Human Embryology:
Heart Development II

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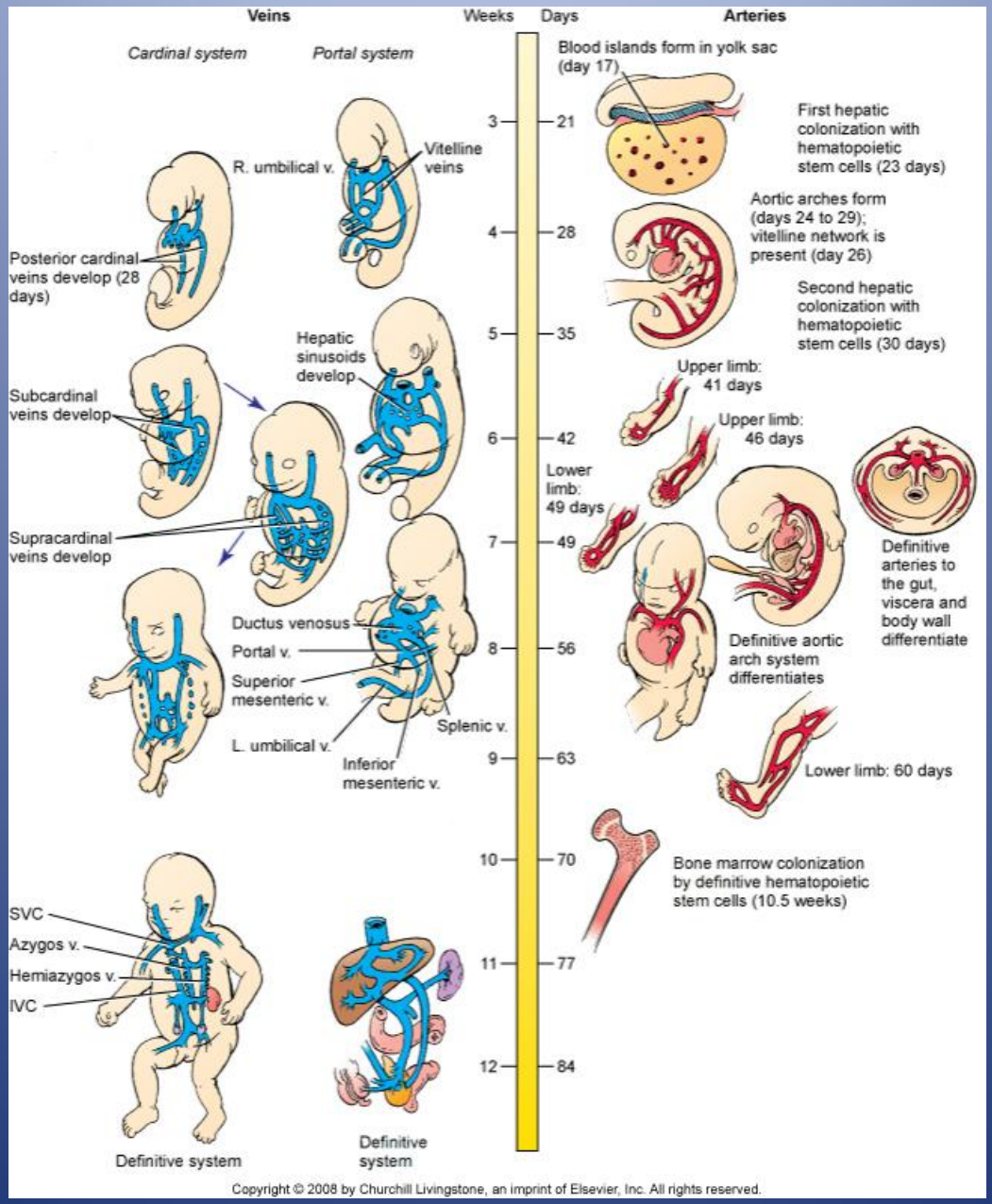
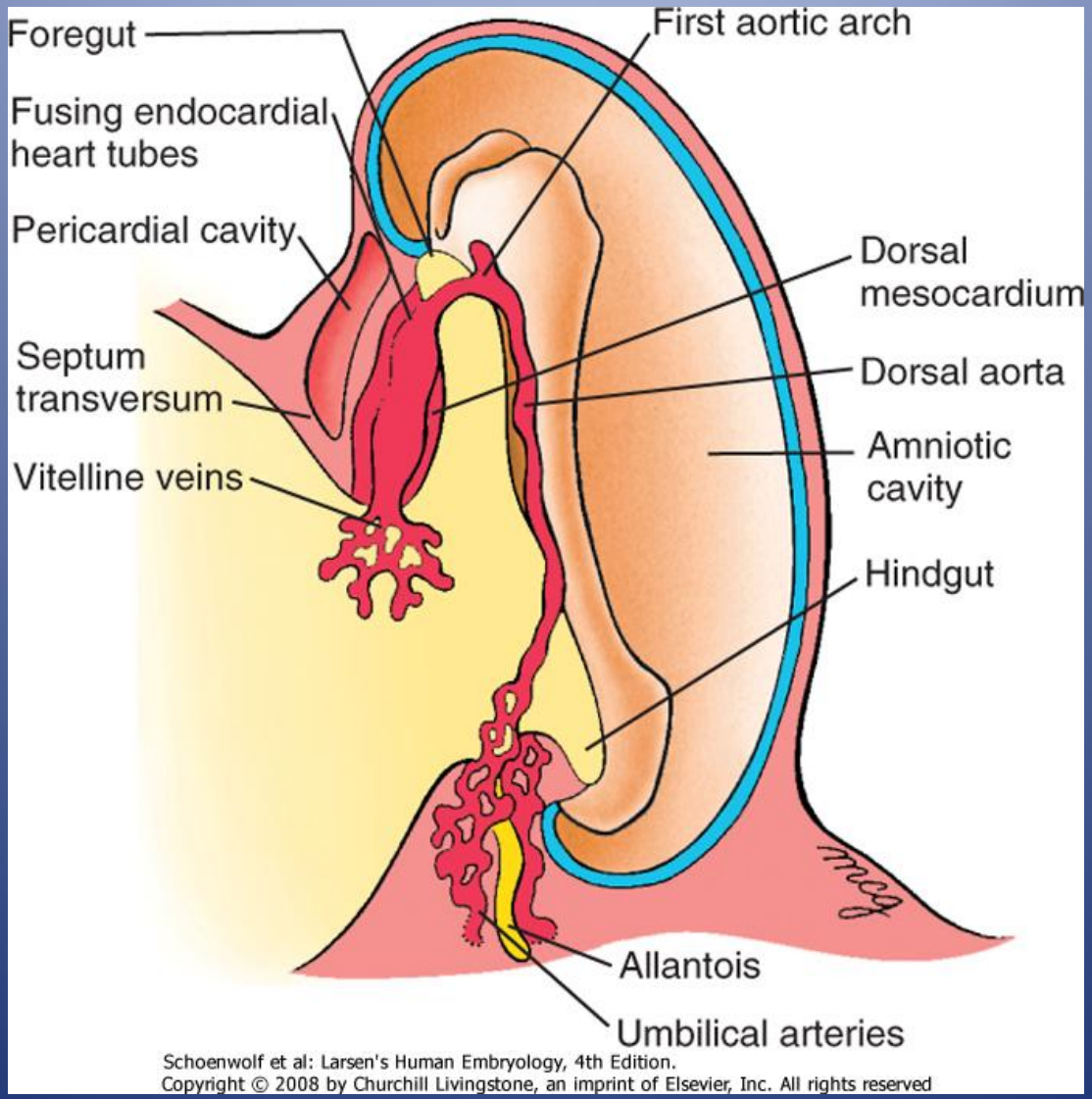
Human Vascular Development

- Overview
- Aortic Arch Development
- Arterial Vascular Development
- Venous System Development
- Lymphatic Development
- Transition from Fetal to Post-Natal Circulation

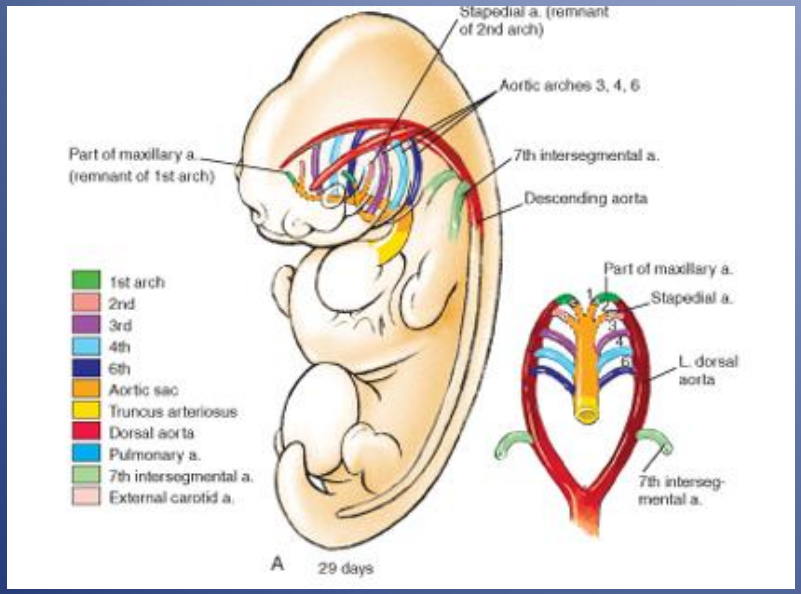
Development of the Arterial and Venous Systems

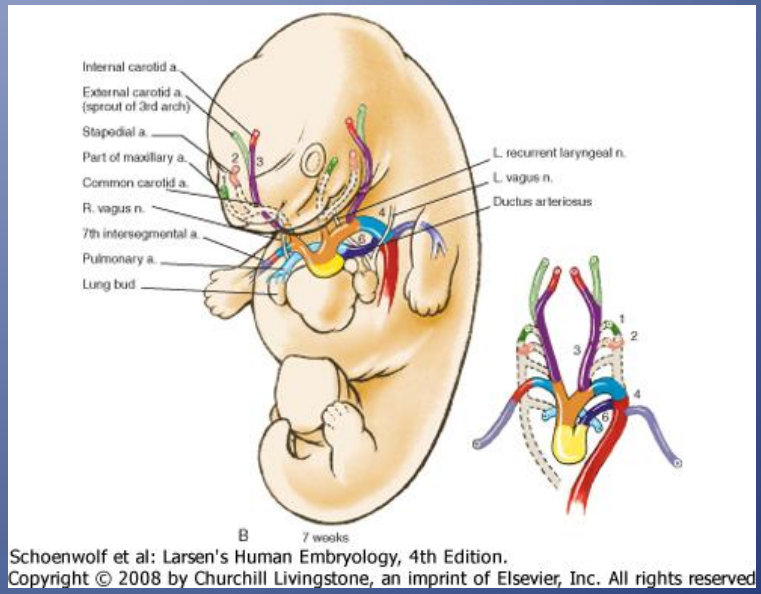


Cranial Ends of the Dorsal Aortae Form a Dorsoventral Loop: The First Aortic Arch



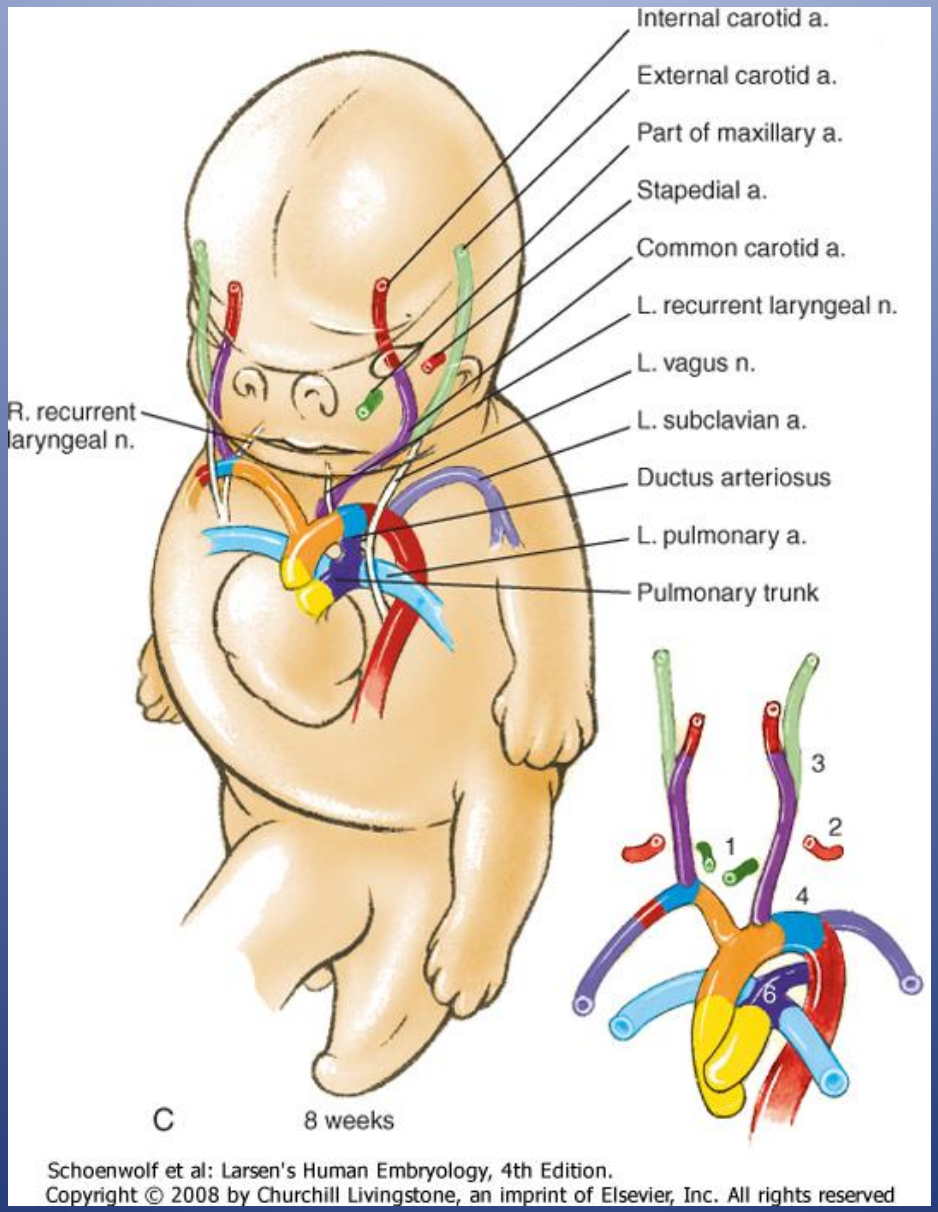
Aortic Arches Arise in a Craniocaudal Sequence Surrounding the Pharynx



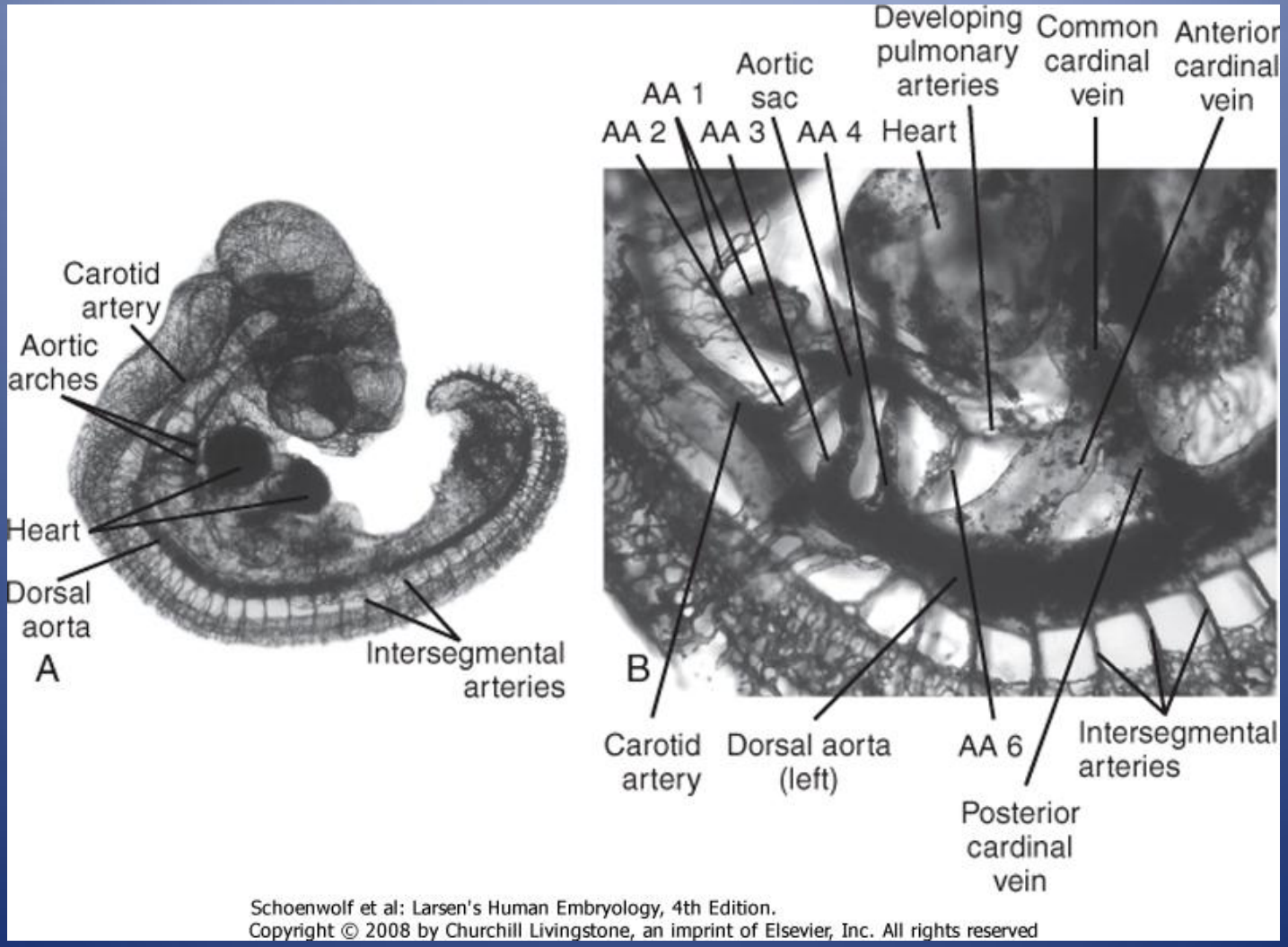


Schoenwolf et al: Larsen's Human Embryology, 4th Edition.

