Arteries and Veins

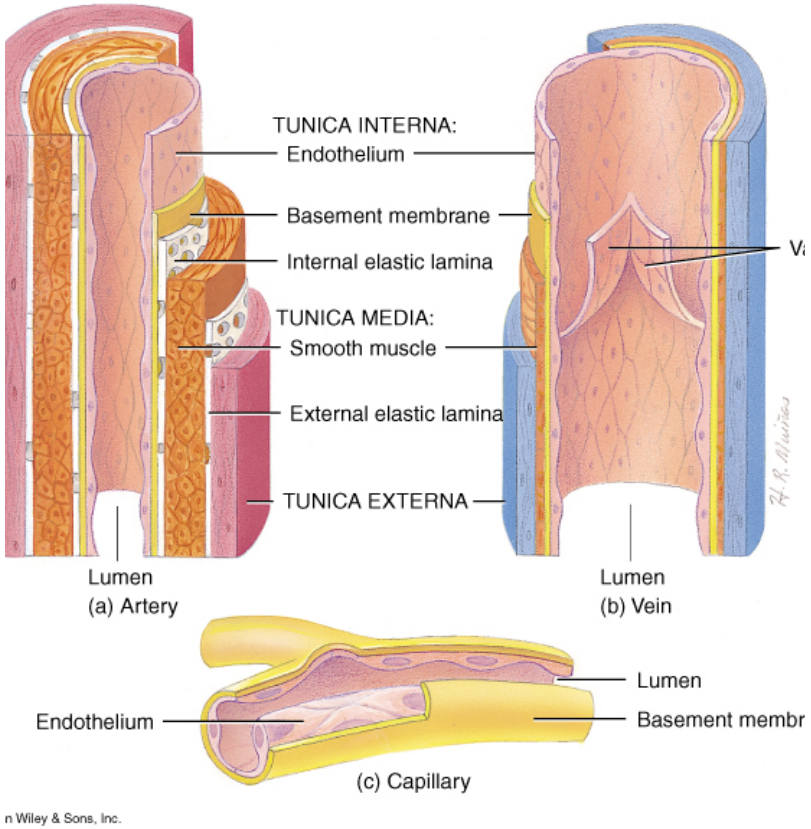
Comparative Structure of Artery and Vein Vessel Walls

- **Arteries:**

1. **Tunica Interna**
   a. **Endothelium**
   b. **Basement membrane**
   c. **Internal elastic lamina**

2. **Tunica Media**
   a. **Smooth muscle**
   b. **External elastic lamina**

3. **Tunica Externa/adventitia**
   a. **Connective tissue**



Comparative Structure of Artery and Vein Vessel Walls

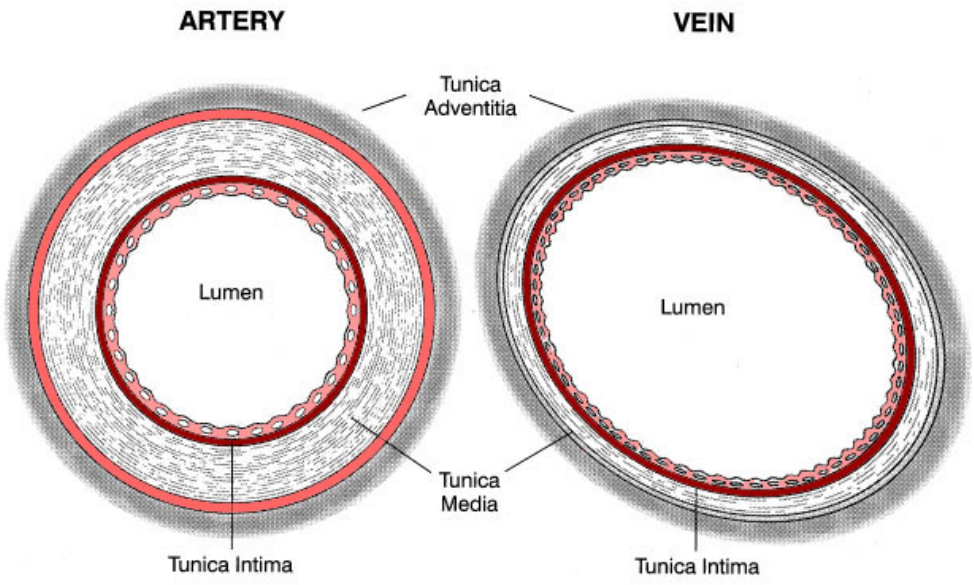
- **Veins:**

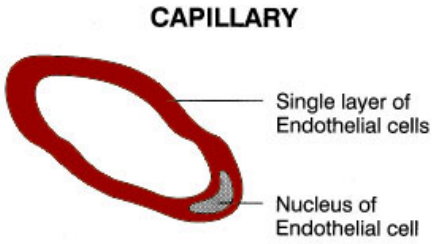
1. Tunica Interna
  a. Endothelium
  b. Basement membrane

2. Tunica Media
  a. Smooth Muscle

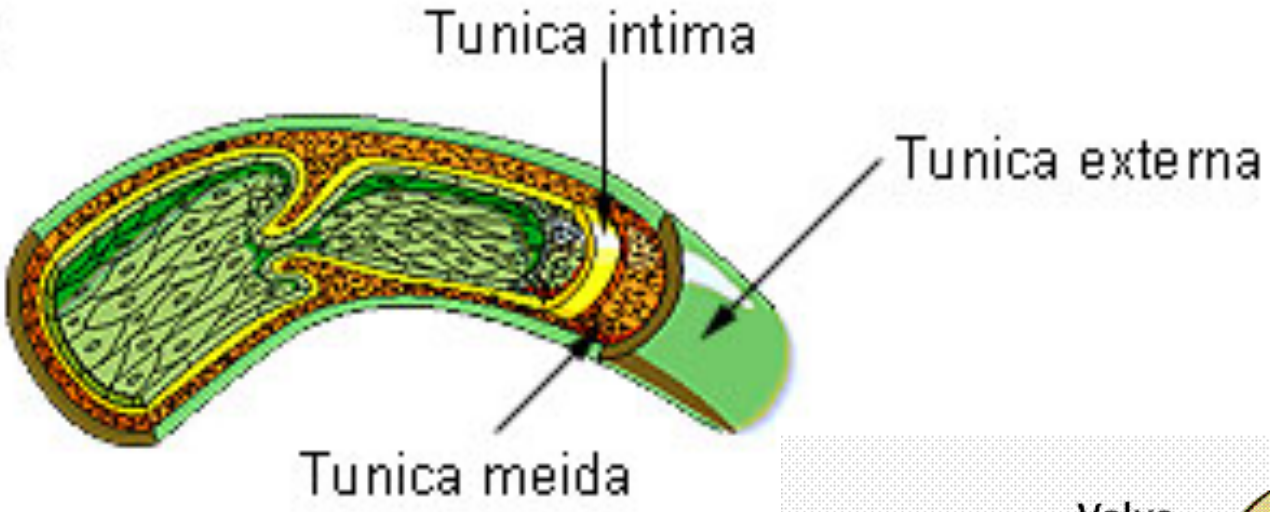
3. Tunica Externa
  a. Connective Tissue

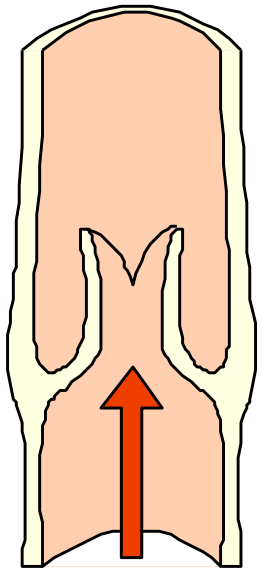
- **Capillary**
  a. Endothelium
  b. Basement membrane

