Arterial System

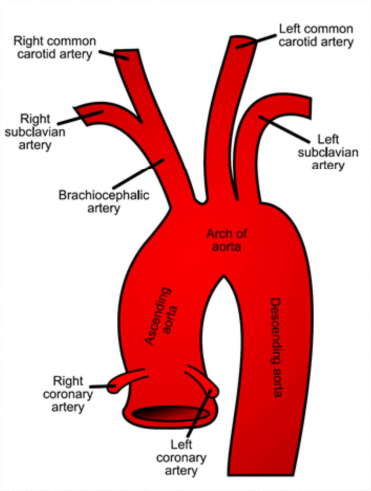
Lecture 11

Aortic Arches and Circulation in Vertebrates

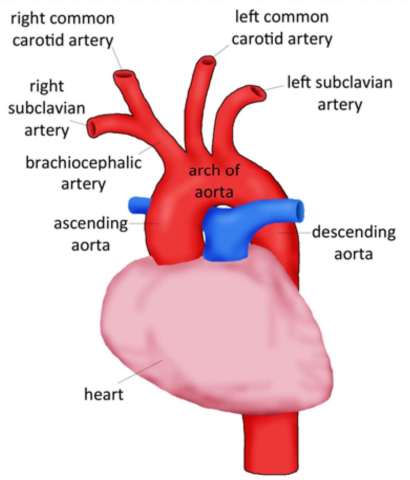
Dr. Istiak Mahfuz
Assistant Professor

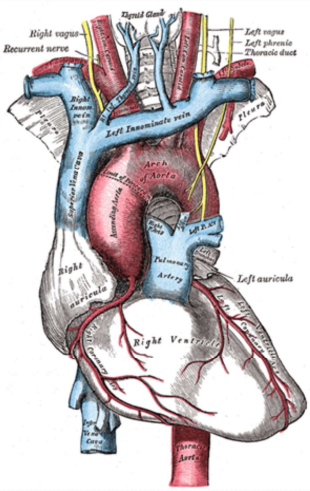
Aortic Arch

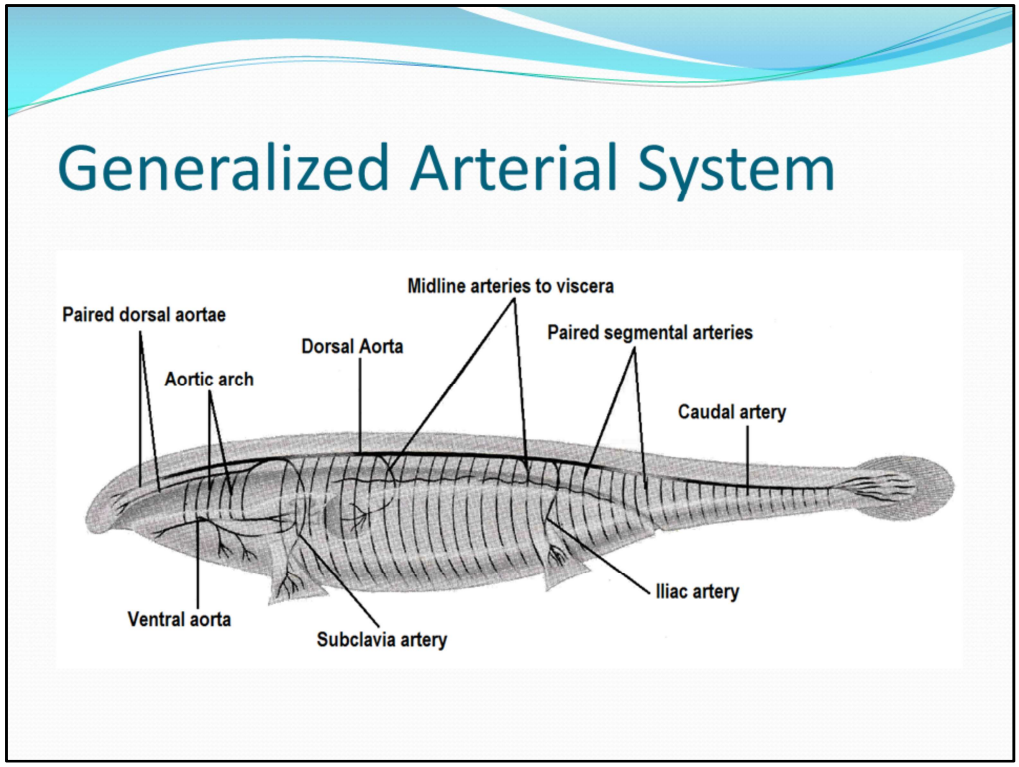
- The aortic arch is the portion of the main artery that bends between the ascending and descending aorta.
- It leaves the heart and ascends, then descends back to create the arch.
- The aorta distributes blood from the left ventricle of the heart to the rest of the body.



Aortic Arch


right common carotid artery
left common carotid artery
right subclavian artery
left subclavian artery
brachiocephalic artery
arch of aorta
ascending aorta
descending aorta
heart


Right vagus
Recurrent nerve
Left vagus
Left phrenic
Thoracic duct
Left Innominate vein
Arch of Aorta
Left auricula
Right Ventricle



The early development of the arterial system is similar in all vertebrates.

Ventral Aorta: Extending anteriorly from the conus arteriosus, just ventral to the pharynx. It gives off paired aortic arches which course dorsally around the pharynx between the developing pharyngeal pouches and then join the paired dorsal aortae.