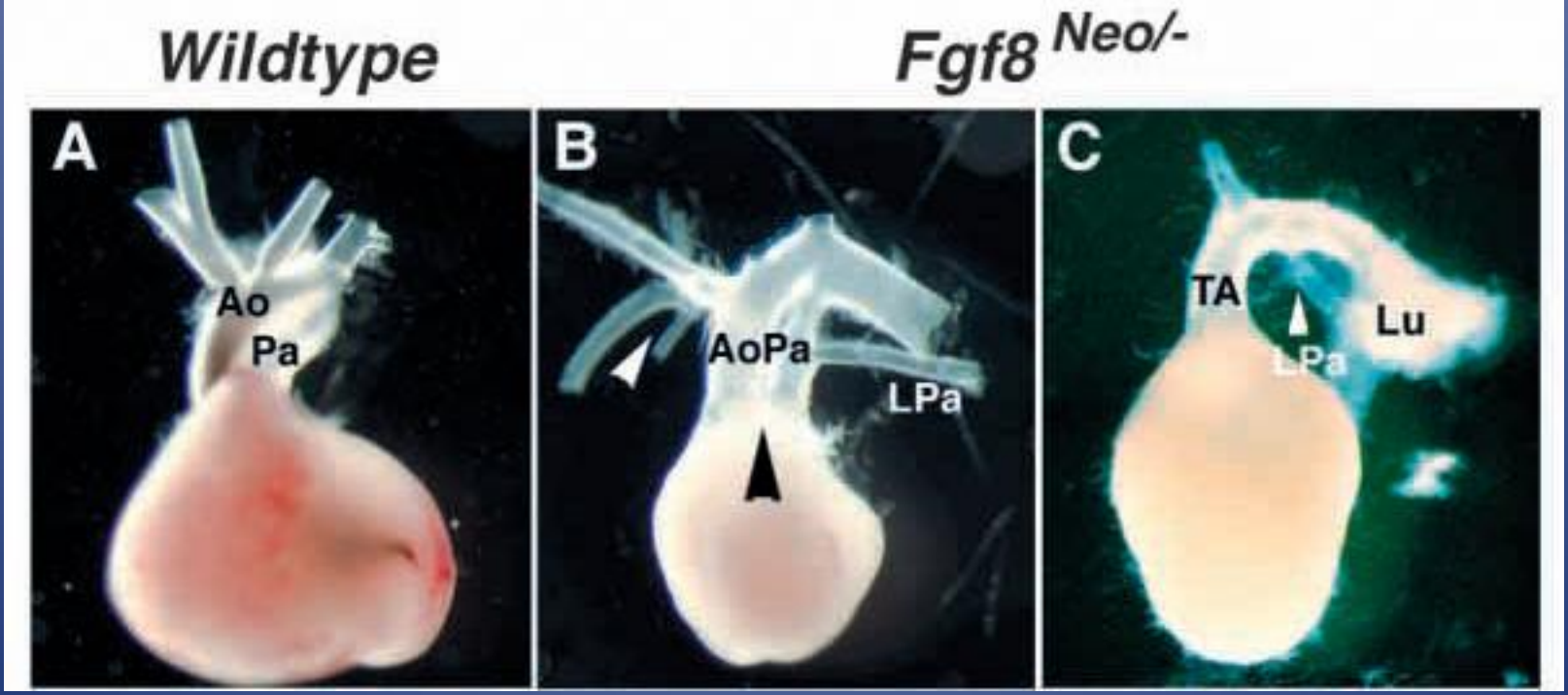
Aortic Arches Give Rise to Important Head, Neck, and Upper Thorax Vessels



Aortic Arch Development in the Chick Embryo

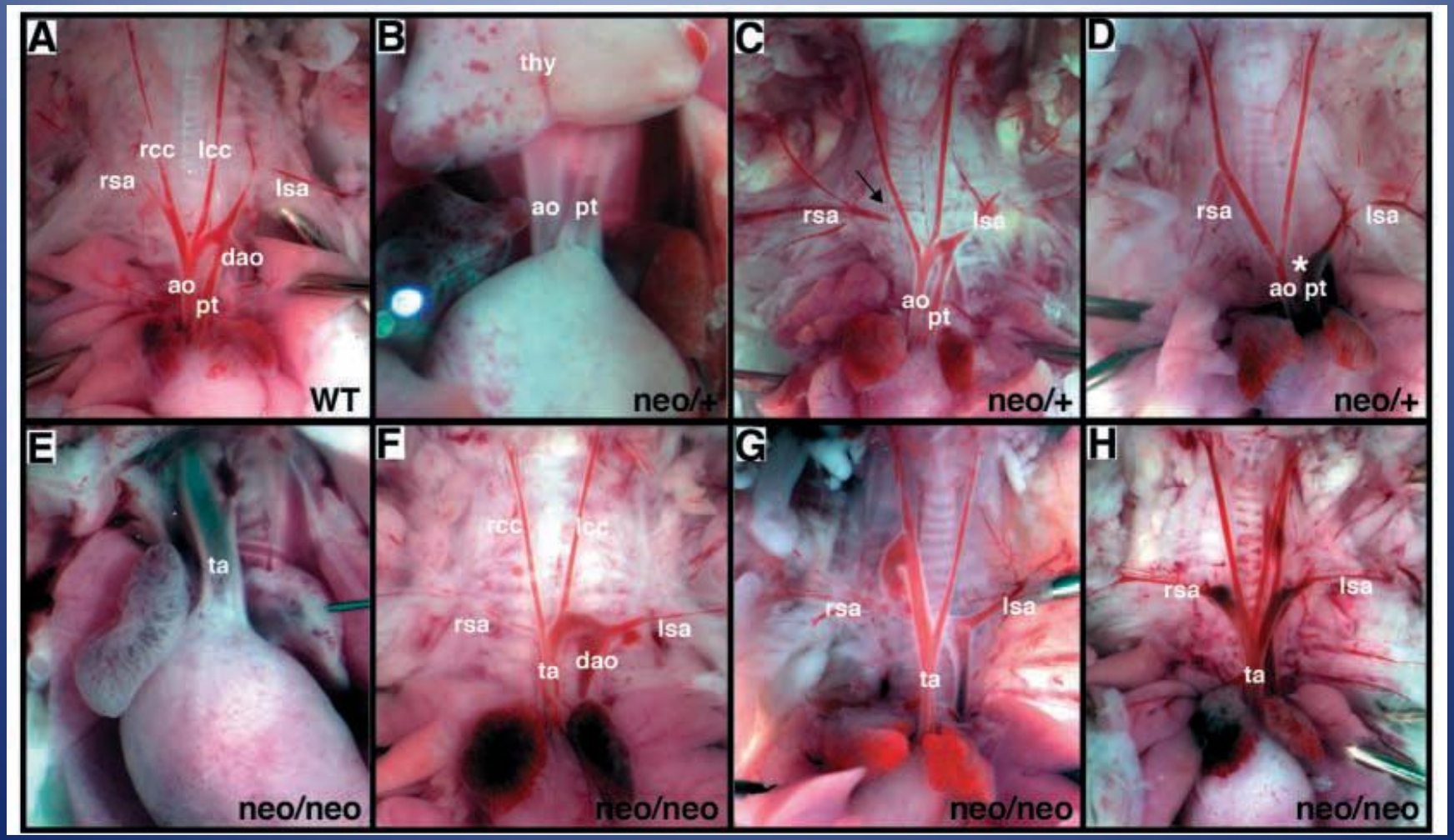


Fgf8 is Required for Pharyngeal Arch Development in Mouse



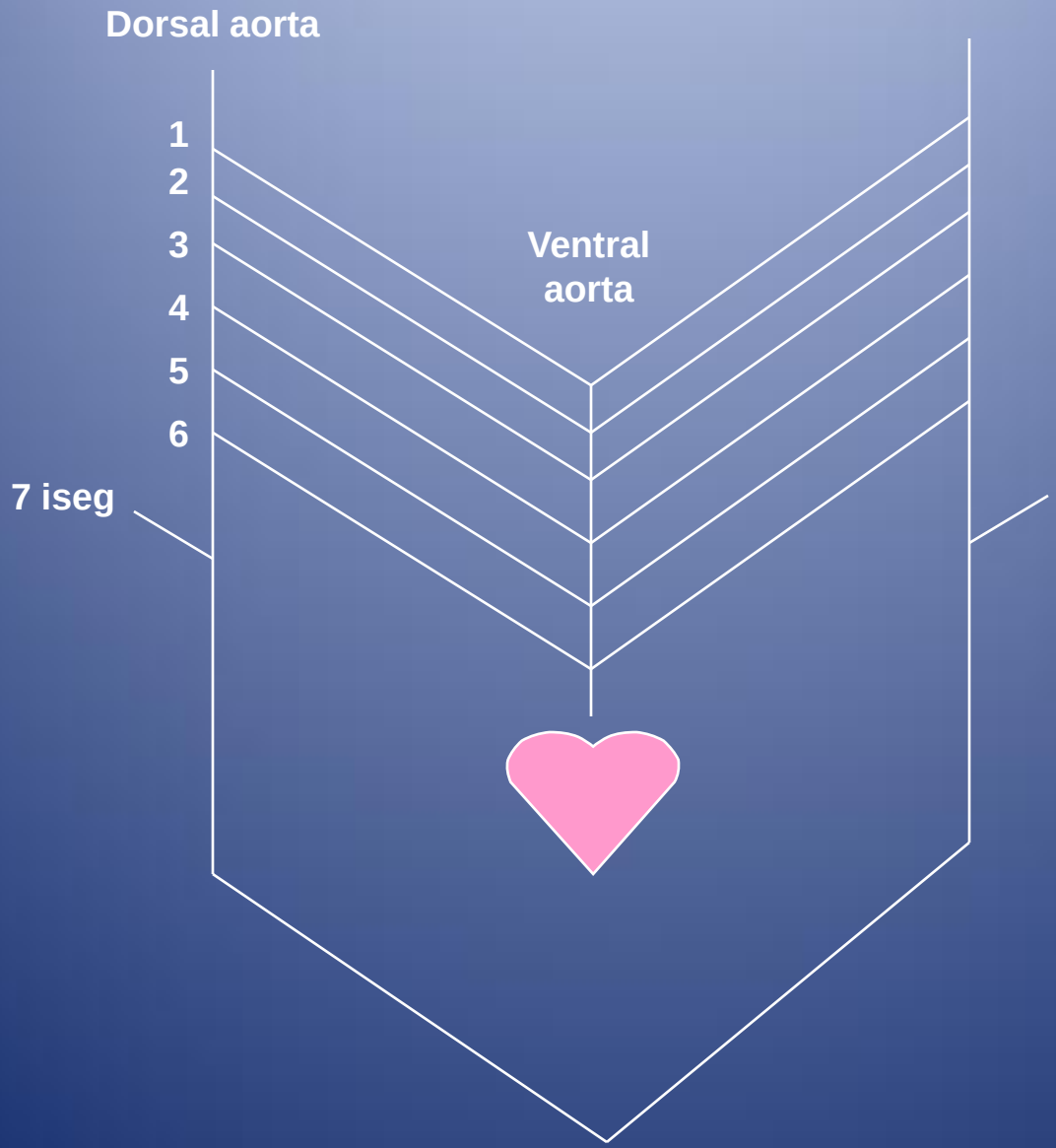
Abu-Issa, R. et al., *Development* 2002.

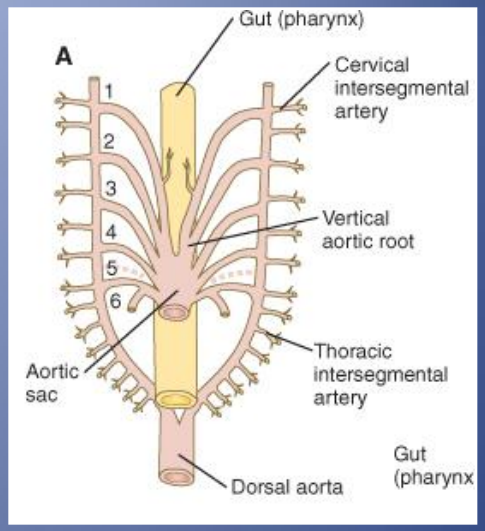
Cardiovascular and Thymic Defects in *Tbx1* Hypomorphic Mutant Neonates



Hu, T. et al., *Development* 2004.

Aortic Arch Development





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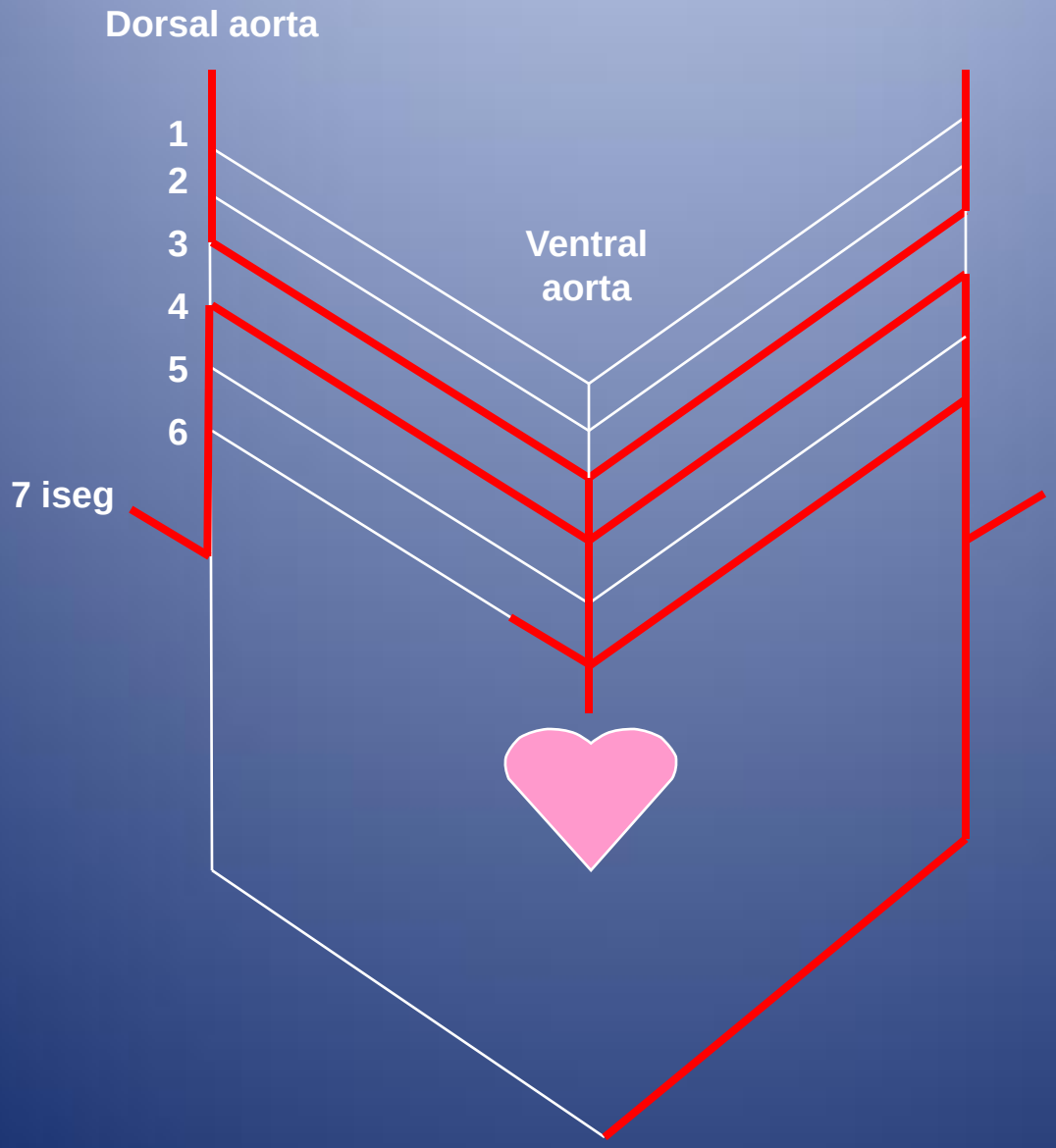
Aortic Arch Development



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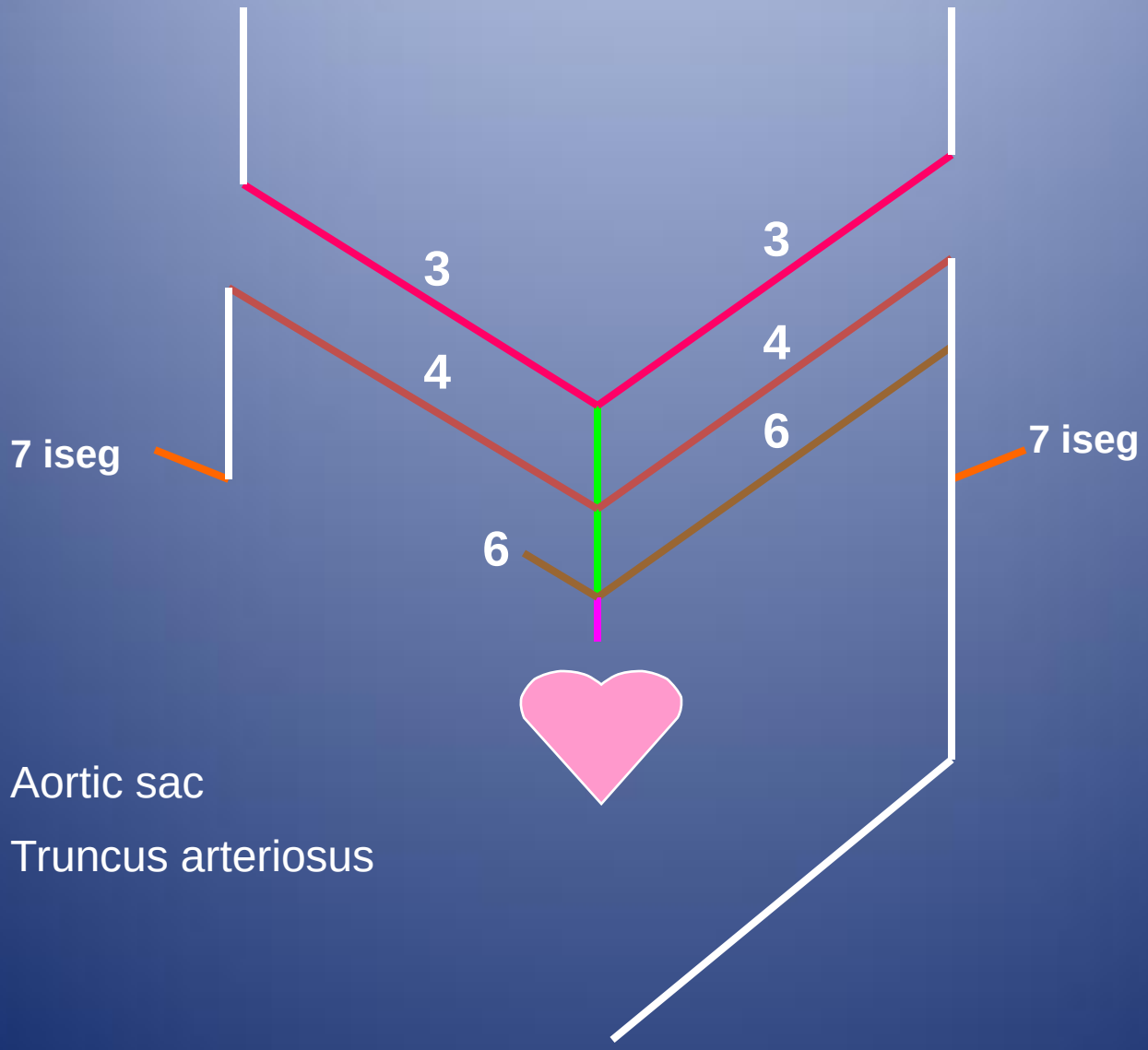
Aortic Arch and Derivatives



