



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

DNS DEPARTMENT OF NEUROSCIENCE



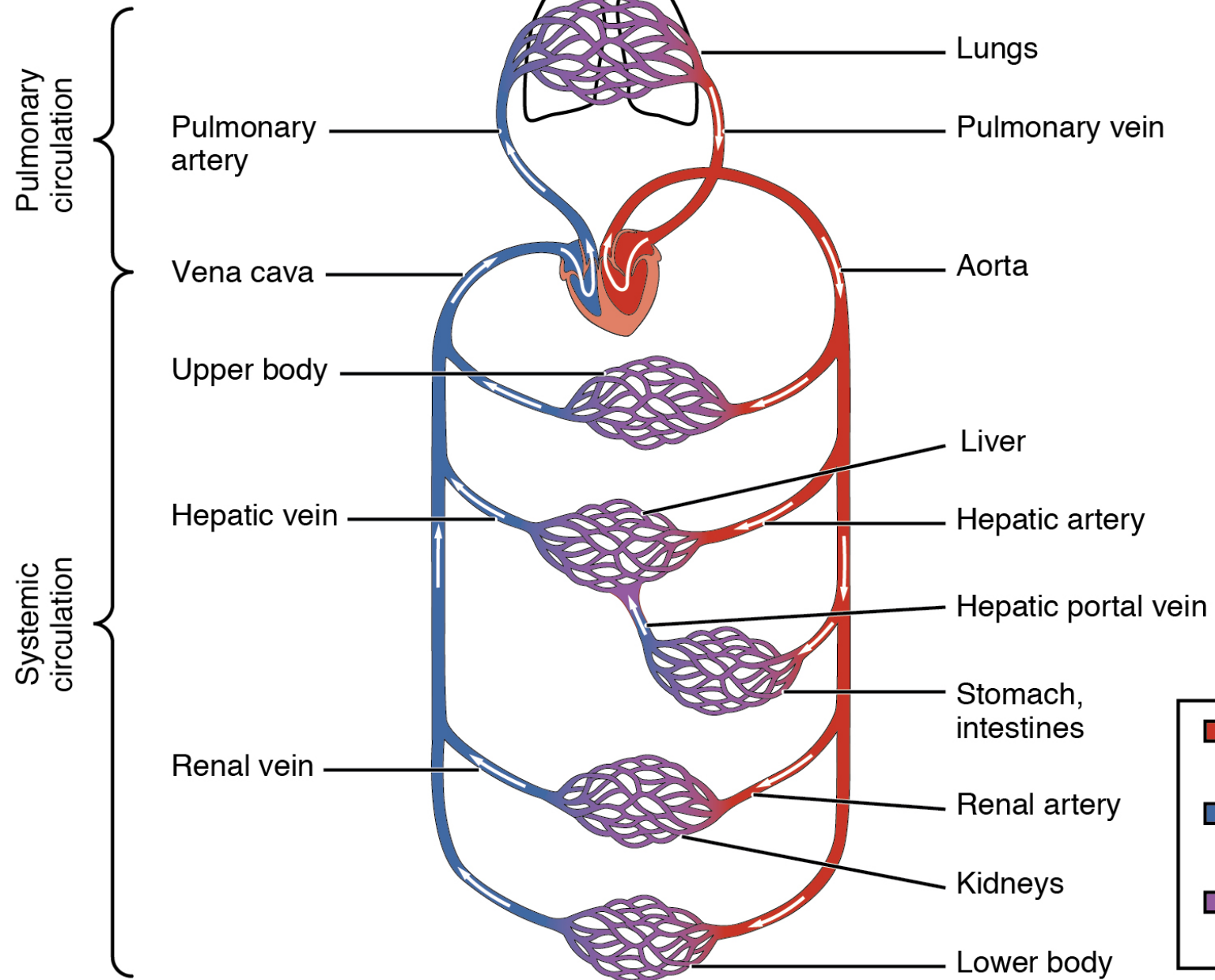
ANATOMY AND PHYSIOLOGY (C.I.)

HUMAN ANATOMY
(Mod. A)

THE CARDIOVASCULAR SYSTEM

BLOOD VESSELS: Arteries and Veins

ARTERIES AND VEINS






Blood is carried through the body via blood vessels.

An **ARTERY** is a blood vessel that **carries blood away from the heart**, where it branches into ever-smaller vessels.

↓
Eventually, the smallest arteries, vessels called **arterioles**, further branch into tiny **capillaries**, where nutrients and wastes are exchanged

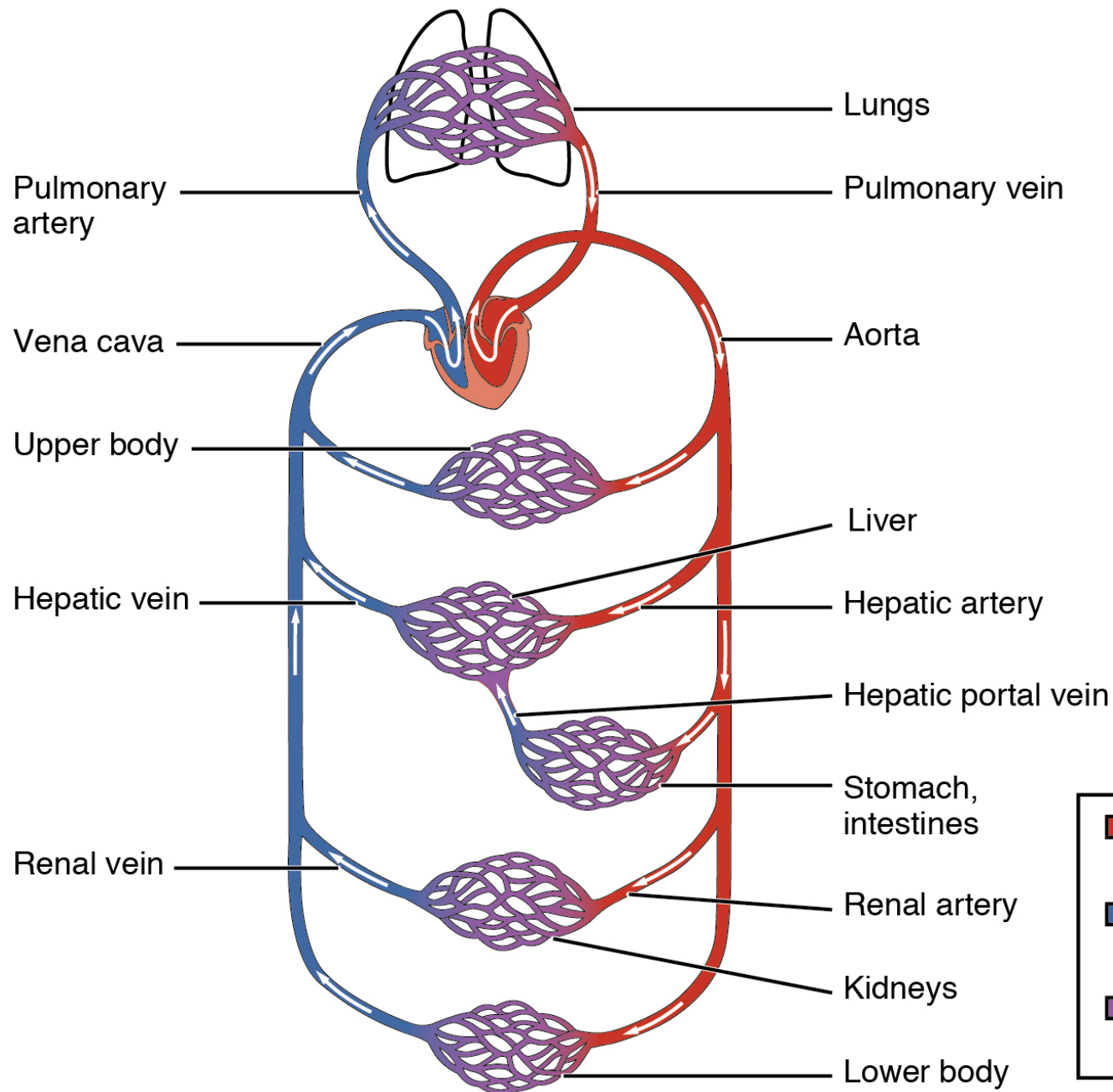
↓
and then combine with other vessels that exit capillaries to form **venules**, small blood vessels that carry blood to

↓
a **VEIN**, a larger blood vessel that **returns blood to the heart**.

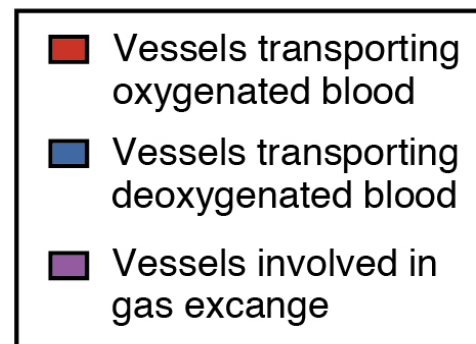
-  Vessels transporting oxygenated blood
-  Vessels transporting deoxygenated blood
-  Vessels involved in gas exchange

Pulmonary circulation

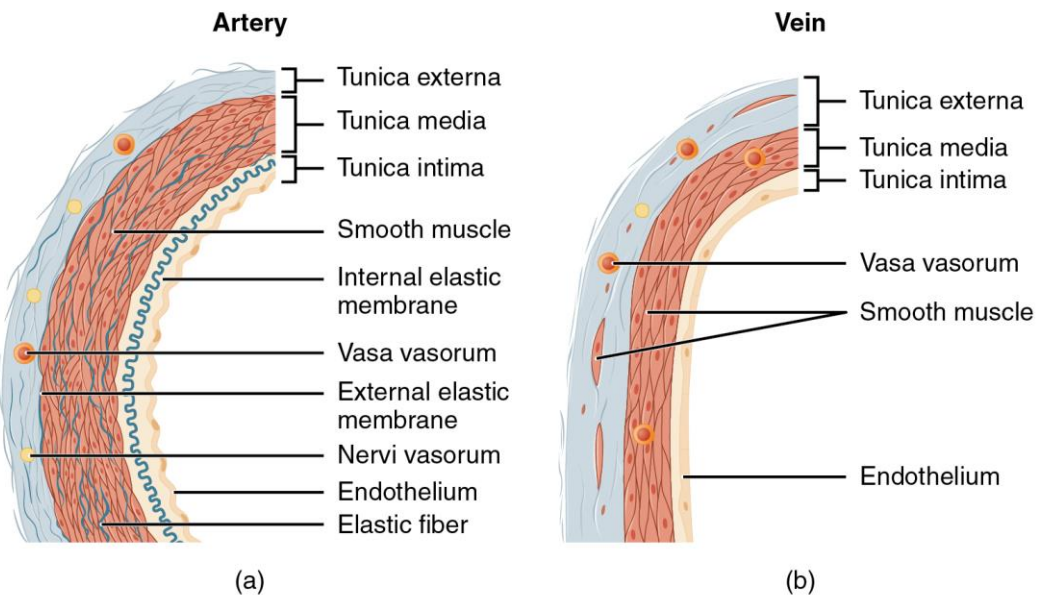
Systemic circulation



- Arteries and veins transport blood in two distinct circuits: the **systemic circuit** and the **pulmonary circuit**.
- **Systemic arteries** provide blood rich in oxygen to the body's tissues.
- The blood returned to the heart through **systemic veins** has less oxygen, since much of the oxygen carried by the arteries has been delivered to the cells.
- In contrast, in the pulmonary circuit, **pulmonary arteries** carry blood low in oxygen exclusively to the lungs for gas exchange.
- **Pulmonary veins** then return freshly oxygenated blood from the lungs to the heart to be pumped back out into systemic circulation.



ARTERIES AND VEINS

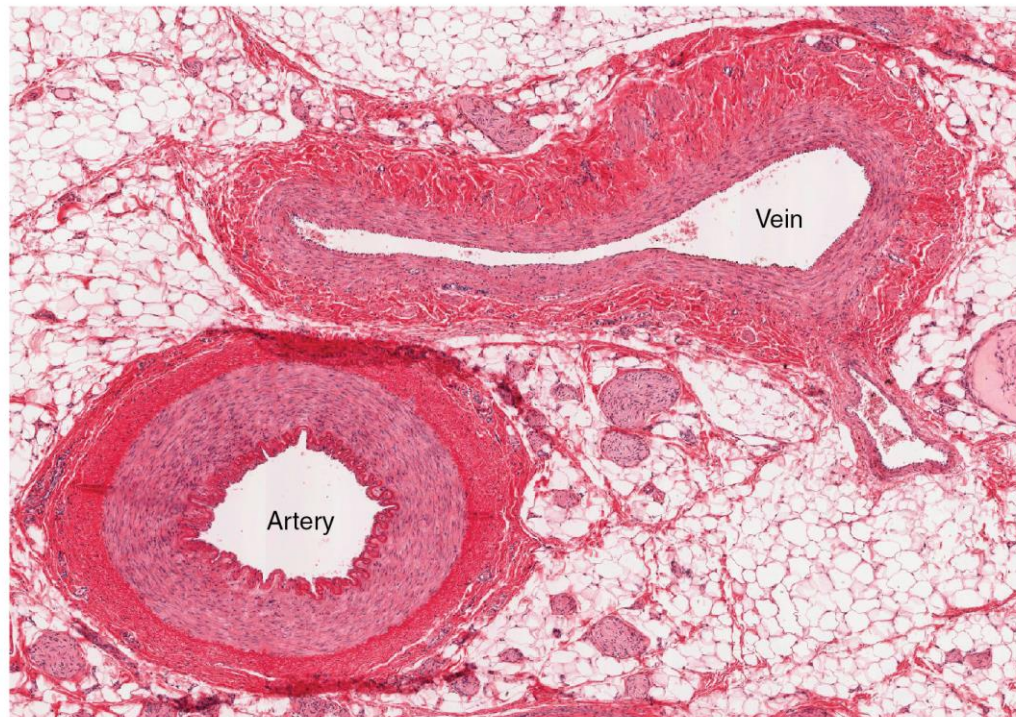


(a)

(b)

Comparison of Arteries and Veins

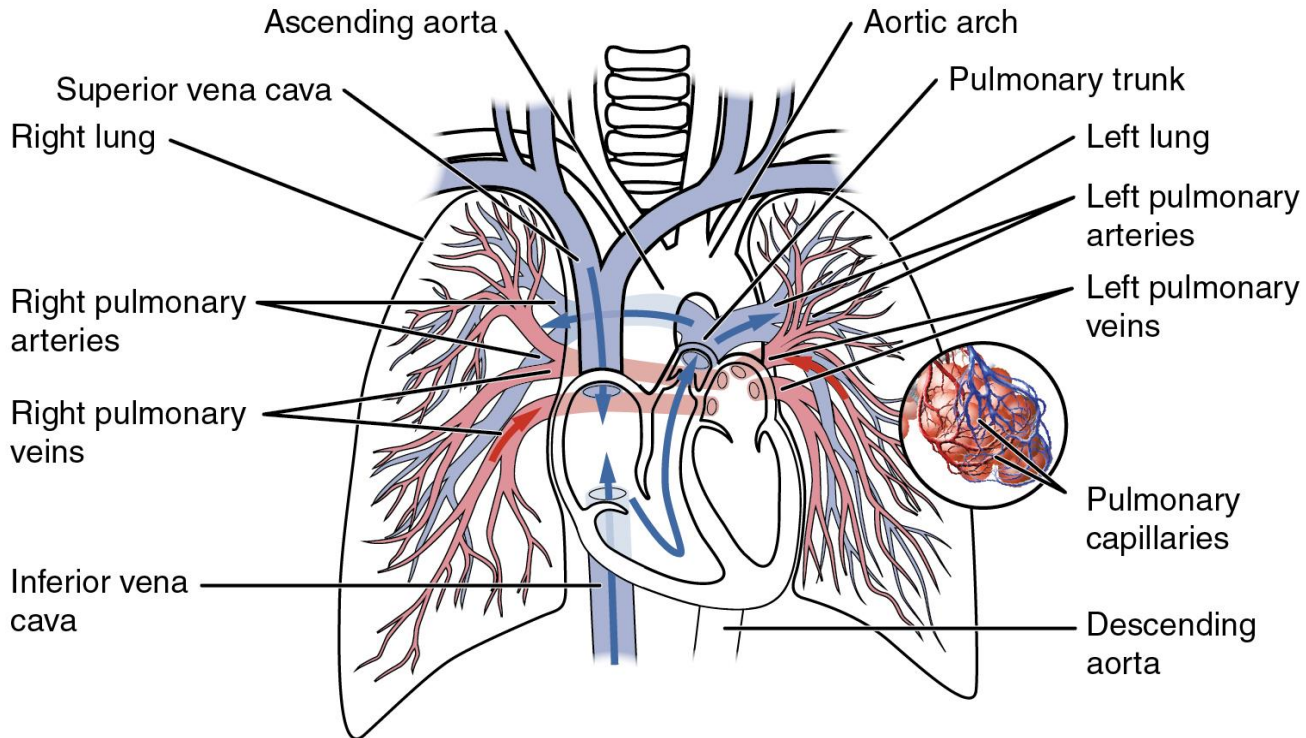
| | Arteries | Veins |
|--------------------------------------|--|---|
| Direction of blood flow | Conducts blood away from the heart | Conducts blood toward the heart |
| General appearance | Rounded | Irregular, often collapsed |
| Pressure | High | Low |
| Wall thickness | Thick | Thin |
| Relative oxygen concentration | Higher in systemic arteries Lower in pulmonary arteries | Lower in systemic veins Higher in pulmonary veins |
| Valves | Not present | Present most commonly in limbs and in veins inferior to the heart |



(c)

PULMONARY CIRCULATION

PULMONARY ARTERIES AND VEINS



Blood returning from the systemic circuit enters the right atrium of the heart via the superior and inferior venae cavae and the coronary sinus, which drains the blood supply of the heart muscle.