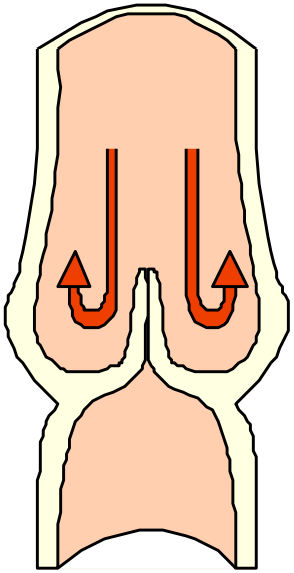


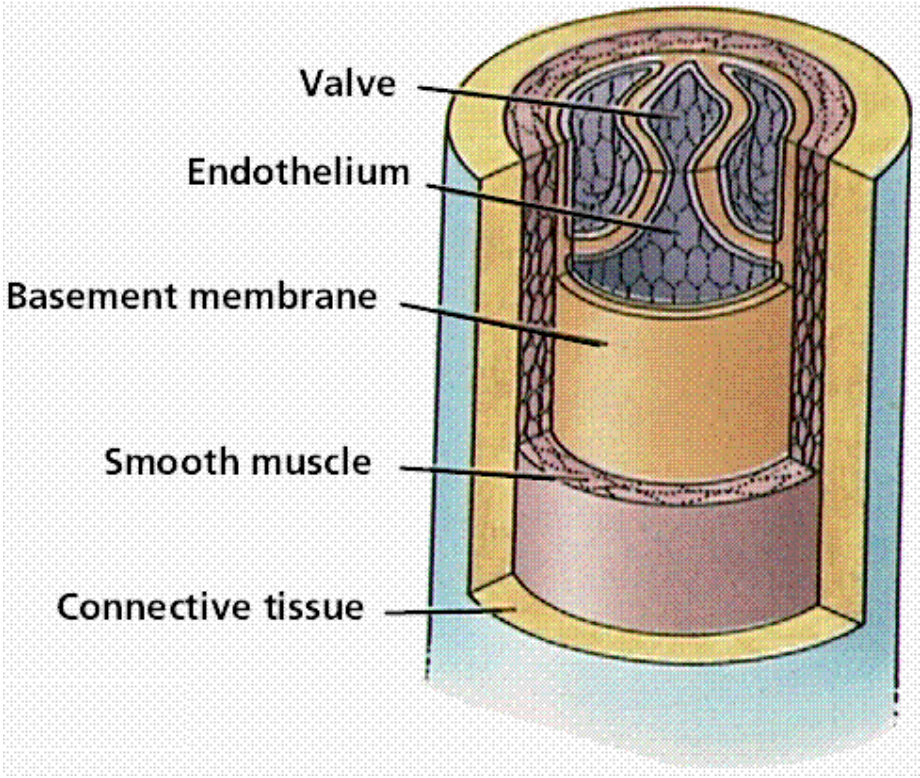


Vein

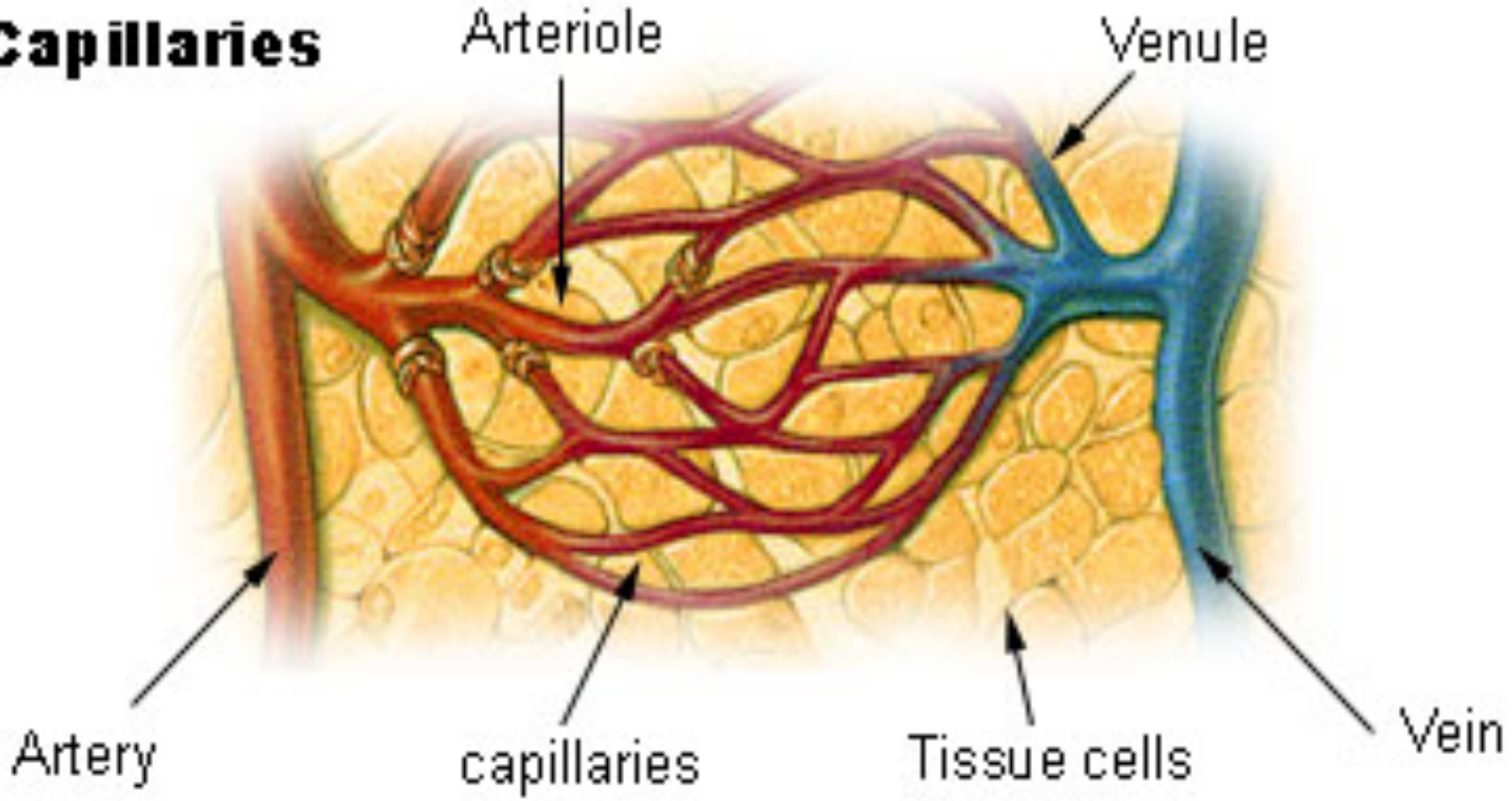

Tunica intima
Tunica externa
Tunica meida

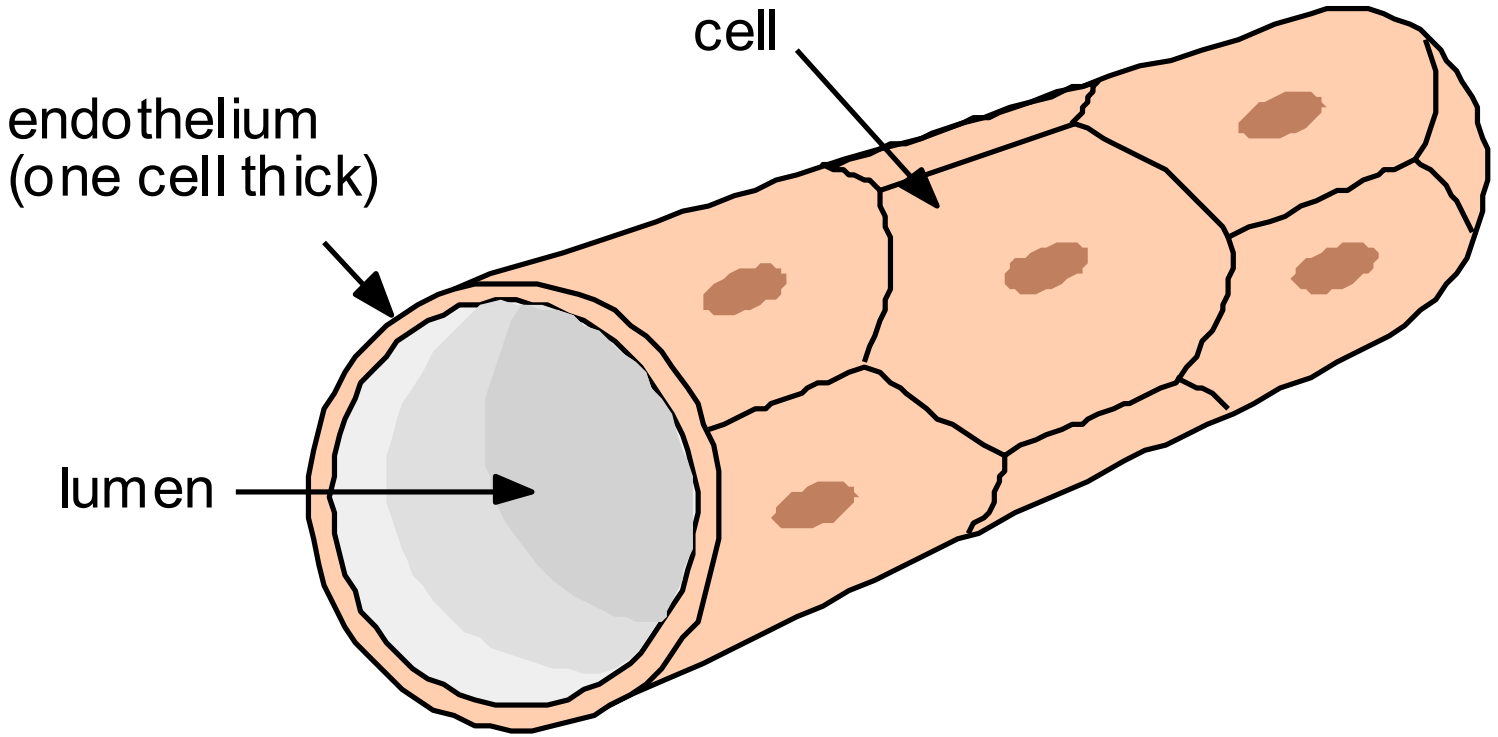





Valve
Endothelium
Basement membrane
Smooth muscle
Connective tissue

Capillaries




cell
endothelium
(one cell thick)
lumen

Classification of Arteries

- **Elastic Arteries**

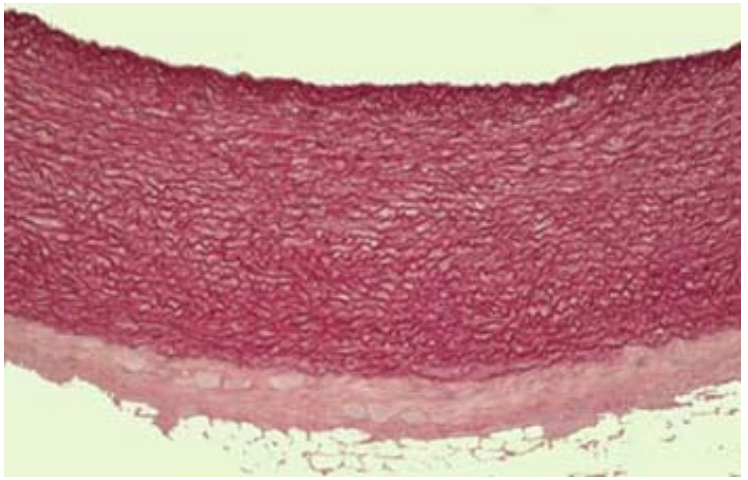
  (Conducting arteries)

  Aorta, Brachiocephalic, Common Carotid, Subclavian, Vertebral, Pulmonary, Common Iliac

- **Muscular Arteries**

  (Distributing Arteries)

  Brachial artery, Radial artery, Popliteal, Common Hepatic



Aortic Arches

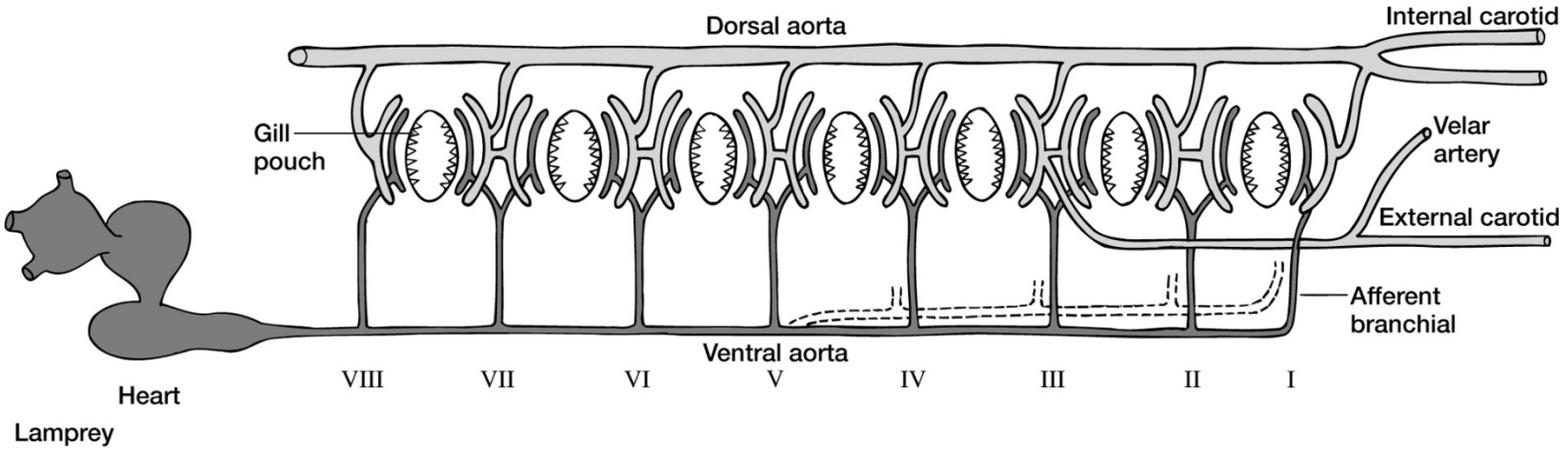
Fish

-Blood exits the heart into the ventral aorta.

