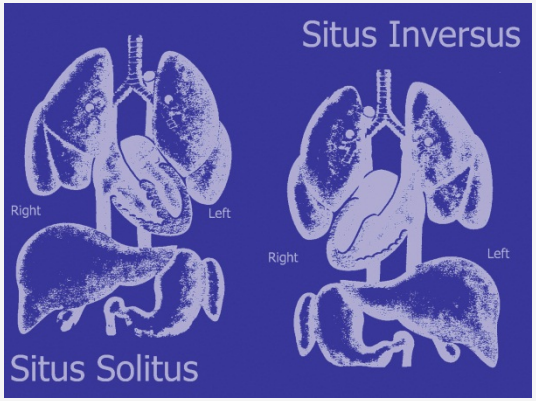
Formation of the Atrioventricular Cardiac Loop

- Rapid growth of heart tube
  - Bends into a U-shaped loop
  - Atria and ventricle shifted to left and dorsally
  - Sinus venosus shifts to the left and dorsally



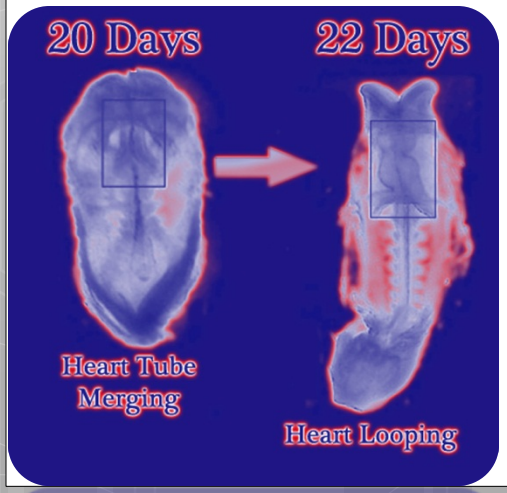


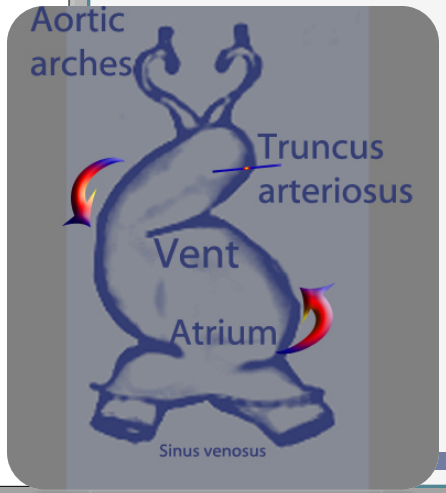
- Bulboventricular Loop
  - D-Looping or dextrolooping
    - Cephalic portion bends ventrally and to the right

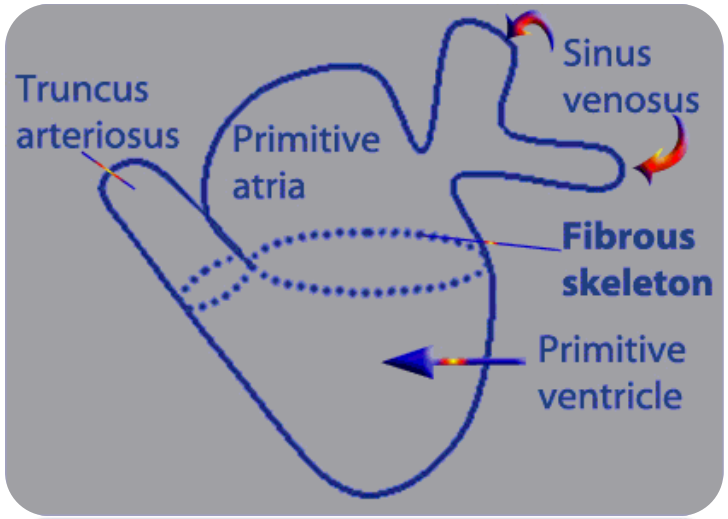


Left to right identity

Situs Solitus





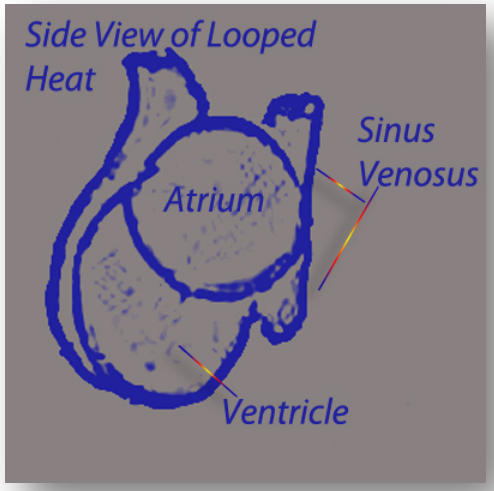


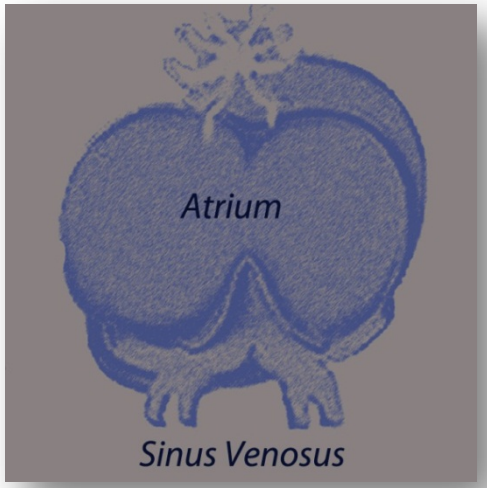
Early Cardiac Flow

- Sinus Venosus
- Primitive Atria
- Atrioventricular Canal
- Primitive Ventricle
- Truncus Arteriosus

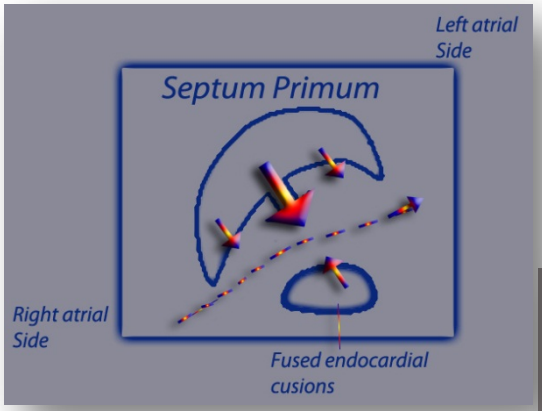
Primitive Atria

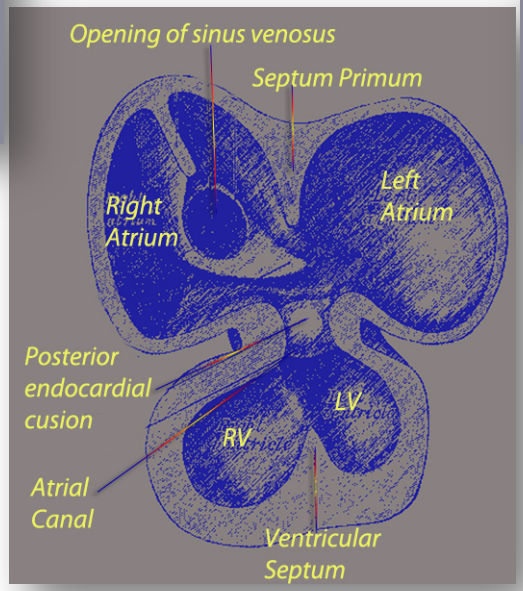
- Initial common atria formed
  - Right and left segments of sinus venosus
    - Superior portion of the atrial septum