This blood is relatively low in oxygen and relatively high in carbon dioxide, since much of the oxygen has been extracted for use by the tissues and the waste gas carbon dioxide was picked up to be transported to the lungs for elimination.

From the right atrium, blood moves into the right ventricle, which pumps it to the lungs for gas exchange. This system of vessels is referred to as the **pulmonary circuit**.

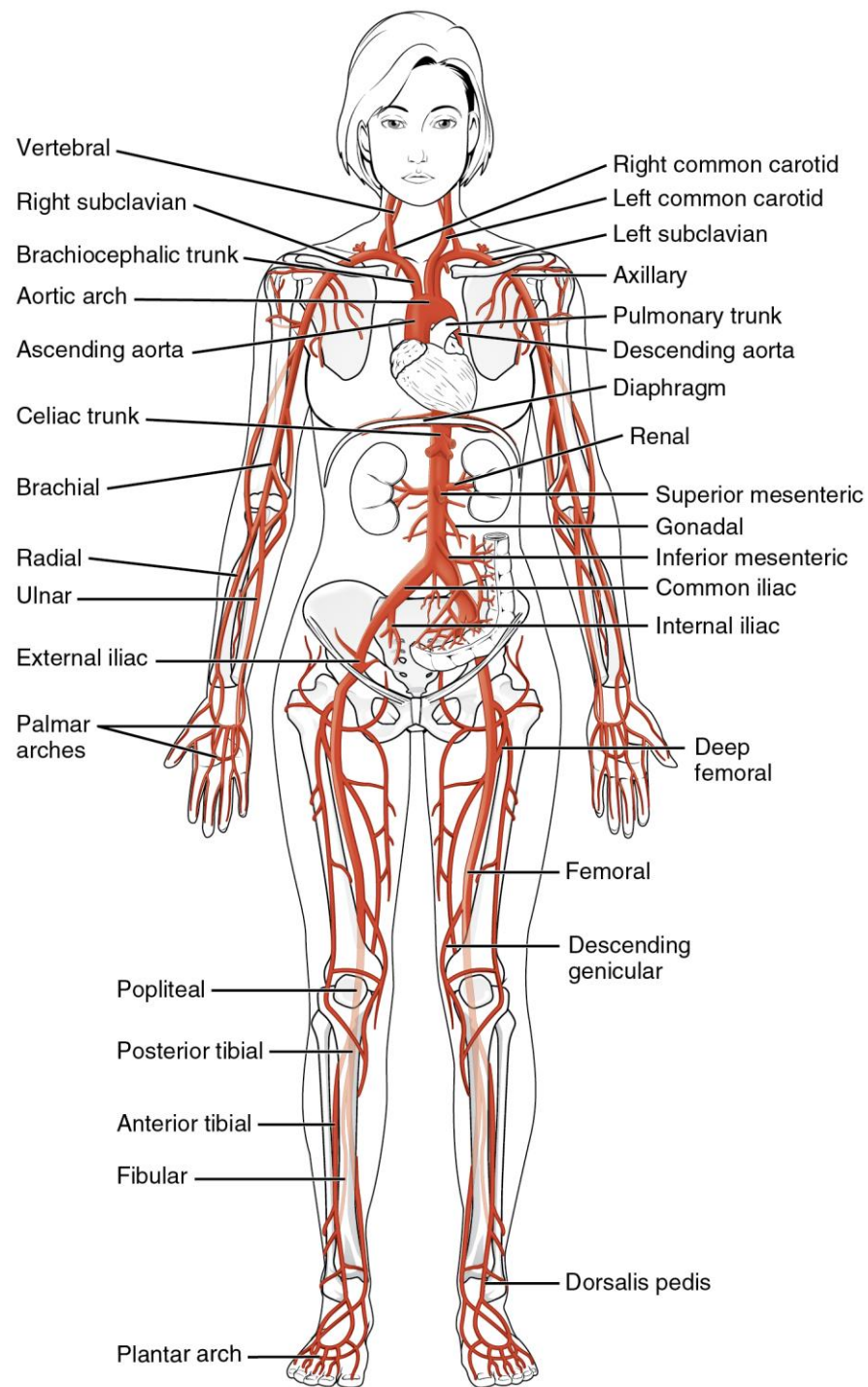
The single vessel exiting the right ventricle is the **pulmonary trunk**. Which curves posteriorly and rapidly bifurcates (divides) into two branches, **a left and a right pulmonary artery**.

The pulmonary arteries in turn branch many times within the lung, forming a series of smaller arteries and arterioles that eventually lead to the pulmonary capillaries, where gas exchange occurs.

After that, oxygenated blood flows from the pulmonary capillaries into a series of pulmonary venules that eventually lead to a series of larger **pulmonary veins**.

Four pulmonary veins, two on the left and two on the right, return blood to the left atrium of the heart. At this point, the pulmonary circuit is complete.

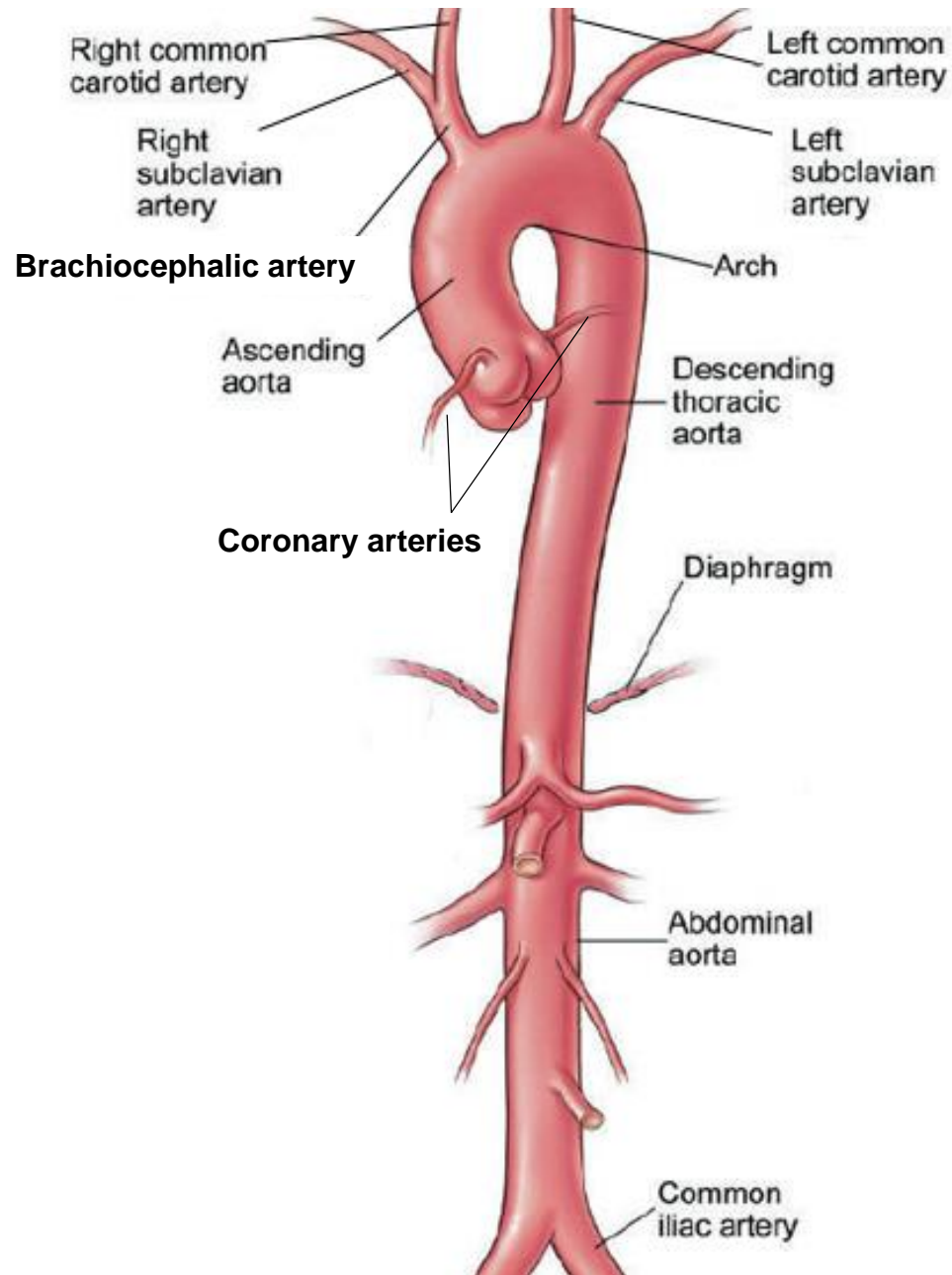
OVERVIEW OF SYSTEMIC ARTERIES



Blood relatively high in oxygen concentration is returned from the pulmonary circuit to the left atrium via the four pulmonary veins.

From the left atrium, blood moves into the left ventricle, which pumps blood into the AORTA.

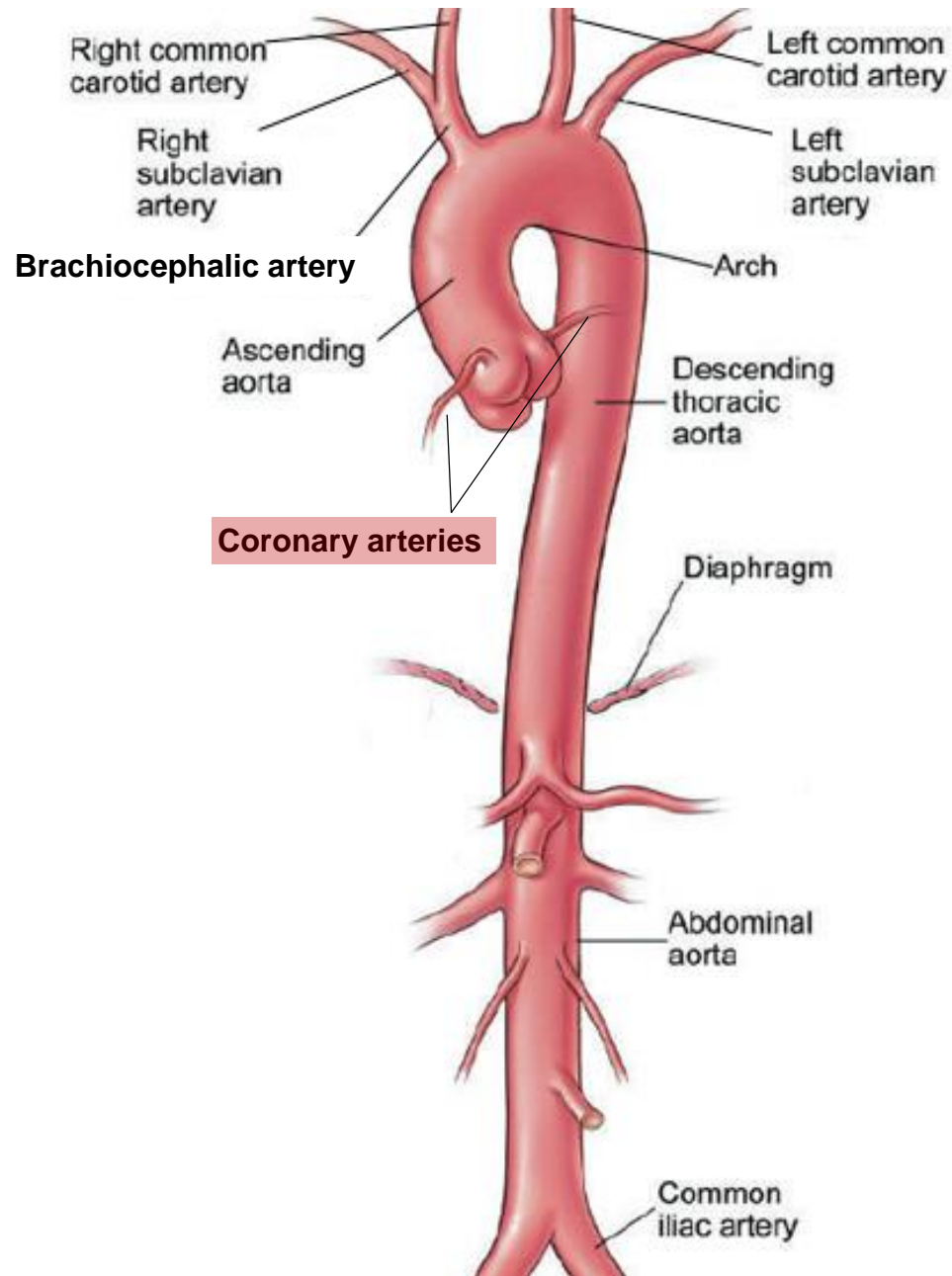
The aorta and its branches - the **systemic arteries** - send blood to virtually every organ of the body.



THE AORTA

The aorta is the largest artery of the body and carries arterial blood saturated with oxygen from your heart to the rest of the circulatory system. It is about an inch wide and has several sections:

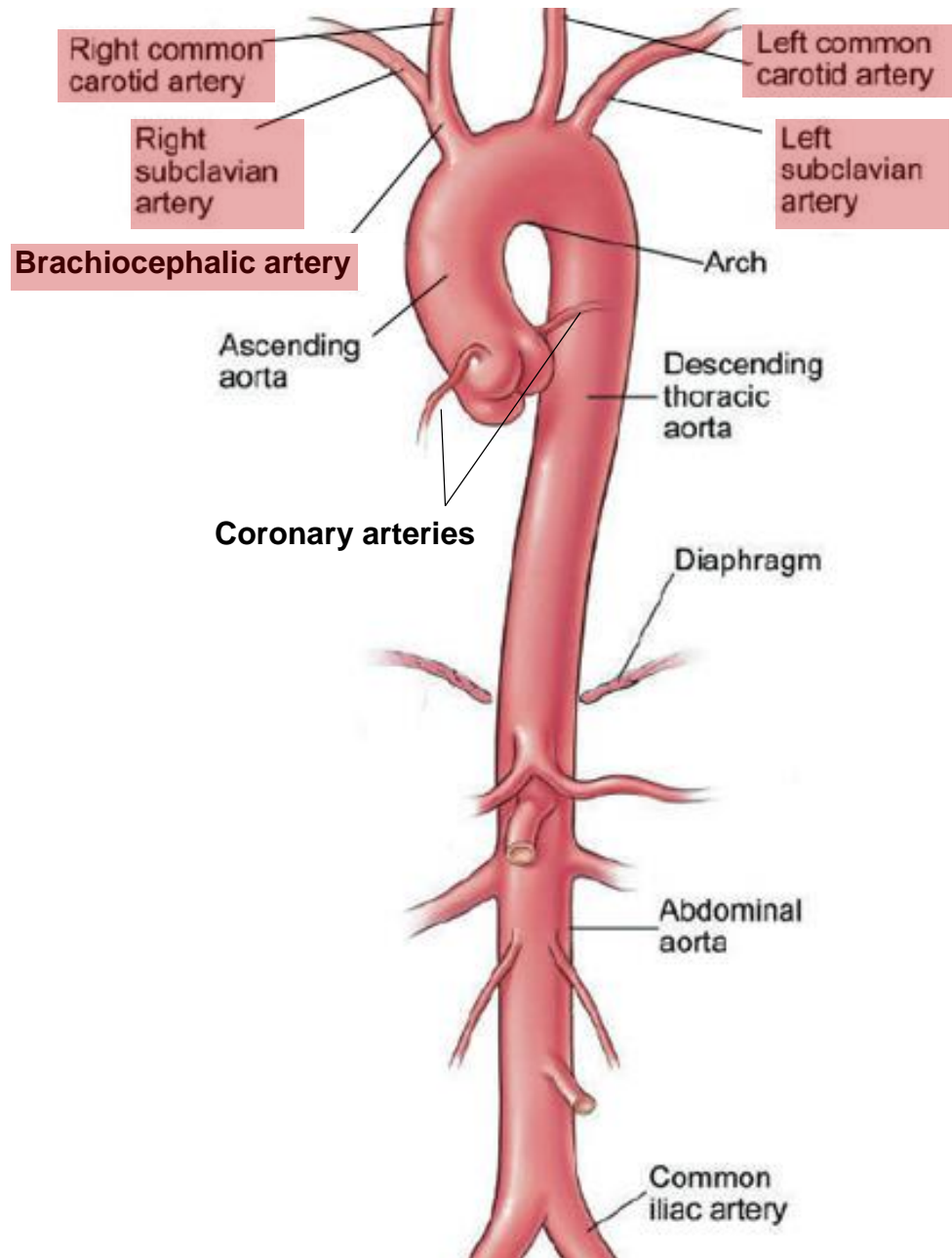
1. **The Aortic Root**, where blood first exits the heart. It starts with the aortic valve and contains the origins of the right and left coronary arteries.
2. **The Ascending Aorta** is the portion of the aorta between the aortic root and the aortic arch.
3. **The Aortic Arch**. Blood vessels from the aortic arch supply blood to your head and brain, spinal cord and upper limbs.
4. **The Descending Aorta** starts after the aortic arch and runs through the chest and abdomen. The descending thoracic aorta travels down through the chest. Its branches supply blood to the ribs, some chest structures and spinal cord.
5. **The Abdominal Aorta** runs from the descending aorta down to just below the navel delivering blood to your intestines, liver, kidneys and other organs in your abdomen. The abdominal aorta terminates when it bifurcates into the two common iliac arteries at the level of the fourth lumbar vertebra.



AORTIC BRANCHES

CORONARY ARTERIES

The first vessels that branch from the ascending aorta are the right and left coronary arteries, which arise respectively from the right and left Valsalva sinuses in the ascending aorta just superior to the aortic semilunar valve.