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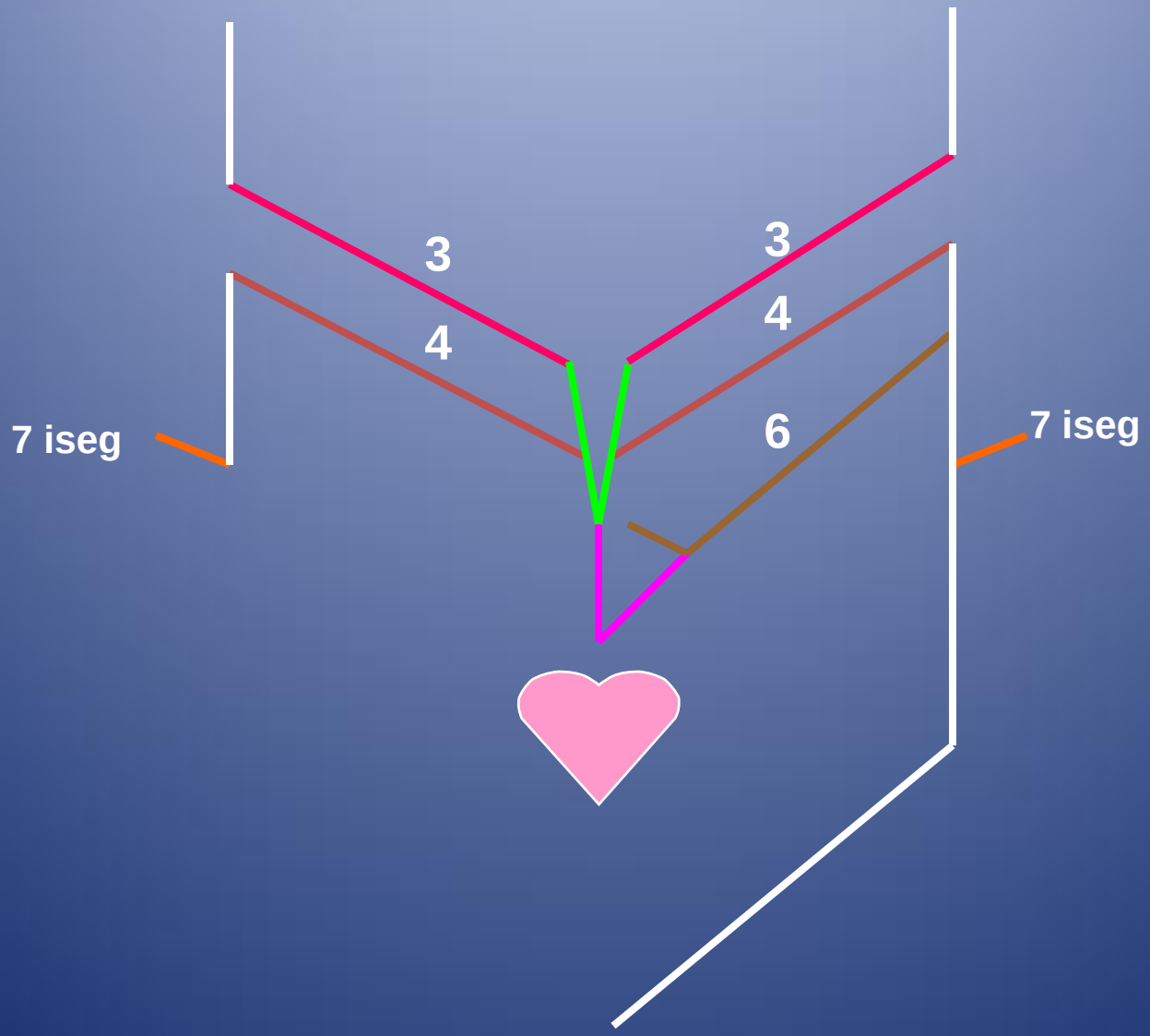
Aortic Arch and Derivatives



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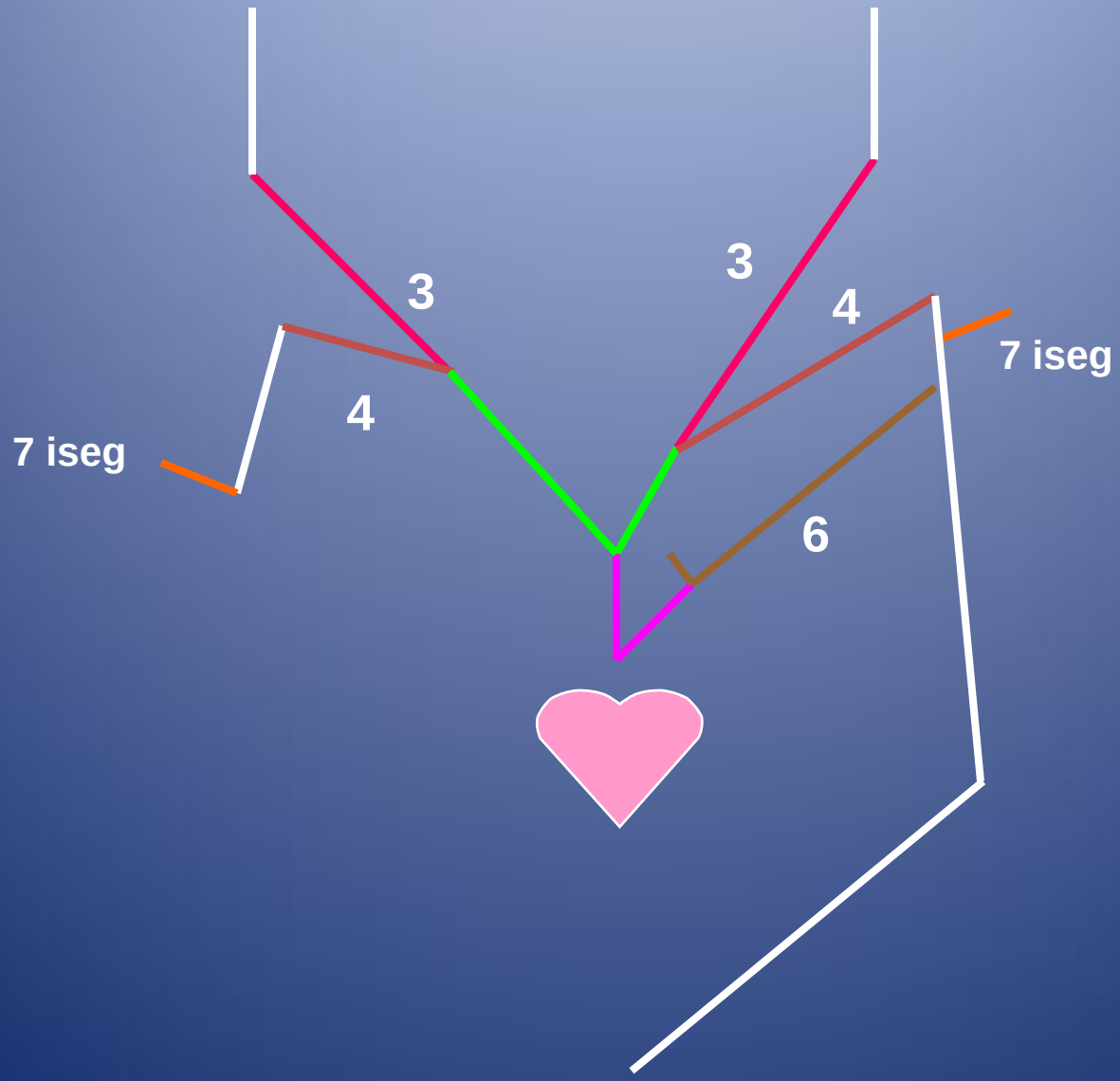

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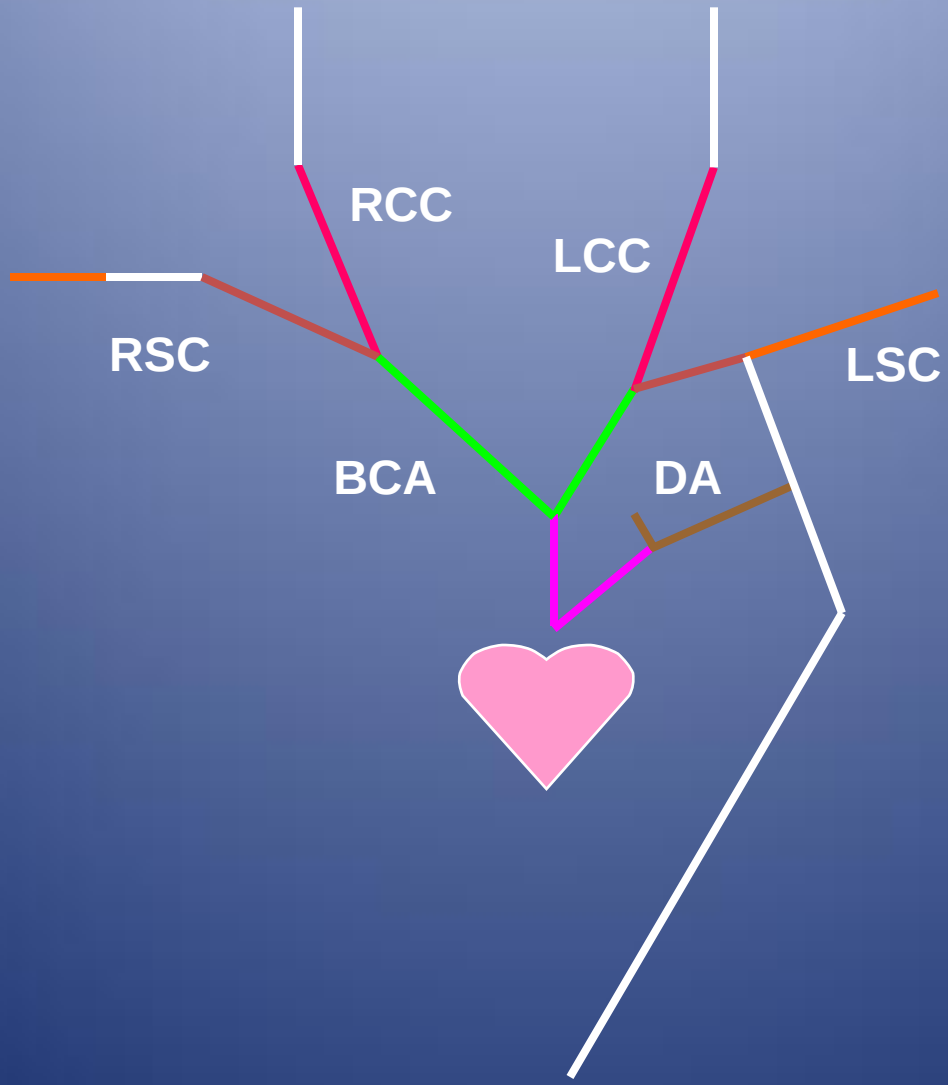
Aortic Arch and Derivatives



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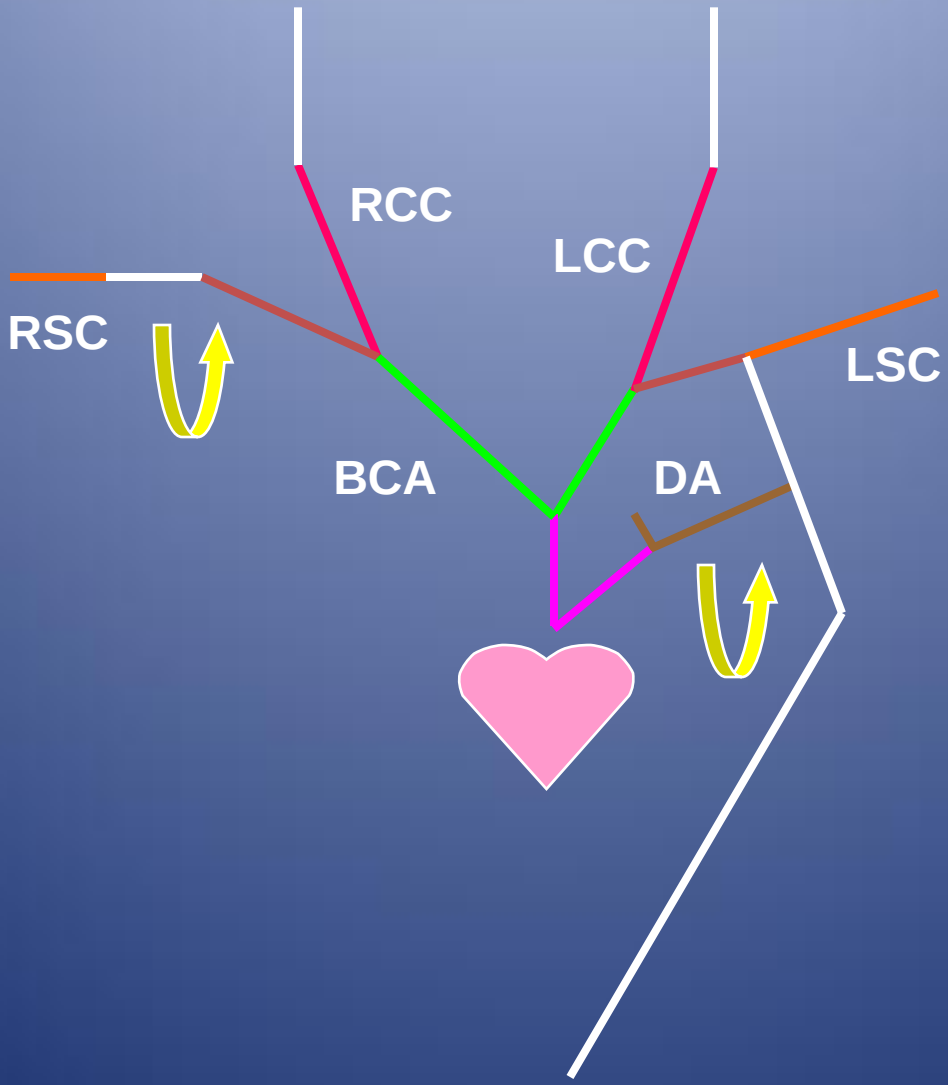
Recurrent Laryngeal Nerves