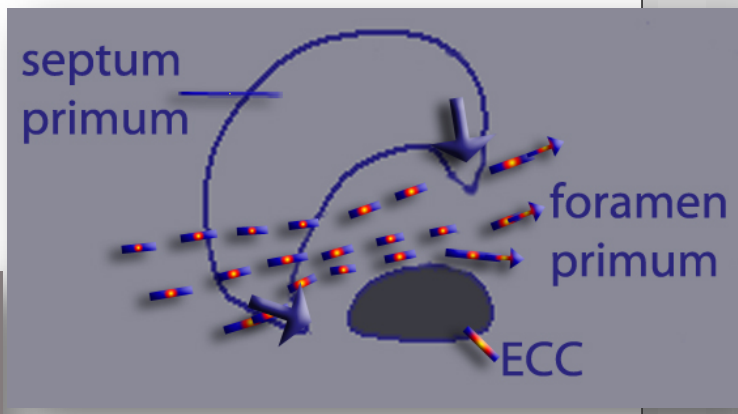




- Septum primum
  - Inferior portion
  - Near endocardial cushions



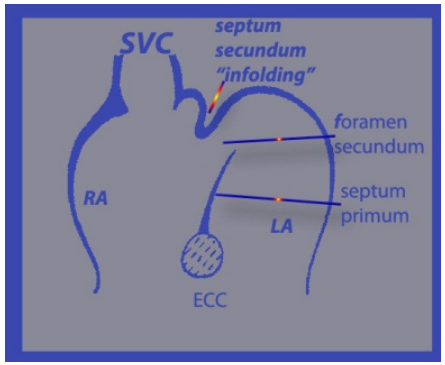


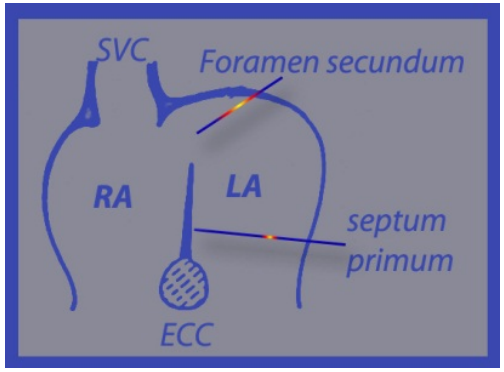


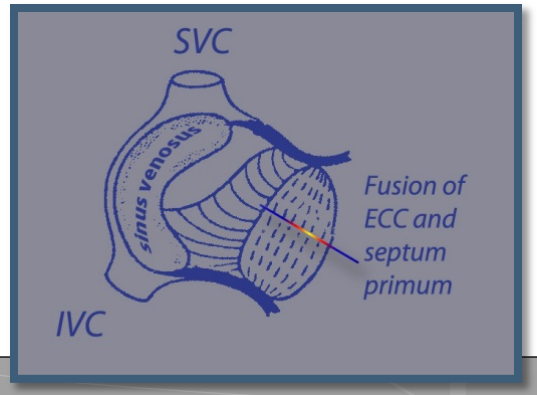
Atrial Septation

Atrial Formation

- Septum secundum-
  - Forms just to the right of septum primum
    - Lower border represents foramen ovale
      - Mid portion of the atrial septum







Atrial Formation

- Initial common atria formed
  - Right and left segments of sinus venosus
    - Superior portion of the atrial septum
  - Septum primum
    - Inferior portion
    - Near endocardial cushions
  - Septum secundum-just to the right of septum primum
    - Lower border represents foramen ovale
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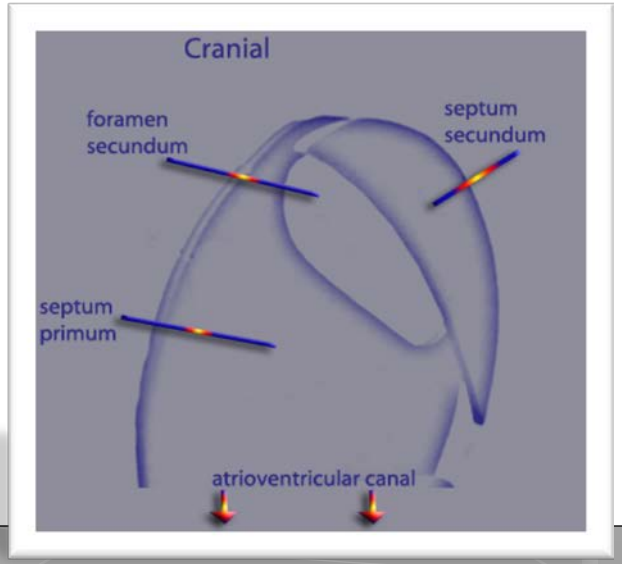
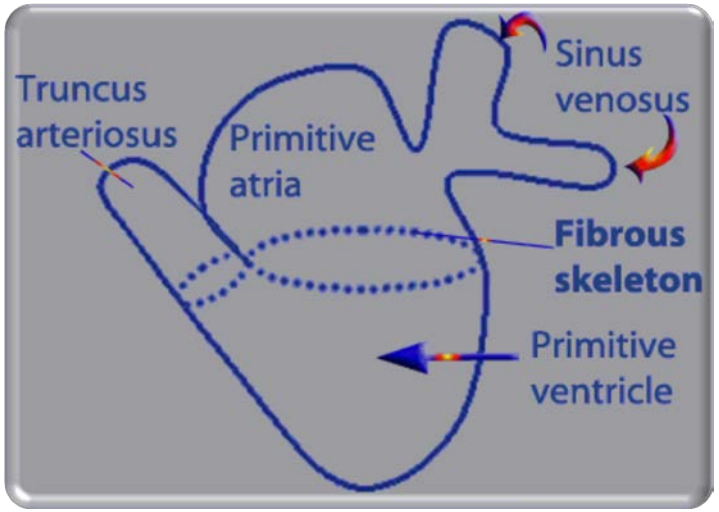
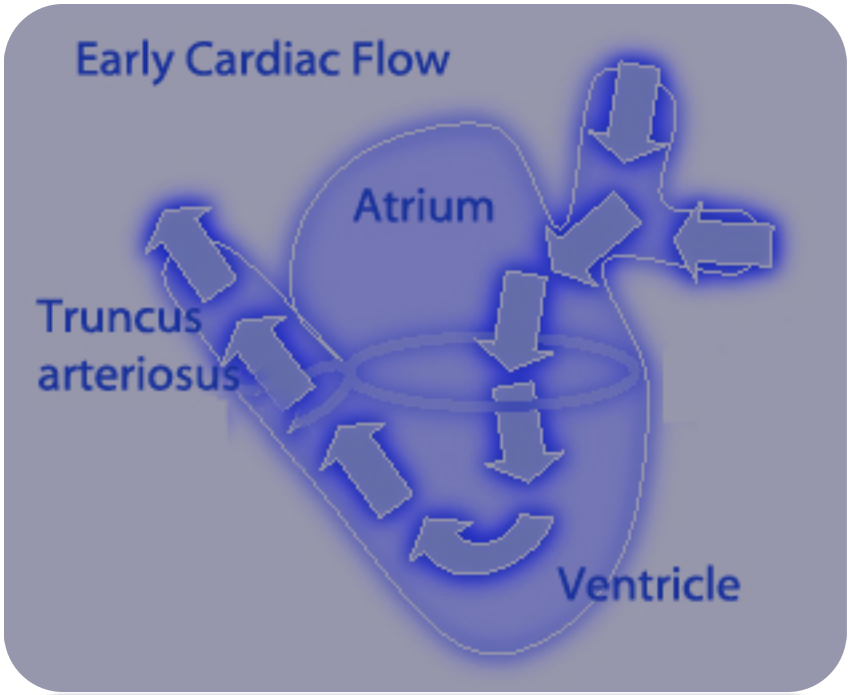


Partition of the Atrioventricular Canal

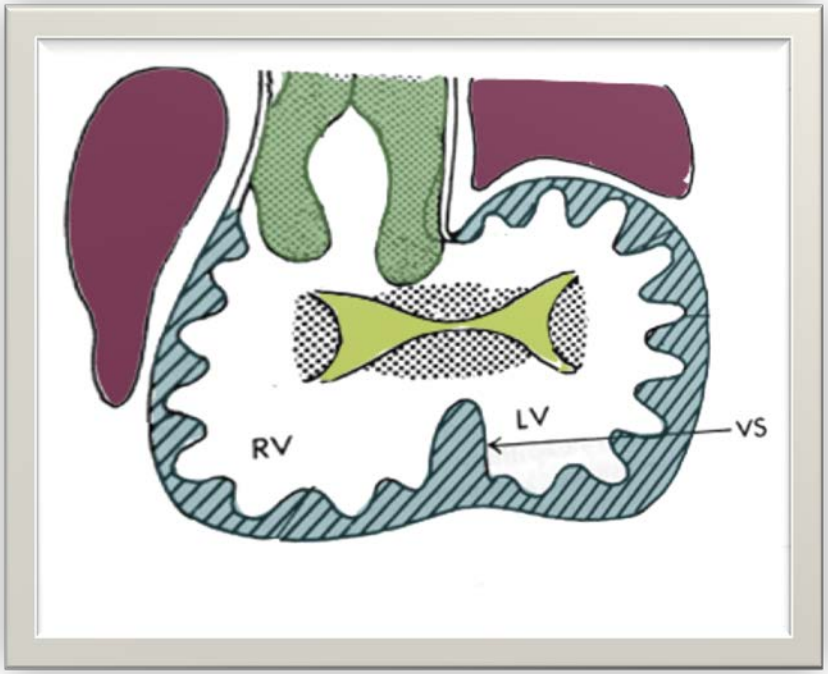
- Begins as a common atrioventricular canal
  - Single channel