AORTIC BRANCHES

AORTIC ARCH BRANCHES

There are three major branches of the aortic arch:

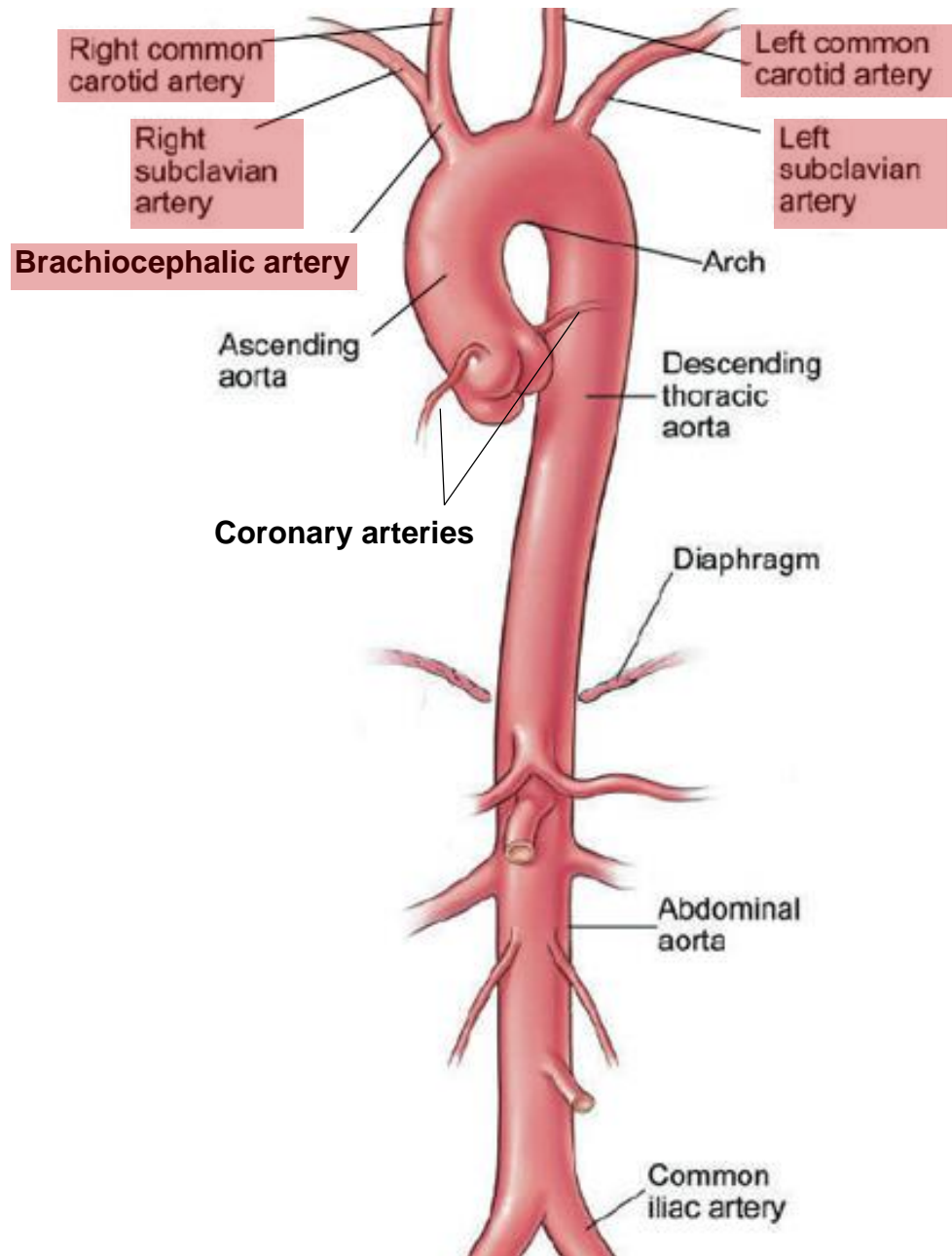
- the brachiocephalic artery
- the left common carotid artery
- the left subclavian (literally “under the clavicle”) artery

The brachiocephalic artery is located only on the right side of the body; there is no corresponding artery on the left.

The brachiocephalic artery branches into:

- the right subclavian artery
- the right common carotid artery

The left subclavian and left common carotid arteries arise independently from the aortic arch but otherwise follow a similar pattern and distribution to the corresponding arteries on the right side.



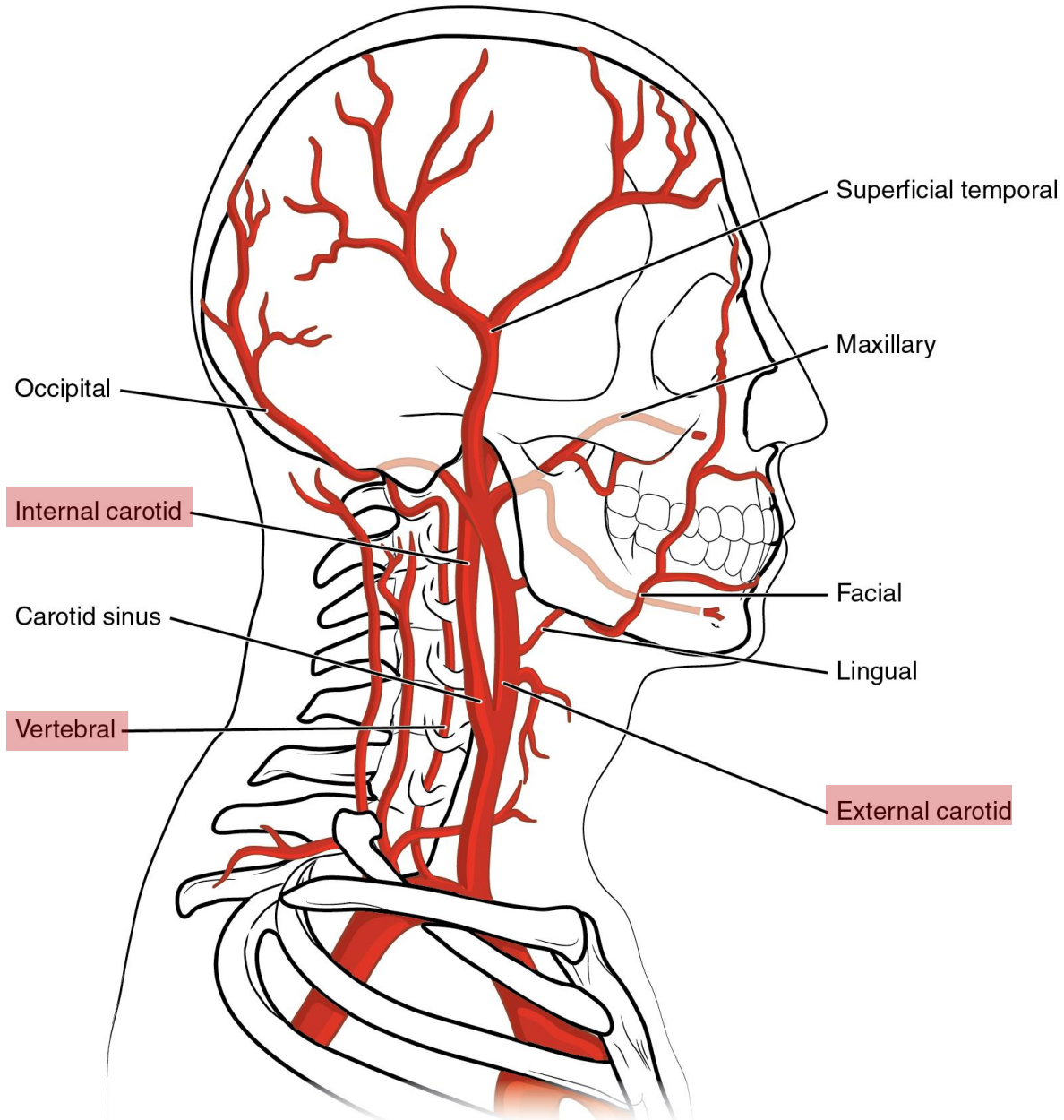
AORTIC ARCH BRANCHES

Each **subclavian artery** supplies blood to the upper limbs, chest, shoulders, back, and central nervous system. It gives rise to three major branches:

- the **internal thoracic artery**, or mammary artery, supplies blood to the thymus, the pericardium of the heart, and the anterior chest wall.
- the **vertebral artery** passes through the transverse foramen in the cervical vertebrae and then through the foramen magnum into the cranial cavity to supply blood to the brain and spinal cord.
- the **thyrocervical artery** that provides blood to the thyroid, the cervical region of the neck, and the upper back and shoulder.

The subclavian artery continues toward the arm as the axillary artery.

AORTIC ARCH BRANCHES



The aortic arch branches give rise to arteries which supplying the head and neck.

Both right and left common carotid artery gives rise to the **external** and **internal carotid arteries**.

- The **external carotid artery** remains superficial and gives rise to many arteries of the head. It supplies blood to numerous structures within the face, lower jaw, neck, esophagus, and larynx. *These branches include the lingual, facial, occipital, maxillary, and superficial temporal arteries.*
- The **internal carotid artery** first forms the carotid sinus and then continues through the carotid canal of the temporal bone and enters the base of the brain through the carotid foramen where it gives rise to several branches.
- The **vertebral artery** branches from the subclavian artery and passes through the transverse foramen in the cervical vertebrae, entering the base of the skull.

The **branches of the internal carotid and vertebral arteries** form an **anastomosis** located at the base of the brain, named **ARTERIAL CIRCLE** or **CIRCLE OF WILLIS** → It ensures continual blood supply to the brain

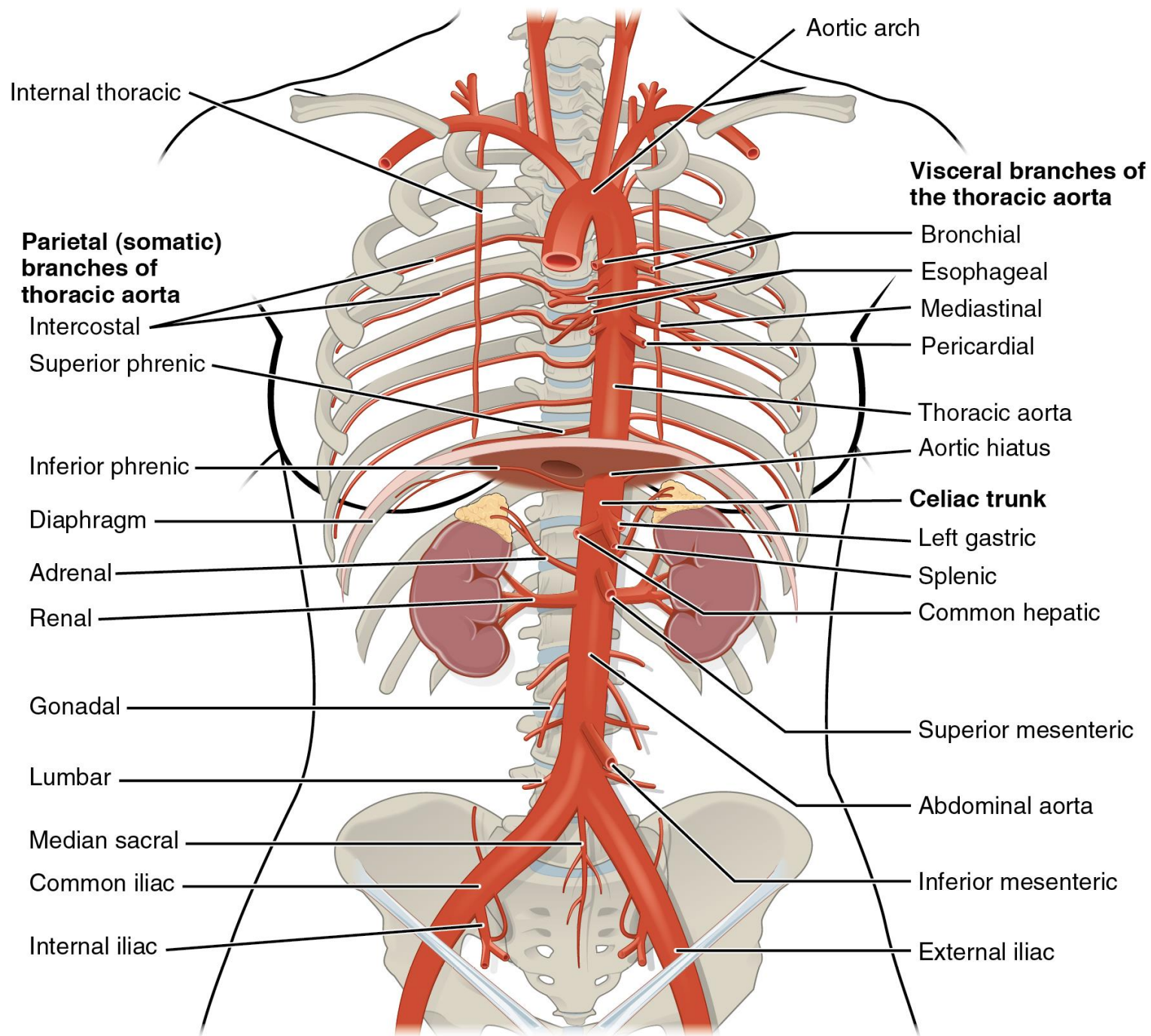
AORTIC BRANCHES

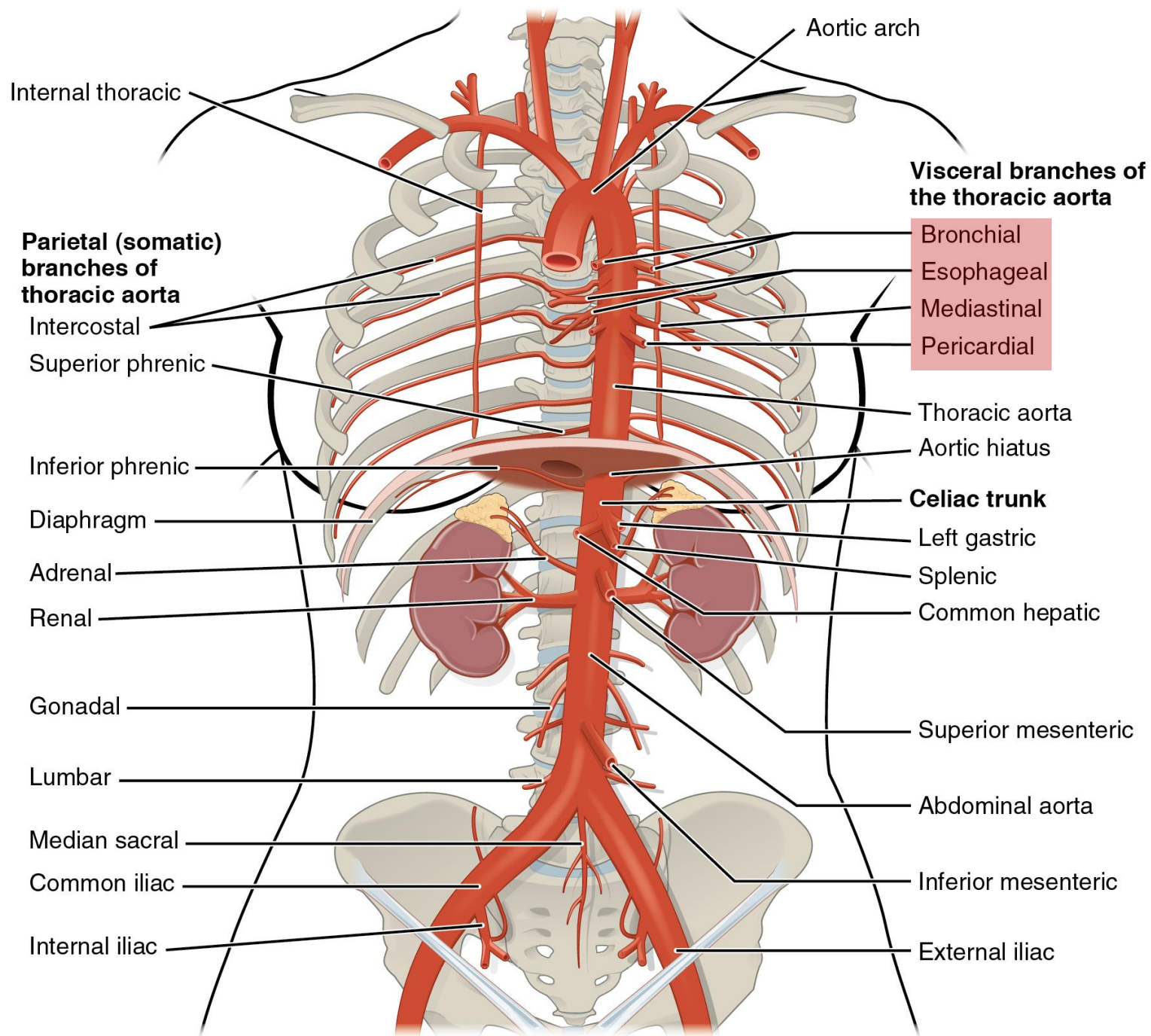
THORACIC AORTA AND MAJOR BRANCHES

The thoracic aorta begins at the level of vertebra T5 and continues through to the diaphragm at the level of T12, initially passing within the mediastinum to the left of the vertebral column.