-The aortic arches branch from the ventral aorta as afferent arteries that carry blood to the gills.

-The afferent arteries break into a capillary plexus in the gills for gas exchange. The capillaries rejoin as efferent arteries.

-The efferent arteries enter paired dorsal aortae which join posteriorly to form a single dorsal aorta.



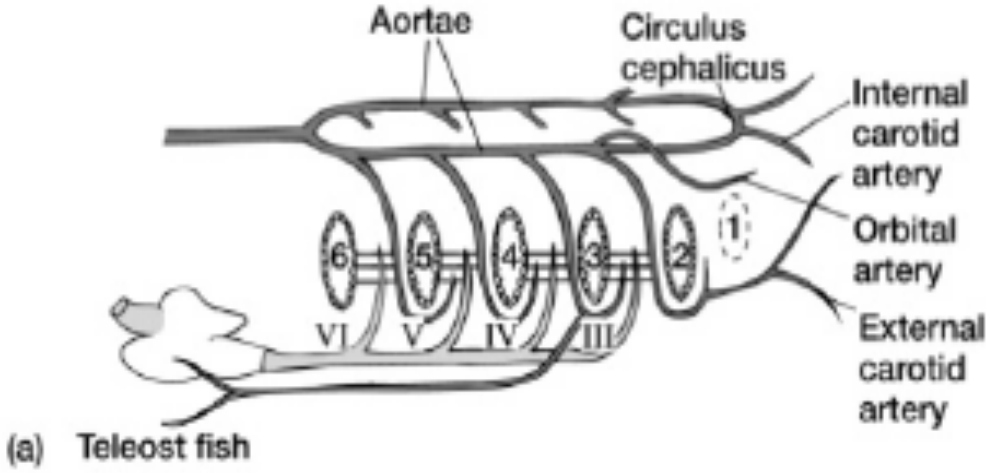
Jawed fish:

-The first aortic arch is present embryologically but the afferent branch disappears in adults.

-In some fish, including elasmobranchs, the efferent branch of aortic arch I is retained.

-Retention of aortic arch II is variable.

-In Actinopterygian fish, 4 pairs of aortic arches are retained



Amphibians

Adult salamanders

-The portion of the dorsal aorta between aortic arches III and IV, called the carotid duct, closes.