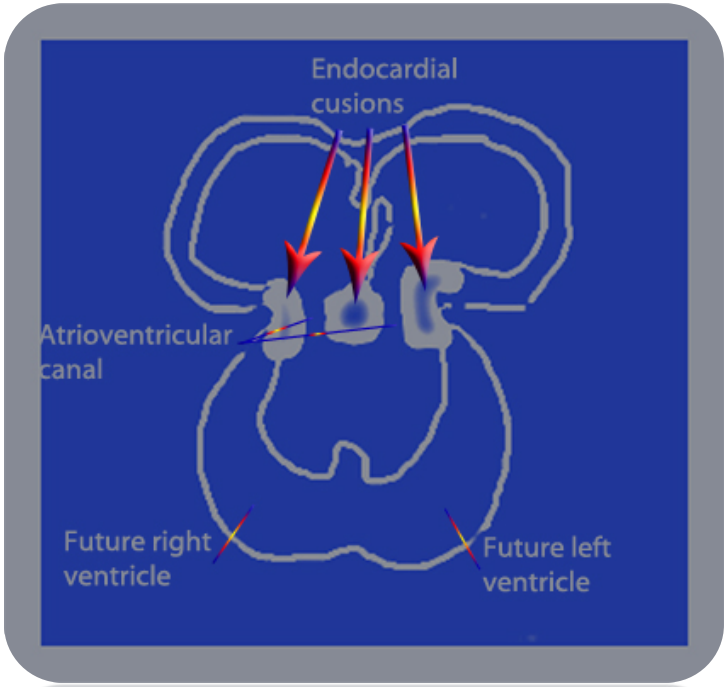




Partition of the Atrioventricular Canal

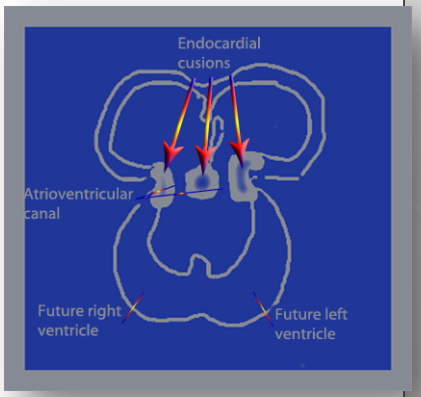
- Endocardial tissues develop
  - During the sixth week
  - Form the right and left atrioventricular canals

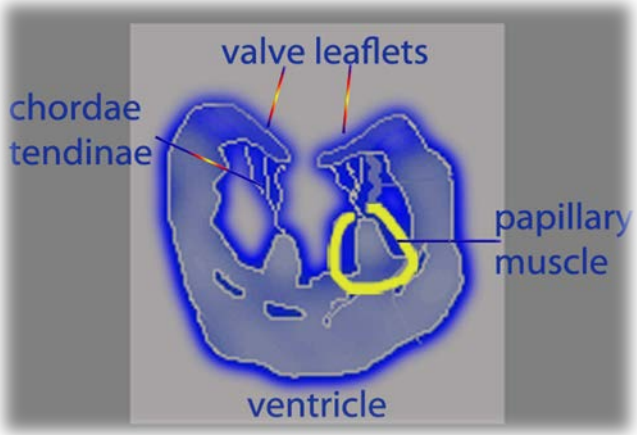




Atrioventricular Canal

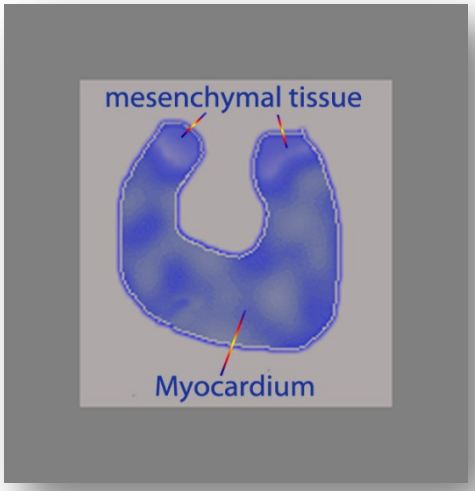
- Connect common atrium to embryonic ventricles
- Endocardial cushions
  - Dorsal and ventral walls
    - As they move closer, begin to define the atrium from the ventricle
  - Develop and function as the atrioventricular valves
    - Mitral valve
    - Tricuspid valve

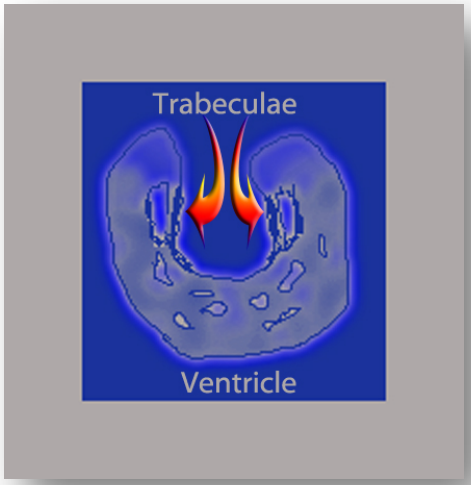


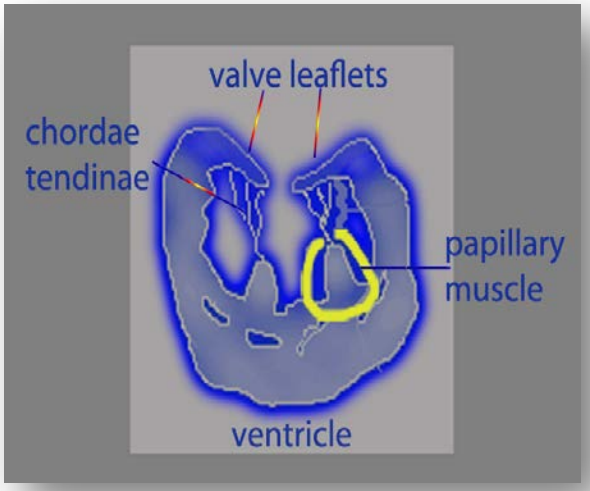


Atrioventricular Valves

- Around day 33 the atrioventricular valves are formed
  - Heart begins to beat on day 36