As it passes through the thoracic region, the thoracic aorta gives rise to several branches, which are collectively referred to as:

- **VISCERAL BRANCHES**
- **PARIETAL BRANCHES**



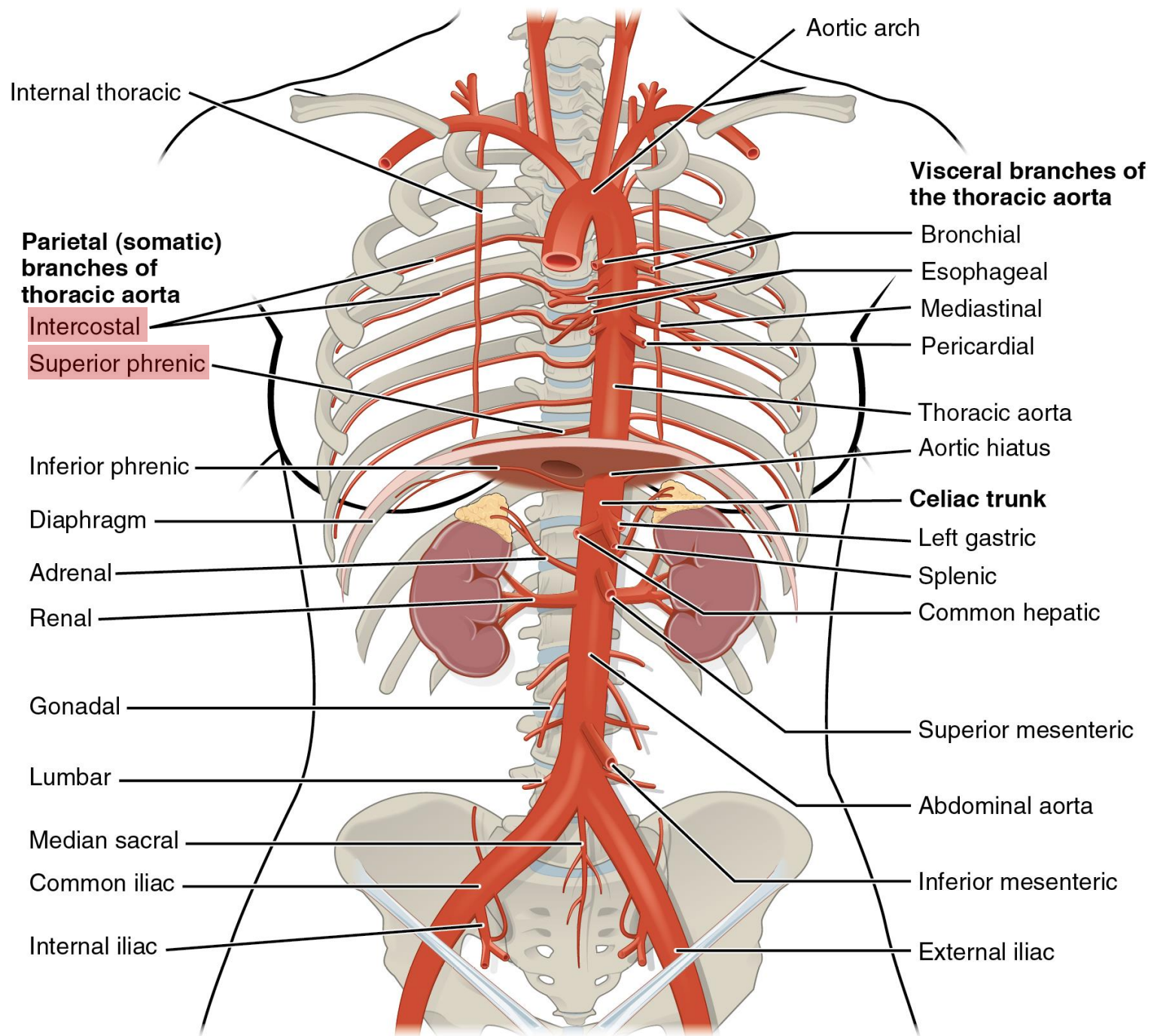


THORACIC AORTA AND MAJOR BRANCHES

VISCERAL BRANCHES of the thoracic aorta supply blood primarily to visceral organs and include:

- the *bronchial arteries* (typically two on the left and one on the right) supply systemic blood to the lungs and visceral pleura, in addition to the blood pumped to the lungs for oxygenation via the pulmonary circuit;
- the *pericardial arteries*, which supply blood to the pericardium;
- the *esophageal arteries*, that provide blood to the esophagus;
- the *mediastinal arteries*, which provides blood to the mediastinum.

[each artery is named after the tissues it supplies]



THORACIC AORTA AND MAJOR BRANCHES

PARIETAL BRANCHES of the **thoracic aorta** (also called somatic branches) supply blood to the thoracic wall, vertebral column, and the superior surface of the diaphragm

They include:

- the *intercostal arteries*, which provide blood to the muscles of the thoracic cavity and vertebral column;
- the *superior phrenic arteries*, that provide blood to the superior surface of the diaphragm.

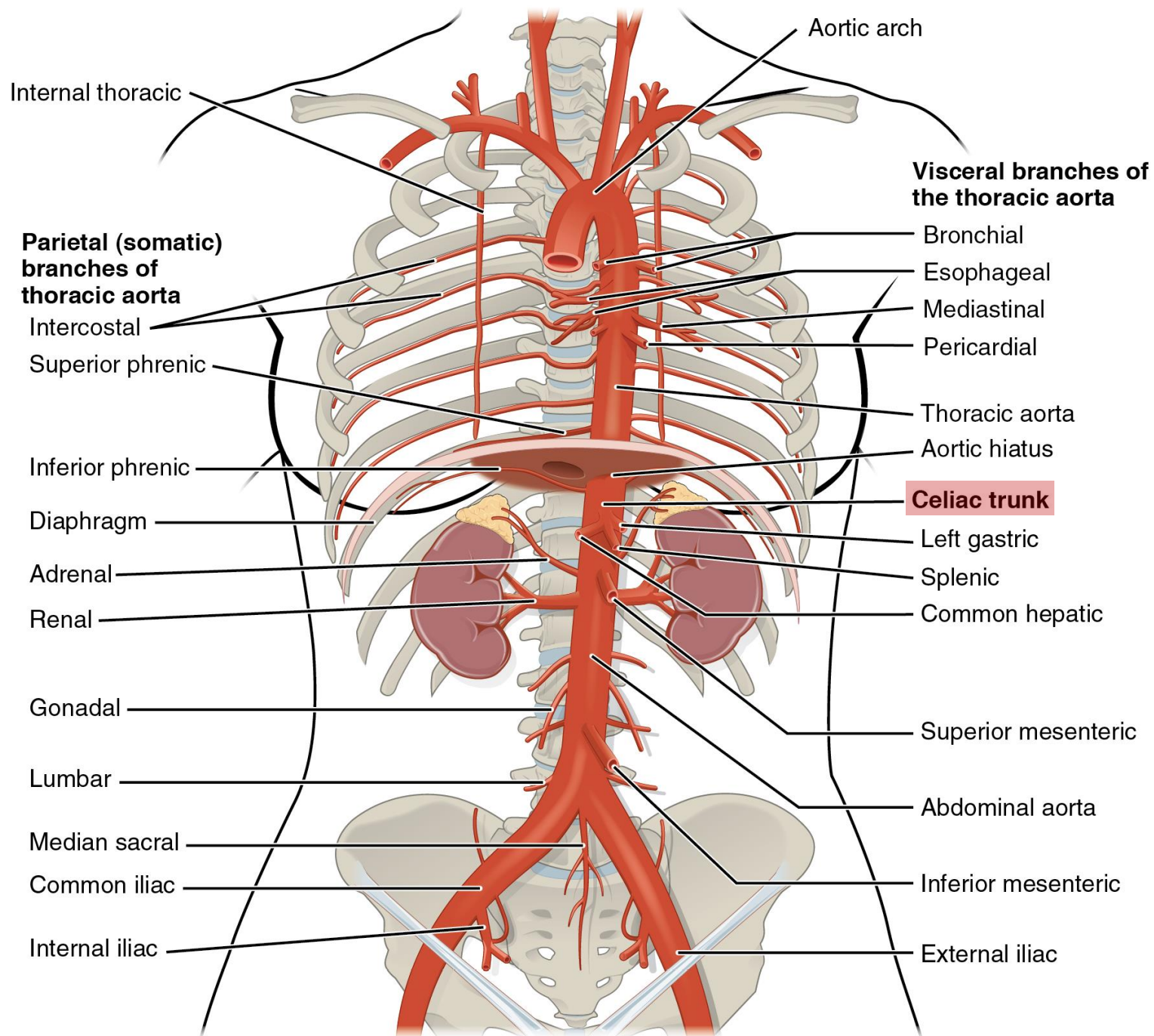
AORTIC BRANCHES

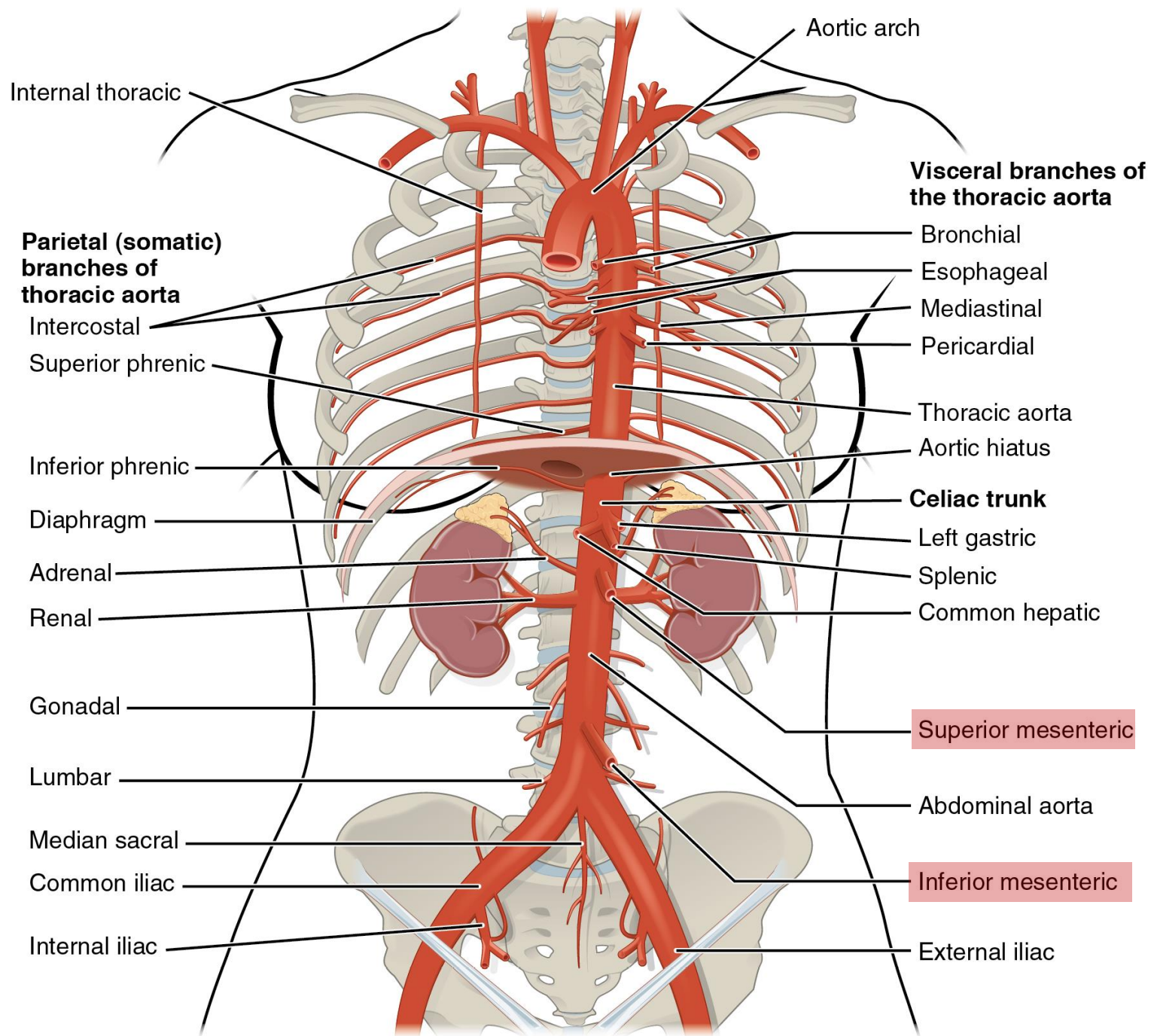
ABDOMINAL AORTA AND MAJOR BRANCHES

After crossing through the diaphragm at the aortic foramen (or hiatus), the thoracic aorta is called the abdominal aorta. It formally ends at approximately the level of vertebra L4, where it bifurcates to form the common iliac arteries. Before this division, the abdominal aorta gives rise to several important branches.

A single **celiac trunk** (artery) emerges and divides into:

- the **left gastric artery** to supply blood to the stomach and esophagus,
- the **splenic artery** to supply blood to the spleen
- the **common hepatic artery**, which in turn gives rise to the **hepatic artery proper** to supply blood to the liver, the **right gastric artery** to supply blood to the stomach, the **cystic artery** to supply blood to the gall bladder, and several branches which supply blood to the duodenum and to the pancreas.

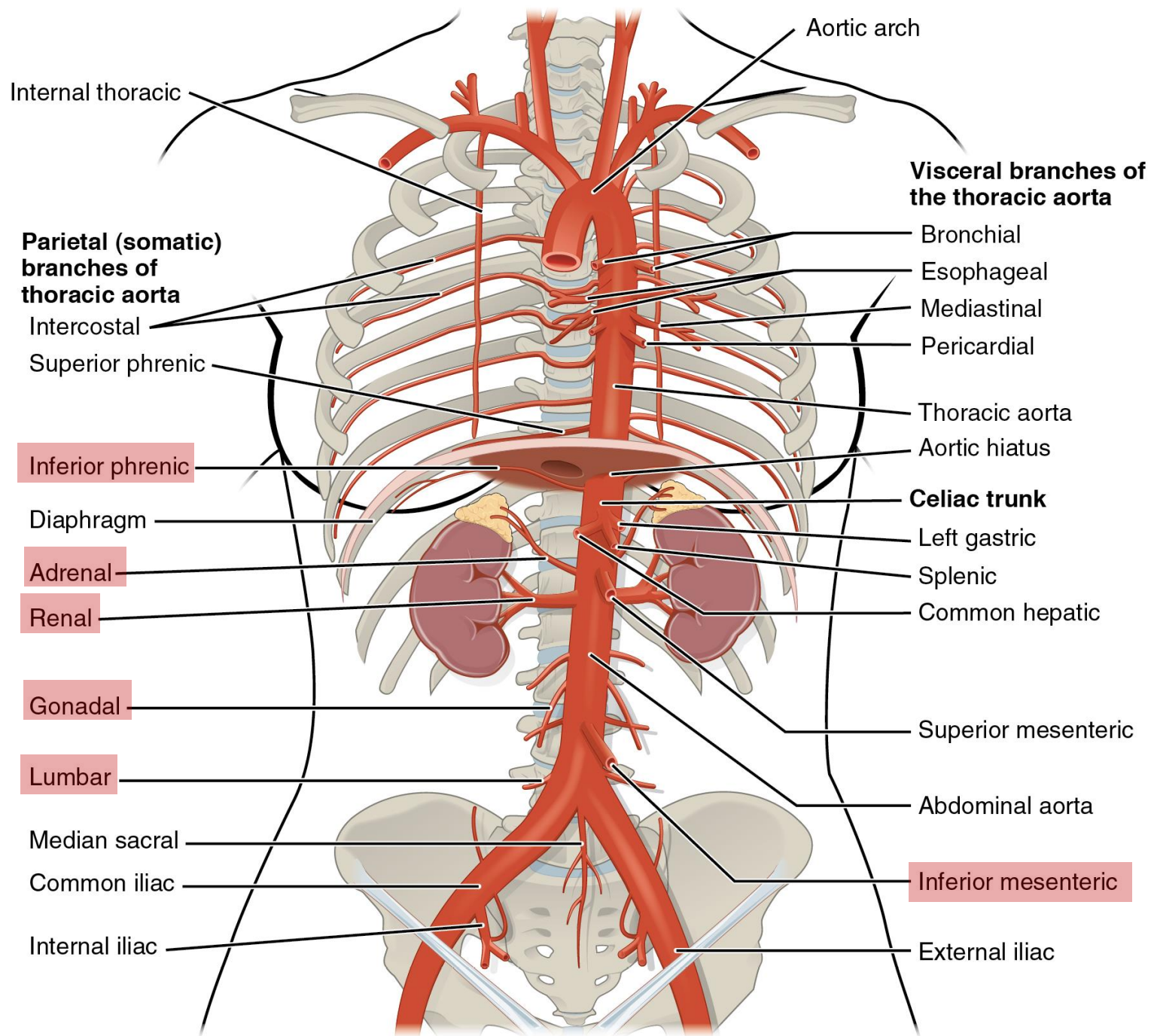




ABDOMINAL AORTA AND MAJOR BRANCHES

Two additional single vessels arise from the abdominal aorta:

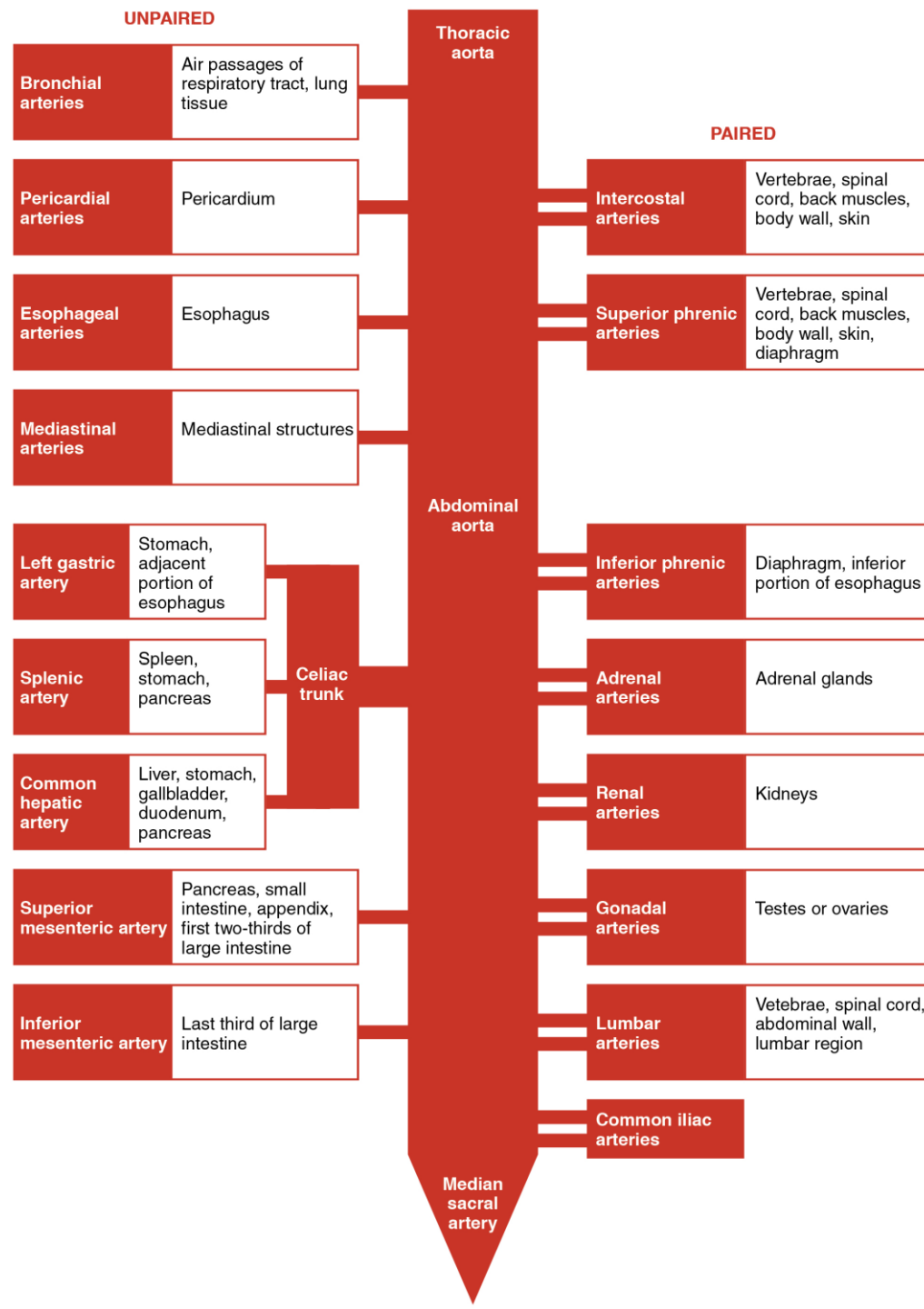
- the **superior mesenteric artery**, which arises approximately 2.5 cm after the celiac trunk and branches into several major vessels that supply blood to the small intestine (duodenum, jejunum, and ileum), the pancreas, and a majority of the large intestine;
- the **inferior mesenteric artery**, that supplies blood to the distal segment of the large intestine, including the rectum. It arises approximately 5 cm superior to the common iliac arteries.