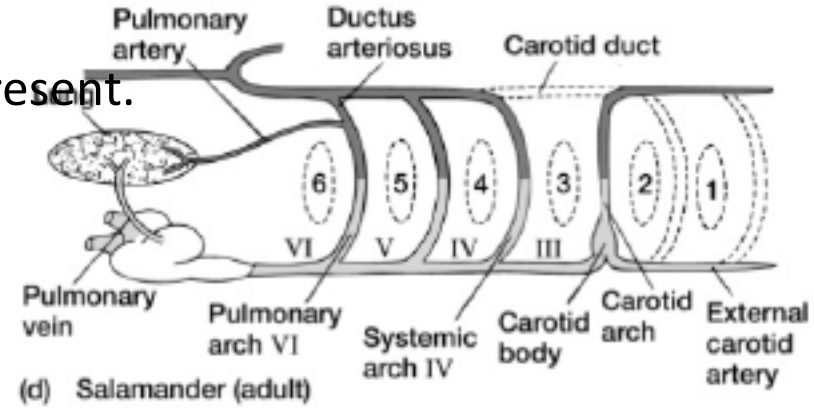
-The IIIrd aortic arch and the anterior portion of the dorsal aorta become the internal carotid artery.

-The ventral aorta between aortic arches III and IV becomes the common carotid artery.

- Aortic arches IV and V become the major systemic vessels.

- Aortic VI gives rise to the pulmonary artery.

-The ductus arteriosus in reduced but still present.



Anurans (frogs)

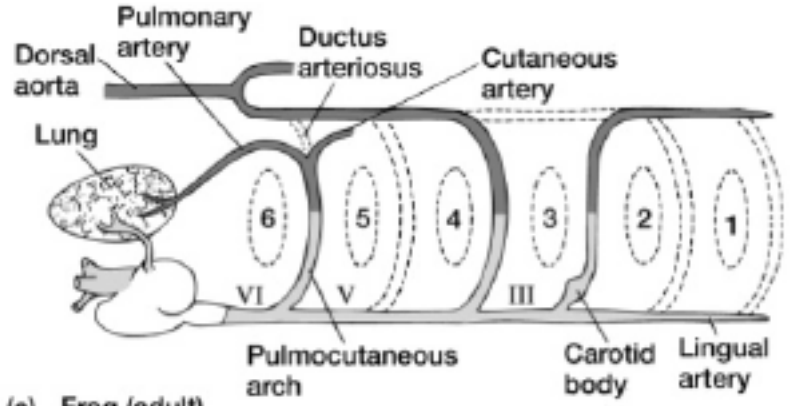
-Larval frogs have internal gills supplied by aortic areches III, IV, V. Aortic arch VI has a branch that will become the pulmonary artery.

-In adults from this group, the gills, carotid duct and aortic arch V are lost. The remaining aortic arches expand:

-Aortic arch III supplies the head

-Aortic arch IV, called the systemic arch, supplies the body

-Aortic arch VI supplies the lung.



(e) Frog (adult)

Reptiles

Aortic arches III, IV, VI persist.

The ventral aorta subdivides into three vessels leaving the heart:

-pulmonary arch,

-the left systemic arch

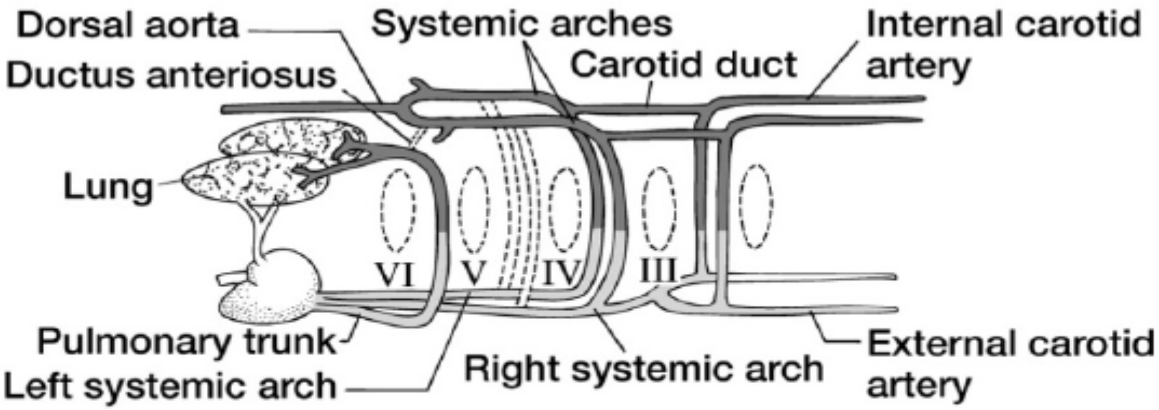
-the right systemic arch.

Aortic arch III remains as a component of the carotids.

The left systemic arch is composed of the left aortic arch IV and left dorsal aorta.

The right systemic arch is composed of the right aortic arch IV and a portion of the right dorsal aorta

The pulmonary trunk incorporates aortic arch VI to form the pulmonary arch.



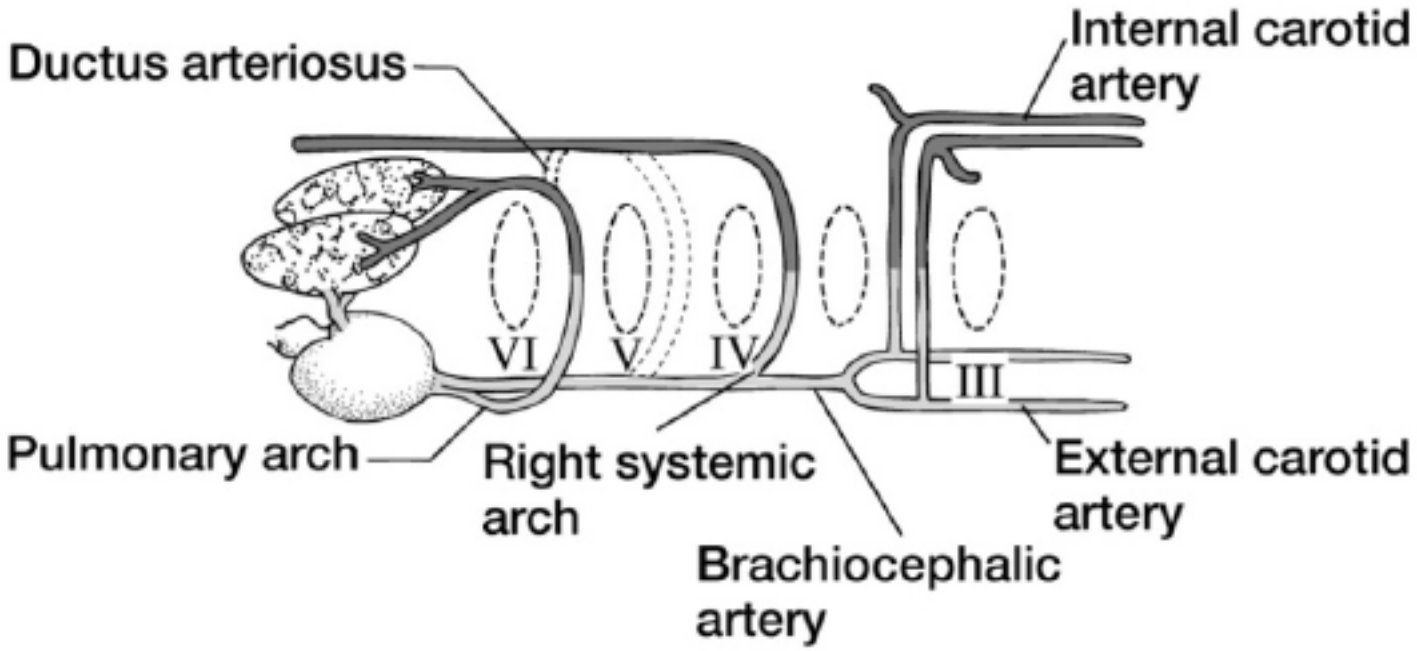
(a) Reptile (lizard)

Birds

-The left systemic trunk is eliminated.