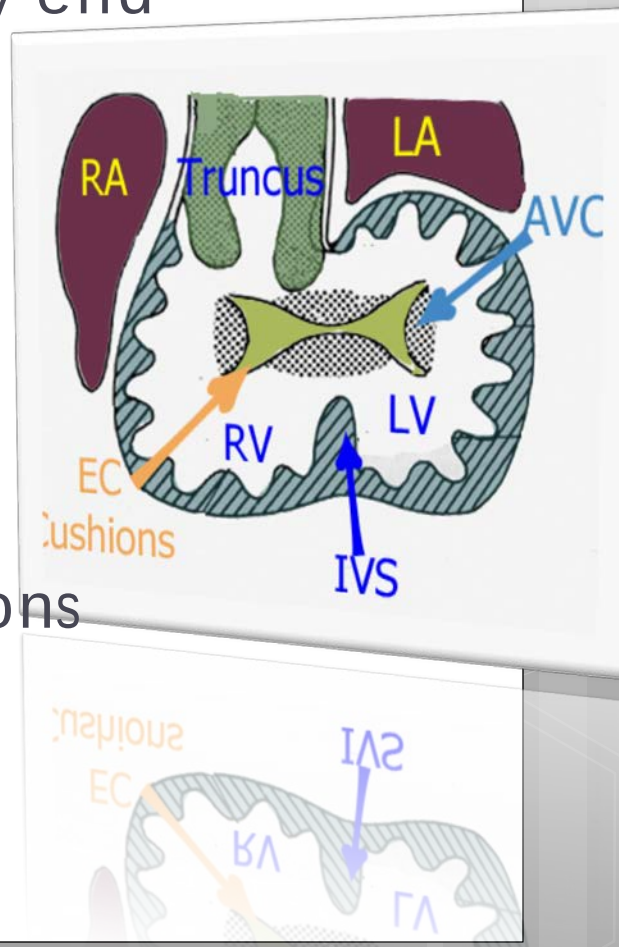






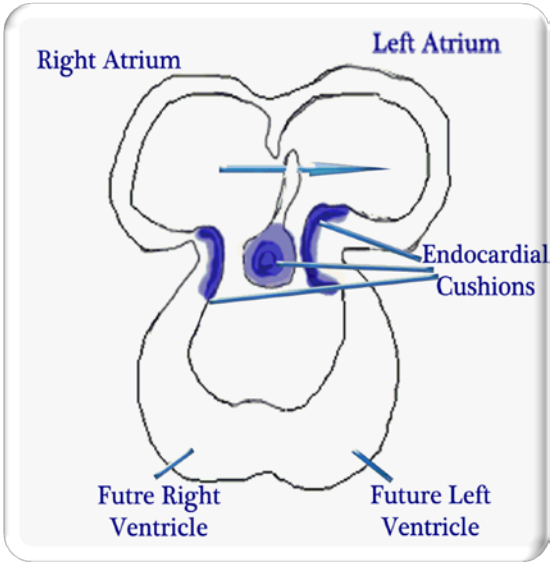
Primitive Ventricle

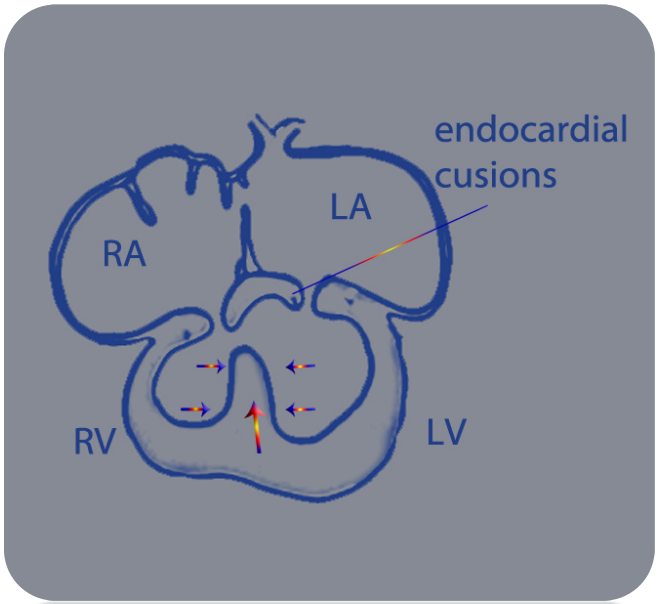
- Interventricular septum formed by end of the seventh week
- Formed from three components
  - Endocardial cushions
  - Conus cushions
  - Muscular tissue of the primitive ventricle
- Muscular and Membranous portions



- Muscular Septum
  - Two primitive ventricles dilate
    - Muscular portion of IVS formed

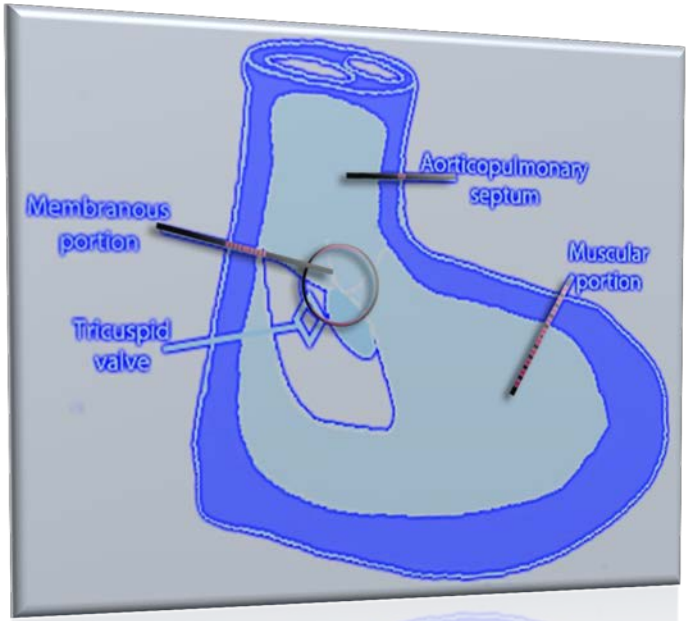
Primitive Ventricle

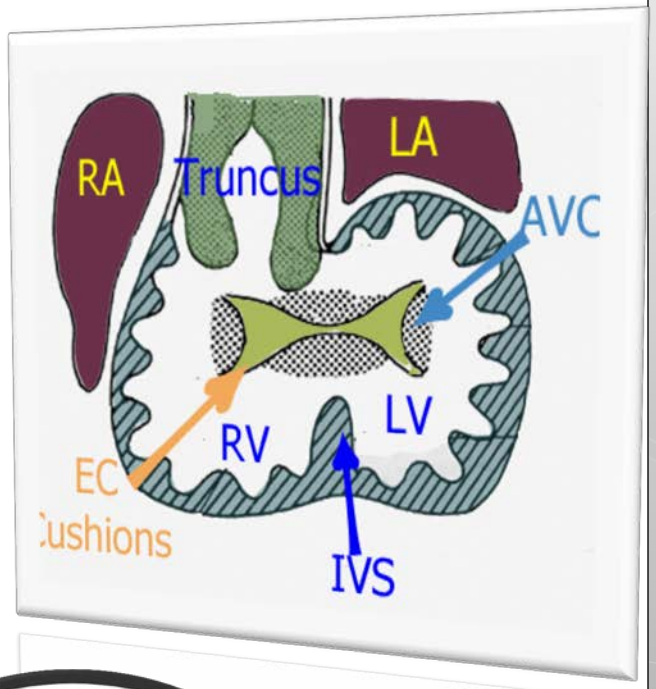


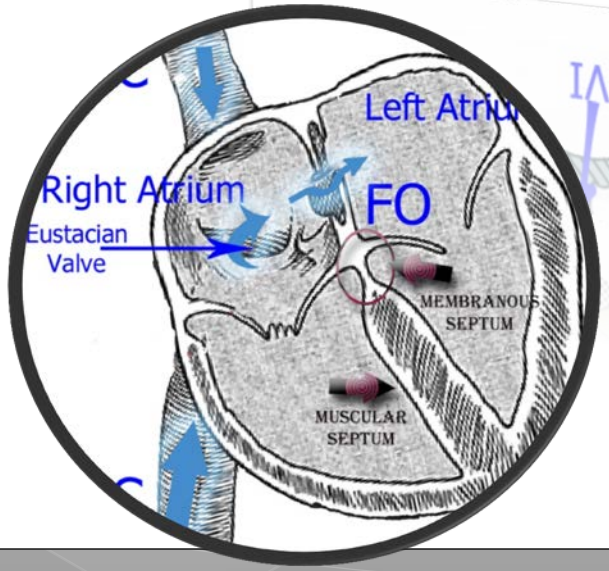


Primitive Ventricle

- Membranous Septum



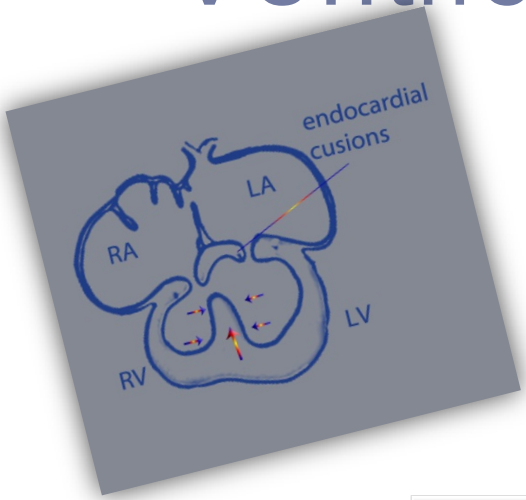


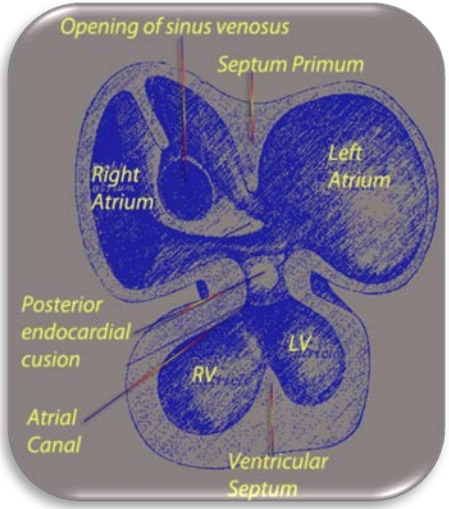


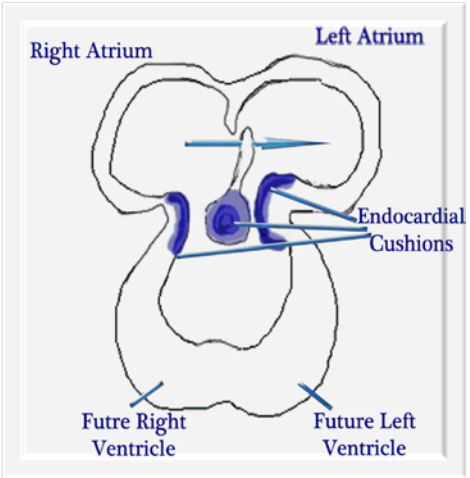
Primitive Ventricle

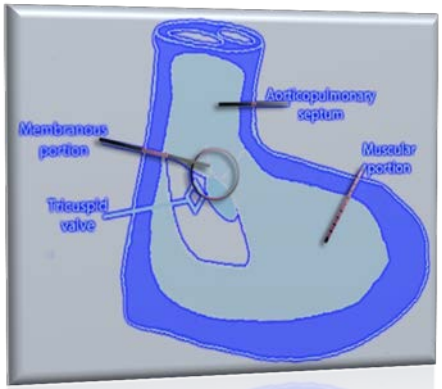
- Interventricular septum formed by end of the seventh week