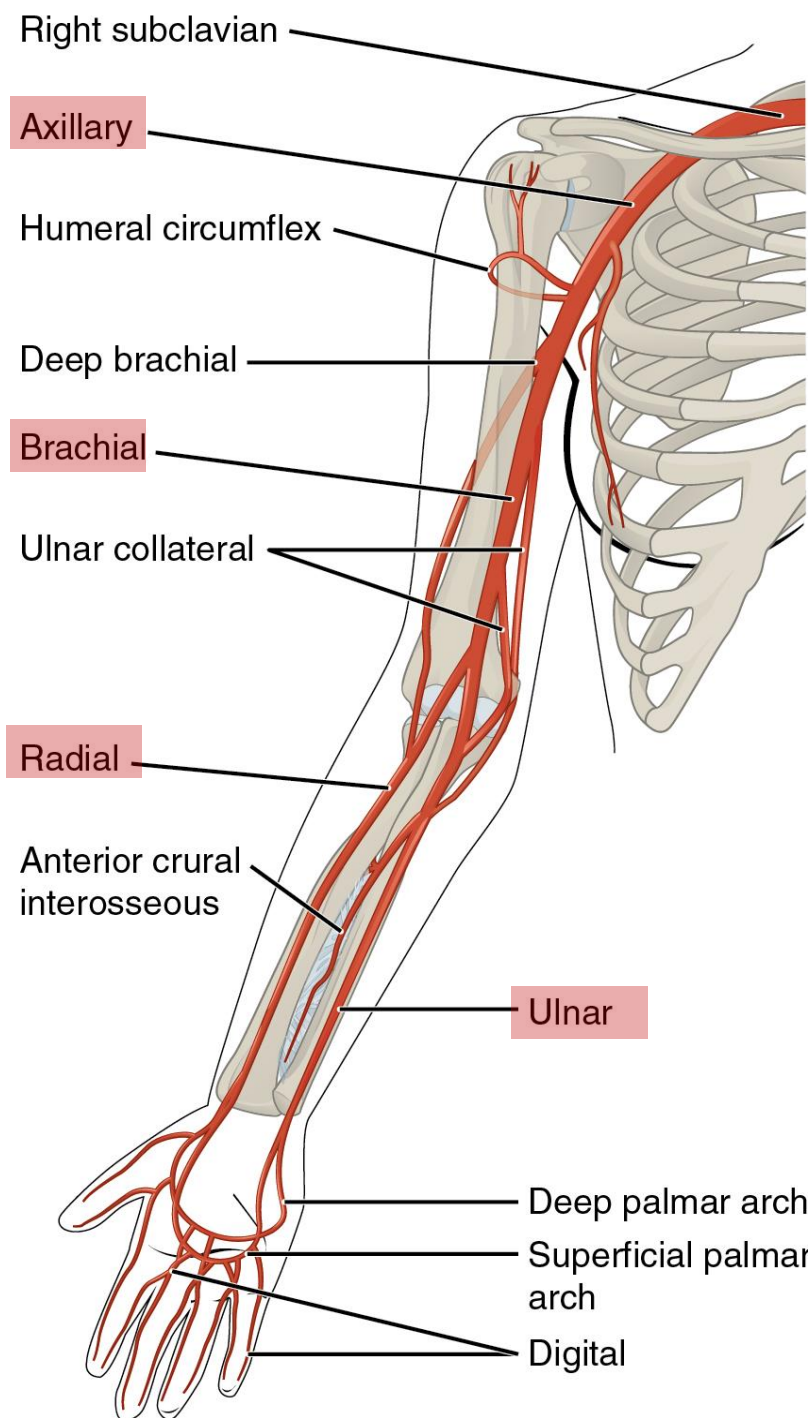
ABDOMINAL AORTA AND MAJOR BRANCHES

In addition to these single branches, the abdominal aorta gives rise to several significant paired arteries:

- the *inferior phrenic arteries*, that supply blood to the inferior surface of the diaphragm;
- the *adrenal arteries*, that supply blood to the adrenal (suprarenal) glands;
- the *renal arteries*, that supply the kidneys;
- the *gonadal arteries*, which supply blood to the gonads, and is also described as either an ovarian artery or a testicular artery, depending upon the sex of the individual;
- the *lumbar arteries*, that are the counterparts of the intercostal arteries and supply blood to the lumbar region, the abdominal wall, and the spinal cord.



Major Branches of the Aorta The flow chart summarizes the distribution of the major branches of the aorta into the thoracic and abdominal regions.



AORTIC BRANCHES

ARTERIES SERVING THE UPPER LIMBS

As the subclavian artery exits the thorax into the axillary region, it is renamed the **axillary artery**, which branches and supplies blood to the region near the head of the humerus (via the humeral circumflex arteries), and then it gives rise to vessels that continue into the upper arm, or brachium, becoming the brachial artery.

The **brachial artery** supplies blood to much of the brachial region and divides at the elbow into several smaller branches, including:

- the *deep brachial arteries*, which provide blood to the posterior surface of the arm,
- the *ulnar collateral arteries*, which supply blood to the region of the elbow.

As the brachial artery approaches the coronoid fossa, it bifurcates into the radial and ulnar arteries, which continue into the forearm, or antebrachium.

- The **radial artery** and **ulnar artery** parallel their namesake bones, giving off smaller branches until they reach the wrist, or carpal region.

- At this level, they fuse to form the superficial and deep **palmar arches** that supply blood to the hand, as well as the **digital arteries** that supply blood to the digits.

AORTIC BRANCHES

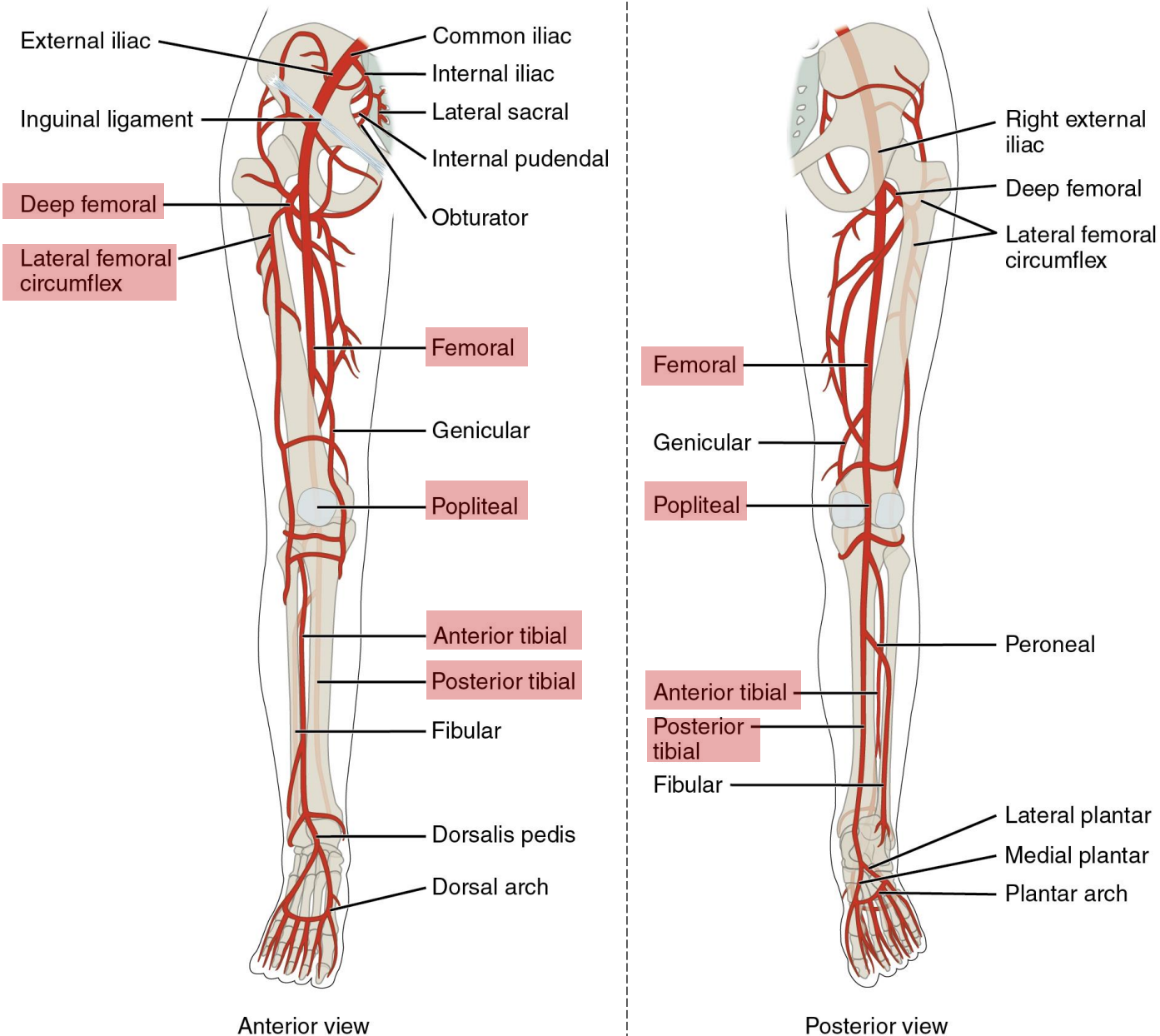
ARTERIES SERVING THE LOWER LIMBS

The common iliac artery gives rise to the external iliac artery, which enters the femoral region of the lower limb, being renamed the **femoral artery**. It gives off several smaller branches as well as the lateral **deep femoral artery** that in turn gives rise to a **lateral circumflex artery**. These arteries supply blood to the deep muscles of the thigh.

The femoral artery also gives rise to the **genicular artery**, which provides blood to the region of the knee.

As the femoral artery passes posterior to the knee near the popliteal fossa, it is called the **popliteal artery**, which branches into:

- the **anterior tibial** artery, located between the tibia and fibula, supplies blood to the muscles of the anterior tibial region. Upon reaching the tarsal region, it becomes the **dorsalis pedis artery**, which branches repeatedly and provides blood to the tarsal and dorsal regions of the foot.
- the **posterior tibial artery** provides blood to the muscles on the posterior surface of the tibial region.



Anterior view

Posterior view

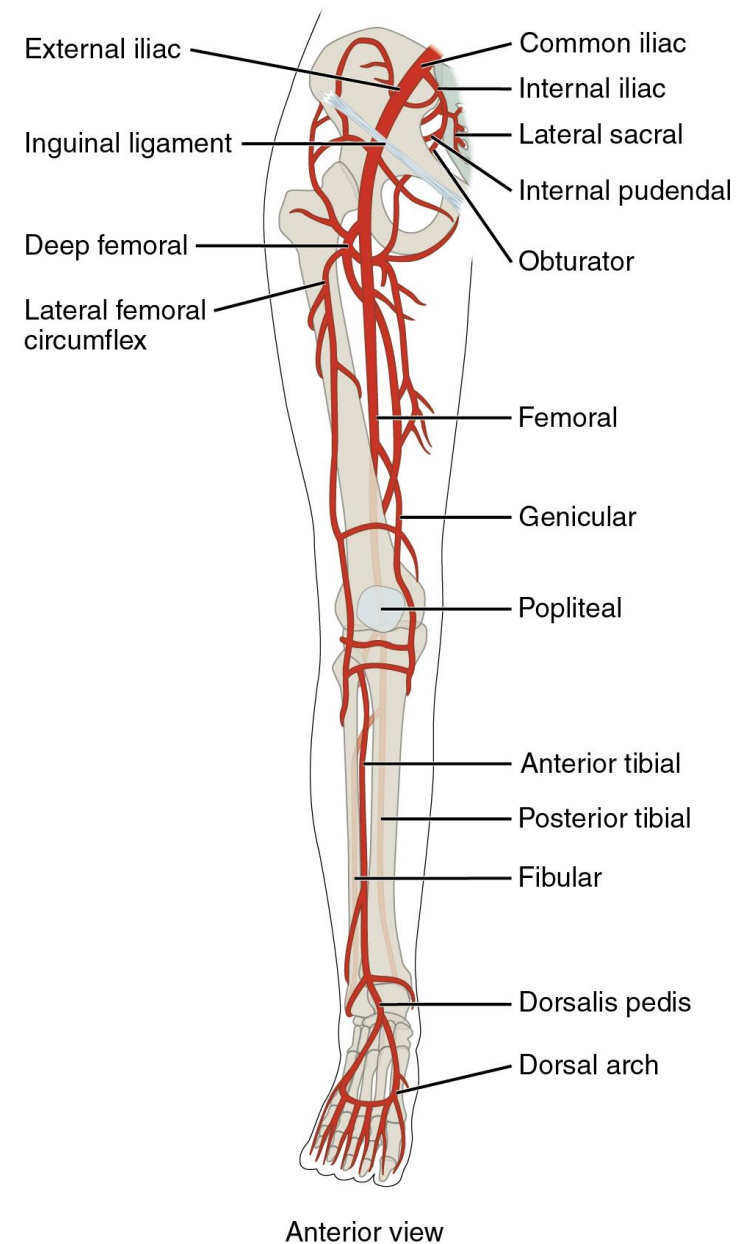
AORTIC BRANCHES

ARTERIES SERVING THE LOWER LIMBS

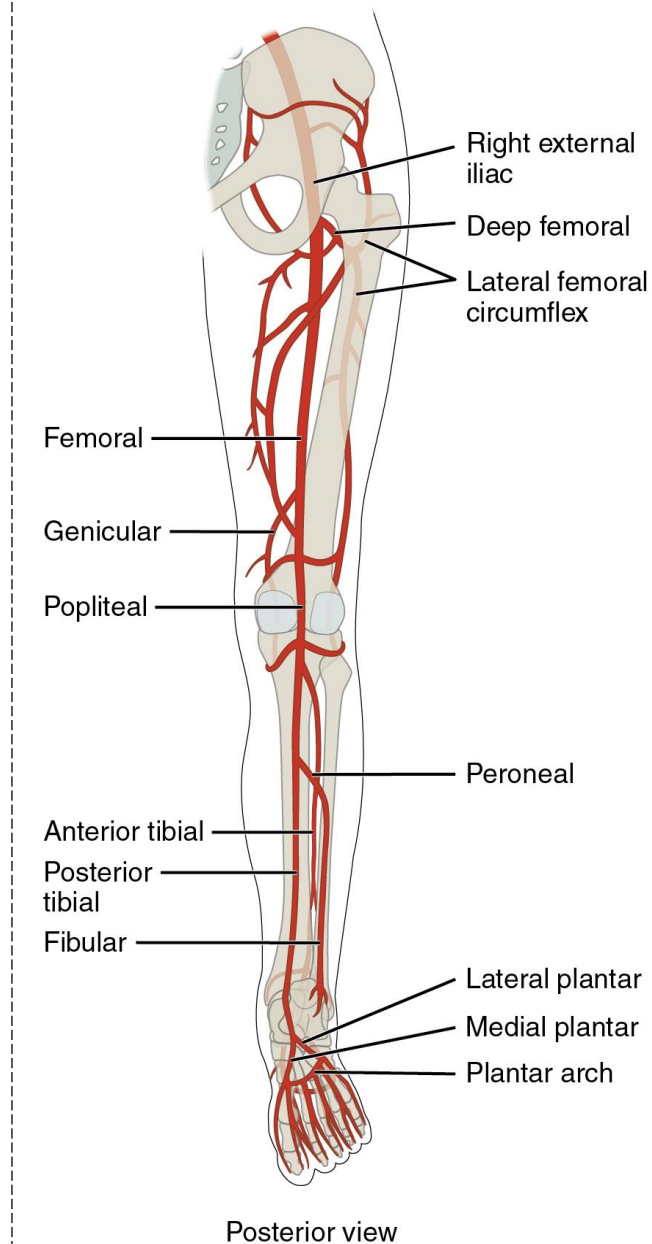
The **fibular or peroneal artery** branches from the posterior tibial artery. It bifurcates and becomes the **medial plantar artery** and **lateral plantar artery**, providing blood to the plantar surfaces.