-The pulmonary stem leaves the right ventricle

-The right systemic trunk, derived from the bases of the right aortic arch IV and a portion of the right dorsal aorta, leaves the left ventricle.



Mammals

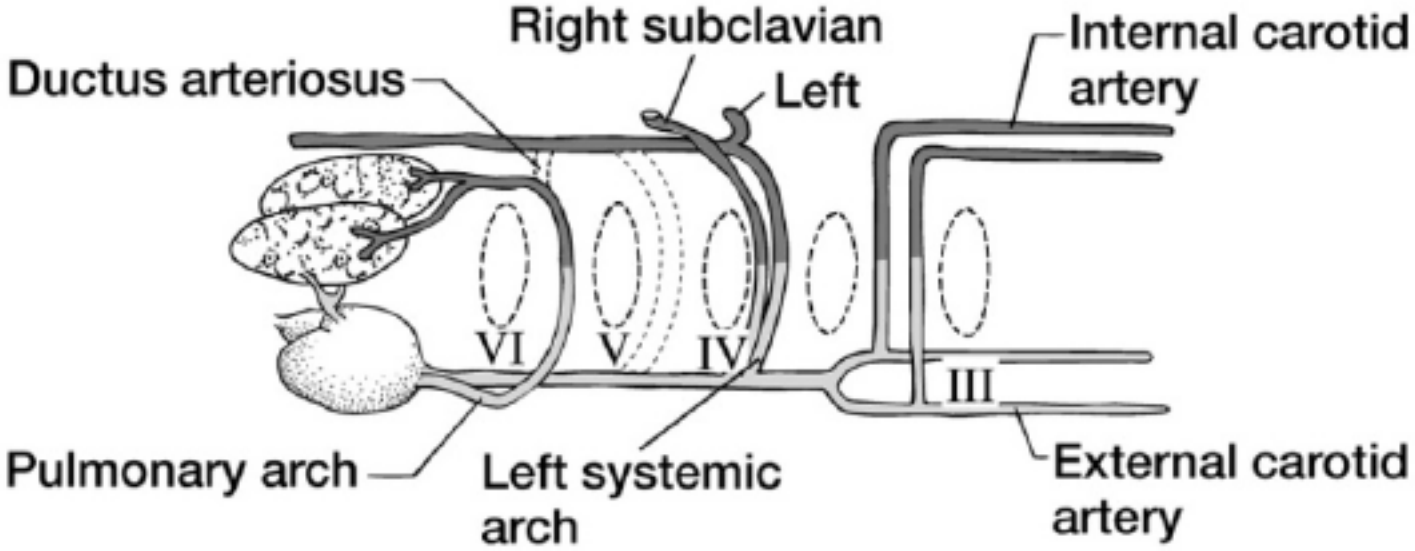
The right aortic arch IV is lost. A remnant is present as a connection of the subclavian artery.

Three arches persist as major arteries:

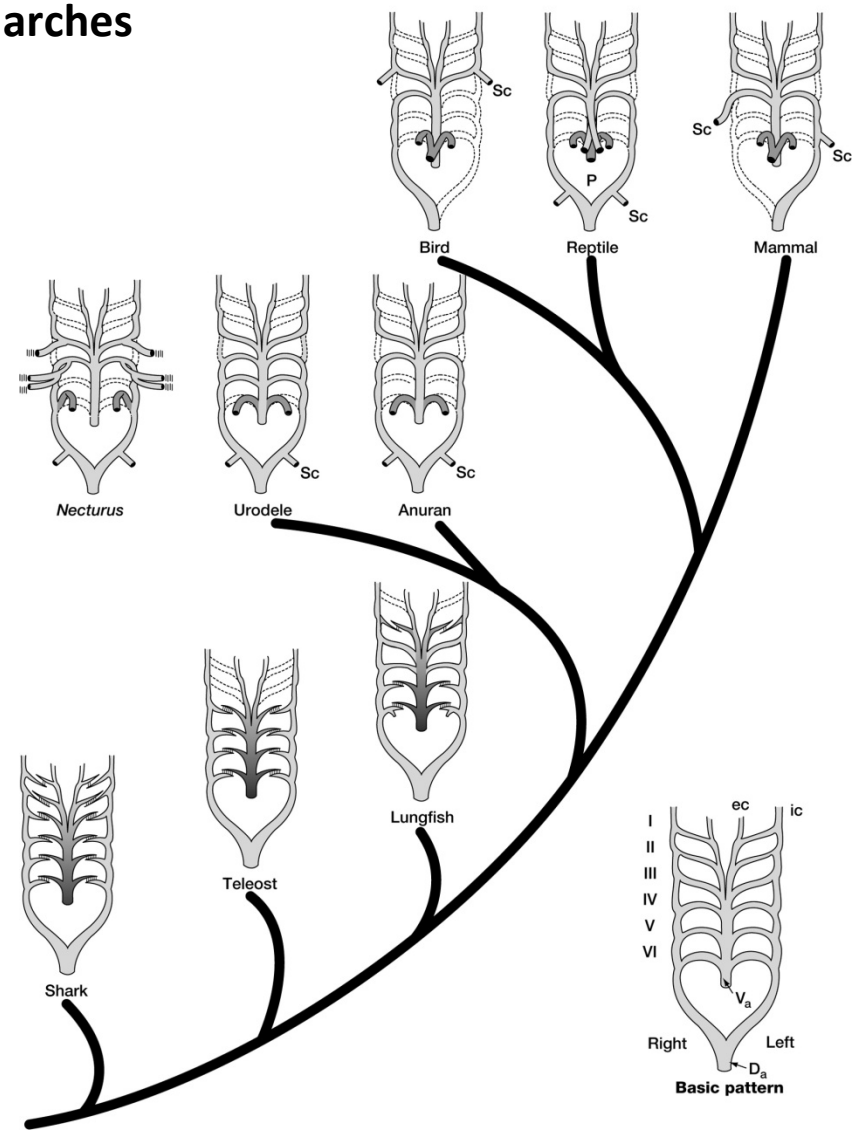
a. carotid arteries: derived from III, ventral and dorsal portion of aortas