Ventricular septation



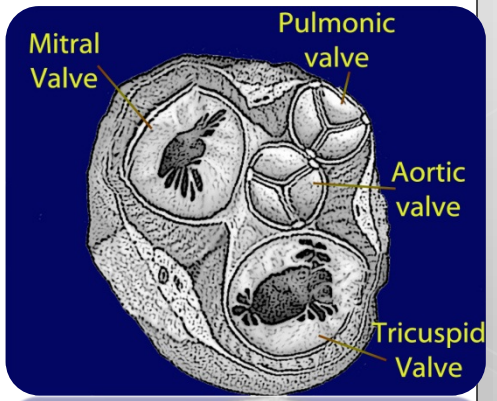


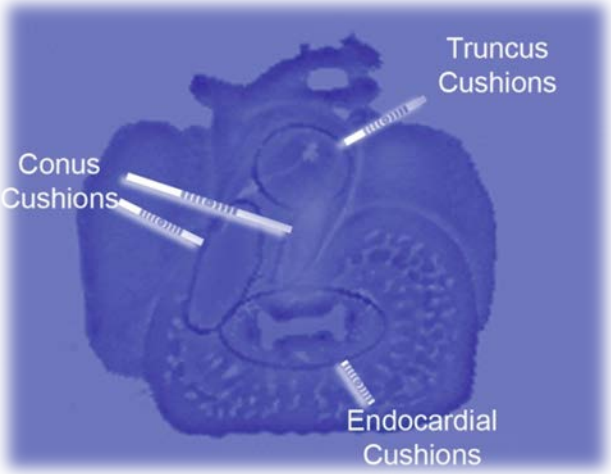


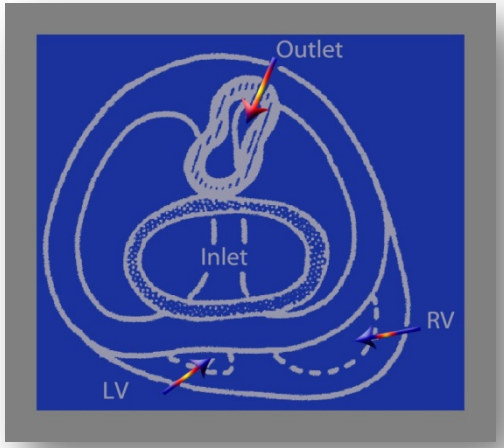


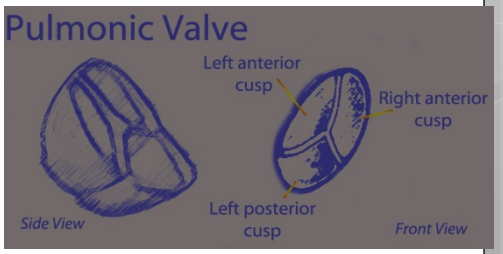
Semilunar Valves

- Tubercles in the bulbus cordis
  - Contribute to truncus arteriosus
- Three cusps
- From between 5-7 weeks



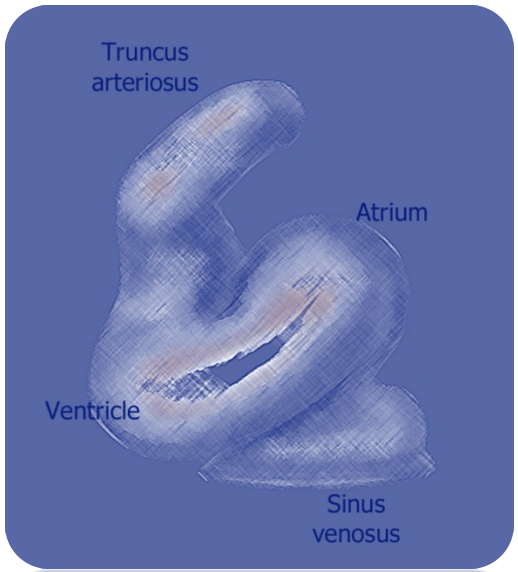


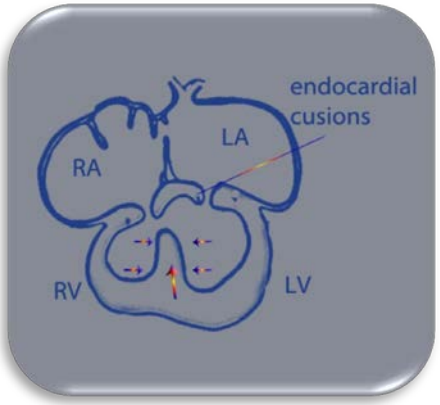


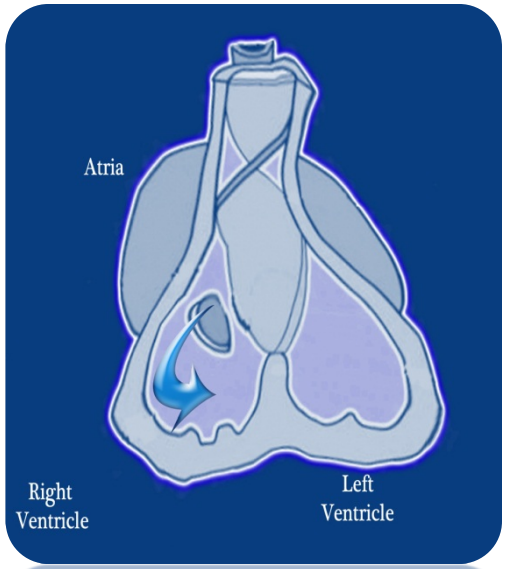


Bulbus Cordis

- AV bulbar loop begins to untwist
  - Cardiac septa develop
    - Forms a four chamber heart
    - Occurs between 27th and 37th day

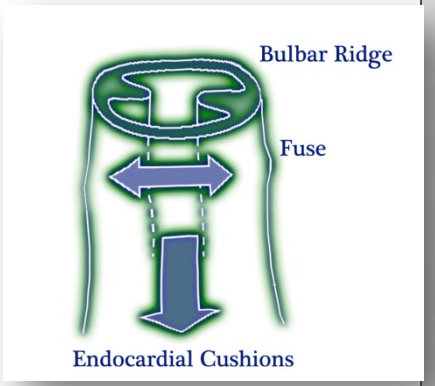


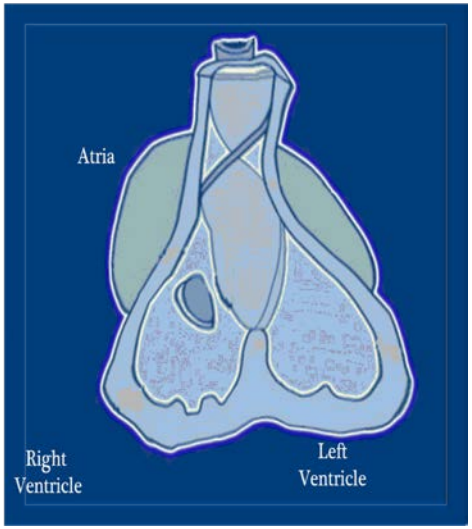


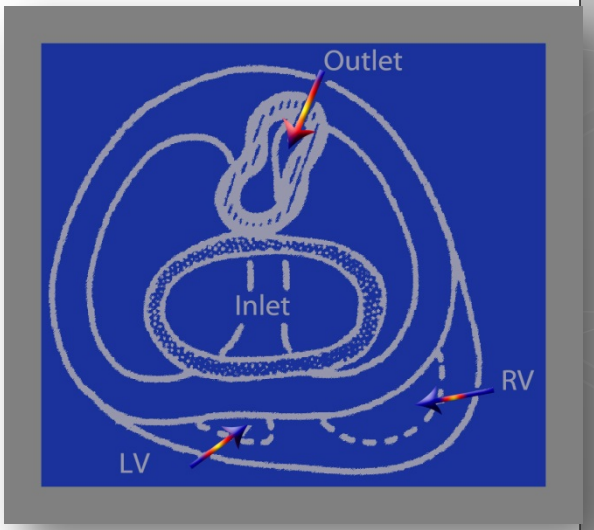


Truncus Arteriosus

- Truncus cusions
  - Grow and twist around each other
    - Form the aorticopulmonary septum
  - Divides the truncus arteriorsus into
    - Aortic channel
    - Pulmonary channel