Dorsal aorta: Caudal to the pharynx the paired dorsal aortae meet, fuse, and form a midline dorsal aorta running caudally just ventral to the notochord.

Paired segmental arteries: Distribute arterial blood to the somatic musculature, paired viscera, and skin.

The head is supplied by paired anterior extensions of, the ventral and dorsal aortae. This basic arterial system is modified in later development to provide the diversity of arterial patterns seen in adult vertebrates.

Aortic Arches

ec- external carotid

ic- internal carotid

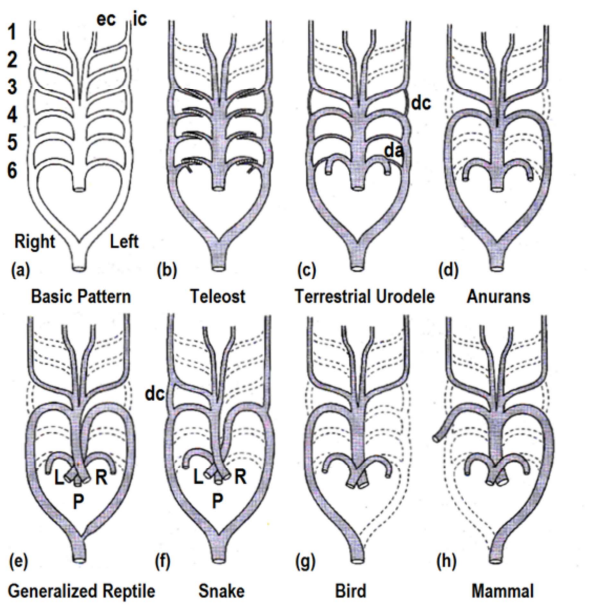
dc- ductus caroticus

da- ductus arteriosus

L- aortic trunk of left systemic arch

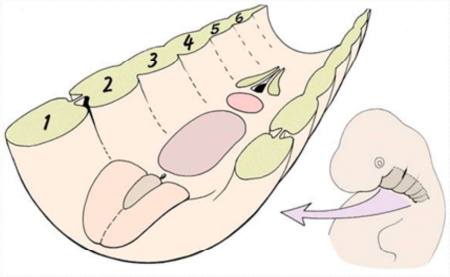
R- aortic trunk of right systemic arch

P- pulmonary trunk



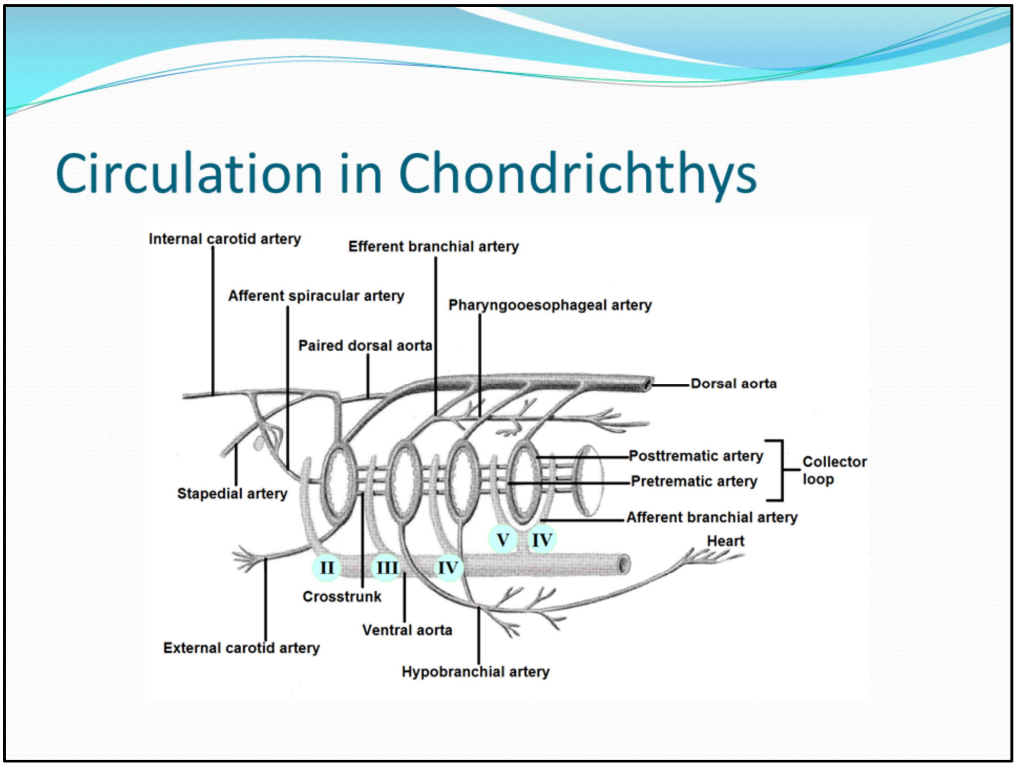
Aortic Arches and Anterior Arteries

- Gnathostomes
  - Six pairs of aortic arches
  - Develop in relationship to the pharyngeal pouches and skeletal branchial arches
  - Gill breathing gnathostomes the first aortic arch is lost
- Amniotes
  - One and two are frequently lost before the posterior arches (five and six) even develop



In the development of vertebrates, the pharyngeal arches (which develop into the branchial arches or gill arches in fish) are primordia for a multitude of structures. In the human embryo (where the vasculature of the pharyngeal arches is also known as theaortic arches), they develop during the fourth week as a series of mesodermal outpouchings on both sides of the developingpharynx. In fish, the branchial arches support the gills.