The medial and lateral plantar arteries form two arches called
 - the **dorsal arch** (also called the arcuate arch)
 - the **plantar arch**

which provide blood to the foot and toes.

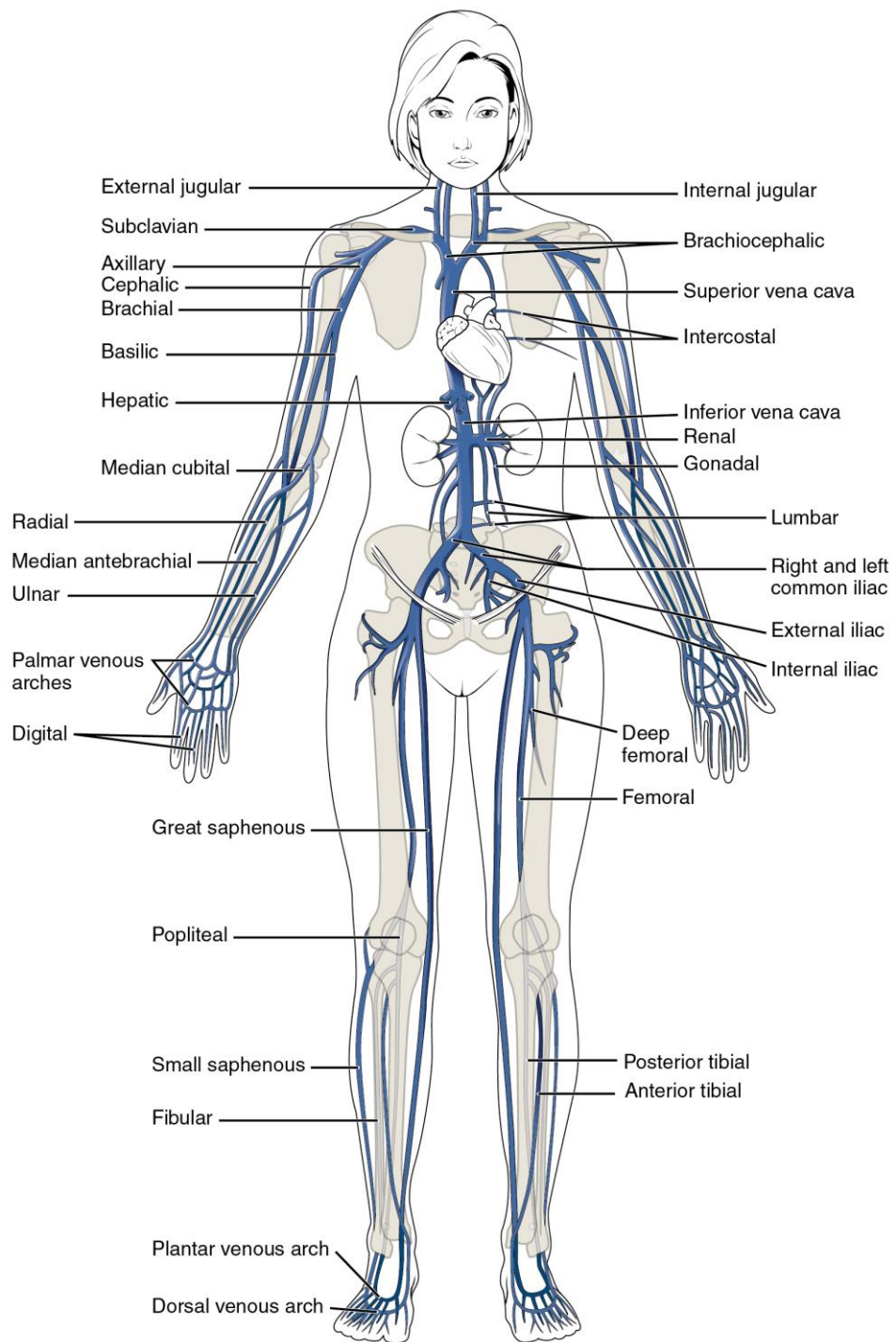


Anterior view



Posterior view

OVERVIEW OF SYSTEMIC VEINS

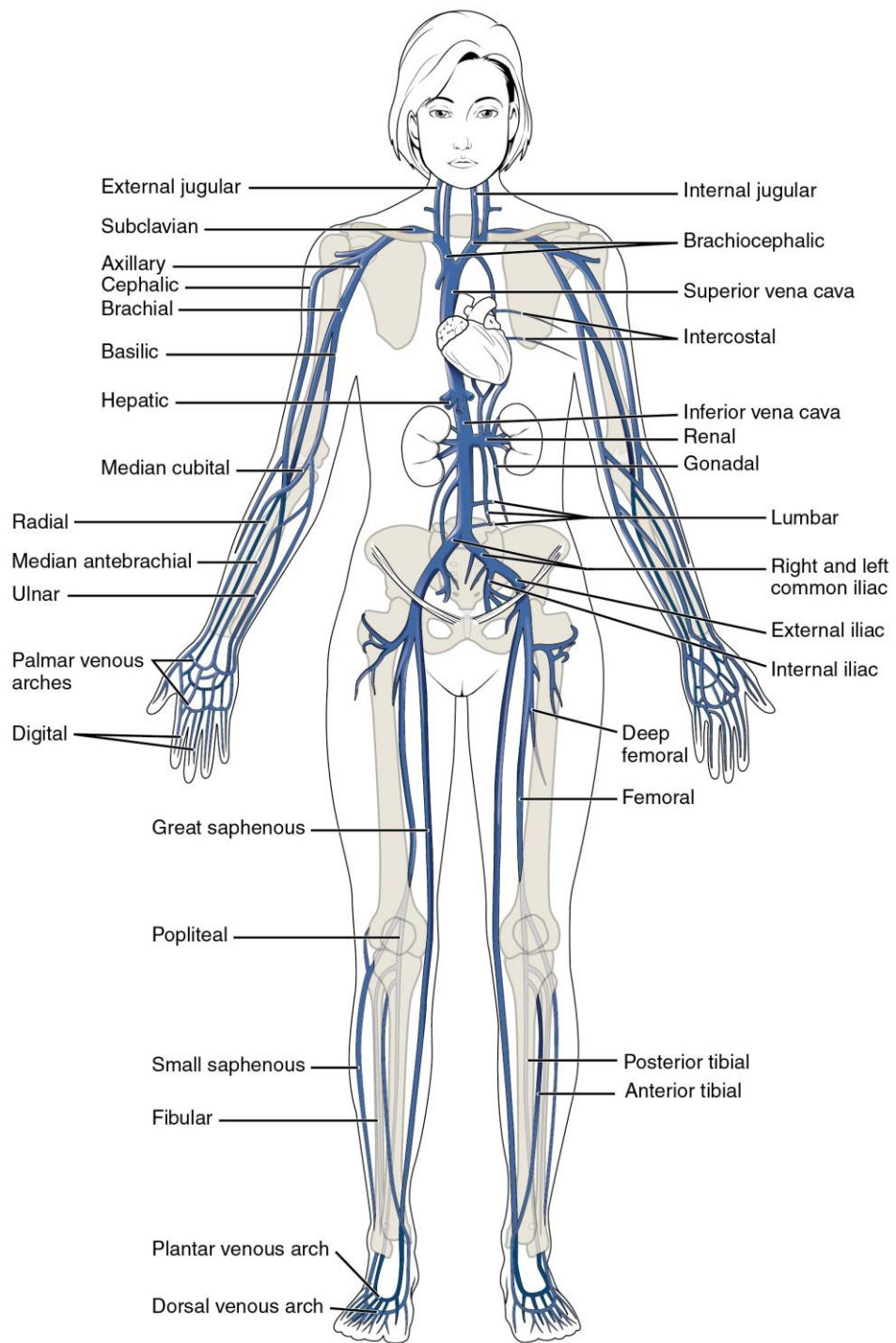


Systemic veins return blood to the right atrium of the heart. Since the blood has already passed through the systemic capillaries, it will be relatively low in oxygen concentration.

In many cases, there will be veins draining organs and regions of the body with the same name as the arteries that supplied these regions and the two often parallel one another. This is often described as a “complementary” pattern.

In both the neck and limb regions, there are often both **superficial** and **deeper levels of veins**.

- The **deeper veins** generally correspond to the complementary arteries.
- The **superficial veins** do not normally have direct arterial counterparts, but in addition to returning blood, they also make contributions to the maintenance of body temperature.



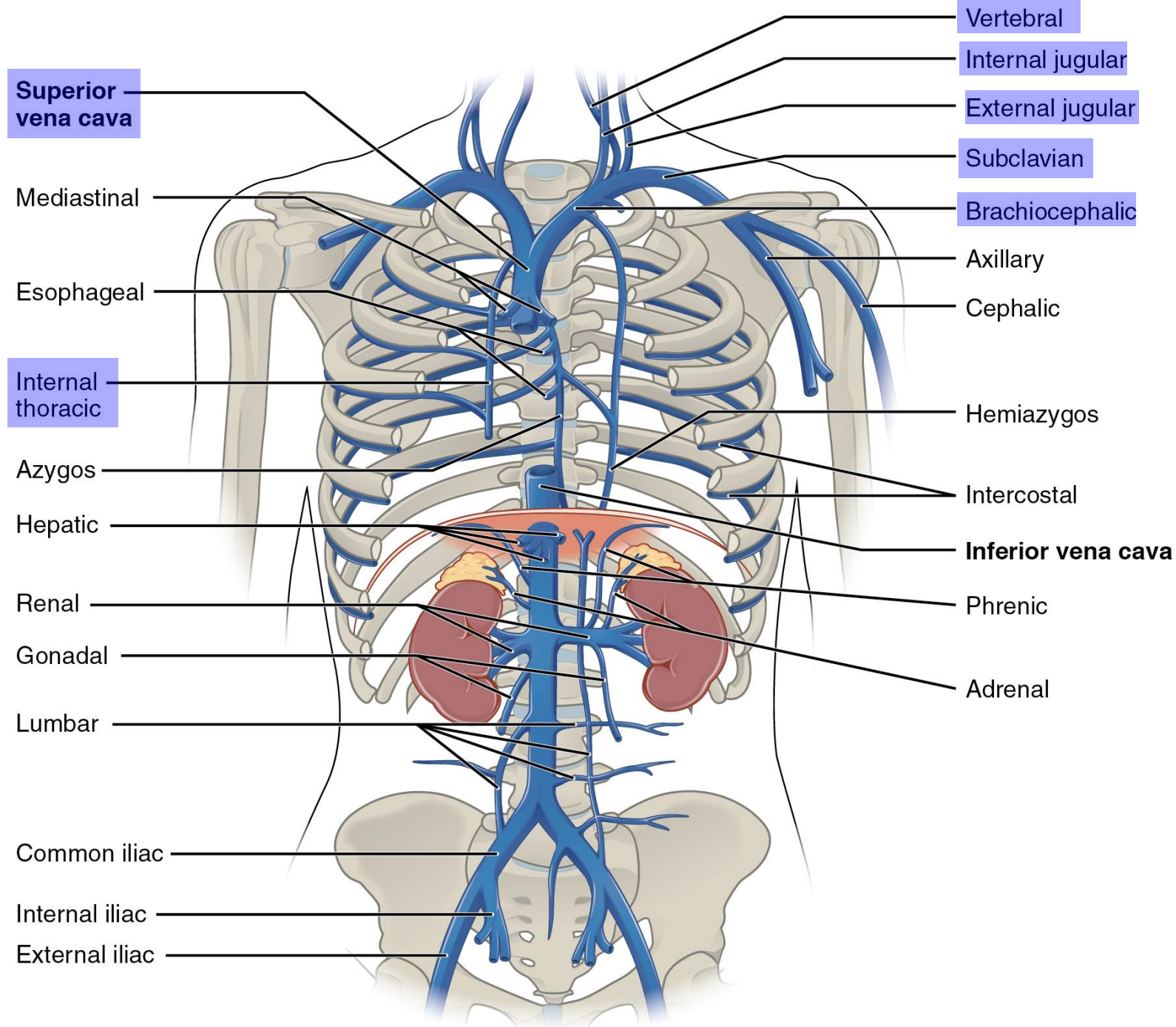
The right atrium receives all of the systemic venous return. Most of the blood flows into either the **superior vena cava** or **inferior vena cava**.

Considering the diaphragm as the separation between the upper and lower portions of the body, **systemic venous circulation from above the diaphragm will generally flow into the superior vena cava**; this includes blood from the **head, neck, chest, shoulders, and upper limbs**.

The exception to this is that most venous blood flow from the coronary veins flows directly into the coronary sinus and from there directly into the right atrium.

Beneath the diaphragm, systemic venous flow enters the inferior vena cava, that is, blood from the **abdominal and pelvic regions and the lower limbs**.

SYSTEMIC VEINS



SUPERIOR VENA CAVA

The **superior vena cava** drains most of the body superior to the diaphragm.

On both the left and right sides, the **subclavian vein** forms when the axillary vein passes from the axillary to the thorax region.

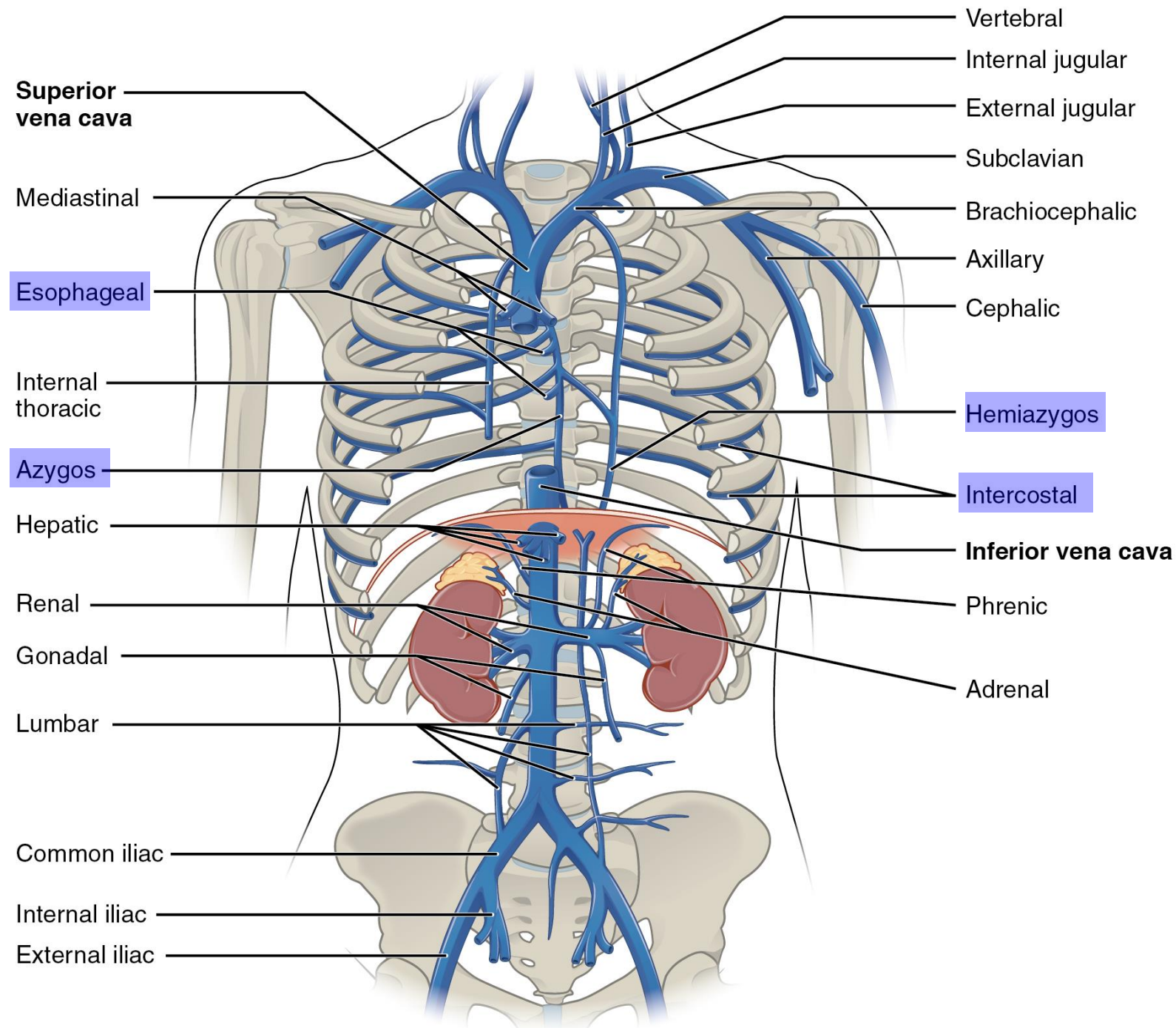
It fuses with the *external* and *internal jugular veins* from the head and neck to form the **brachiocephalic vein**.

Each **vertebral vein** also flows into the brachiocephalic vein close to this fusion.

Vertebral veins arise from the base of the brain and the cervical region of the spinal cord, and flow largely through the transverse foramina in the cervical vertebrae. They are the counterparts of the vertebral arteries.

Each **internal thoracic vein**, also known as an internal mammary vein, drains the anterior surface of the chest wall and flows into the brachiocephalic vein.

SYSTEMIC VEINS



SUPERIOR VENA CAVA

The **superior vena cava** drains most of the body superior to the diaphragm.