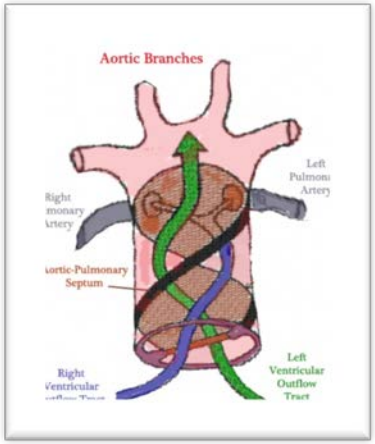


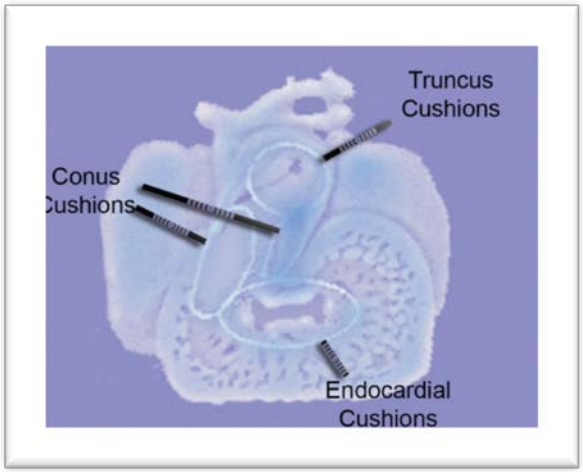




Truncus Arteriosus

- Truncus cusions
  - Cusions of conus cordis simultaneously develop
    - Anterolateral (RVOT)
    - Posterolateral (LVOT)



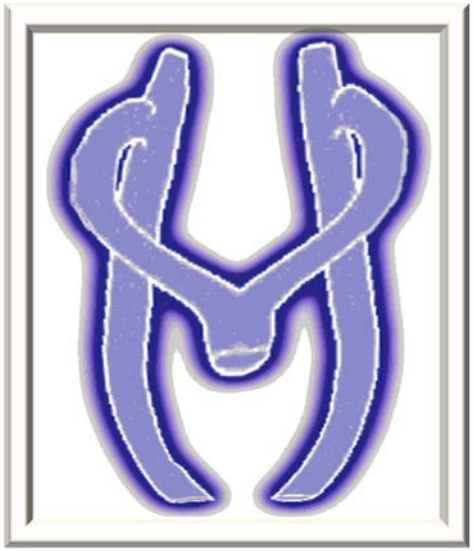


Growth So Far……

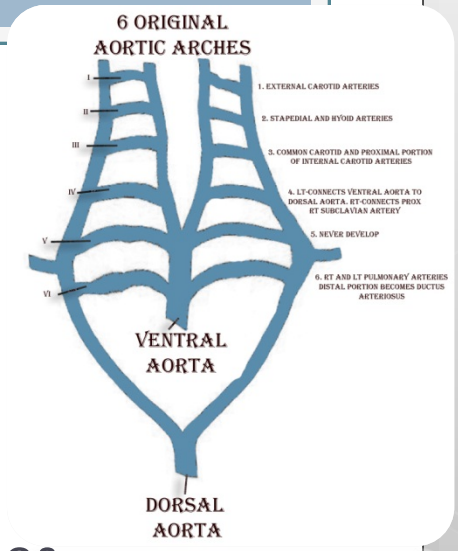
- Two angioblastic cords fused=heart tube
- Atrioventricular canal formed by endocardial cushions
  - Valves formed
- Atrium septated
- Ventrical septated
- Truncus arteriosus septated
  - Aorta
  - Pulmonary artery

Aortic Arches

- 6 Pairs originally begin the process
  - Never present at the same time
  - Give rise to several major arteries
  - Develop in a cephalocaudal direction



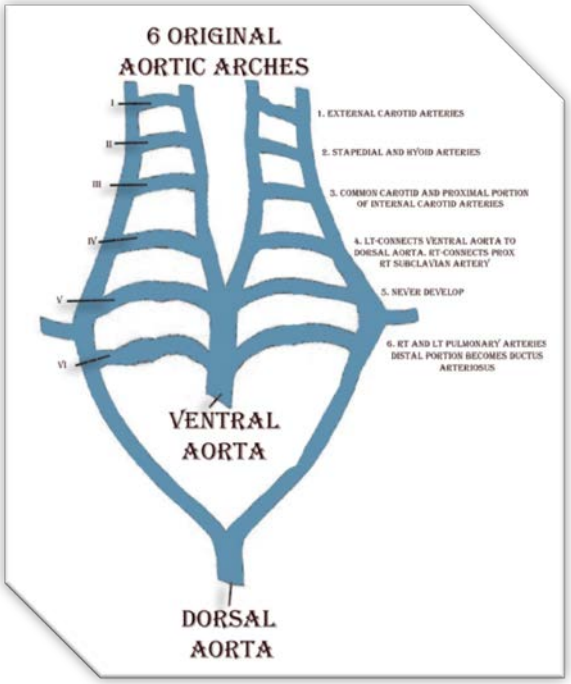
Aortic Arches

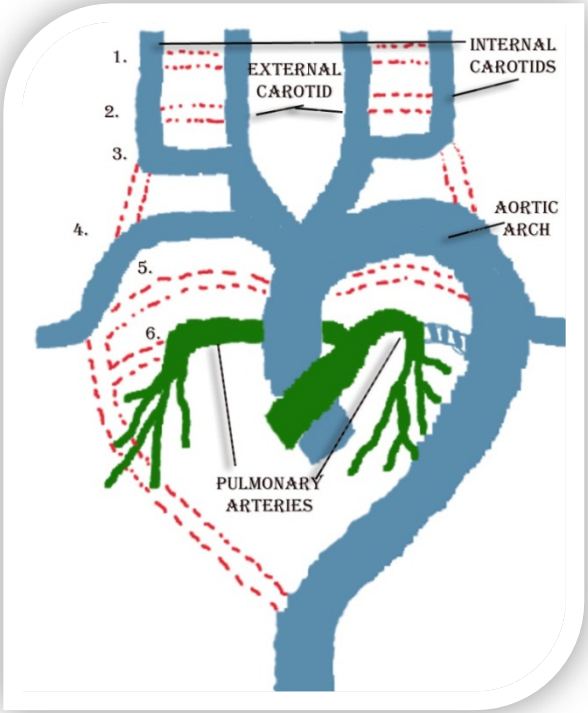


- 6 Pairs originally begin the process
  - 1st pair embryo and 2nd pair
    - These first two reabsorbed
  - 3rd pair
    - Common, internal and external carotid arteries
  - 4th pair
    - Becomes definitive aorta, right subclavian and innominate artery
  - 5th pair
    - Never fully develops
  - 6th pair
    - Forms the right pulmonary artery, left pulmonary artery and the ductus arteriosus in fetal life

Aortic Arches

- 6 Pairs originally begin the process
  - 1st pair embryo and 2nd pair
    - These first two reabsorbed