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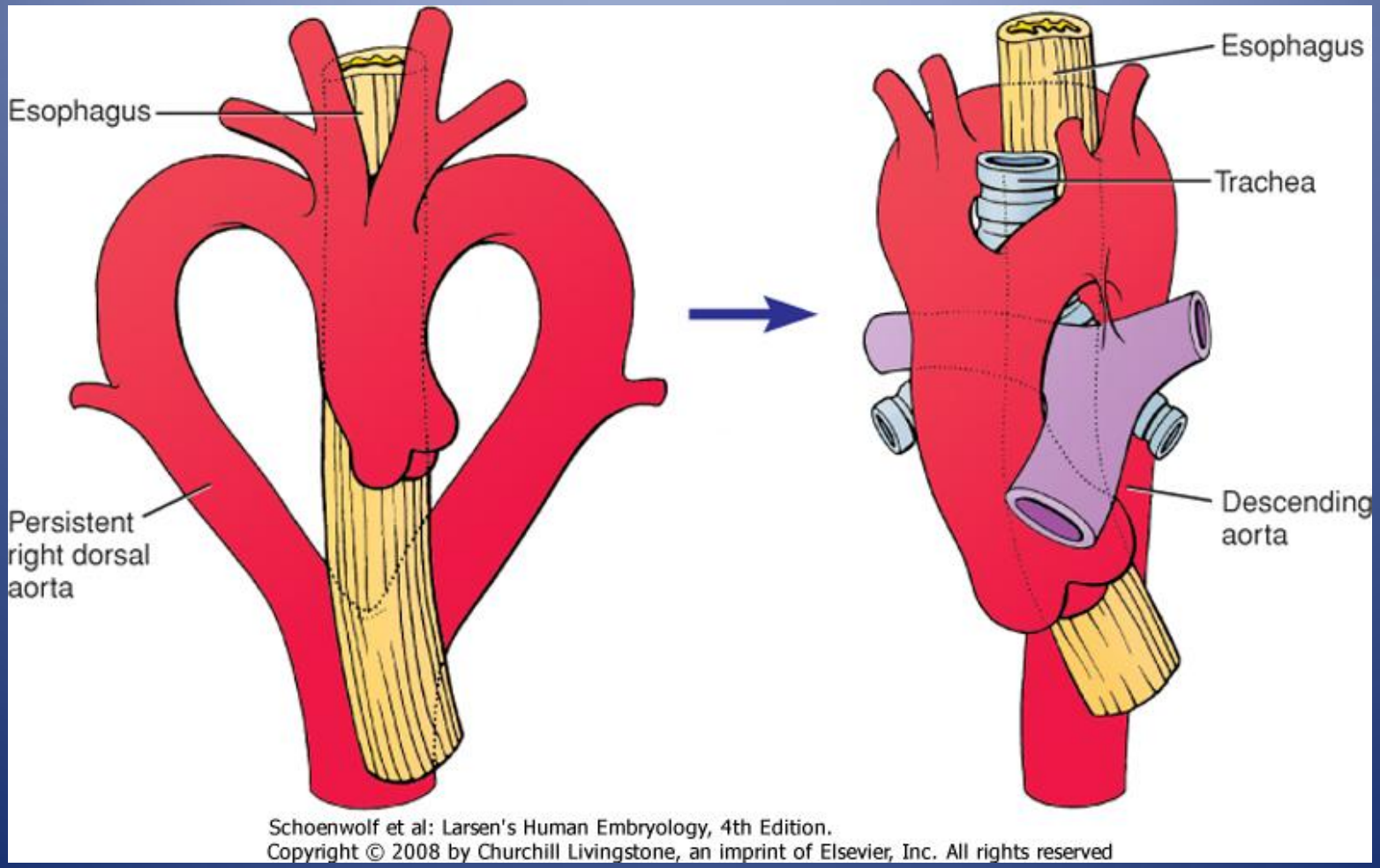
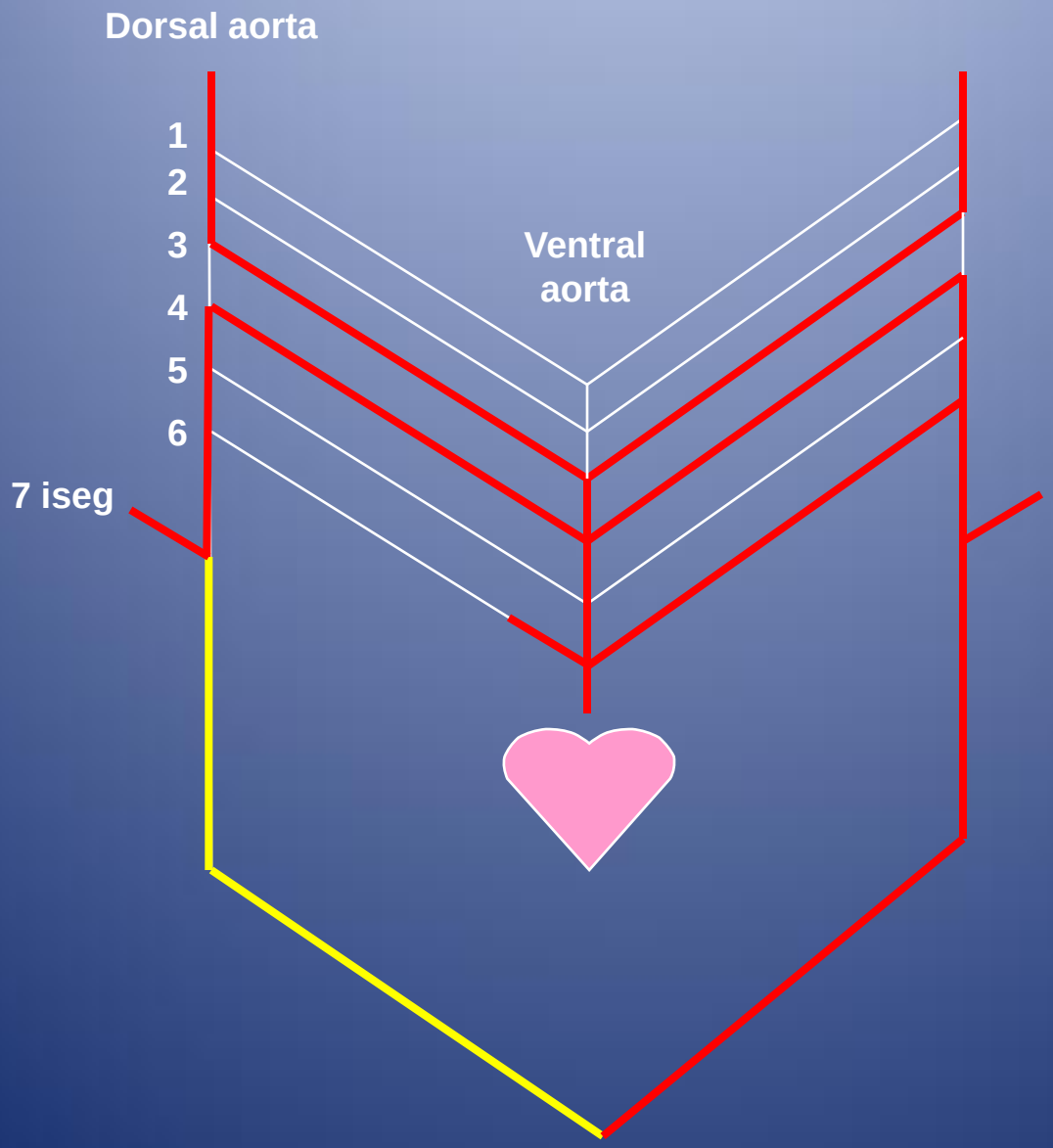
Defects in Normal Regression of the Arterial System Lead to Vascular Anomalies

- Double Aortic Arch
  - Failure of the right dorsal aorta to regress
- Aberrant Right Subclavian Artery
  - Regression of the right fourth arch
  - 1% of the general population
  - 40% of patients with Trisomy 21 and CHD
- Right Aortic Arch
  - Retention of the right dorsal aorta segment
  - 13-35% of patients with TOF
  - 8% of patients with TGA

Failure of Regression of the Right Dorsal Aorta Leads to a Double Aortic Arch



Double Aortic Arch



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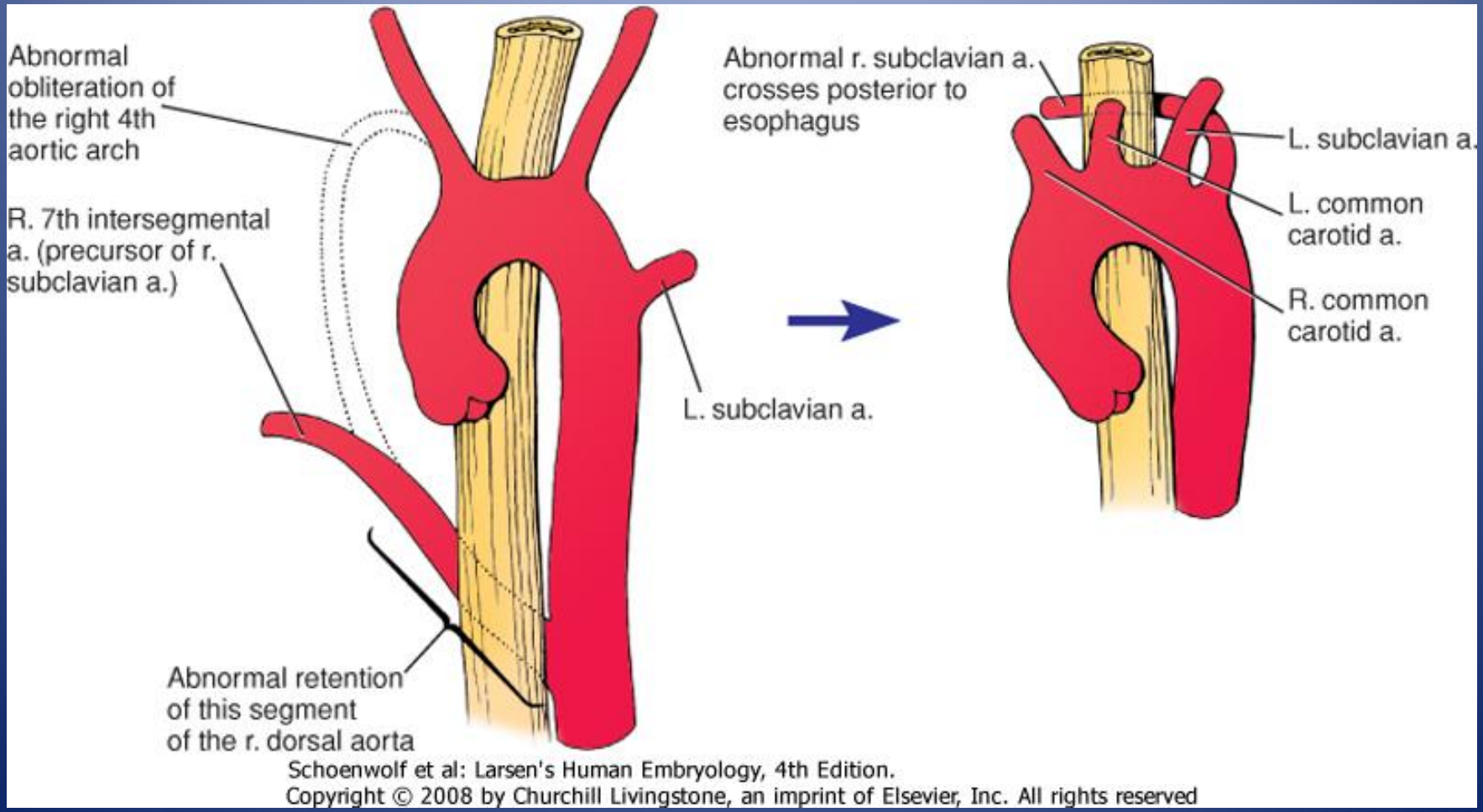
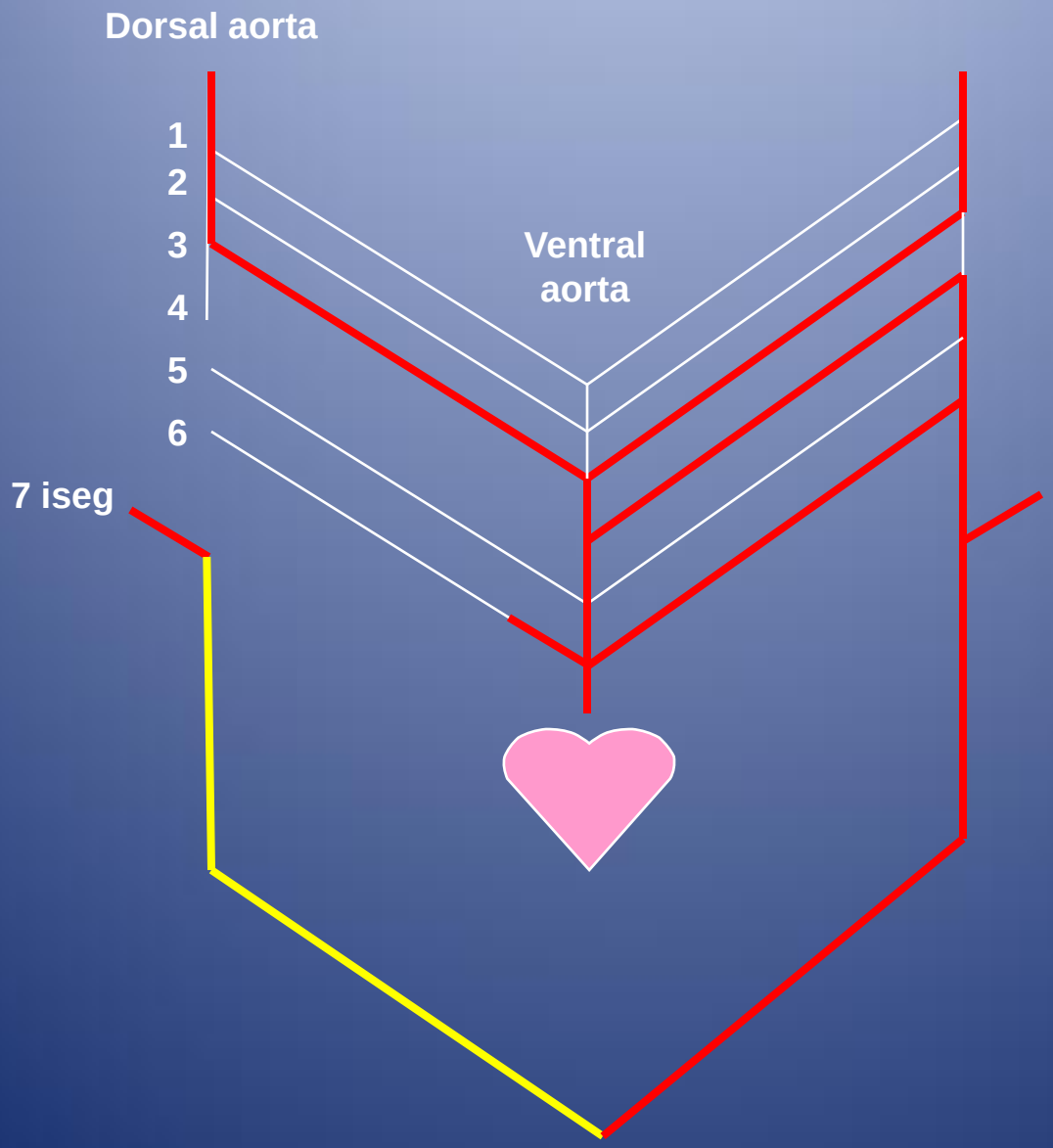
Regression of the Right Fourth Arch Results in an Aberrant Right Subclavian Artery



Aberrant Right Subclavian Artery



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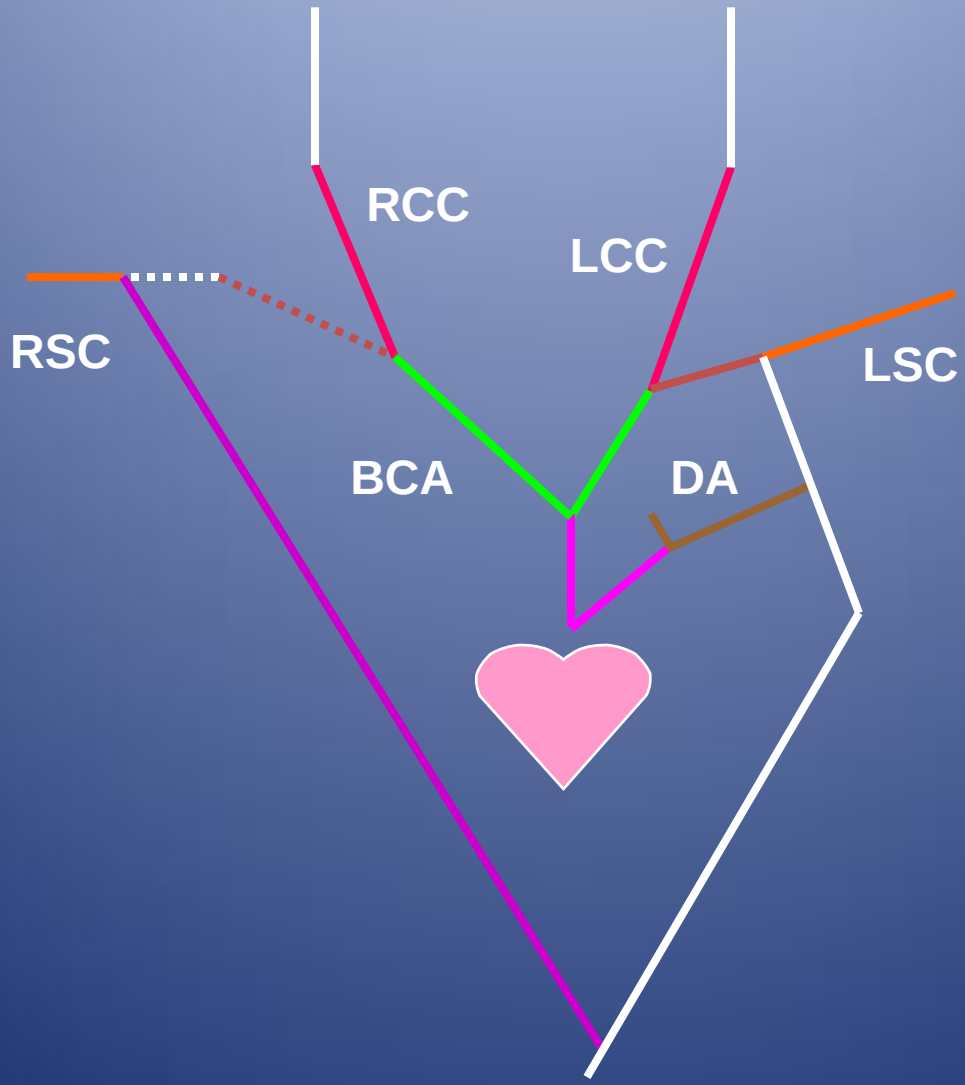
Aberrant Right Subclavian Artery