Not surprisingly the adult fate of each aortic arch is closely related to the fate of the corresponding pharyngeal pouch.



The ventral portions of aortic arches two through six form five pairs of afferent branchial arteries traveling up their respective pharyngeal arches.

The second aortic arch, giving rise to the most anterior afferent branchial artery, passes between the spiracle and the first gill slit. Each gill slit has gill lamellae on either side.

Around the gill slit, collecting from the capillaries of the gill lamellae, is a closed loop of efferent arteries. The anterior portion of each loop is called the pretrematic efferent artery, and the posterior, the posttrematic efferent artery; together they are called the collector loop.

The situation is complicated by so-called cross trunks or anastomotic connections between the pretrematic efferent branch of one loop and the posttrematic efferent branch of the next.

These collector loops give rise to four efferent branchial arteries from the dorsal portions of aortic arches three, four, five, and six. These four arteries form the descending midline dorsal aorta.

Afferent spiracular artery☛ oxygenated blood to the spiracle; External carotid artery☛ oxygenated blood to the lower jaw; Internal carotid artery☛ oxygenated blood to the dorsal portion of the head and to the brain

Hypobranchial artery☛ blood to the hypobranchial musculature and to the muscular walls of the heart

Aortic Arches

ec- external carotid

ic- internal carotid

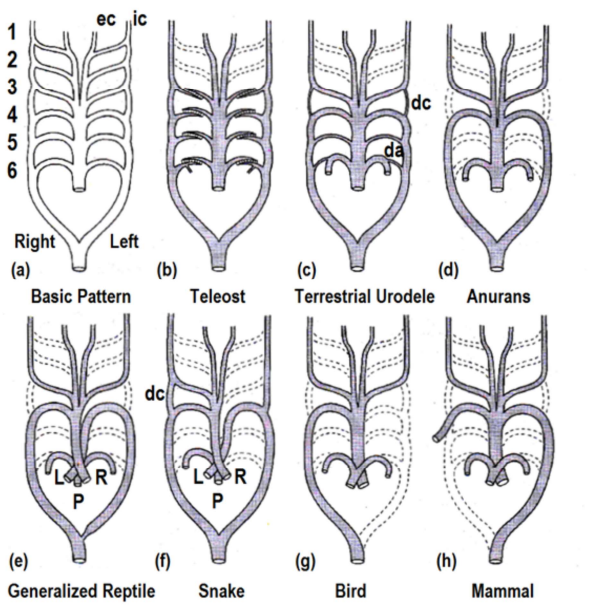
dc- ductus caroticus

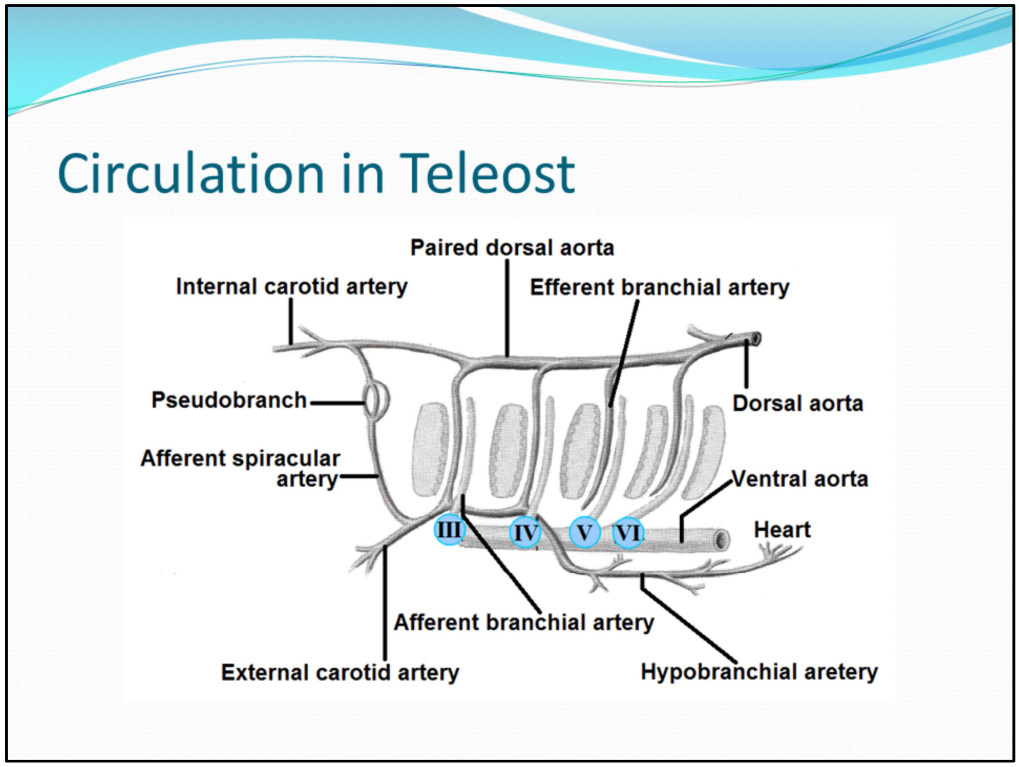
da- ductus arteriosus

L- aortic trunk of left systemic arch

R- aortic trunk of right systemic arch

P- pulmonary trunk





In adult teleosts there are only four functional afferent branchial arteries, which are formed from the ventral portions of aortic arches three through six; these four arteries bring unoxygenated blood to the gill lamellae.