b. pulmonary arch: bases of VI

c. systemic arch: left IV and associated left portion of dorsal aorta

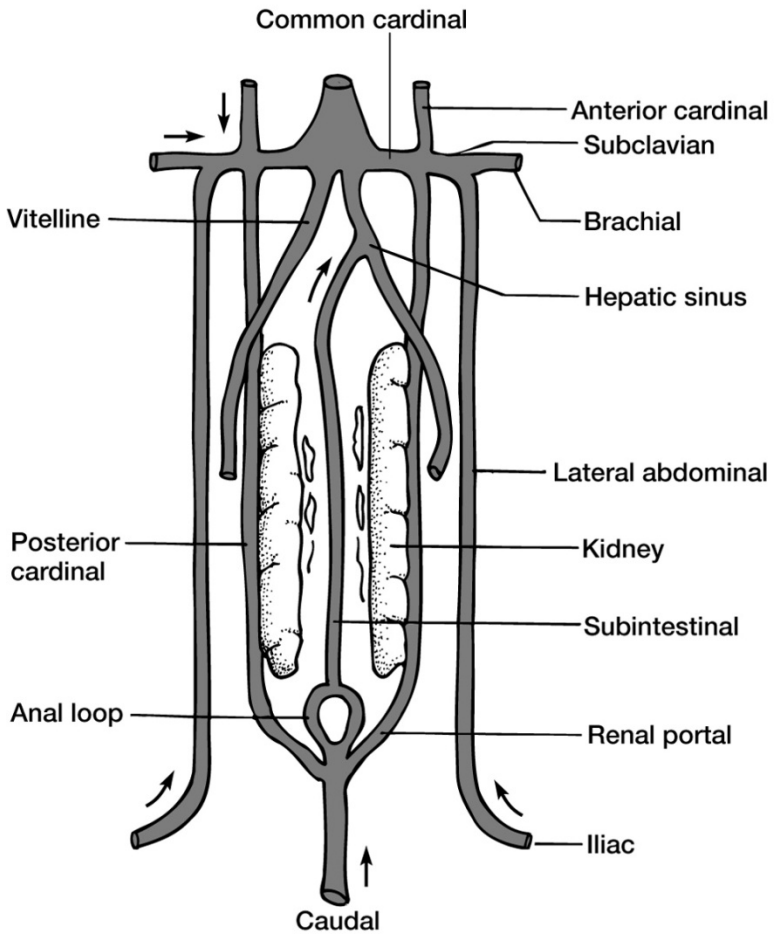


Evolution of aortic arches

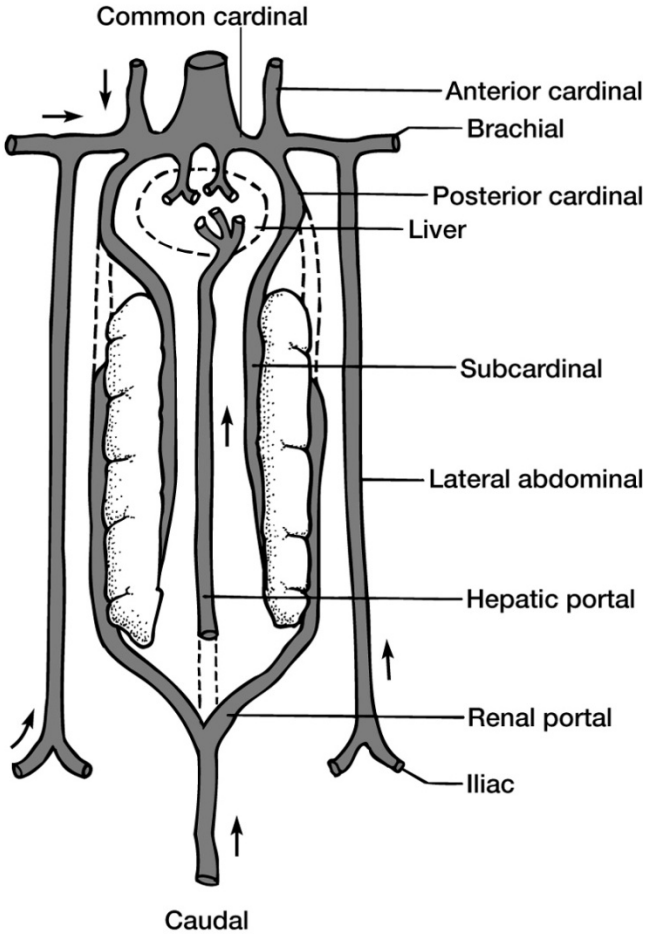


Venous vessels

- Two gral functional systems of venous circulation: **Systemic system** draining the general body tissues, and the **Pulmonary system** draining the lungs
- Systemic System: 3 sets of paired veins present in early development:
  - **Vitelline veins** - from the yolk sac
  - **Cardinal veins** -from the body of the embryo itself
  - **Lateral abdominal veins -**from the pelvic region



(a) Basic embryo pattern



(b) Adult fish

Vitelline veins

-Among the first vessels to appear in the embryo
-They arise over the yolk and follow the yolk stalk into the body

Lateral abdominal veins

-Present in fishes, usually merged or absent in tetrapods

Hepatic Portal Vein: It runs from the digestive tract to the liver and forms a direct route to transport absorbed end products of digestion immediately to the liver. It collects blood also from stomach, pancreas, and spleen and delivers it to the liver.
it is common to all vertebrates and develops mostly from the embryonic subintestinal vein

Renal Portal System

-In gral, blood entering the RPS arrives from the caudal vein draining the tail. But:
In cyclostomes and teleost, blood of the RPS enters the kidney via segmental veins from the body wall.
In some lungfishes, additional blood from the pelvic fins and the posterior abdominal region contributes to the RP flow entering the kidneys.

- **Cardinal Veins**

Embriologically, all vertebrates develop paired veins. These veins appear early and are located on either side of midline above the coelomic cavity.

The vessels are collectively termed the primitive cardinals or cardinal veins:

1. The posterior cardinals are found on either side of the aorta and run to a region dorsal to the heart.

2. The anterior cardinals are head veins that line either side of the embryonic braincase and continue posteriorly along the neck or dorsal to the gills.

3. The anterior and posterior cardinal join to form a common carotid (also called common cardinal) vein on each side.

Anterior Cardinals:

-With the exception of mammals, the main stem of the anterior cardinals (or anterior vena cava in some forms) is called the lateral head vein.

-It starts out in the orbit, travels posteriorly, picking up drainage vessels from brain and drains into the common cardinal

In **mammals** the system is modified.

-In the cranium, the lateral head veins disappear.

-Drainage from the anterior head enters the braincase, collects additional venous return from the brain and leaves posteriorly in the internal jugulars.

-The external jugulars, which drain the superficial portions of the head, join the internal jugulars to form the common jugular.

-The common jugulars join the subclavian to form the anterior or superior vena cava which empties into the heart.

-Thus, these veins are derived from the anterior cardinals and the common cardinals except for the loss of the anterior portion of the anterior cardinal (the lateral head veins).

-In some mammals, including man, the left common cardinal regresses and a remnant is retained as the coronary sinus.

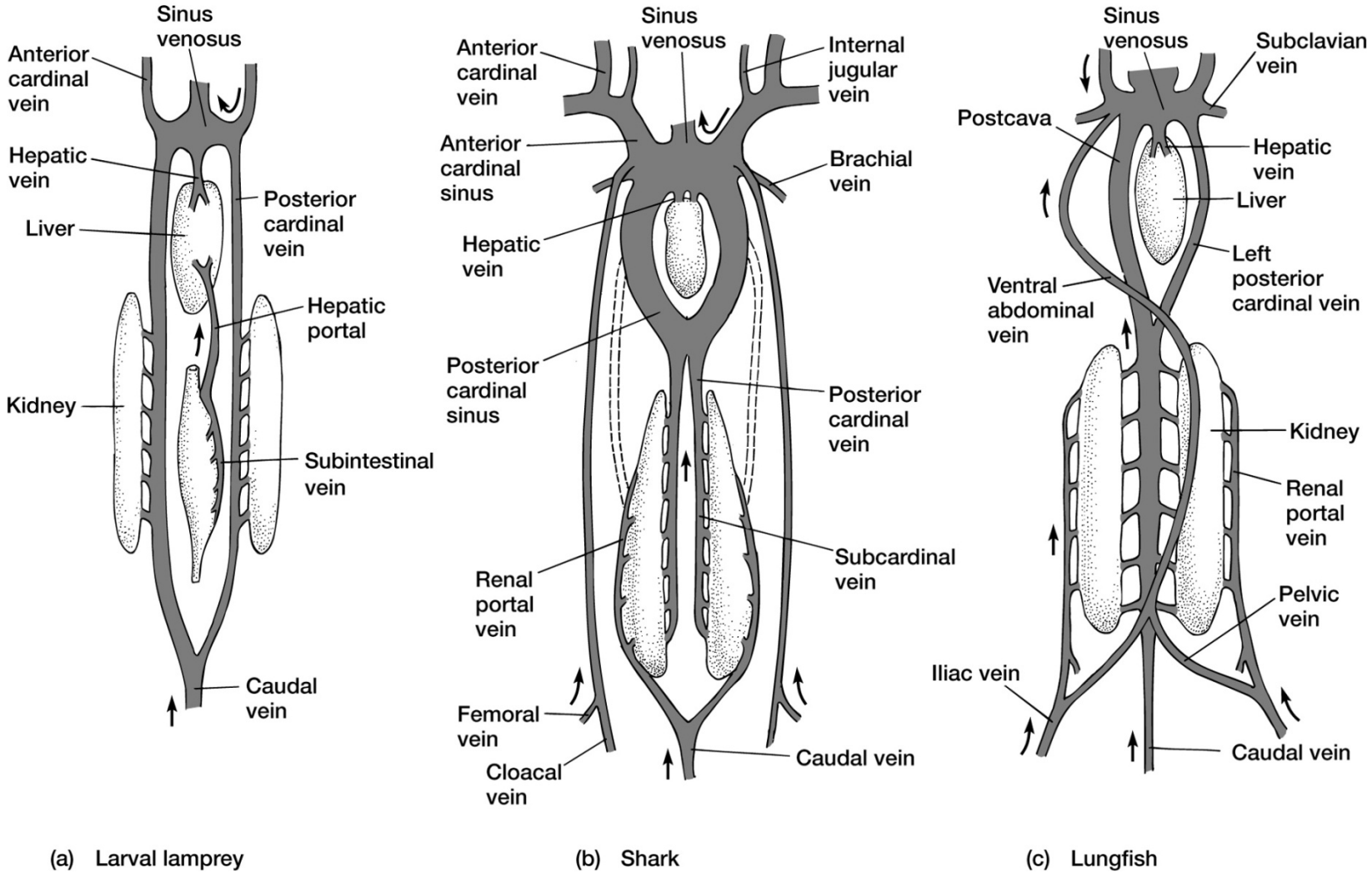
Posterior Cardinals

-The posterior cardinals in **cyclostomes** are paired vessels that empty into the common cardinals.