Aortic Arches

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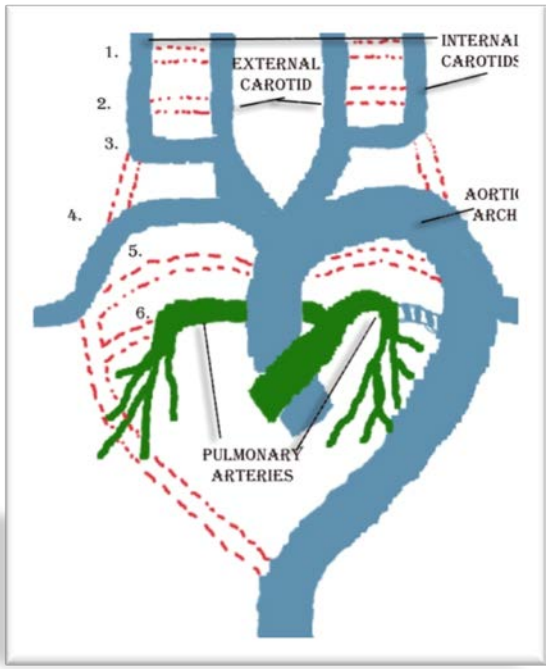
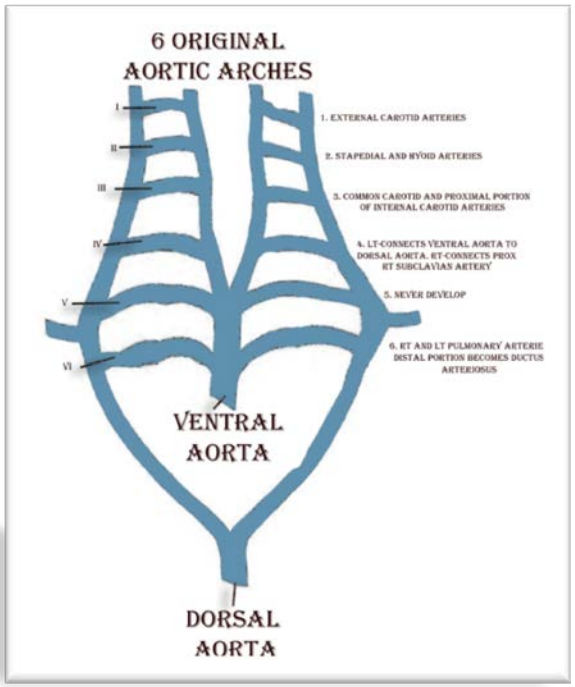
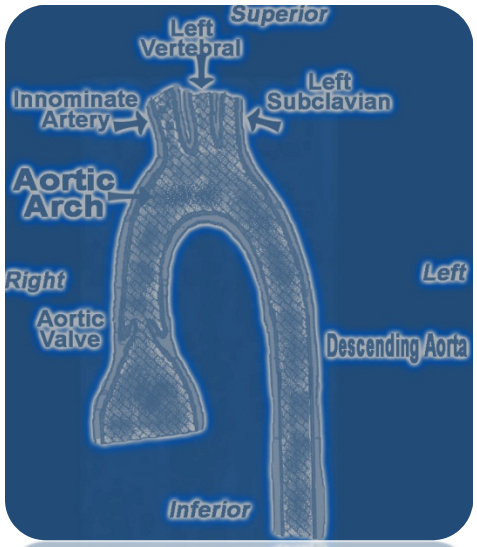
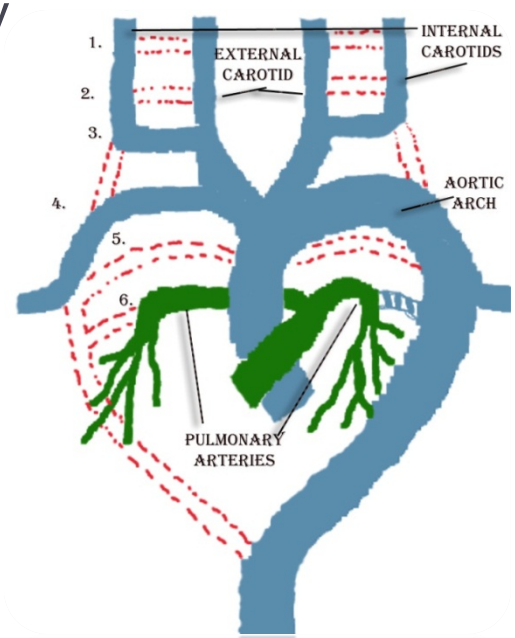




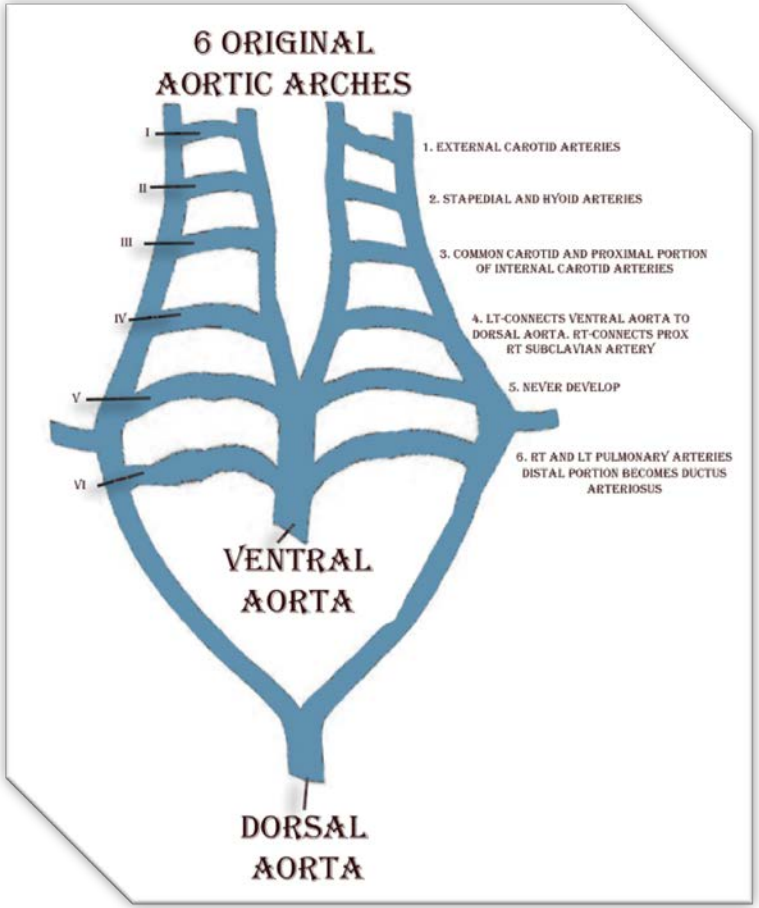
Aortic Arches

- 6 Pairs originally begin the process
  - 4th pair
    - Becomes definitive aorta, right subclavian and innominate artery





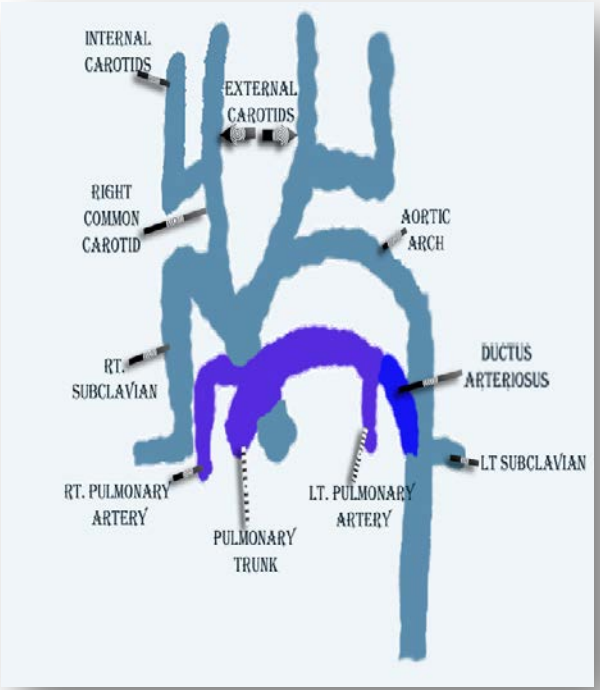
Aortic Arches



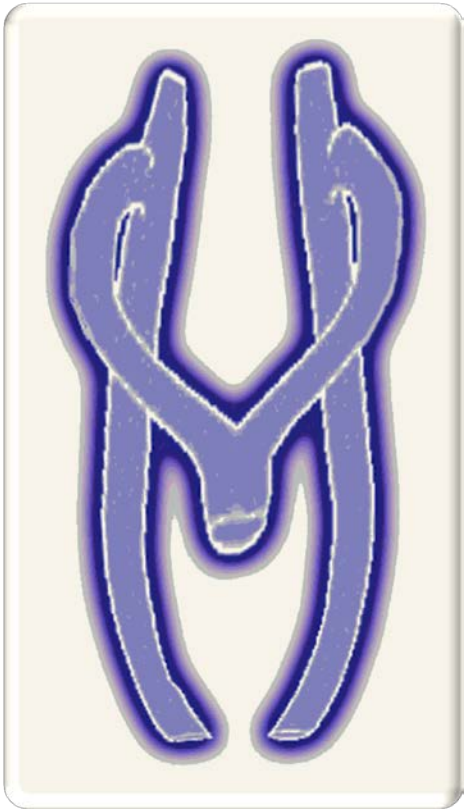
- 6 Pairs originally begin the process
  - 5th pair
    - Never fully develops