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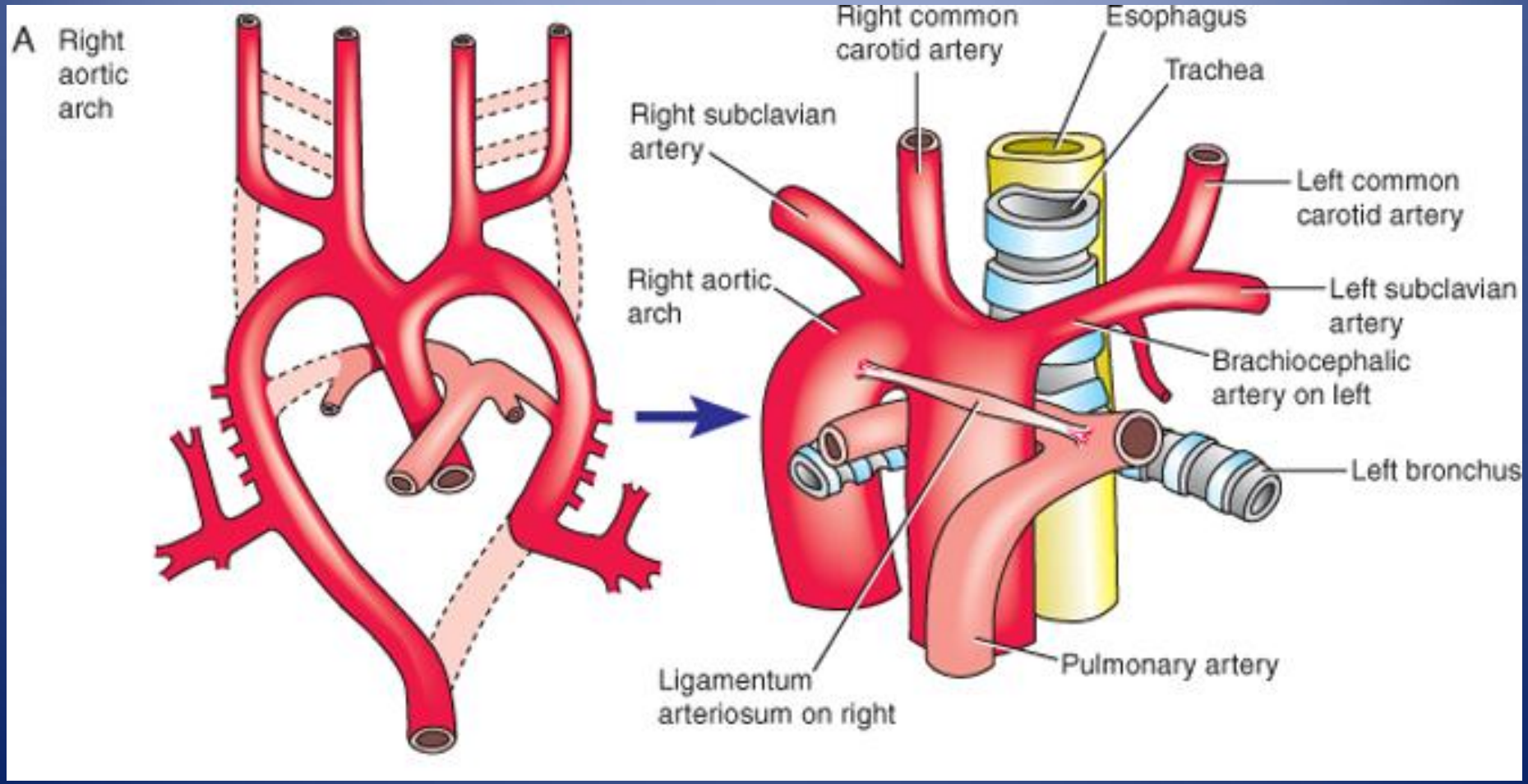
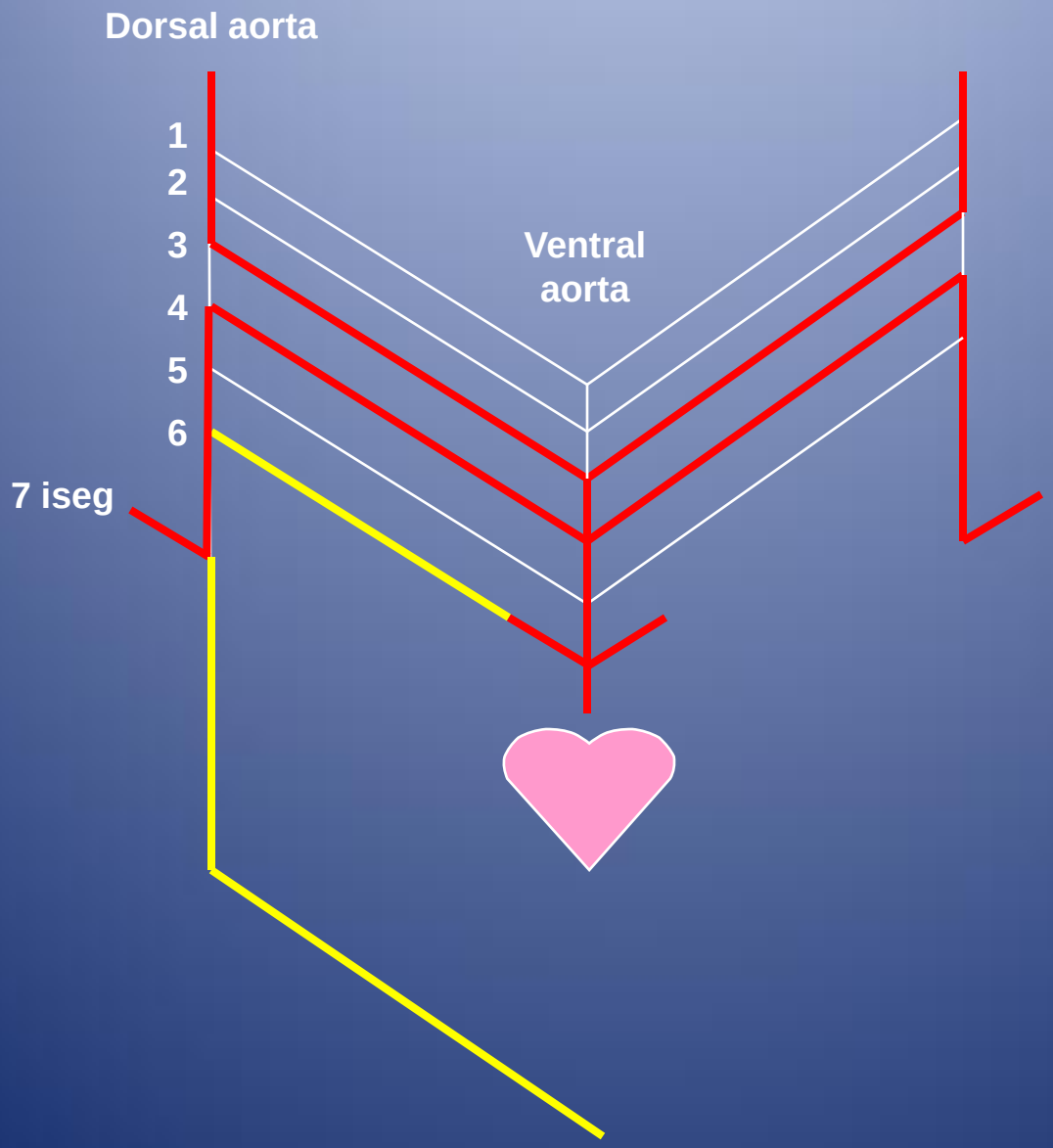
Retention of the Right Dorsal Aortic Segment Yields a Right Aortic Arch



Right Aortic Arch



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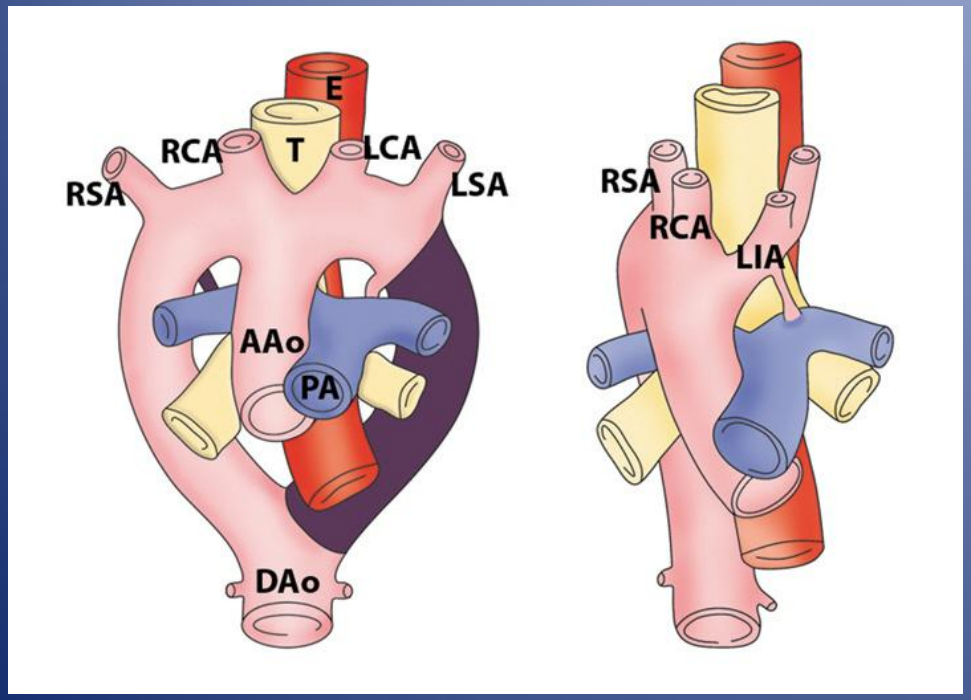
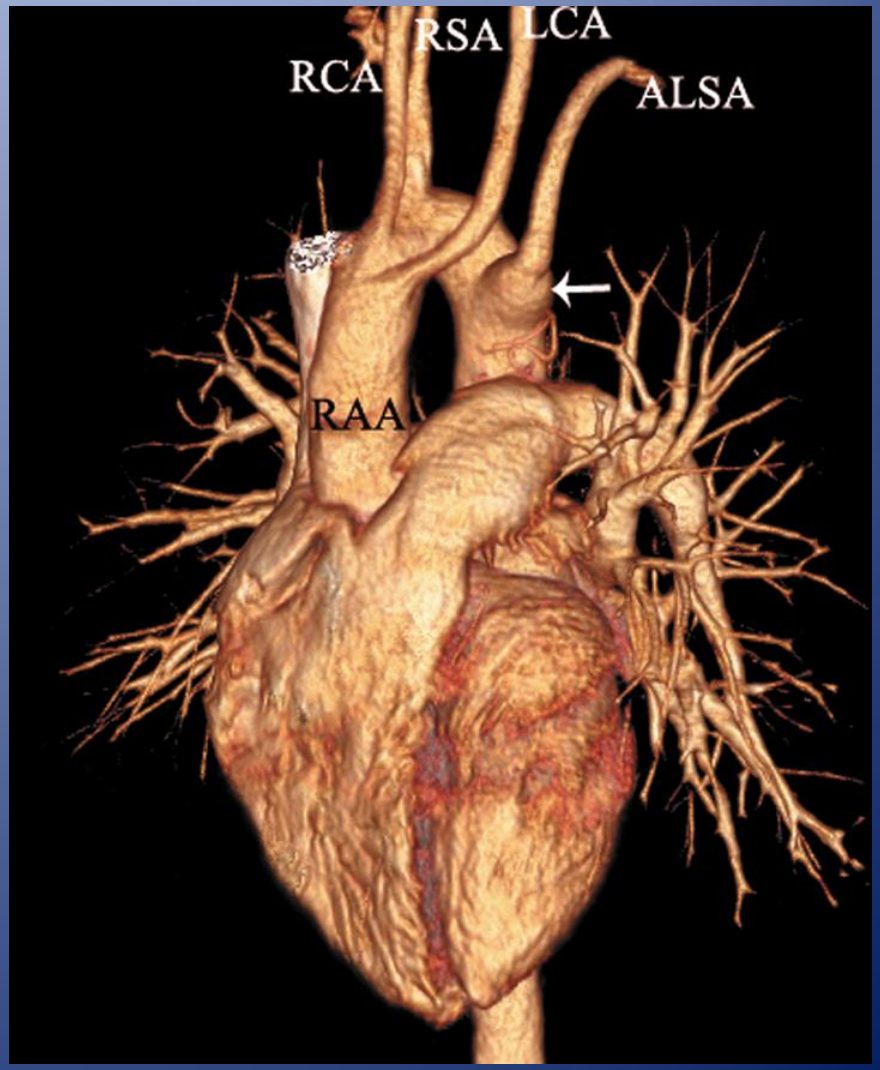
Right Aortic Arch: Mirror Image Branching versus Aberrant Left Subclavian Artery

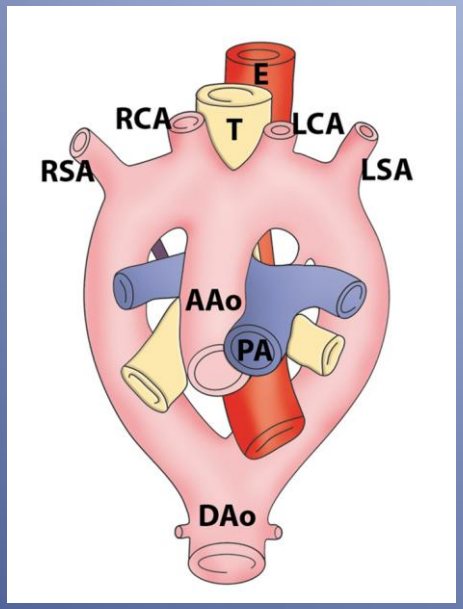


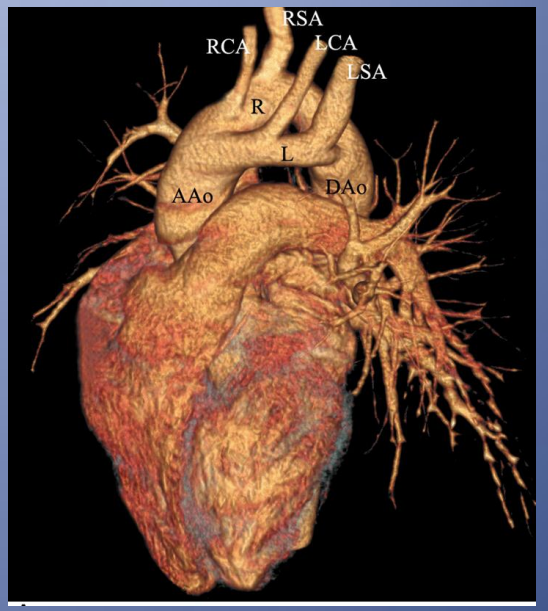


Vascular Rings May Cause Compression of the Trachea and the Esophagus

- Double Aortic Arch
  - Failure of the right dorsal aorta to regress
- Right Aortic Arch
  - Ductus arteriosus is directed towards the right
  - If the ductus, or later, the ligamentum arteriosum, passes behind the esophagus, constriction may occur

Double Aortic Arch Presenting with Dysphagia in a 31-Year-Old Woman

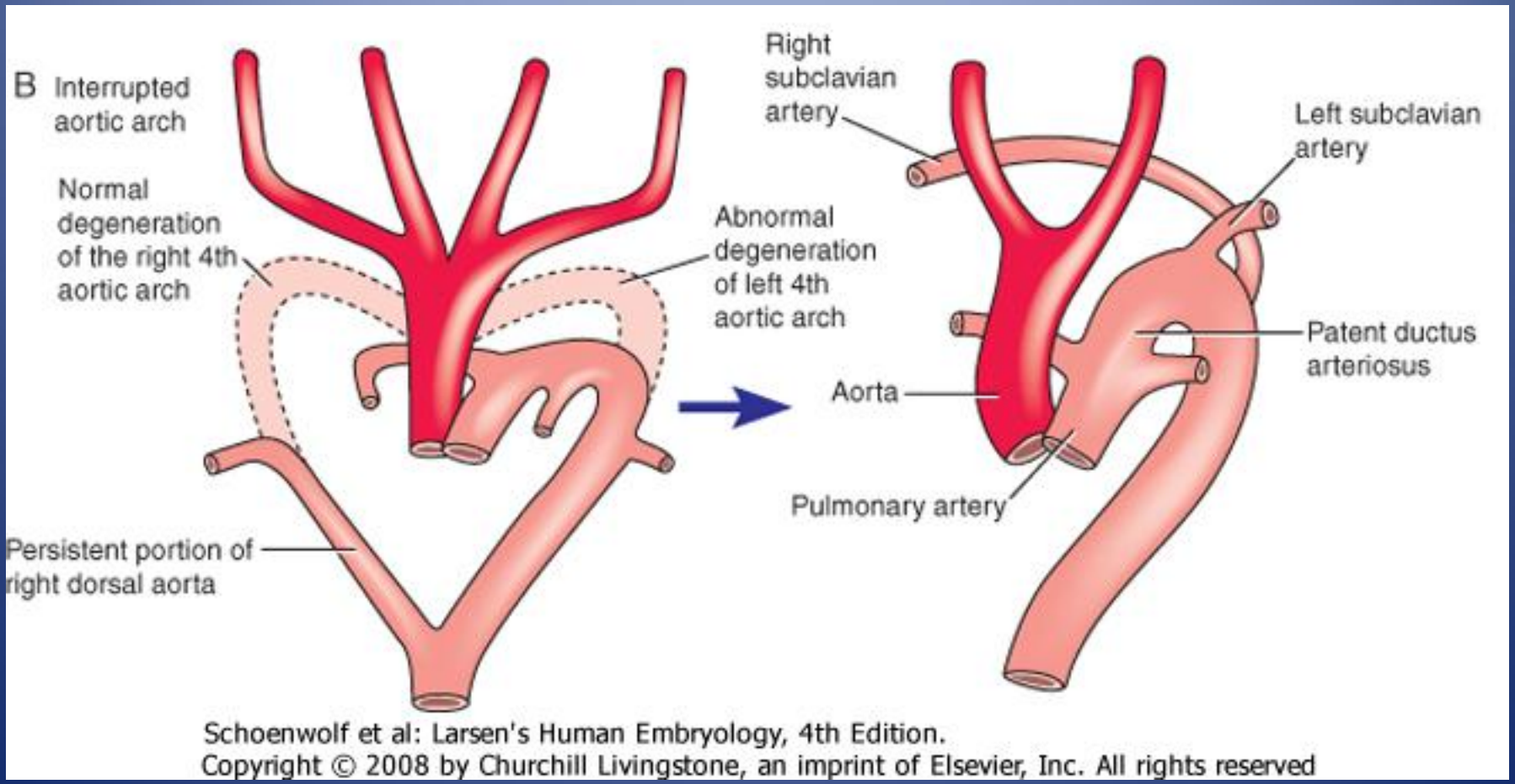




Aortic Arch Anomalies Can Cause Significant Clinically Compromise in the Neonatal Period