The posterior cardinals receive blood from the median caudal vein, the kidneys, gonads and dorsal portions of the musculature.

-In **fish**, the system is modified to form a renal portal system. Blood from the tail and posterior trunk flows into veins called renal portal veins through capillaries along the kidneys and is collected by new vessels that carry it to the posterior cardinals.

This condition is retained in amphibians, reptiles and birds, although it degenerates to some degree.



-A second change is found in the **lungfish** that leads to the formation of the posterior vena cava.
A branch of the hepatic vein develops posteriorly and taps the right posterior cardinal.

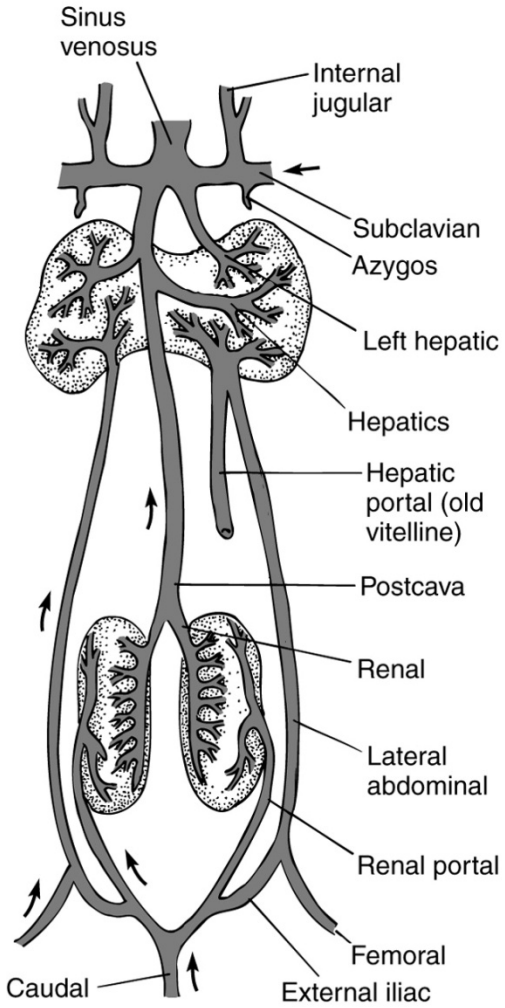
In addition, fusion of the right and left posterior cardinals in the kidney region often occurs and blood from both posterior cardinals flows into the posterior vena cava.

Reduced posterior cardinal veins are retained.

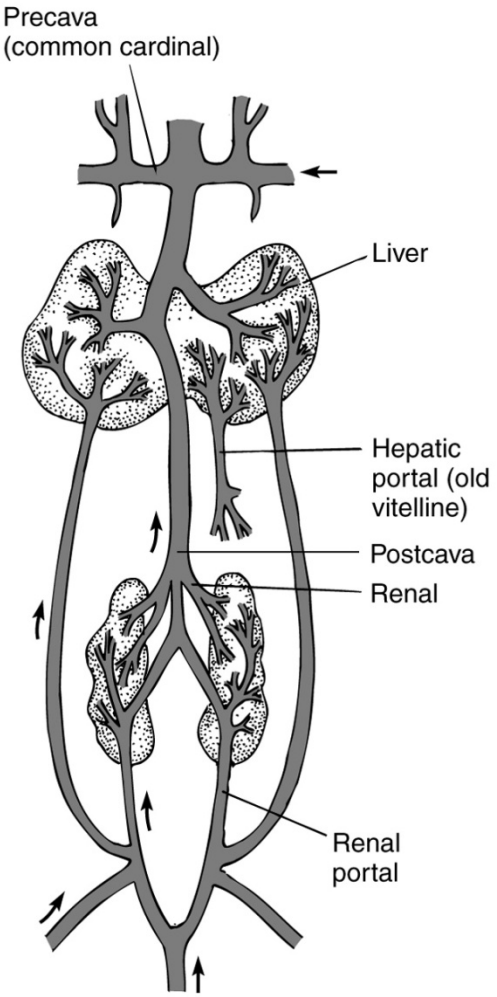
In **higher tetrapods (e.g. reptiles)**, the posterior cardinals lose connection with the posterior and are retained as azygous veins that drain the flanks.

Birds

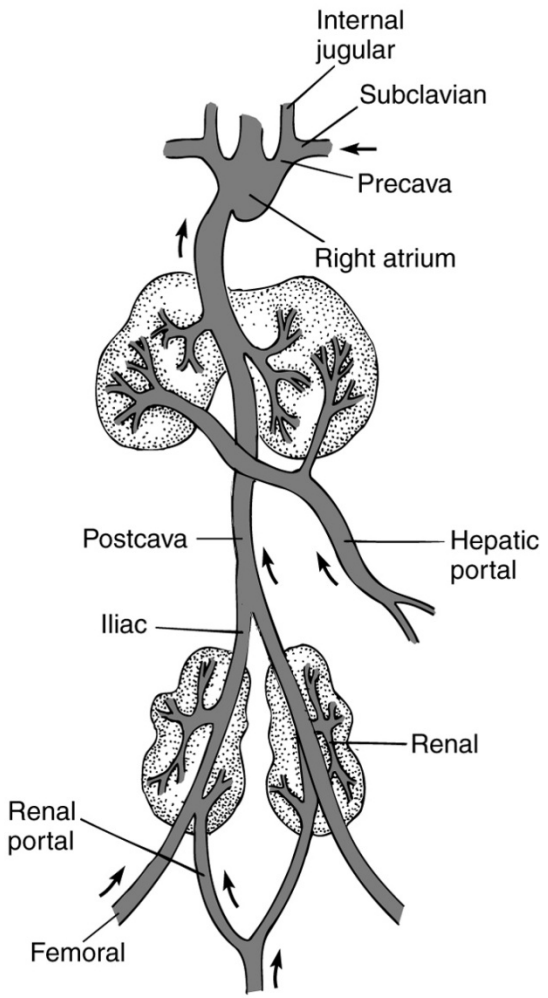
- The hepatic portal and renal portals are present
- Short external jugulars join long internal jugulars to return blood to the common cardinals, which are modified into the paired precava.
- The femoral, caudal, and renal veins are tributaries of the postcava, which receives hepatic veins before entering the heart.