The superior vena cava collects blood from many other smaller veins:

- the **intercostal vein** which drain muscles of the thoracic wall

- the **esophageal vein** that delivers blood from the inferior portions of the esophagus

- the **bronchial vein** that drains the systemic circulation from the lungs, and several smaller veins drain the mediastinal region.

These veins flow into the **azygos vein**, and with the smaller **hemiazygos vein** (hemi- = "half") on the left of the vertebral column, drain blood from the thoracic region.

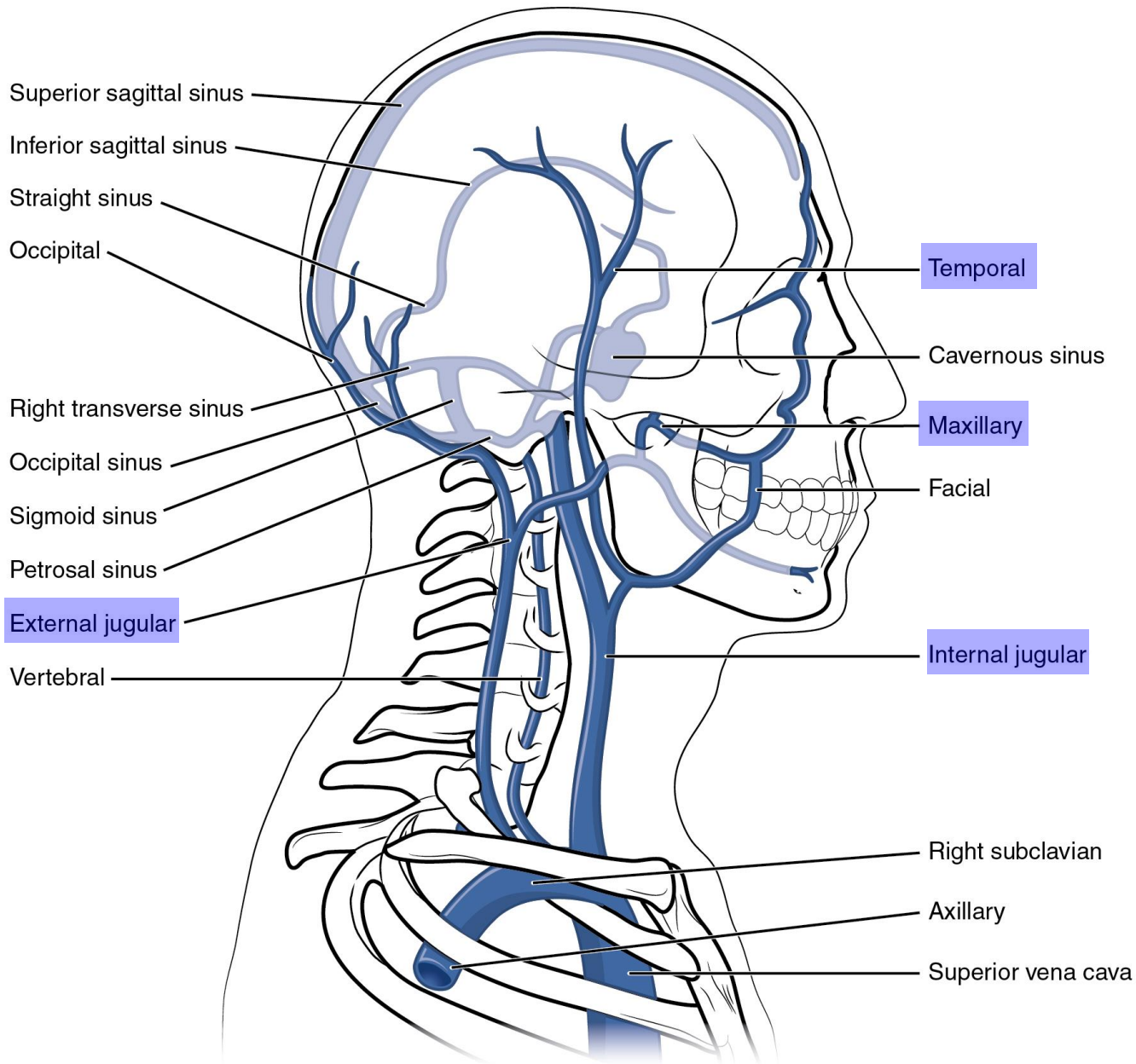
VEINS OF THE HEAD AND NECK

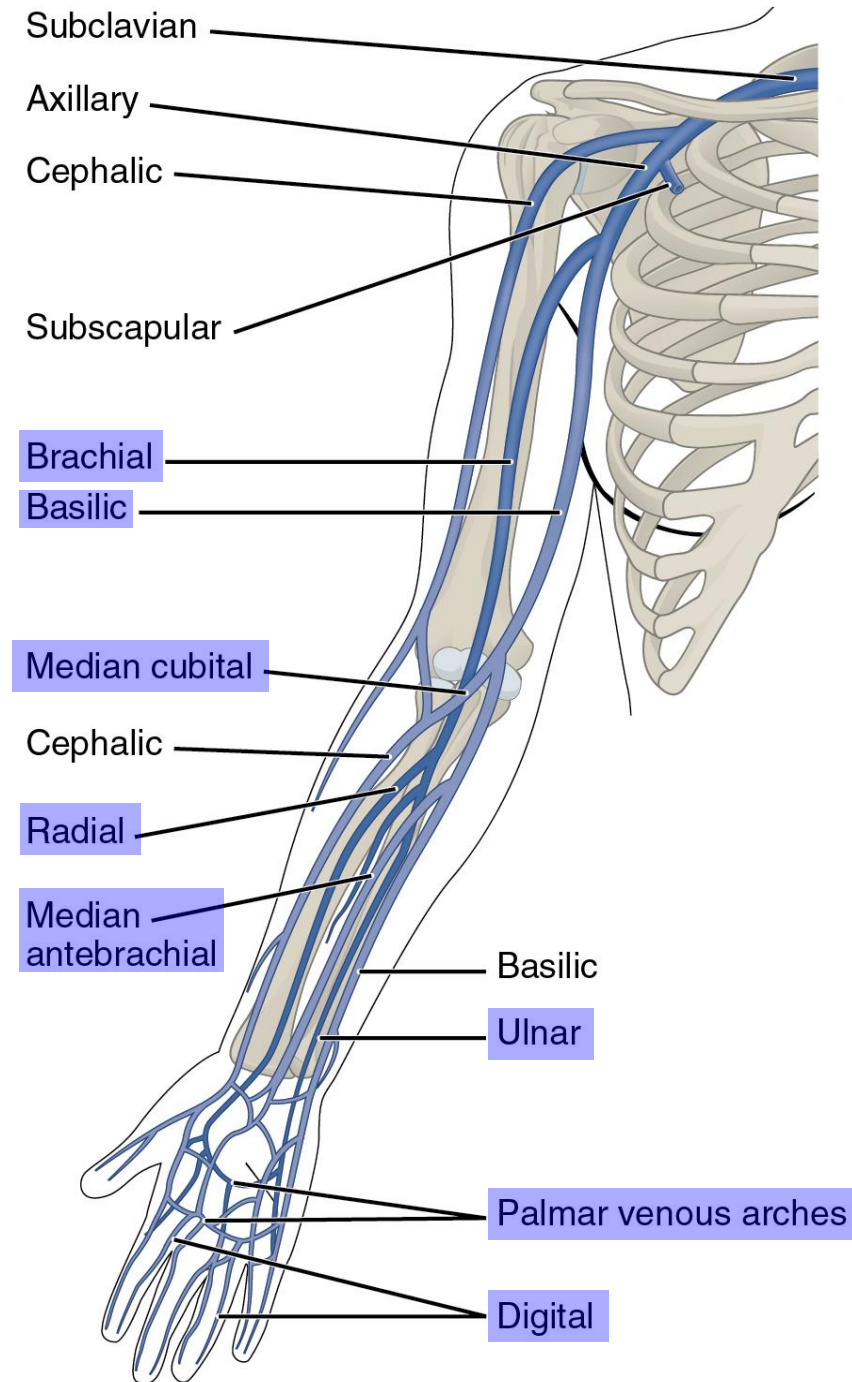
Blood from the brain and the superficial facial vein flow into each **internal jugular vein**.

Blood from the more superficial portions of the head, scalp, and cranial regions, including the **temporal vein** and **maxillary vein**, flow into each **external jugular vein**.

Although the external and internal jugular veins are separate vessels, there are anastomoses between them close to the thoracic region.

Blood from the external jugular vein empties into the subclavian vein.



VEINS DRAINING THE UPPER LIMBS

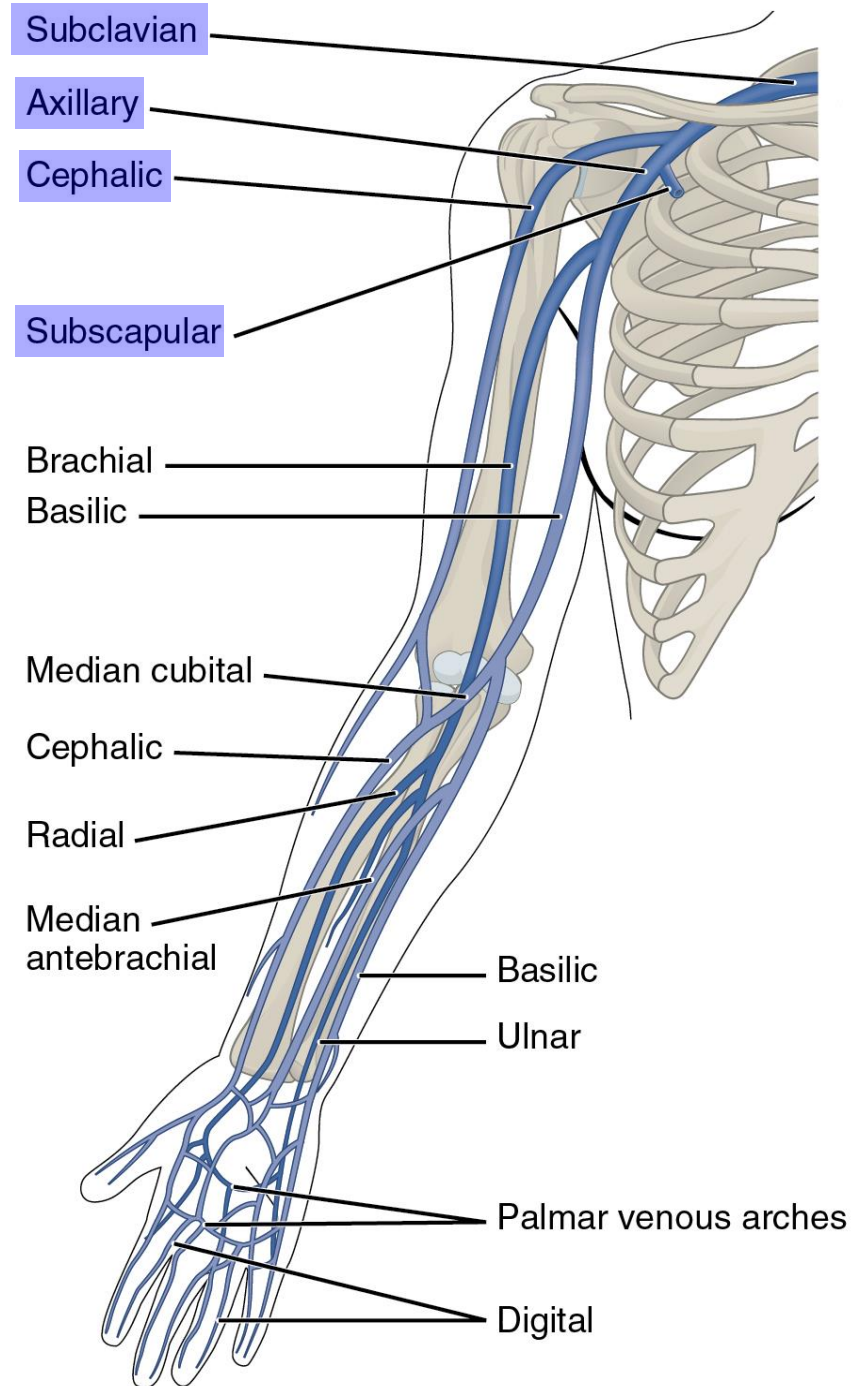
The **digital veins** in the fingers come together in the hand to form the **palmar venous arches**. From here, the veins come together to form the *radial vein*, the *ulnar vein*, and the *median antebrachial vein*.

The **radial vein** and the **ulnar vein** parallel the bones of the forearm and join together at the antebrachium to form the **brachial vein**, a deep vein that flows into the axillary vein in the brachium.

The **median antebrachial vein** parallels the ulnar vein, is more medial in location, and joins the **basilic vein** in the forearm.

As the basilic vein reaches the antecubital region, it gives off a branch called the **median cubital vein** that crosses at an angle to join the cephalic vein.

The median cubital vein is the most common site for drawing venous blood in humans. The basilic vein continues through the arm medially and superficially to the axillary vein.

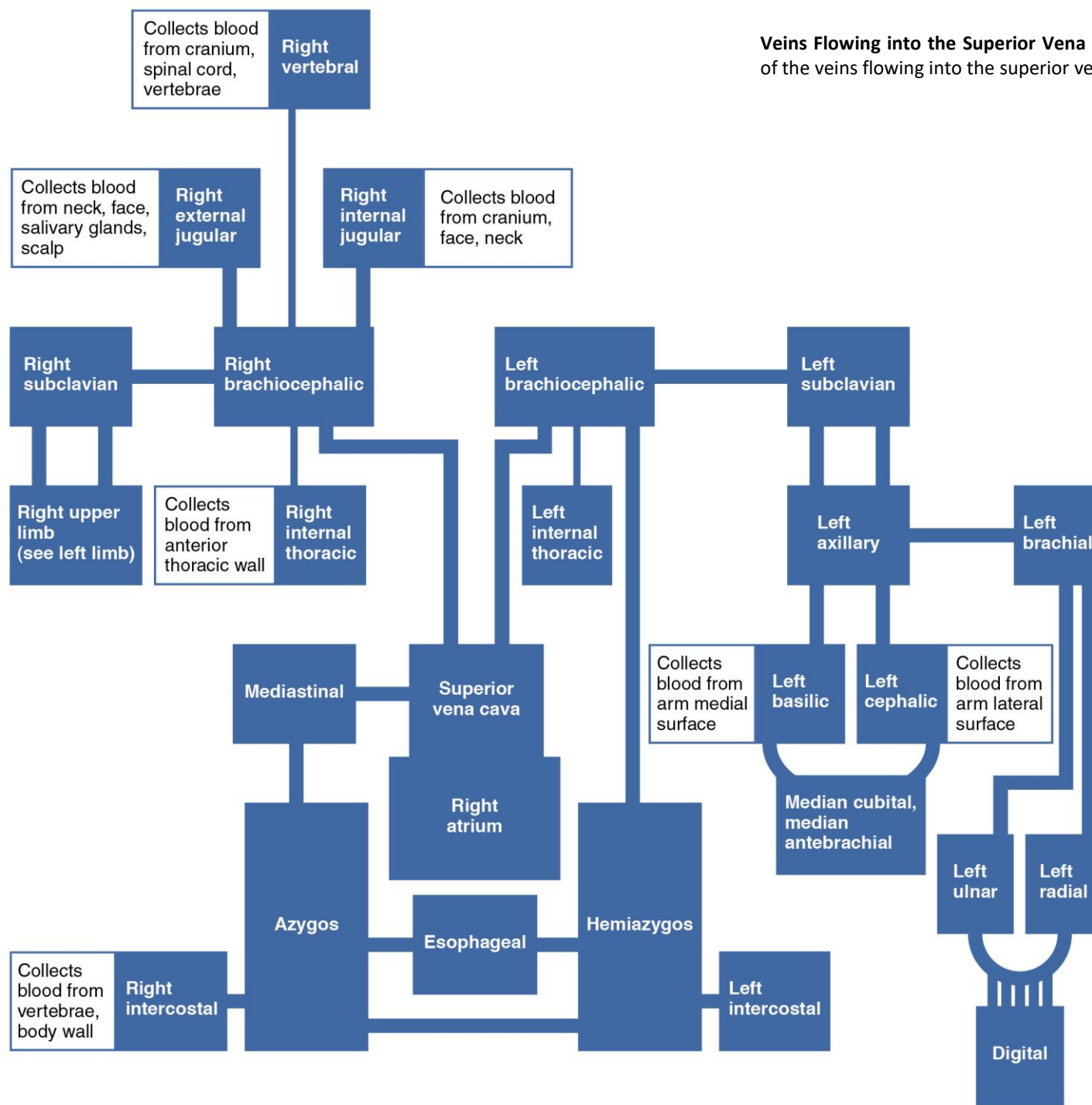
VEINS DRAINING THE UPPER LIMBS

The **cephalic vein** begins in the antebrachium and drains blood from the superficial surface of the arm into the axillary vein.