The efferent branchial arteries do not form collector loops; each efferent branchial artery collects from an entire, single holobranch and travels up to one of a pair of dorsal aortae as the dorsal portion of aortic arch three, four, five, or six.

The anterior extensions of the ventral aortae, which would carry unoxygenated blood, become separated from their more posterior parts and gain anastomotic connections with the ventral tips of the third and fourth efferent branchial arteries, from which they receive oxygenated blood.

External carotid arteries☛ oxygenated blood to the lower jaw; Afferent spiracular artery☛ separate branch of the external carotid☛ oxygenated blood to the pseudobranch.

Internal carotid☛ oxynated blood into the head and brain.

The efferent branchial arteries from the third and fourth aortic arches, in addition to contributing to the external carotid, also send a ventral branch to the hypobranchial and heart muscles.

Aortic Arches

ec- external carotid

ic- internal carotid

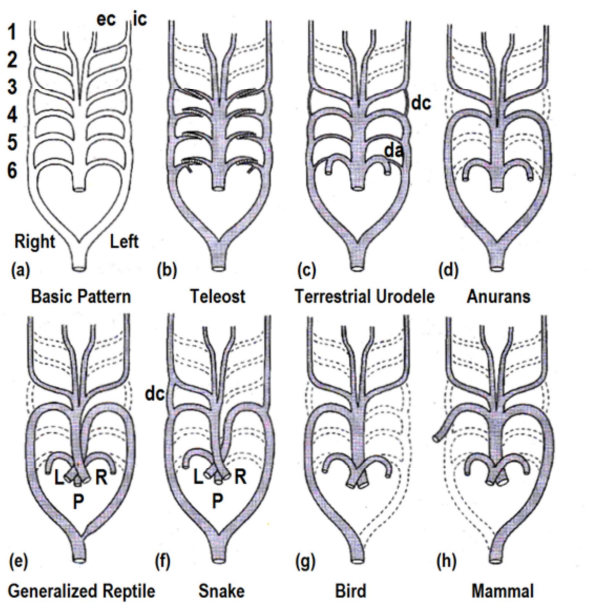
dc- ductus caroticus

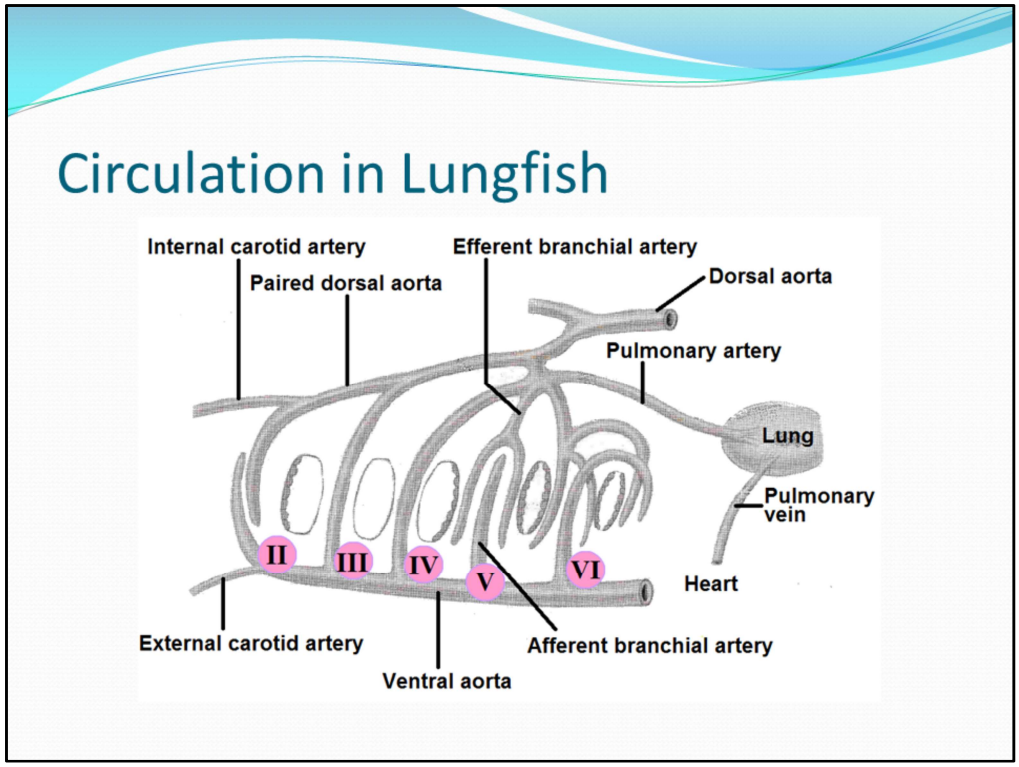
da- ductus arteriosus

L- aortic trunk of left systemic arch

R- aortic trunk of right systemic arch

P- pulmonary trunk





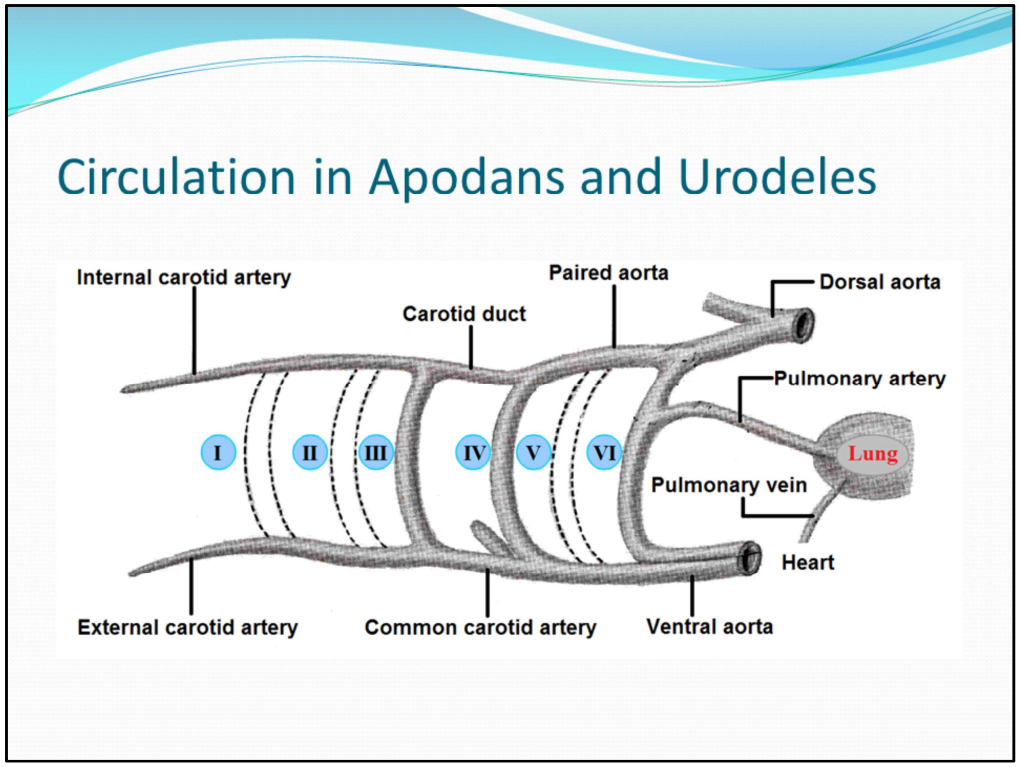
The gills of the three genera of lungfish are best developed in the Australian, *Neoceratodus*, less developed in the African, *Protopterus*, and least developed in the South American, *Lepidosiren*.