(f) Turtle



(g) Crocodilian

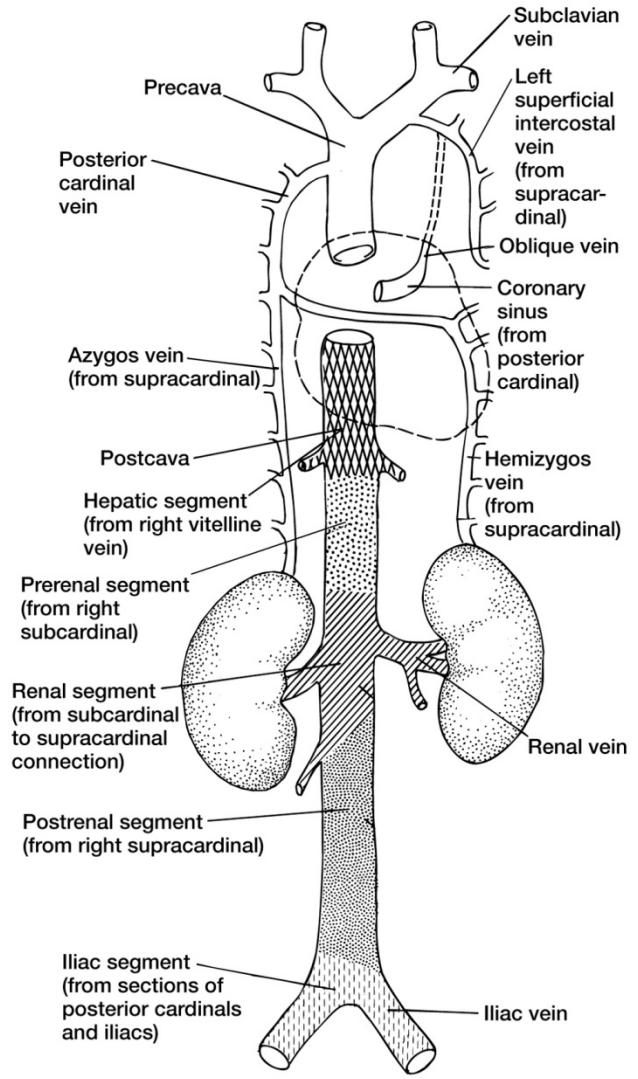


(h) Bird

Mammals

- -In mammals, the renal portal system is lost and blood from the posterior enters directly into the posterior vena cava.

- The mammalian posterior vena cava is derived from a mixture of vessels, which include a portion of the posterior cardinals, a system of veins derived from the renal portal and a branch of the hepatic vein.



(i) Mammal

Pulmonary system

- Many fishes have supplementary air breathing organs but only fished with lungs possess a pulmonary system.
- Among living fishes, only dipnoans have true lungs.
- If the ancient placoderms had lungs, then the pulmonary system would have evolved earlier in verterbrate evolution

Pulmonary veins

- They return blood from the paired lungs to the heart.
- Before entering the heart, they usually unite into a single vein
- Embryologically, the pulmonary vein does not arise by conversion of existing vascular channels. Instead, numerous small vessels originate separately within and drain the embryonic lung buds. They then converge into several common vessels that become the pulmonary veins entering the left atrium

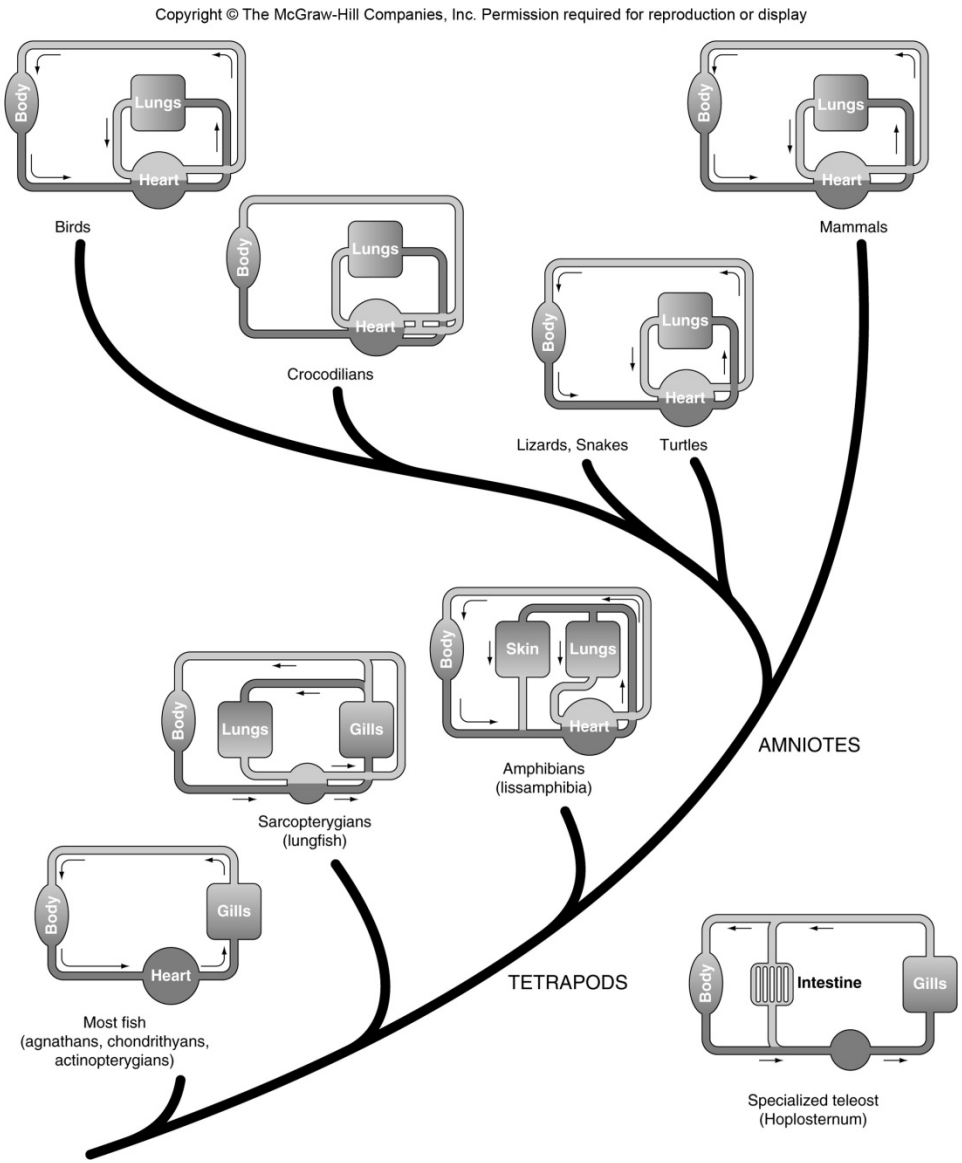
Overview of the Circulatory System

- The cardiovascular system aids passive diffusion of gases between internal tissues and blood. It is the complement of the respiratory system.
- The cardiovascular system also carries heat and hormones, components of the immune system end products of digestion, and molecules contributing to or derived from metabolism

- It is a system of connecting tubes and pumps that are filled with blood.
- The major pump is the **branchial heart**, a series of one way chambers receiving blood, generating force, and sending the blood to respiratory organs (gills or lungs) and to systemic tissues.
- The **blood vessels** include arteries that carry away from the heart, veins that return it, and the microcirculation (capillary beds) between, where internal respiration occurs.

- Along with microcirculation, the **lymphatic system** collects and returns excess tissue fluid to general circulation, aided by body movements and in some species by lymph hearts.
- The **lacteals**, a specialized set if lymp vessels, gather fatty acids from the alimentary canal and carries them to the liver.
- The lymphatic syst does not have erythrocytes, but includes lymphocytes and other components of the immune system

- A **major evolutionary transition** was from a single to a double circulation.
- The **double circulation** evolved independently twice, once in birds and a second time in mammals



-The **aortic arches** are a major set of blood vessels with a pattern of six aortic arches, connecting ventral to dorsal aortae.

-The **arterial supply** of to a region or organ is usually matched by a venous drainage returning blood to the heart.

-The **hepatic portal system** carries end products of digestion directly to the liver.

-**Lungs** or lunglike organs were present in some early fishes, evolving into specialized gas bladders supplementing gill respiration in bony fishes and later replacing gills in tetrapods as the primary respiratory organ

-**Lungs** brought advantages in supplying systemic tissues with oxygen and in fishes provided a means of buoyancy control

-However, lungs may have evolved in earlry fishes to supply the heart with oxygen.

-In the transition to land, gills became lost and the air-breathing lung of fish ancestor expanded its physiological role to get oxygen to systemic capillary beds.

-**Heart septation**, along with modifications of the vascular system, helped meet these needs by selective channeling of two streams of blood: systemic and pulmonary.

-The fully **divided hearts** of birds and mammals have several **advantages**:

1-**prevent mixing** of oxygen-rich blood (from the lungs) with oxygen- poor blood (returning from syst. tissues)

2- **Blood pressure can be separated**. High systemic pressure can be generated w/o exposing delicate pulmonary tissue.