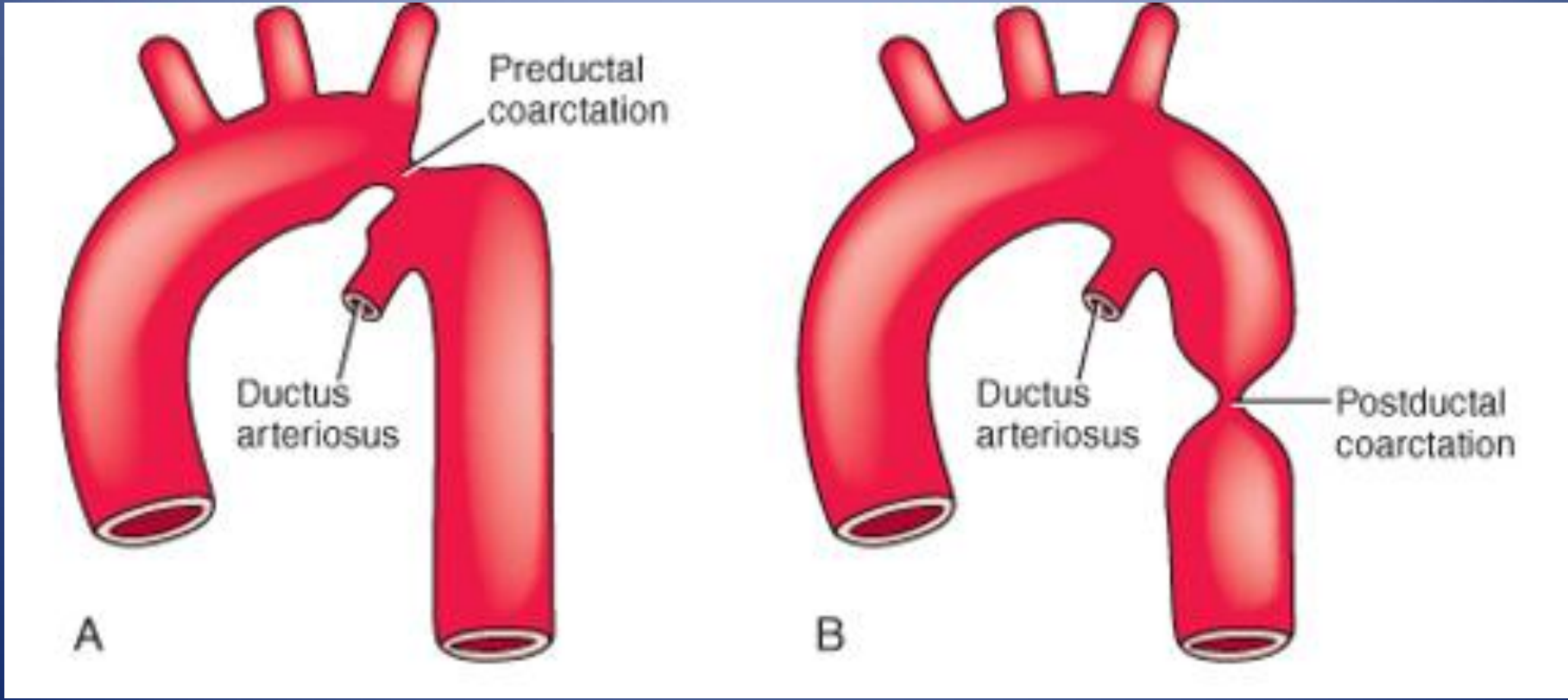
- Interrupted Aortic Arch
  - Obliteration of the right and left fourth aortic arches
- Coarctation of the Aorta
  - Constriction of the aorta in the region of the ductus arteriosus
  - 0.3% of live births
  - Most common cardiac anomaly in Turner's Syndrome

Obliteration of the Right and Left Fourth Aortic Arches Leads to Interruption of the Aorta

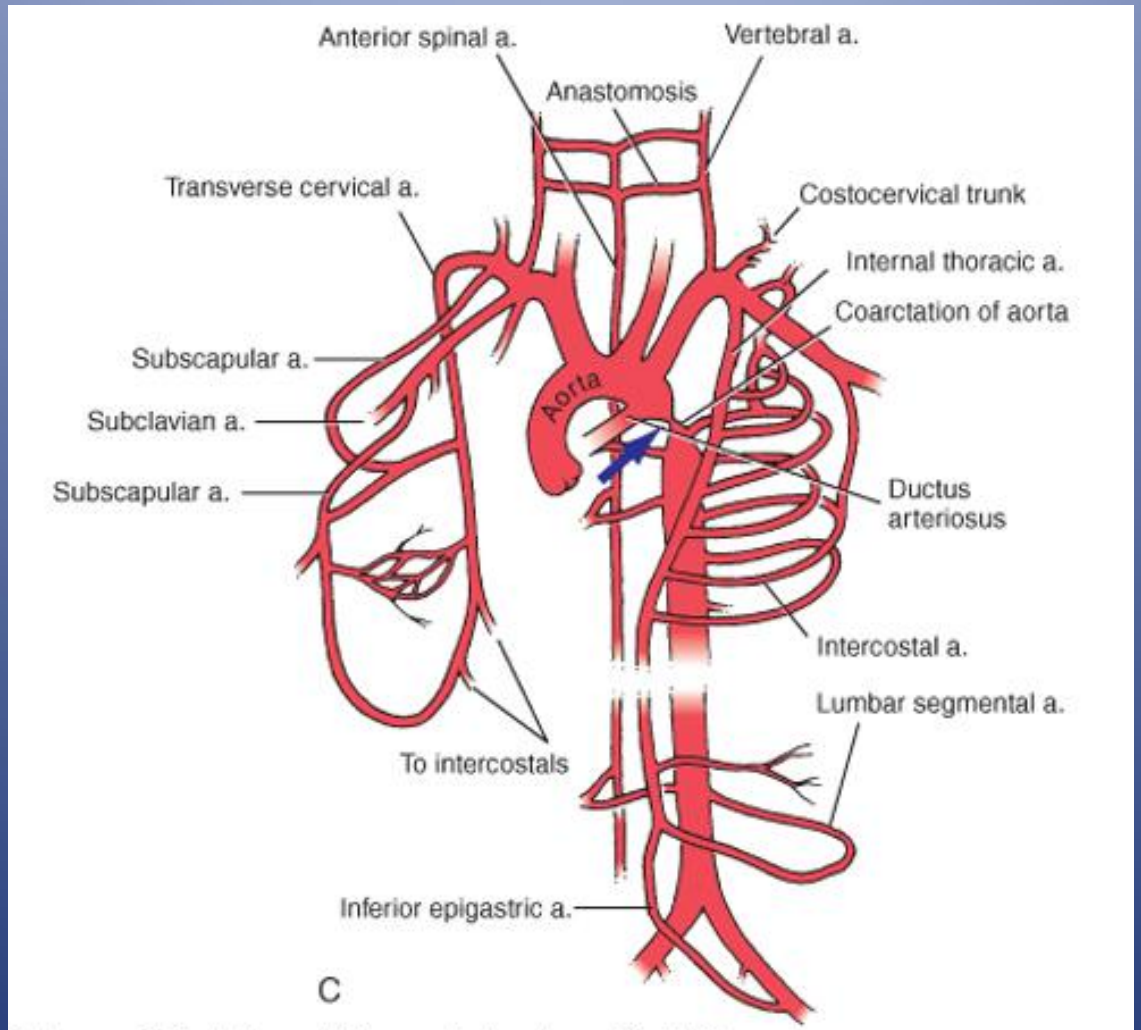


Schoenwolf et al: Larsen's Human Embryology, 4th Edition.

Constriction of the Aorta in the Region of the Ductus Arteriosus Produces Coarctation



Post-ductal Coarctation of the Aorta Utilizes Collateral Circulation to Supply Blood to the Lower Body



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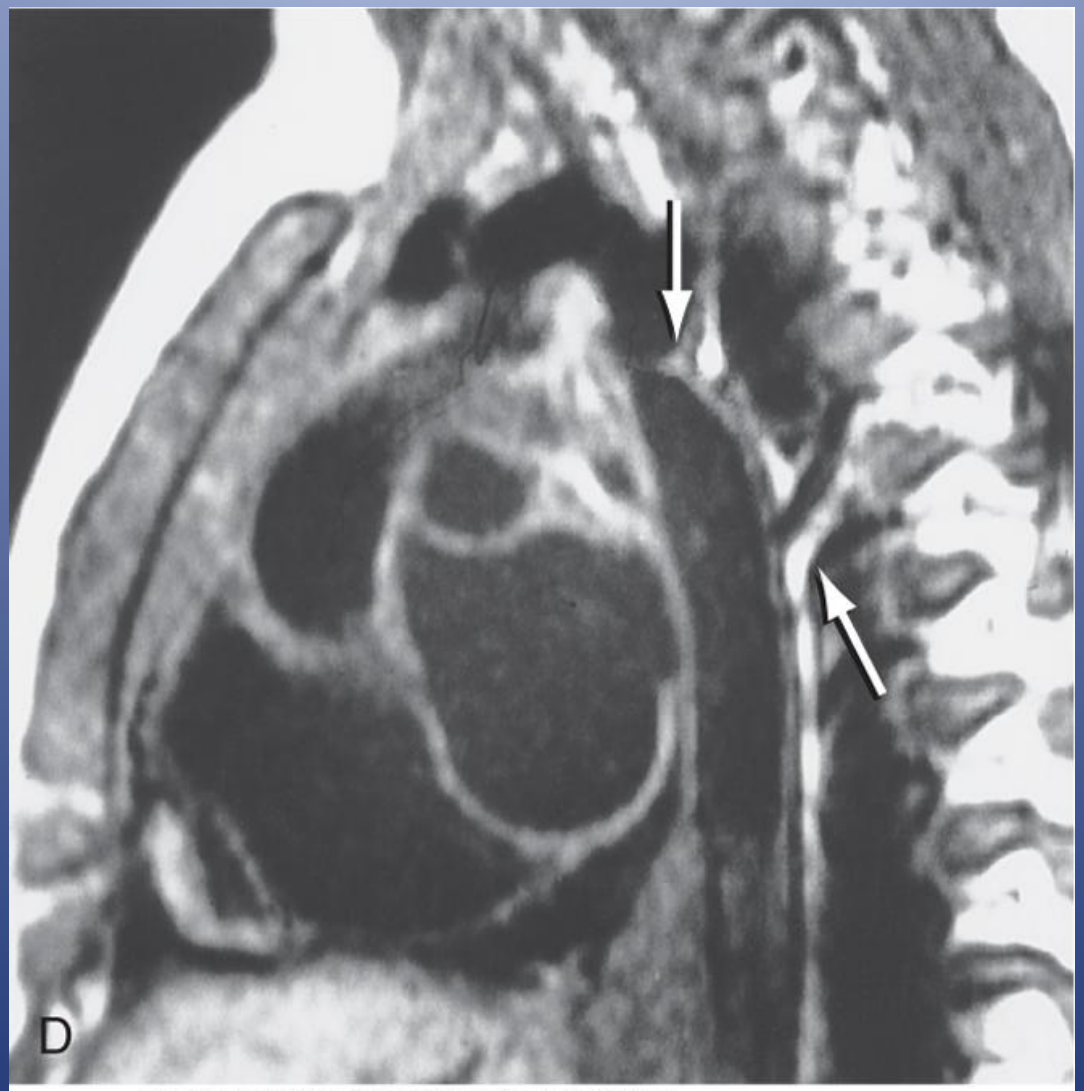
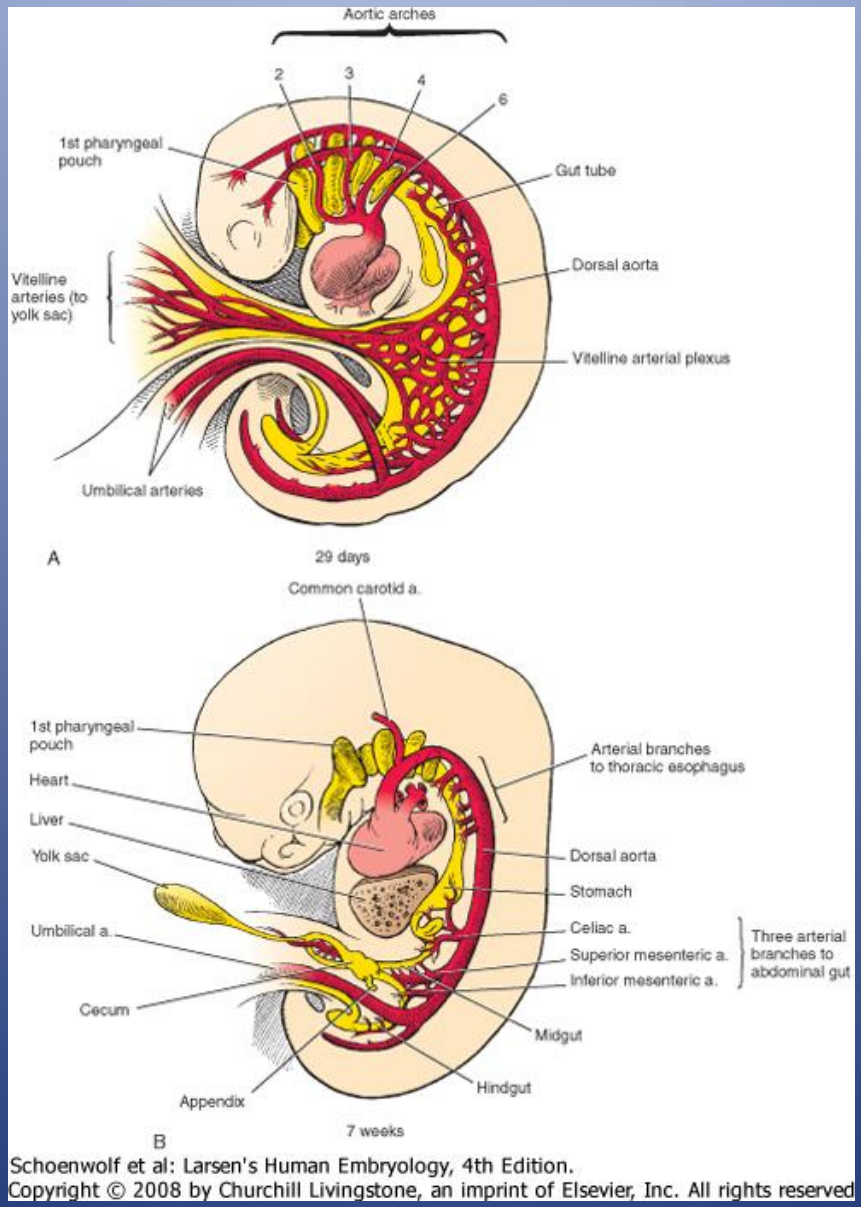
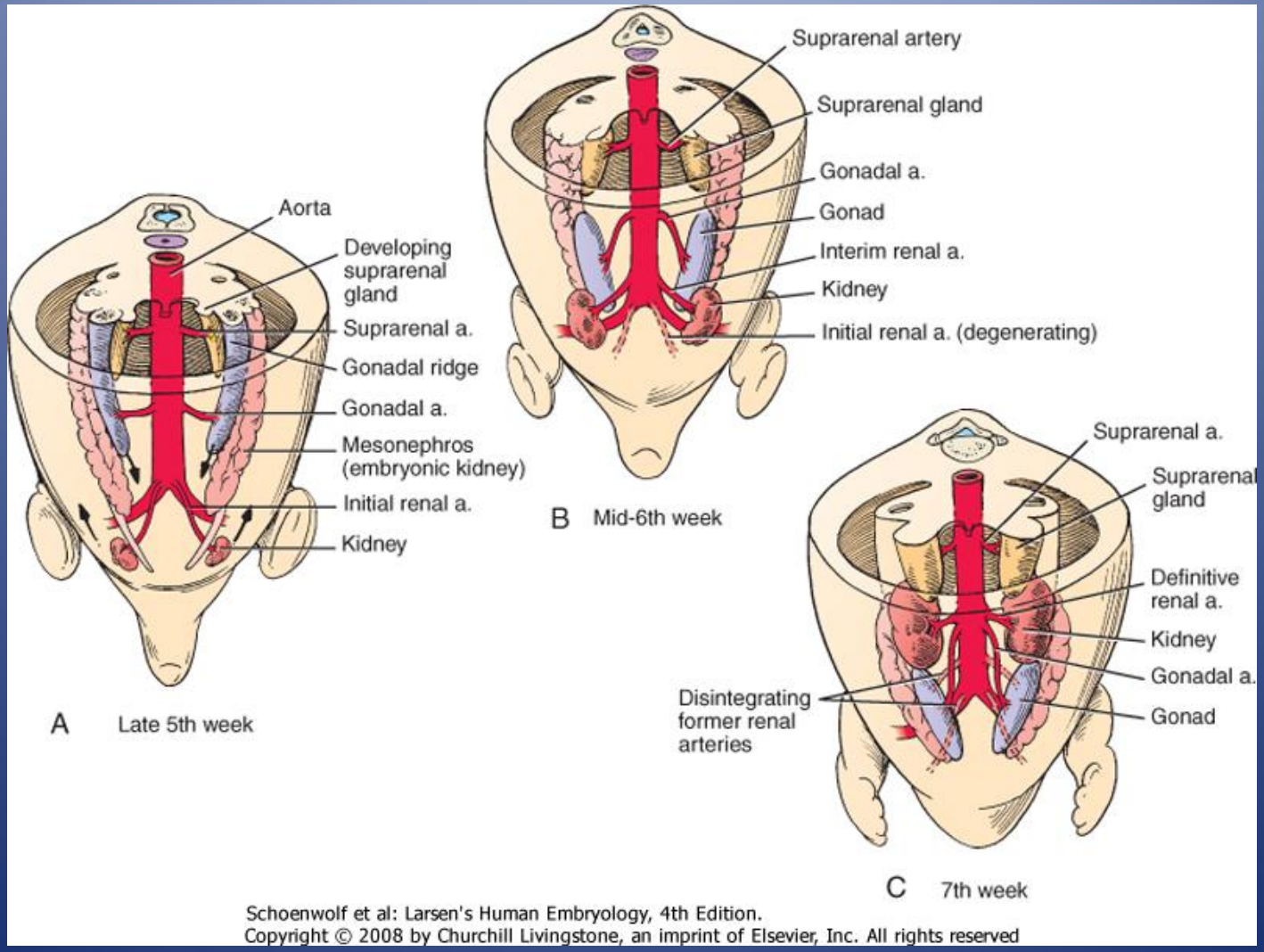


Vitelline Arteries Give Rise to the Arterial Supply of the Gastrointestinal Tract