In *Protopterus*, aortic arches two, five, and six form capillary networks in the gills. There are no gills for branchial arches three and four, and their aortic arches shunt the blood directly from the ventral aorta to the paired dorsal aortae

Anterior extensions of the ventral aorta form the external carotid, and extensions of the paired dorsal aortae form the internal carotid arteries. A branch from the sixth efferent branchial artery goes to the lungs as the pulmonary artery.

Circulation in Amphibia

Apodans, Urodeles and Anurans



In larval amphibians, and in neotenic adults, aortic arches three, four, and six are interrupted by capillary networks in the external gills, and aortic arches one, two, and five are lost.

During metamorphosis the external gills are lost, and their aortic arches are reconstituted as complete vessels, going from the ventral aorta to the dorsal aorta.

In adult urodeles and apodans, anterior extensions of the ventral aorta form the external carotid artery; the internal carotid is formed by arch three and the anterior extension of the paired dorsal aortae.

Arches four and six persist as the systemic arch and the pulmonary arch, respectively, but both reach dorsally to join paired dorsal aortae which then unite posteriorly to form the descending aorta.

The pulmonary artery to the lung comes off the pulmonary arch.

On each side, the portion of each dorsal aorta between arches three and four is called the carotid duct; it remains as an anastomosis between the dorsal aorta and the internal carotid artery.