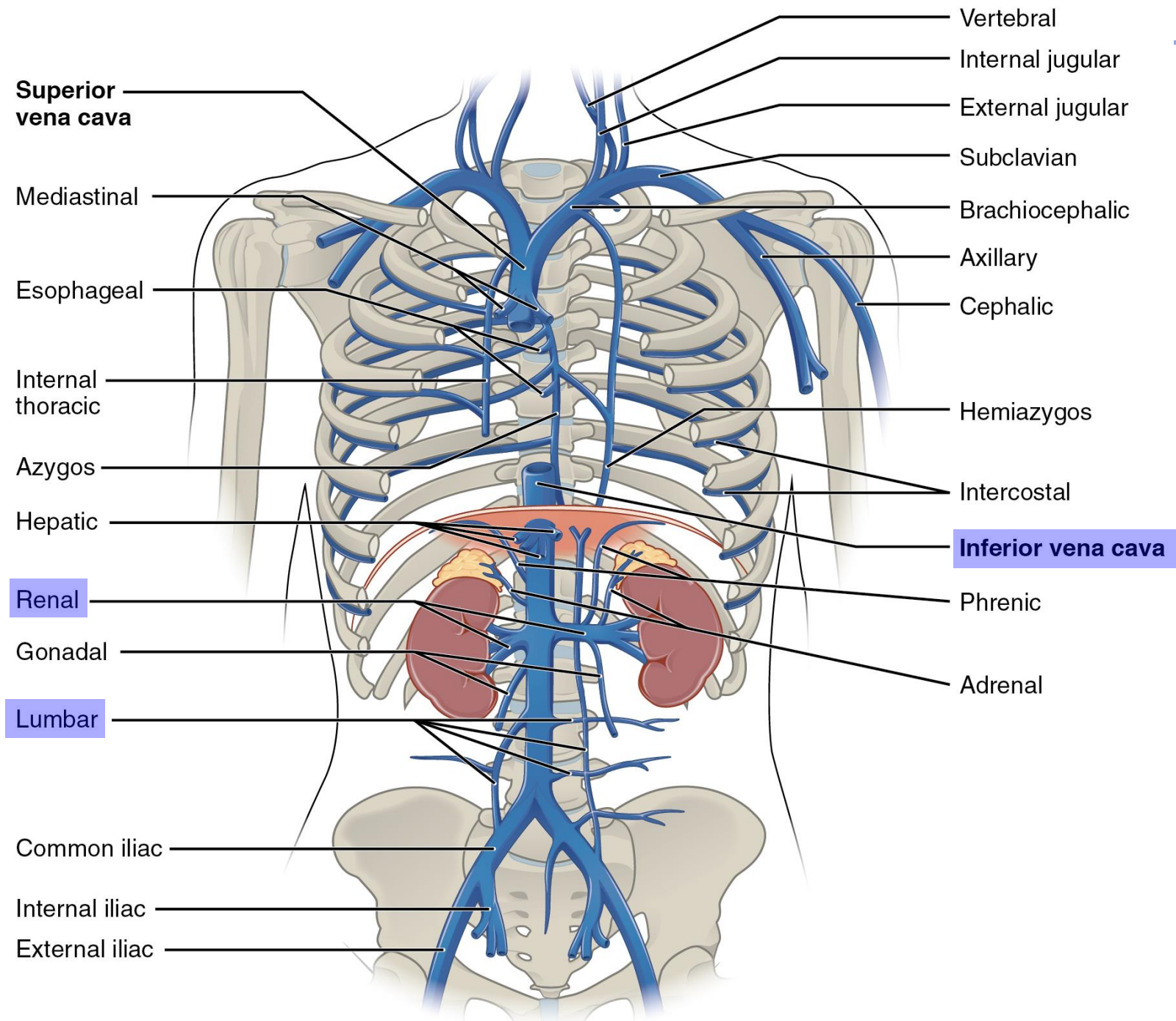
It is extremely superficial and easily seen along the surface of the biceps brachii muscle in individuals with good muscle tone and in those without excessive subcutaneous adipose tissue in the arms.

The **subscapular vein** drains blood from the subscapular region and joins the cephalic vein to form the **axillary vein**. As it passes through the body wall and enters the thorax, the axillary vein becomes the **subclavian vein**.

Veins Flowing into the Superior Vena Cava The flow chart summarizes the distribution of the veins flowing into the superior vena cava.



SYSTEMIC VEINS



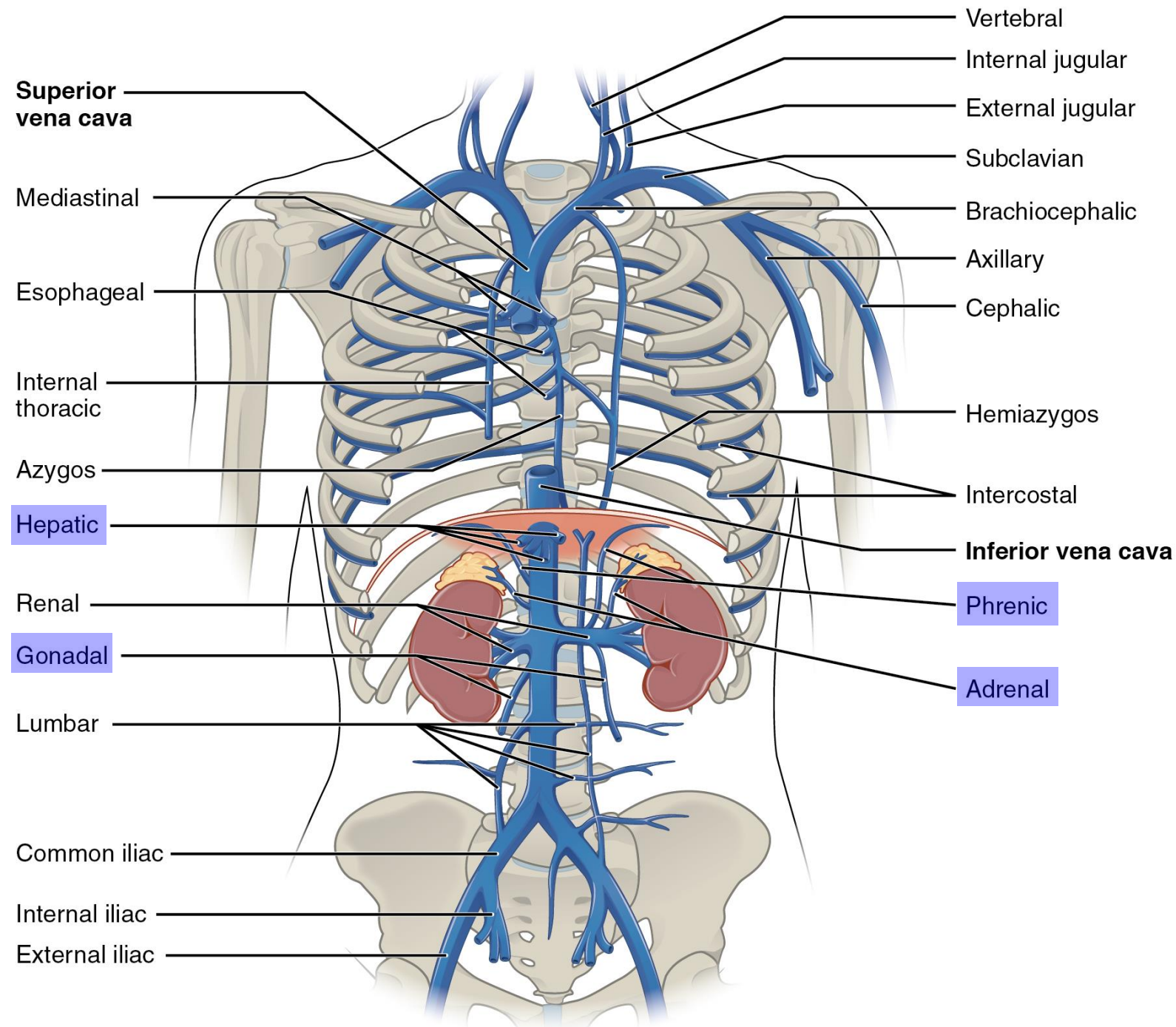
INFERIOR VENA CAVA

The blood inferior to the diaphragm drains into the inferior vena cava before it is returned to the heart. Lying just beneath the parietal peritoneum in the abdominal cavity, the **inferior vena cava** parallels the abdominal aorta, where it can receive blood from abdominal veins.

The lumbar portions of the abdominal wall and spinal cord are drained by a series of **lumbar veins**, usually four on each side. The ascending lumbar veins drain into either the azygos vein on the right or the hemiazygos vein on the left, and return to the superior vena cava. The remaining lumbar veins drain directly into the inferior vena cava.

Blood supply from the kidneys flows into each **renal vein**, normally the largest veins entering the inferior vena cava.

SYSTEMIC VEINS



INFERIOR VENA CAVA

Adrenal veins drain the adrenal or suprarenal glands located immediately superior to the kidneys. The right adrenal vein enters the inferior vena cava directly, whereas the left adrenal vein enters the left renal vein.

From the male reproductive organs, each **testicular vein** flows from the scrotum, whereas each **ovarian vein** drains an ovary in females.

Each of these veins is generically called a **gonadal vein**. The right gonadal vein empties directly into the inferior vena cava, and the left gonadal vein empties into the left renal vein.

Each side of the diaphragm drains into a **phrenic vein**; the right phrenic vein empties directly into the inferior vena cava, whereas the left phrenic vein empties into the left renal vein.

Blood supply from the liver drains into each **hepatic vein** and directly into the inferior vena cava.

VEINS DRAINING THE LOWER LIMBS

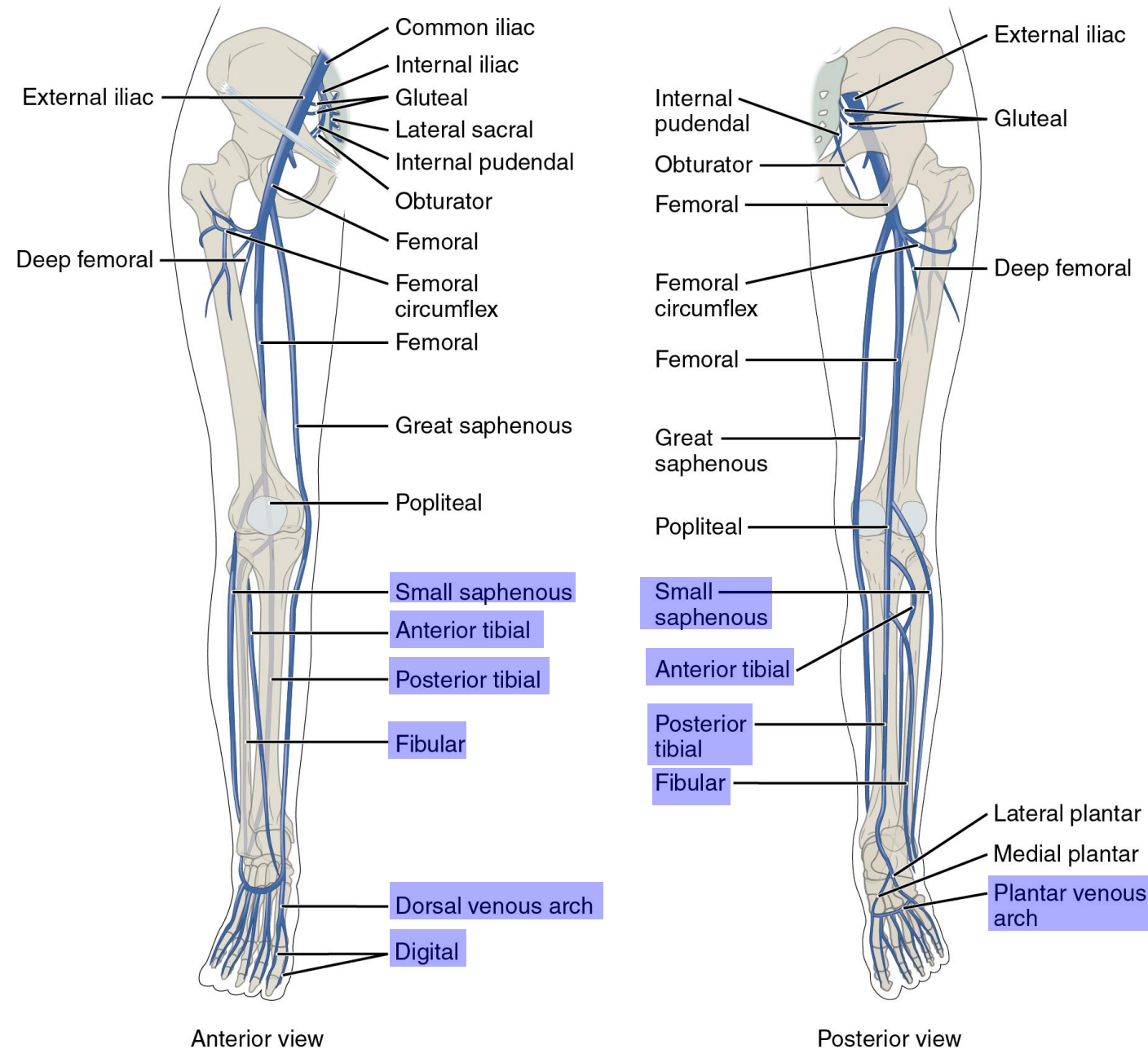
The superior surface of the foot drains into the **digital veins**, and the inferior surface drains into the **plantar veins**, which flow into a complex series of anastomoses in the feet and ankles, including the **dorsal venous arch** and the **plantar venous arch**.

From the dorsal venous arch, blood supply drains into the anterior and posterior tibial veins.

- The **anterior tibial vein** drains the area near the tibialis anterior muscle and combines with the posterior tibial vein and the fibular vein to form the **popliteal vein**.
- The **posterior tibial vein** drains the posterior surface of the tibia and joins the popliteal vein.

The **fibular vein** drains the muscles in proximity to the fibula and also joins the popliteal vein.

The **small saphenous vein** located on the lateral surface of the leg drains blood from the superficial regions of the lower leg and foot, and flows into to the popliteal vein.



Anterior view

Posterior view

VEINS DRAINING THE LOWER LIMBS

Other veins which drain into the femoral vein are:

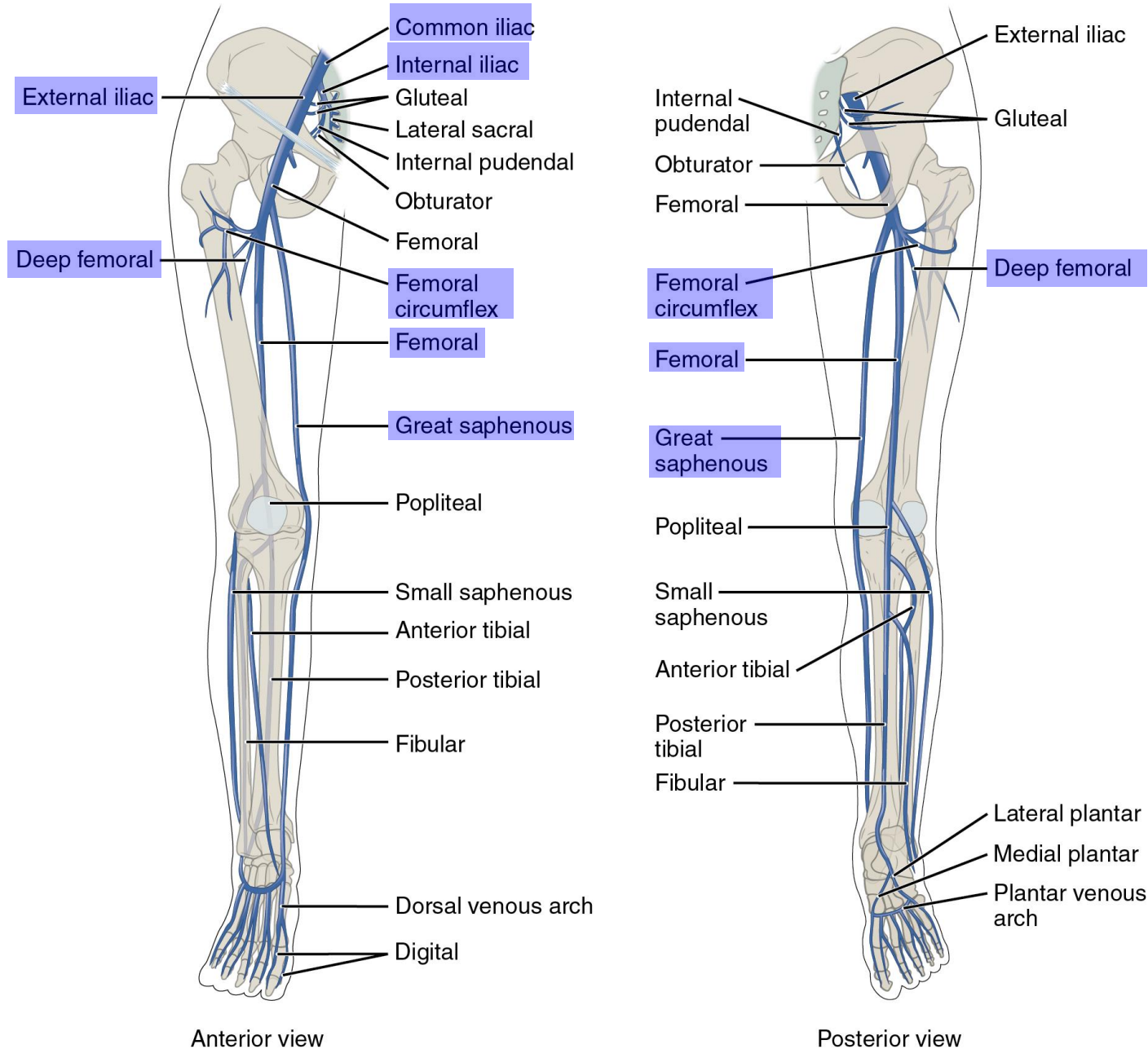
- the **great saphenous vein**, which is a prominent surface vessel located on the medial surface of the leg and thigh that collects blood from the superficial portions of these areas.
- the **deep femoral vein**, which, as the name suggests, drains blood from the deeper portions of the thigh
- the **femoral circumflex vein**, which forms a loop around the femur and drains blood from the areas in proximity to the head and neck of the femur.

As the **femoral vein** penetrates the body wall from the femoral portion of the upper limb, it becomes the **external iliac vein**, a large vein that drains blood from the lower limb to the **common iliac vein**.

The pelvic organs drain into the **internal iliac vein**, which forms from several smaller veins in the region, including the umbilical veins that run on either side of the bladder.

The external and internal iliac veins combine near the sacroiliac joint to form the common iliac vein.

The **middle sacral vein** drains the sacral region into the common iliac vein.



Anterior view

Posterior view