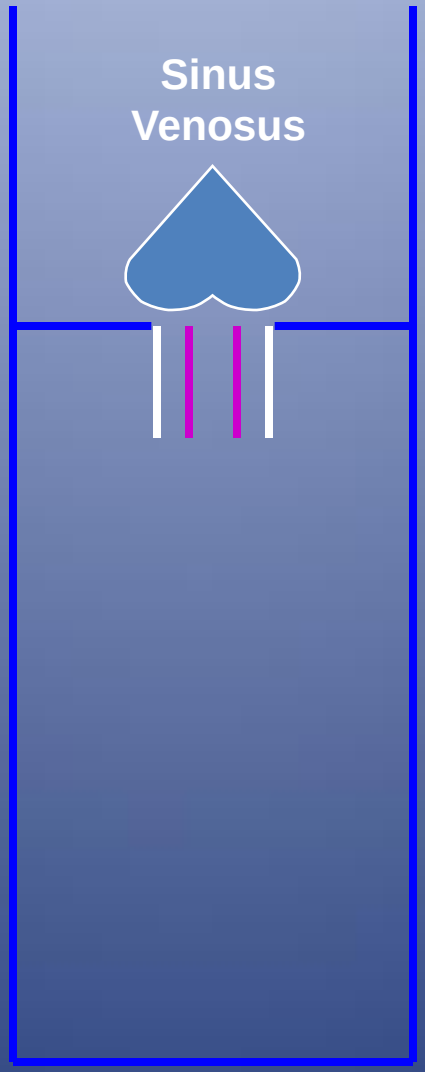


Lateral Branches of the Descending Aorta Highlight Developmental Histories of Each Organ



The Developing Venous System

- Vitelline
- Umbilical
- Cardinal



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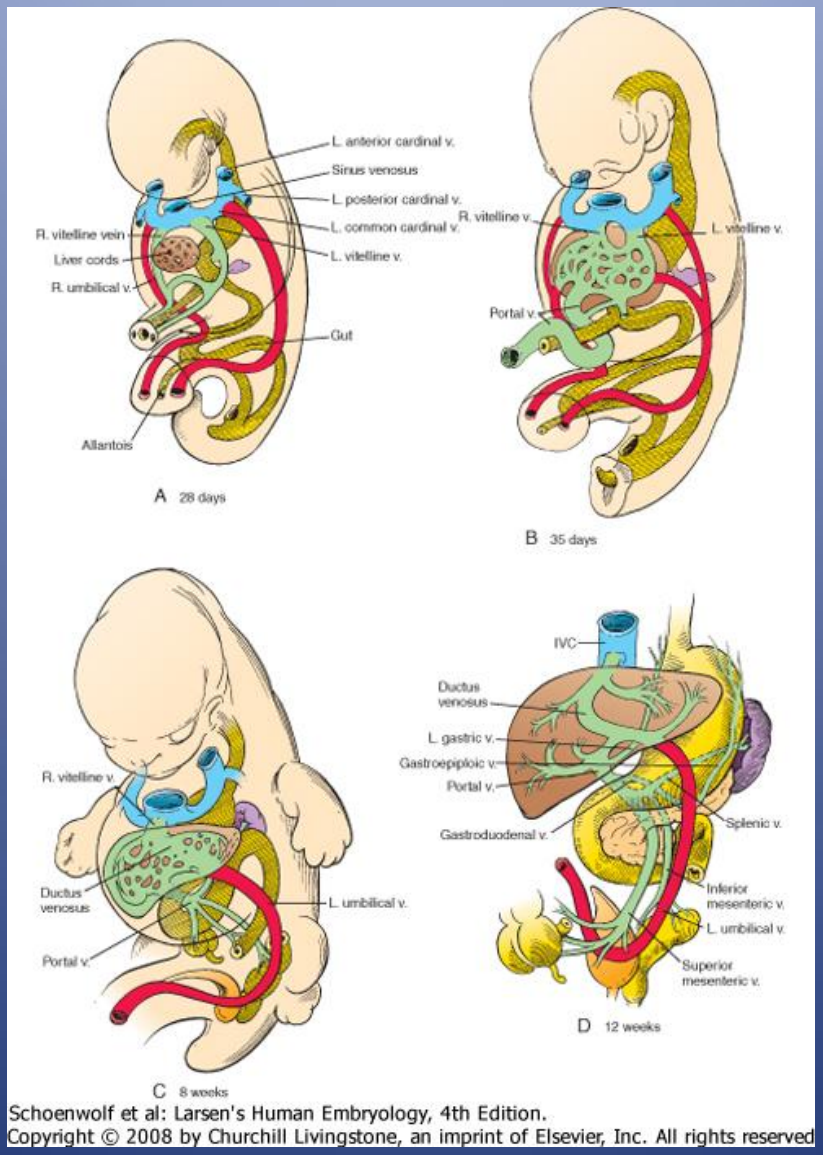
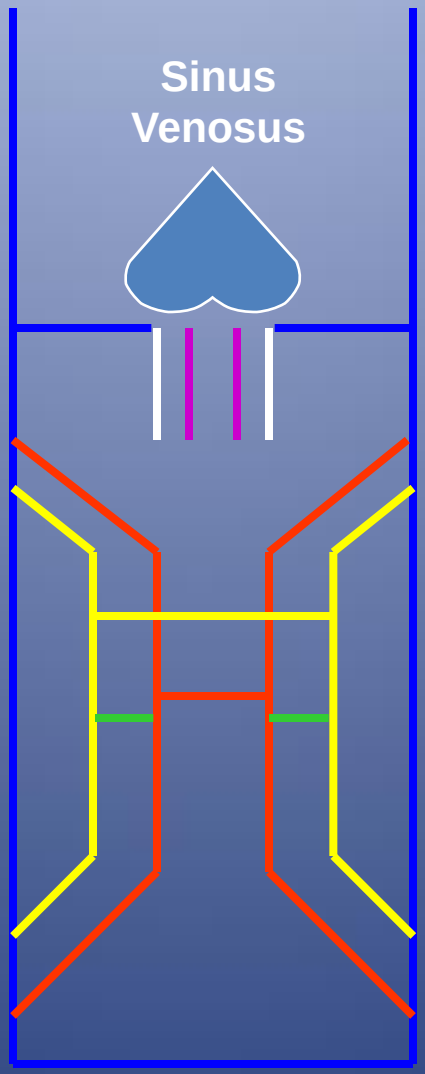
Vitelline Veins Form a Portal System to Drain Blood from the Foregut, Midgut, and Part of the Anorectal Canal



The Developing Venous System

- Vitelline
- Umbilical
- Cardinal
- Subcardinal
- Supra cardinal
- Supra-Subcardinal Anastomosis



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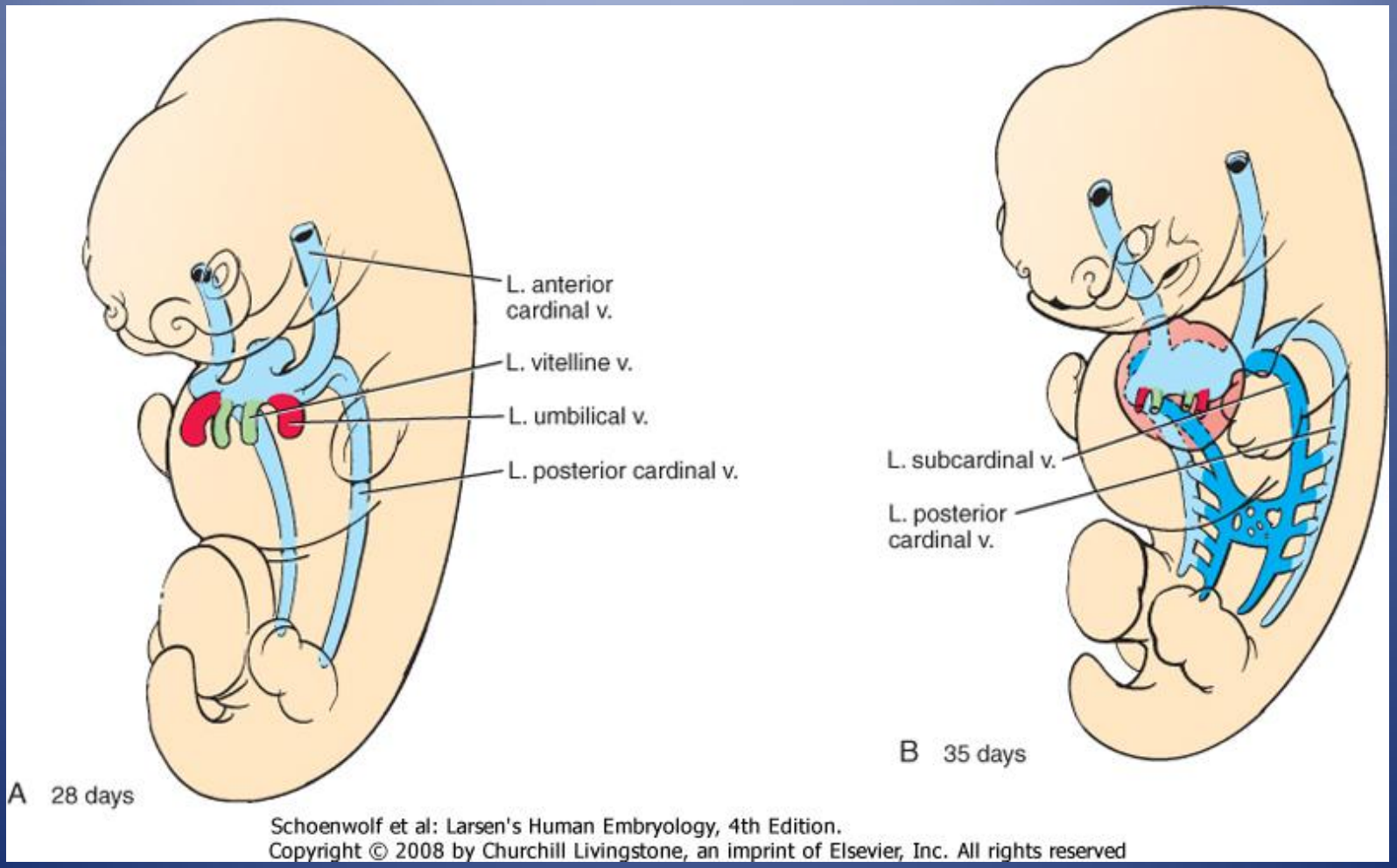
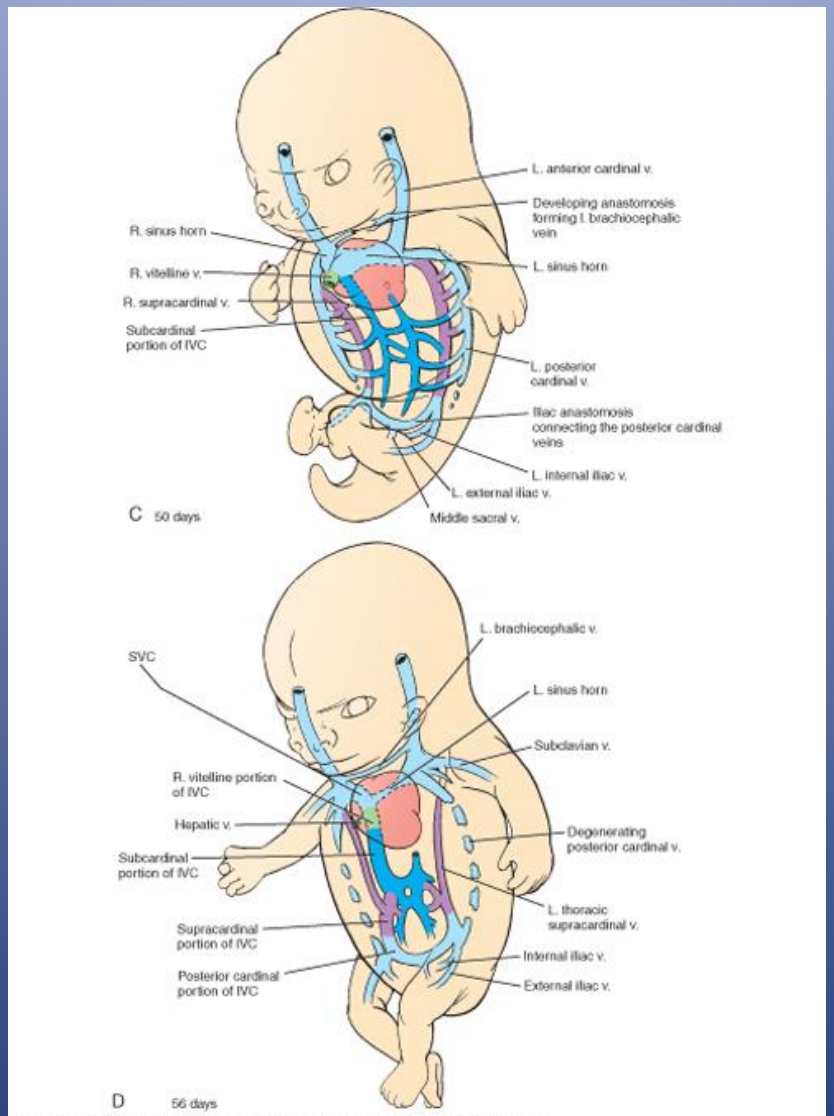
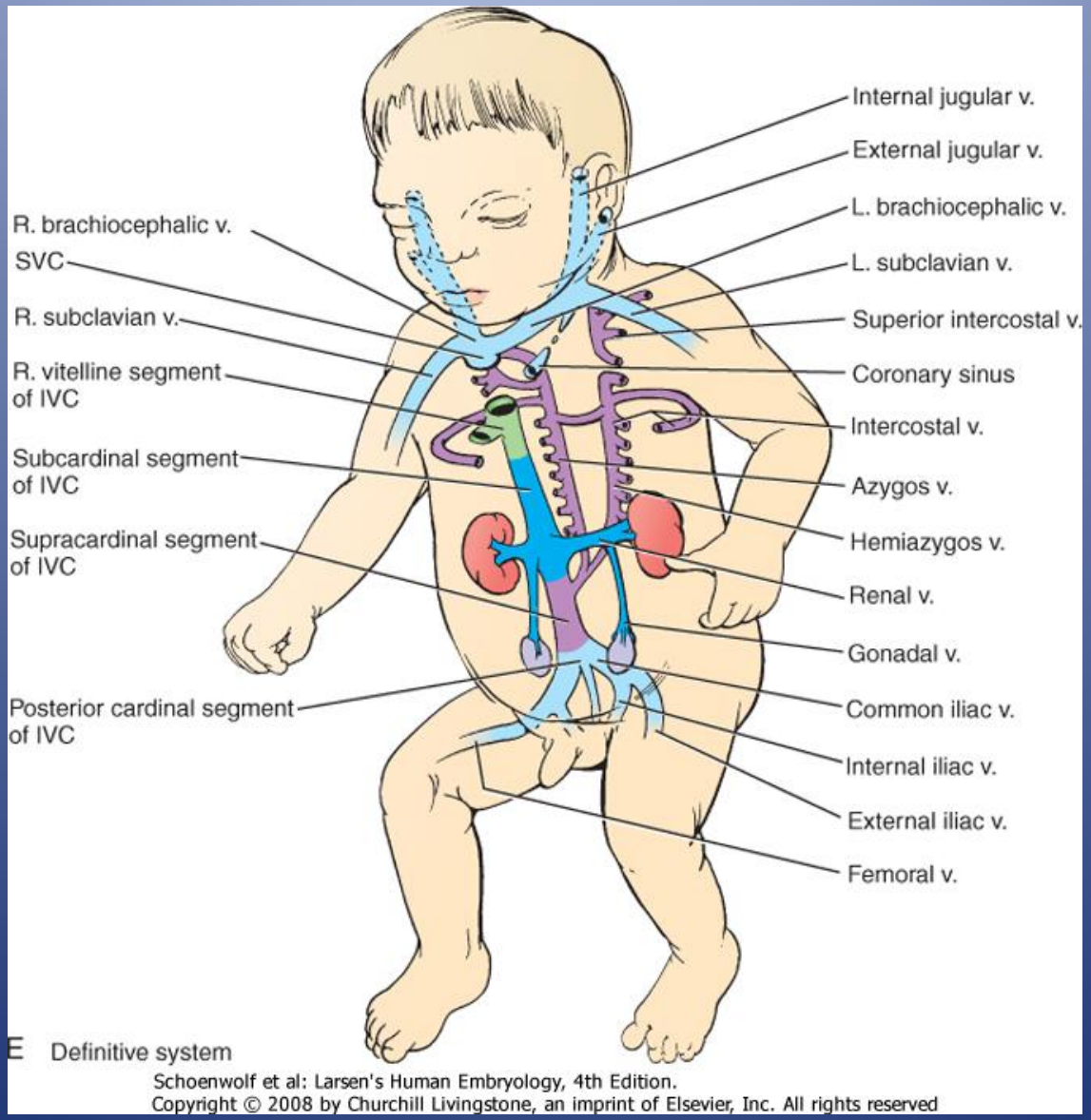
The Systemic Venous System Develops from Four Bilaterally Symmetric Cardinal Veins