Aortic Arches

ec- external carotid

ic- internal carotid

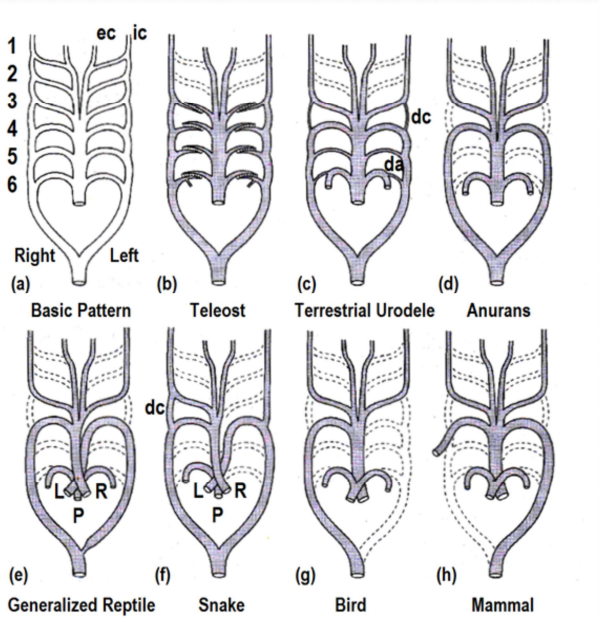
dc- ductus caroticus

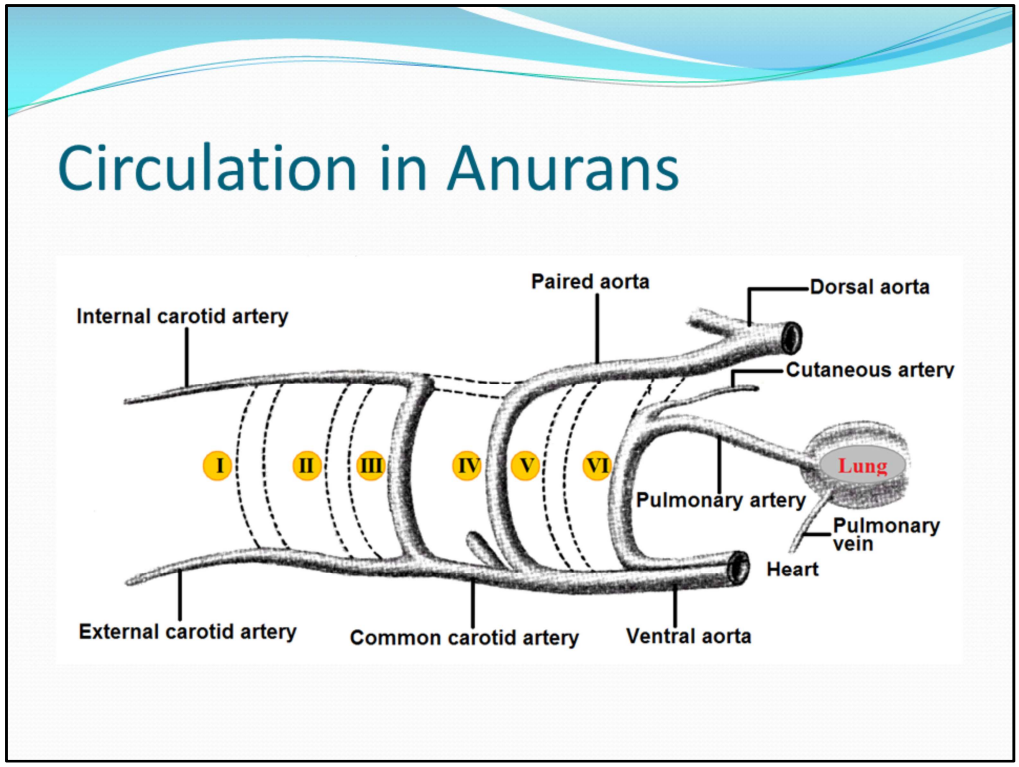
da- ductus arteriosus

L- aortic trunk of left systemic arch

R- aortic trunk of right systemic arch

P- pulmonary trunk





In anurans there is a slightly different condition. The connection between the internal carotid artery and the paired dorsal aortae, formed by the carotid duct in other amphibians, is lost in anurans.

The portion of the ventral aorta between the third and fourth aortic arches forms the common carotid artery; the third aortic arch forms the proximal part of the internal carotid artery.

The connection between the dorsal portion of the sixth aortic arch and the paired aortae is also lost; only the ventral portion of the sixth aortic arch and its posterior extension to the lung remain, forming the base of the pulmonary artery.