Aortic Arches

- 6 Pairs originally begin the process
  - 6th pair
    - Forms the right pulmonary artery, left pulmonary artery and the ductus arteriosus in fetal life



Aortic Arches



- 6 Pairs originally begin the process
  - Never present at the same time
  - Give rise to several major arteries
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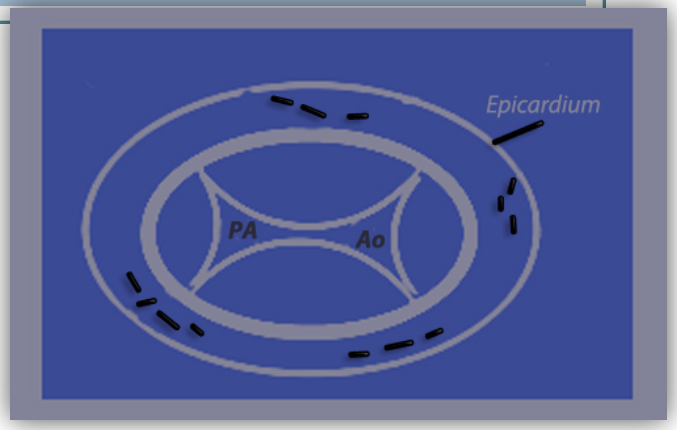
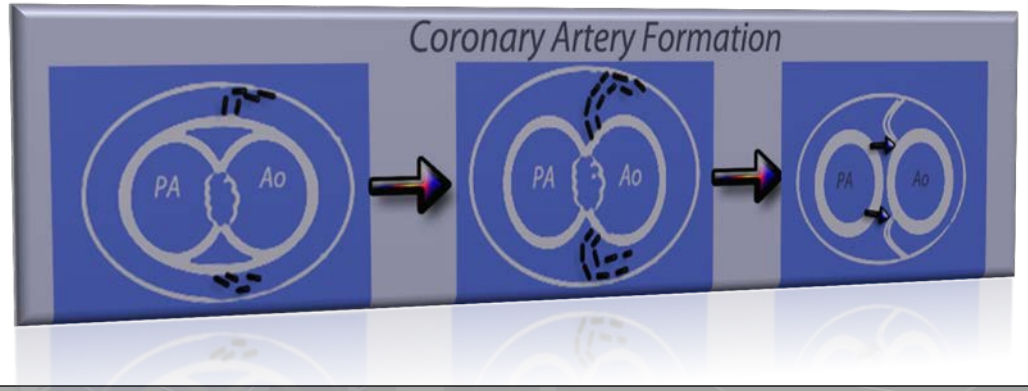
    - 5th pair
      - Never fully develops
    - 6th pair
      - Forms the right pulmonary artery, left pulmonary artery and the ductus arteriosus in fetal life

Coronary Arteries

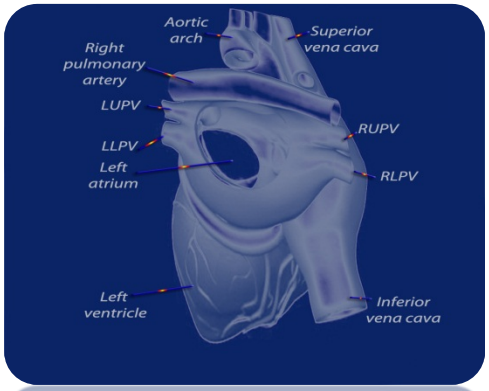


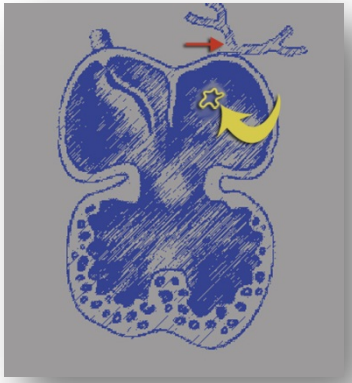
- Day 35-42
  - Arise as thickenings of the aortic endothelium
  - Occurs at the same time as the truncus arteriosus divides into the aortic and pulmonary segments

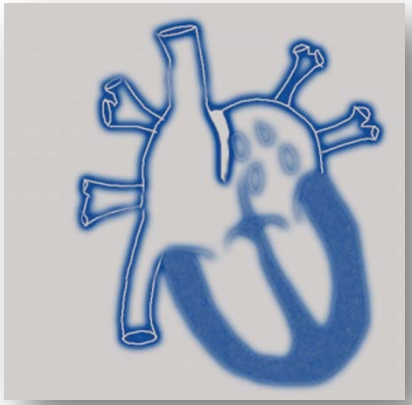


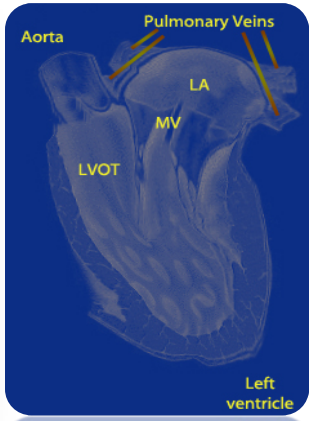
Pulmonary Veins

- Two sources
  - Presplanchnic
    - Channel formed from the confluence of the vascular plexus of the lung
  - Main pulmonary stem
    - Outgrowth of the heart tube



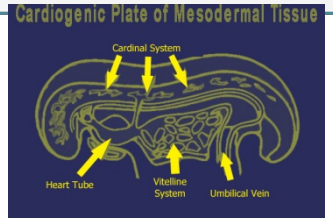


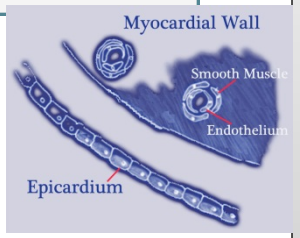


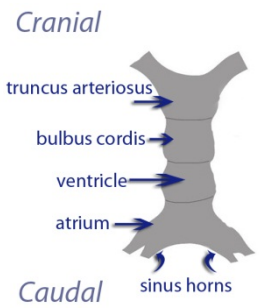


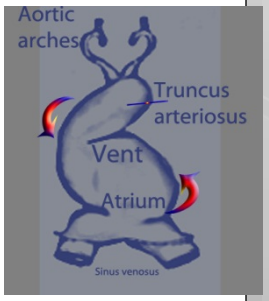
Conclusion

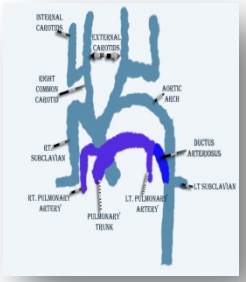
- Prechordal plate region
- Three vascular circuits
- Primitive cardiac tube
- Cardiac Looping
- Septations
  - Atrial
  - Ventricular
  - Aorticopulmonary
- Valve formation
- Aortic Arches

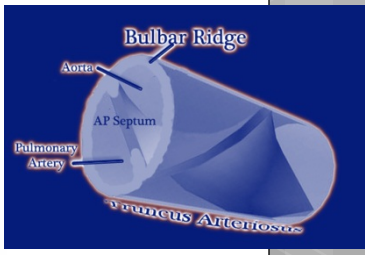












Thank you!

NCER Cardiac Embryology

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Clinical Considerations:

- What might be the outcome if the aorticopulmonary septum only partially develops?

Clinical Considerations:

- What might be the outcome if the aorticopulmonary septum only partially develops?
  - A condition called persistent truncus arteriosus will occur, with only **partial development**

Clinical Considerations:

- What might be the outcome if the aorticopulmonary septum does not spiral completely?

Clinical Considerations:

- What might be the outcome if the aorticopulmonary septum does not spiral completely?

D-Transposition

Complete

Clinical Considerations:

- What might be the outcome if the dorsal and ventral atrioventricular endocardial cushions don't fuse correctly?

Clinical Considerations:

- What might be the outcome if the dorsal and ventral atrioventricular cushions don't fuse correctly?
  - Persistent common AV canal defect

Clinical Considerations:

- What might be the outcome if the muscular and membranous interventricular septa don't form?

Clinical Considerations:

- What might be the outcome if the muscular and membranous interventricular septa don't form?

Common ventricle

Clinical Considerations:

- What might be the outcome if the aorticopulmonary septum is skewed or doesn't form correctly?

Clinical Considerations:

- What might be the outcome if the aorticopulmonary septum is skewed or doesn't form correctly?
  - Tetralogy of Fallot

Clinical Considerations:

- What might be the outcome if the endocardial tube does not loop to the right?

Clinical Considerations:

What might be the outcome if the endocardial tube does not loop to the right?

L-Transposition of the Great Vessels