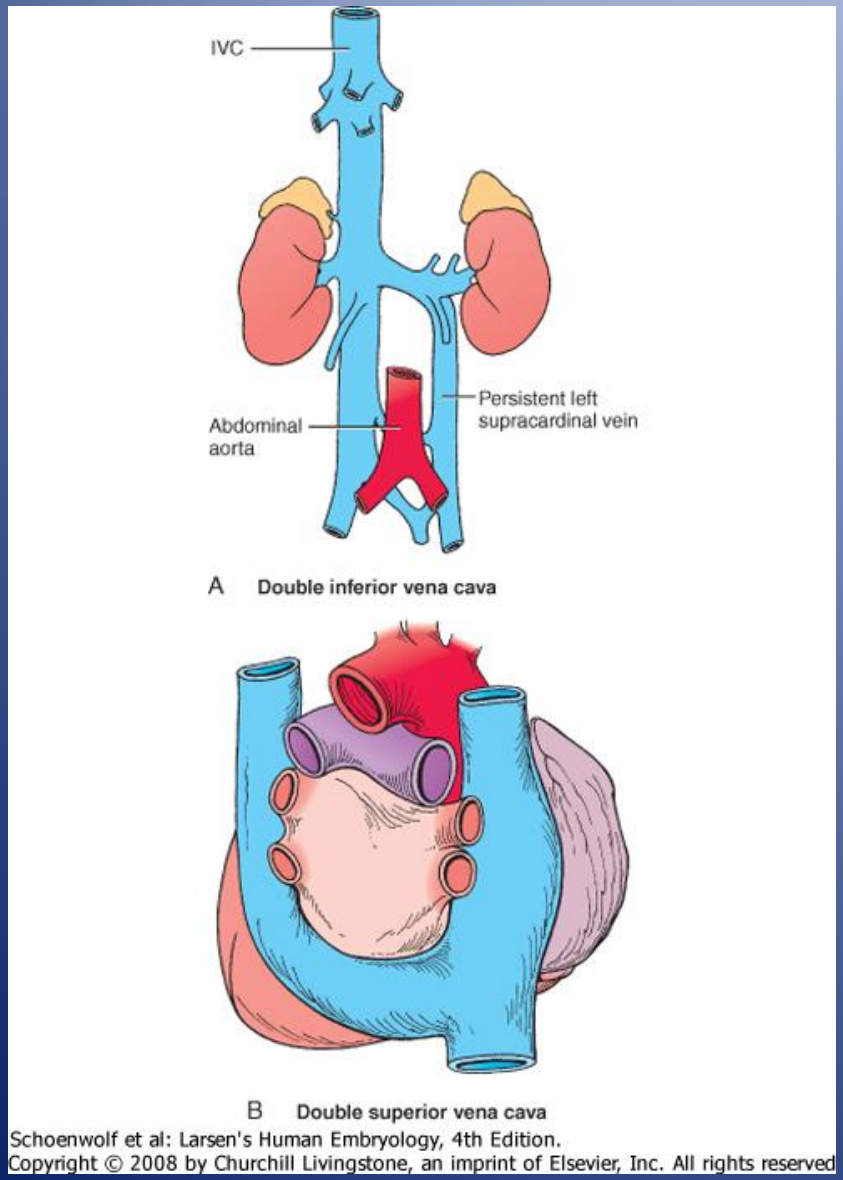
Following Remodeling of the Subcardinal System, the Supracardinal Veins Sprout



Remodeling of Abdominal Venous System Occurs through Obliteration of the Left Supracardinal Vein

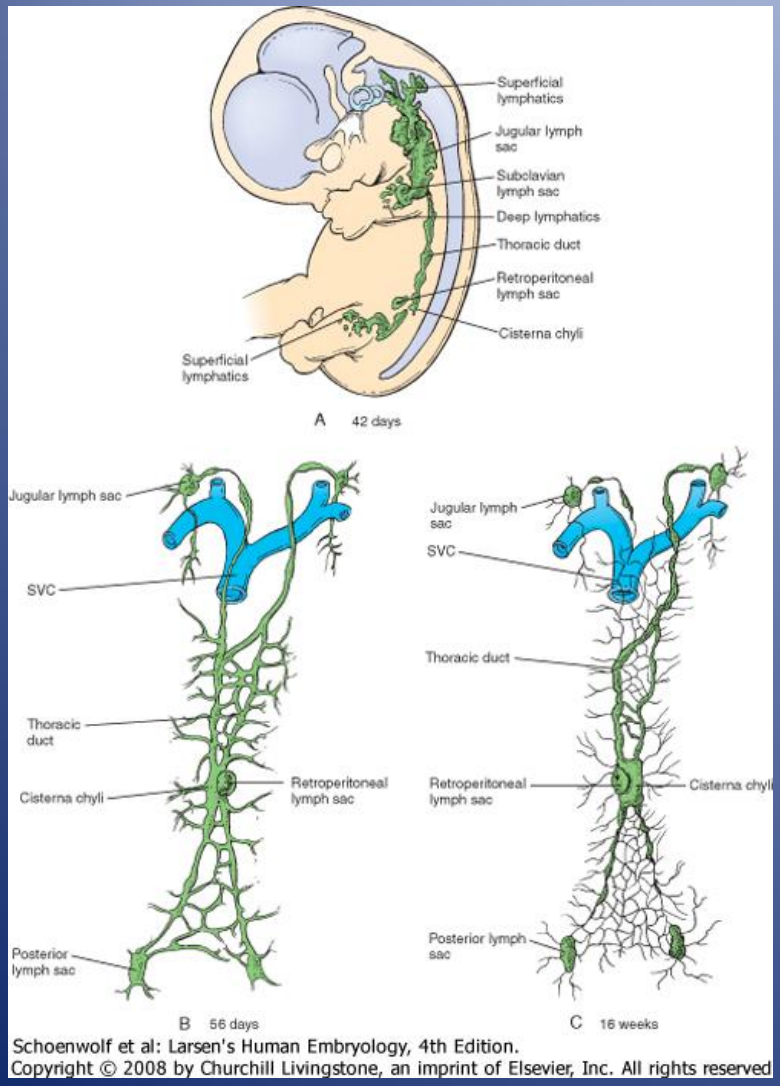


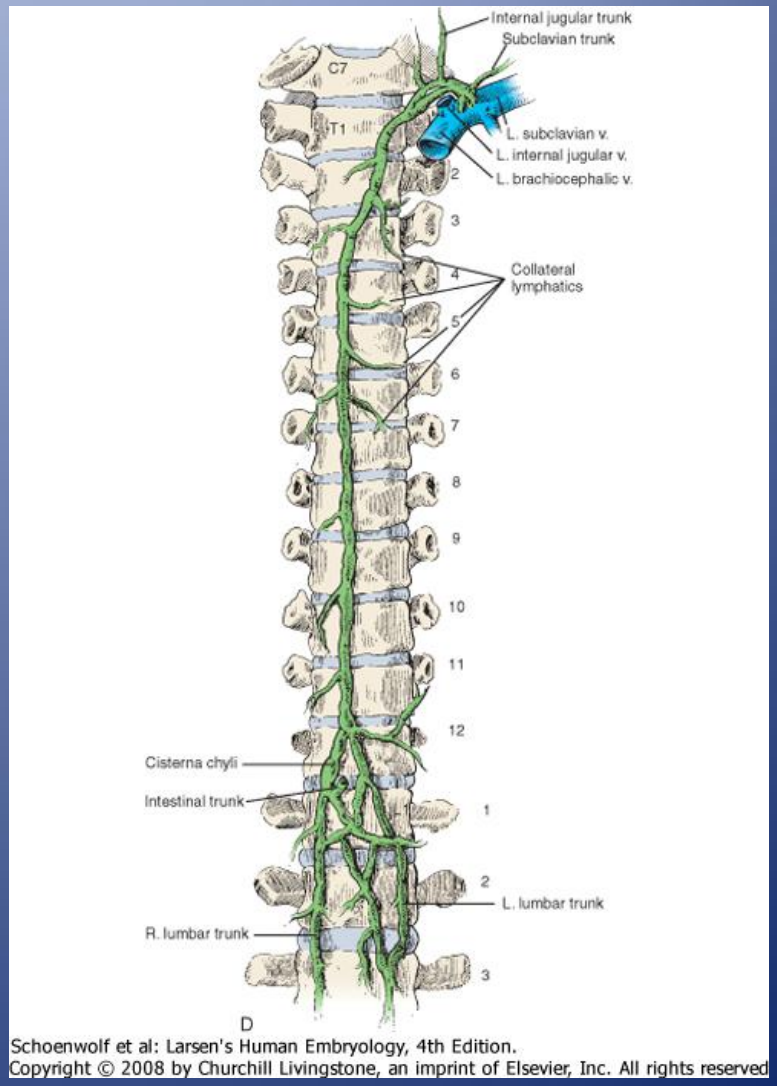
Failure of Left Cardinal Veins to Undergo Normal Regression Leads to Venous Anomalies



- LSVC occurs in 0.3% to 0.5% of the normal population
- In 65% of cases, left brachiocephalic vein is also missing
- 4% of patients with CHD have an LSVC
- Usually drains to the coronary sinus

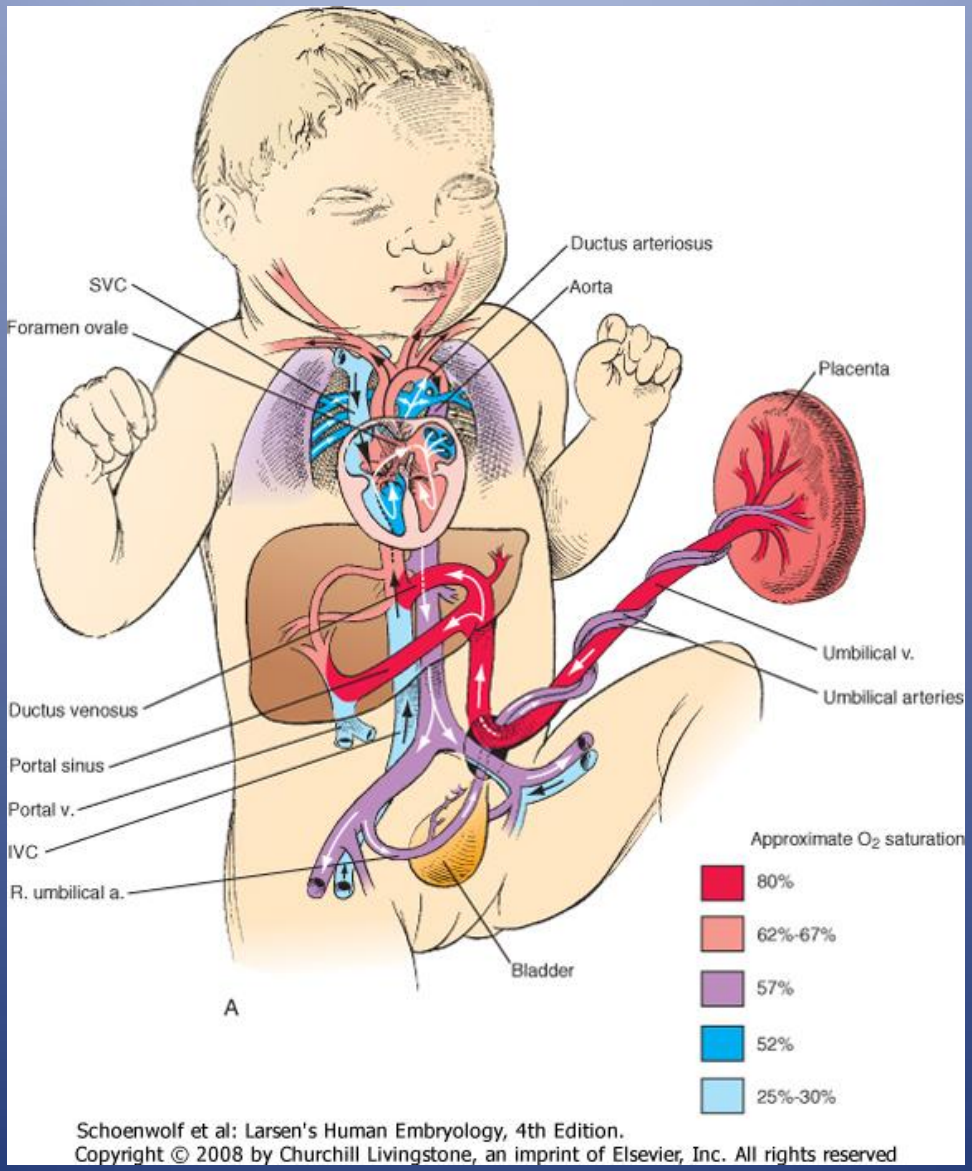
Lymph Sacs and Ducts Form by Lymphangiogenesis to Drain Fluid from Tissue Spaces Throughout the Body



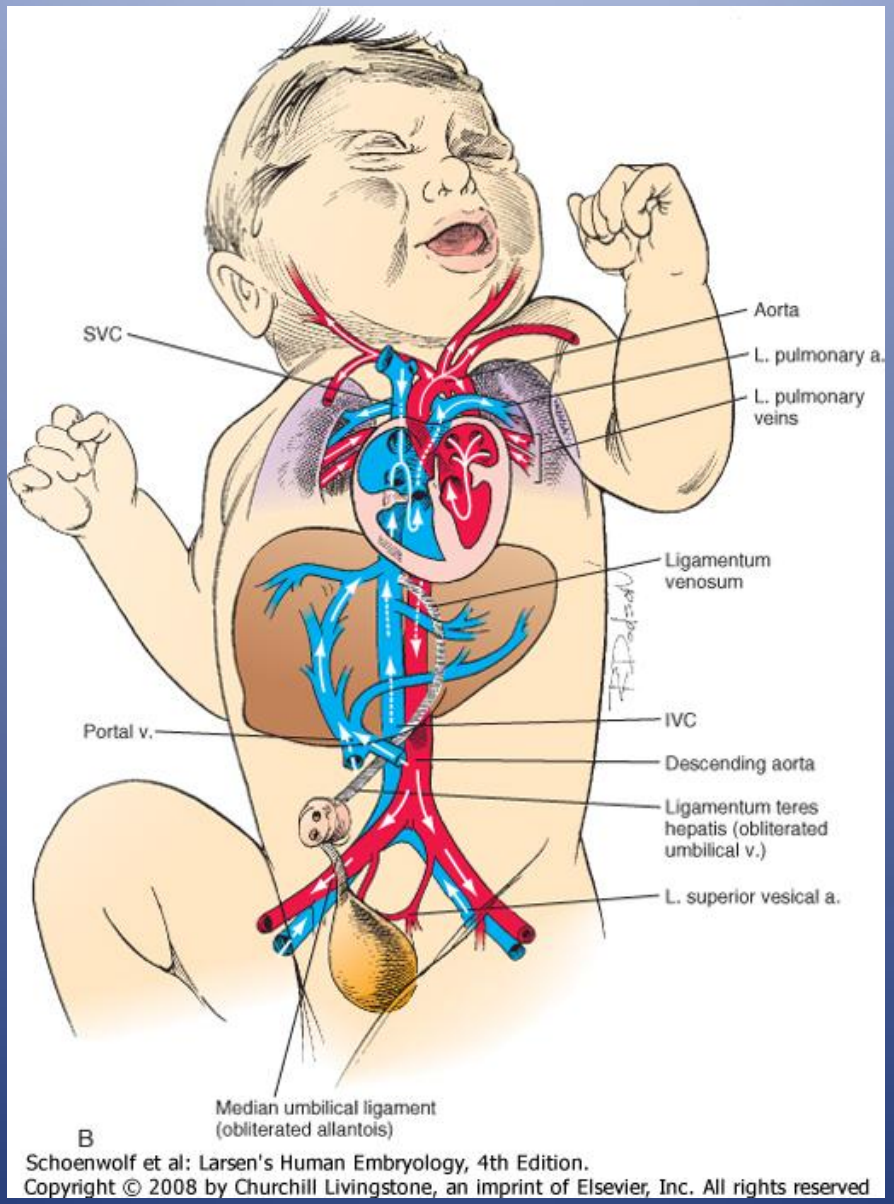


Cystic Hygromas Develop in Turner's Syndrome Patients Secondary to Blockage of Lymphatic Ducts

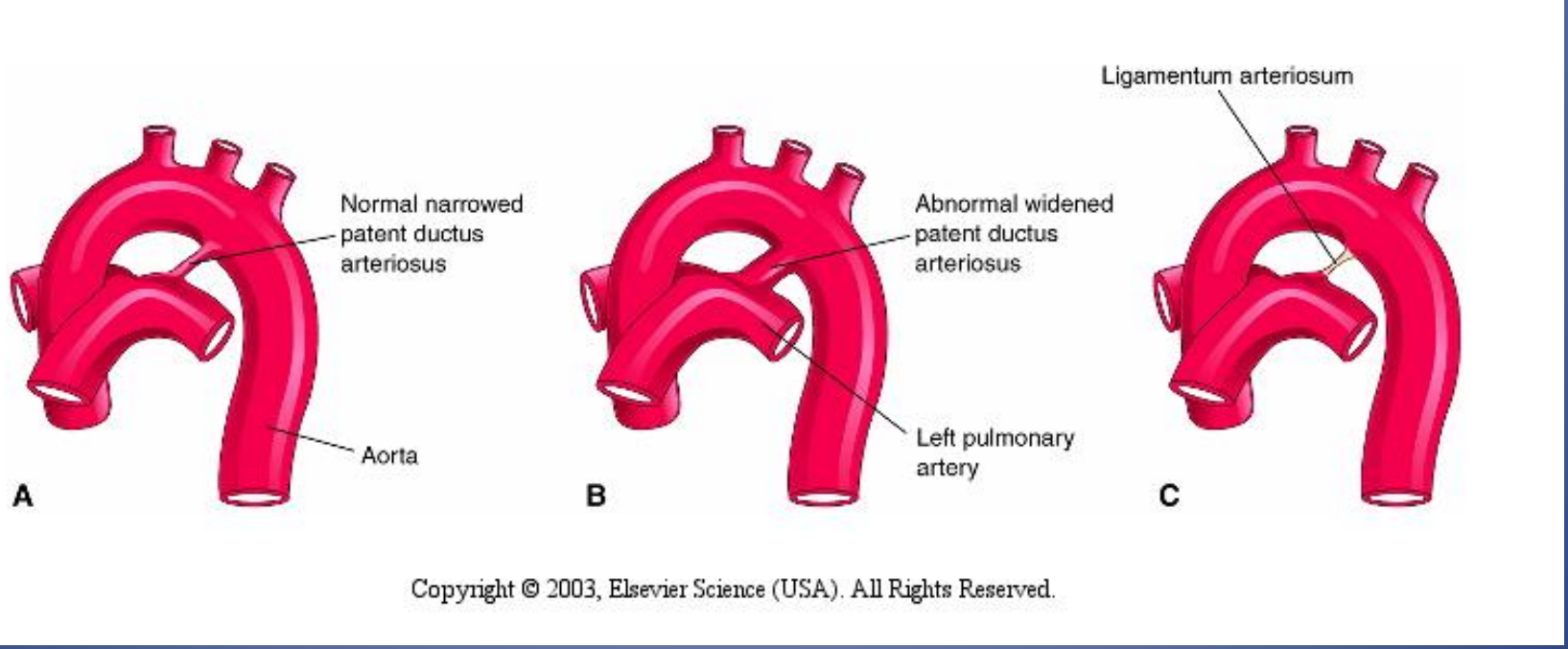
Fetal Circulation Bypasses the Developing Pulmonary Circulation



Pulmonary Vascular Resistance Drops Precipitously and Initiates the Transition to Post-Natal Circulation



Normal Closure of the Ductus Arteriosus Occurs during the Transition to Neonatal Circulation in Series



- Prostaglandins maintain a patent ductus arteriosus
- Indomethacin is used to induce ductal closure
- Physiologic closure occurs by 2 days in 82% of patients