Aortic Arches

ec- external carotid

ic- internal carotid

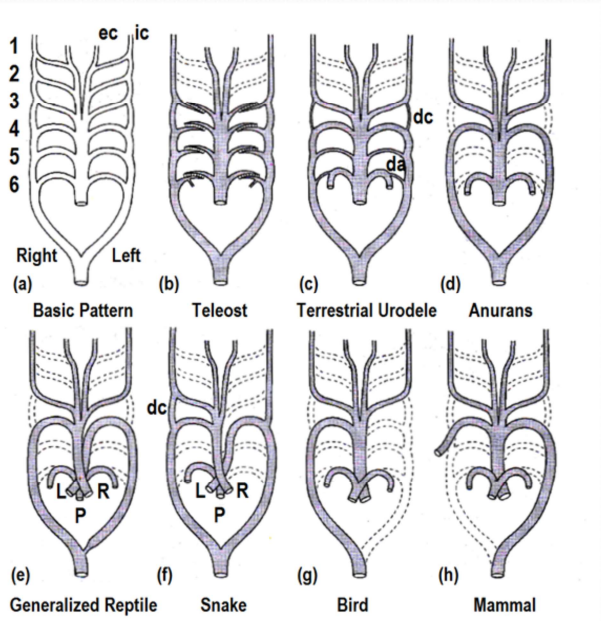
dc- ductus caroticus

da- ductus arteriosus

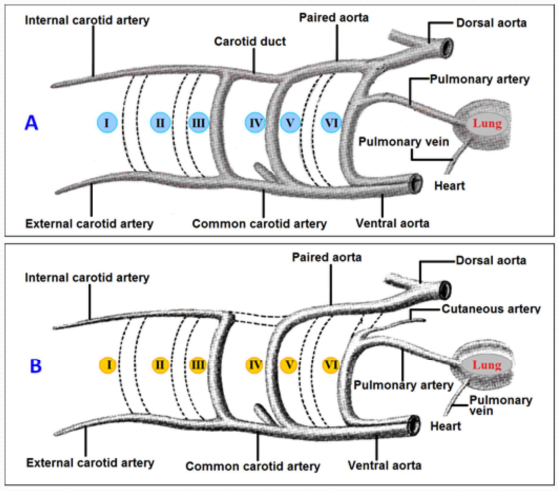
L- aortic trunk of left systemic arch

R- aortic trunk of right systemic arch

P- pulmonary trunk

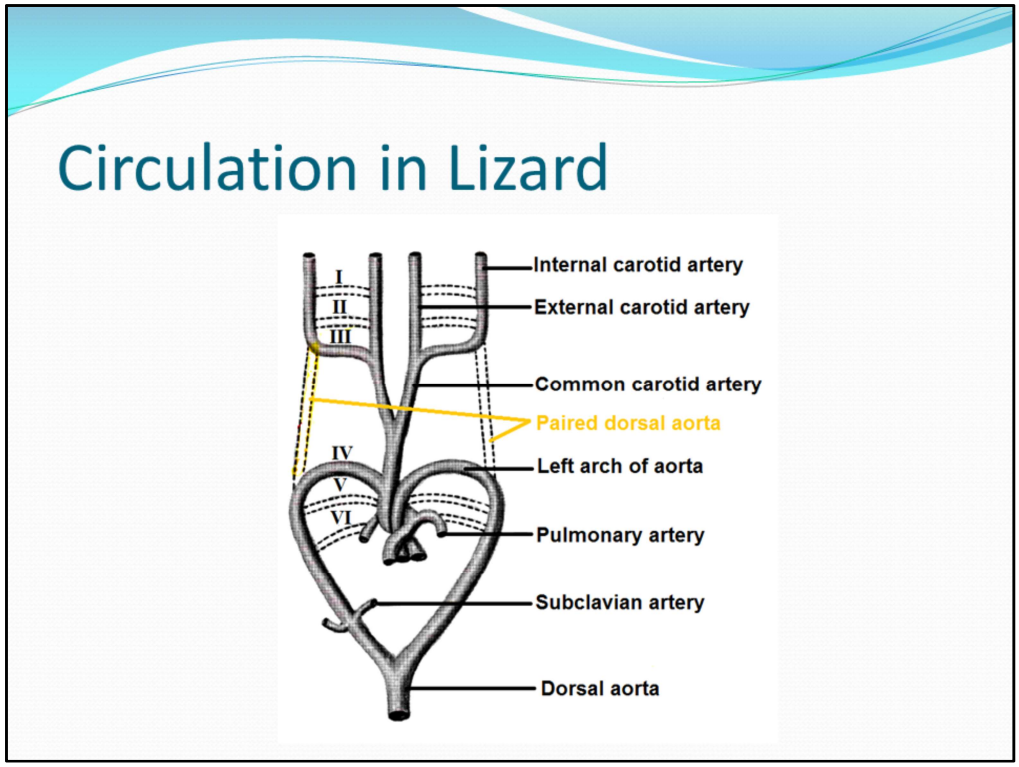


Apodans, Urodeles and Anurans



Circulation in Amniotes

Reptiles, Birds and Mammals



The aortic arch system of reptiles is very similar to that of anuran amphibians, except in the conus arteriosus and ventral aorta which are divided into three separate vessels coming out of the ventricles.

One of these vessels, derived from the sixth aortic arch, forms the two pulmonary arteries. The fifth aortic arch is lost.

The fourth forms the systemic arch; except for the crocodilians' foramen of Panizzae there is no connection between the right and left systemic arches.

At the base of the right fourth aortic arch arises the common carotid artery, developing from the portion of the ventral aorta which runs between aortic arches three and four.

The more anterior portions of the ventral aorta form the paired external carotid arteries.

The third aortic arch forms the proximal portion of the internal carotid arteries, and extensions of the paired dorsal aortae form its distal portions.

Aortic arches one and two, as well as five, are lost in adult reptiles.

Aortic Arches

ec- external carotid

ic- internal carotid

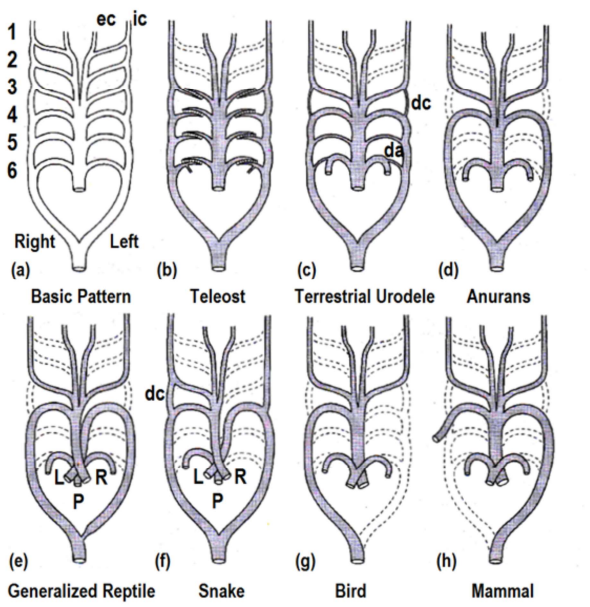
dc- ductus caroticus

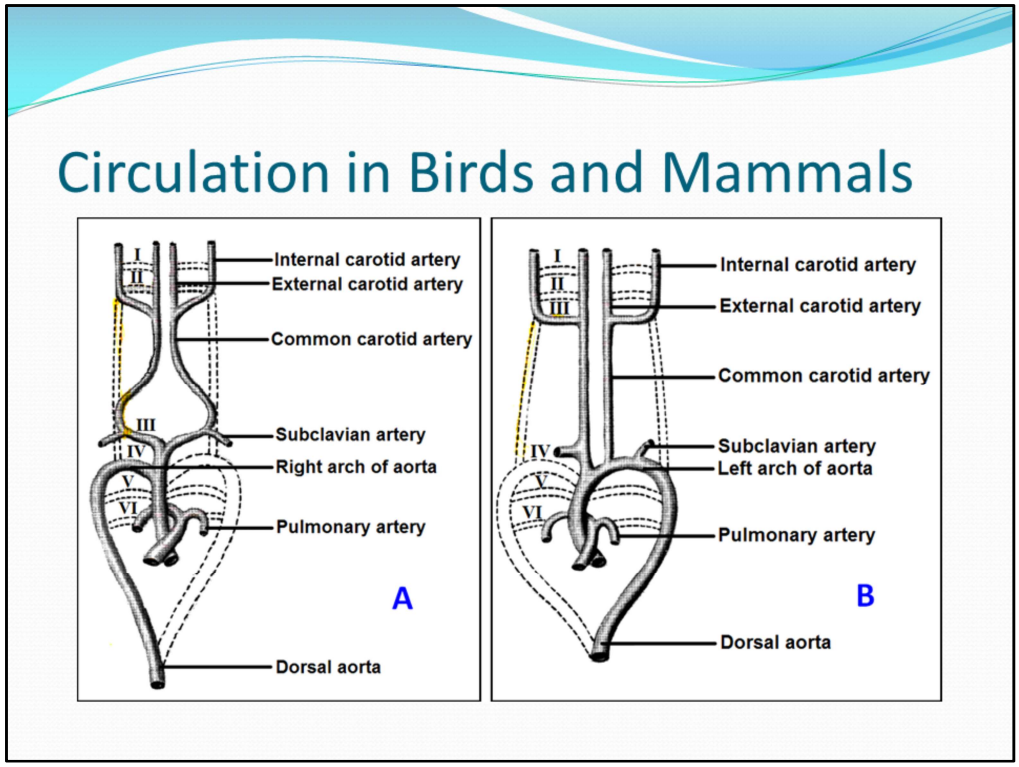
da- ductus arteriosus

L- aortic trunk of left systemic arch

R- aortic trunk of right systemic arch

P- pulmonary trunk





In mammals and birds the ventral aorta and the aortic arches develop very similarly to those of reptiles, with exceptions only in the systemic arches (the fourth).

In birds the left systemic arch is lost; all blood to the descending aorta passes through the right systemic arch and back to the descending aorta. In mammals just the opposite is true: the right systemic arch is lost, and the left arch persists.

Aortic Arches

ec- external carotid

ic- internal carotid

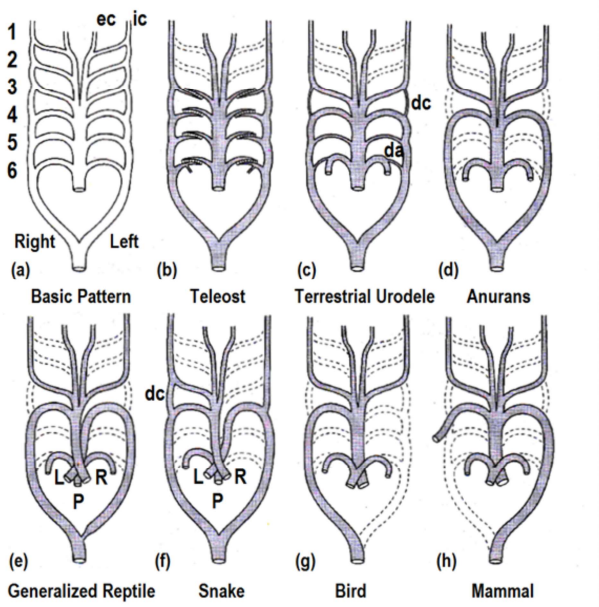
dc- ductus caroticus

da- ductus arteriosus

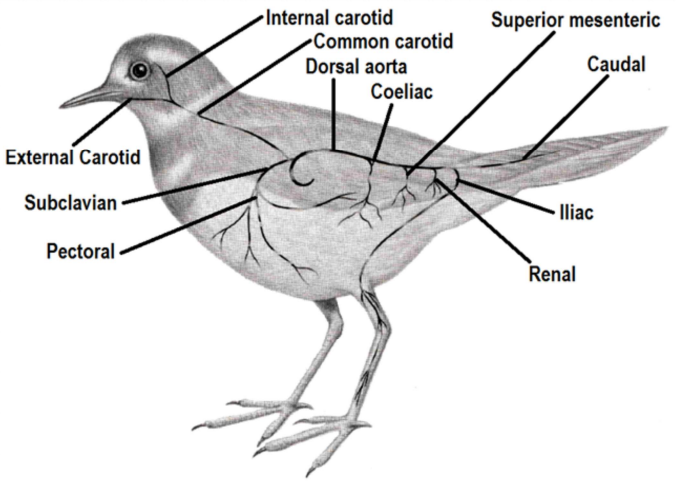
L- aortic trunk of left systemic arch

R- aortic trunk of right systemic arch

P- pulmonary trunk



Posterior Arteries



Next Class

Thursday, 9:10 am
10 December 2015