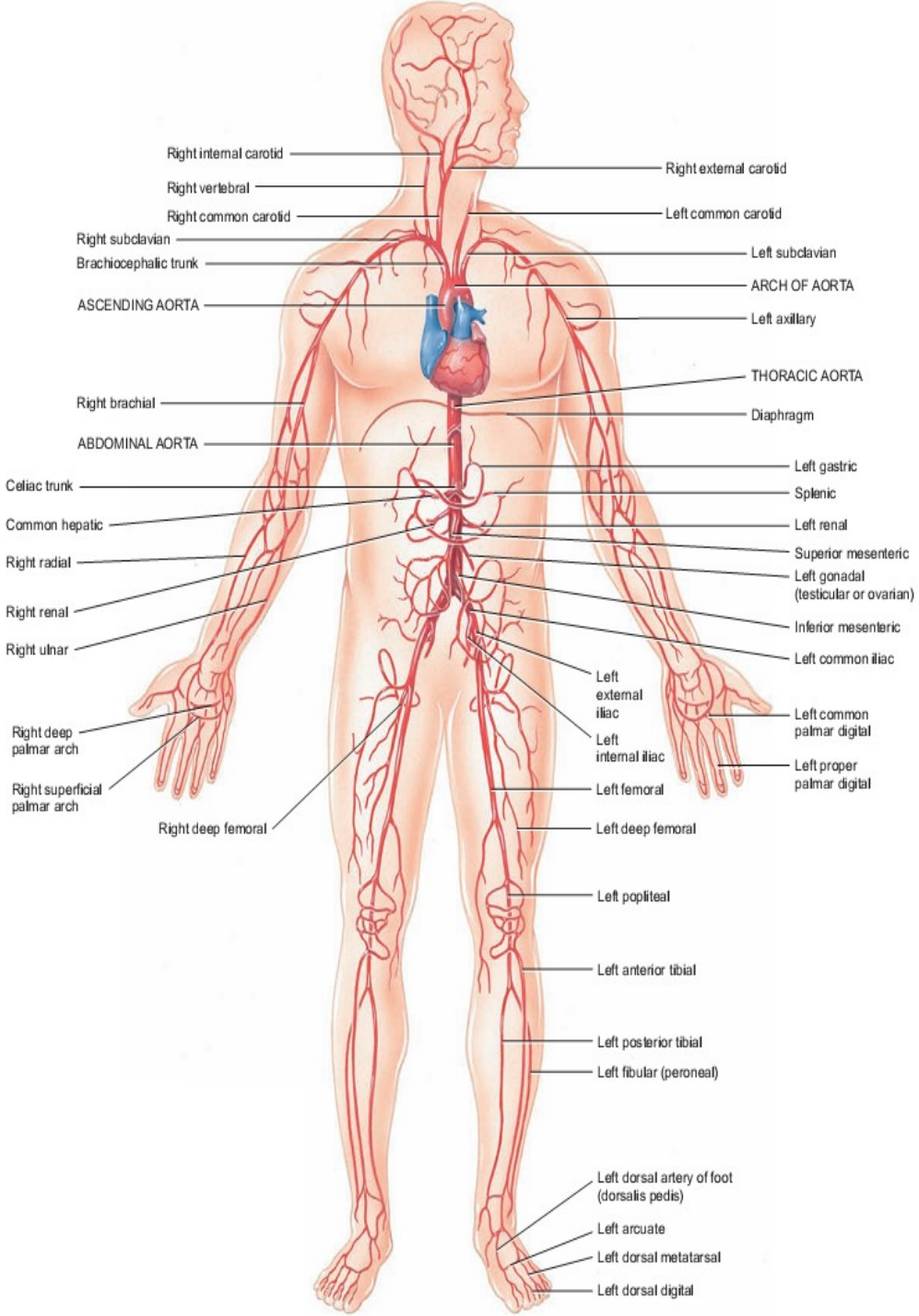
Chapter VI

THE CIRCULATORY SYSTEM



Learning objectives

- Distinguish between the cardiovascular system and lymphatic system.
- Discuss about the blood
- Describe the location and general structure of heart.
- Distinguish among the types of blood vessels.
- Describe the locations of major arteries of body.
- Describe the about venous drainage of body.
- Name the major parts of the hepatic portal system.
- Describe the structures of the lymphatic system.

General Overview

- The circulatory system is frequently divided into:
  - **the cardiovascular system**
    - consists of
      - **the heart**
      - **blood vessels**
  - **the lymphatic system**, which
    - consists of
      - **lymph vessels**
      - **lymph nodes**

Functions of the circulatory system:

- Distribute **nutrients**
- **Transport and exchange O_2 & Co_2**
- Remove **waste** materials,
- Prevent excessive **bleeding**,
- Prevent **infection**, and
- Regulate body **temperature**.

Major Parts of the Cardiovascular system

- **Blood Vessels** - routes blood travels
- **Heart** – pumps or pushes blood through body
- **Blood** – carries important " ***stuff** " through body

Blood

- is a liquid connective tissue
- consists of cells surrounded by an extracellular matrix.

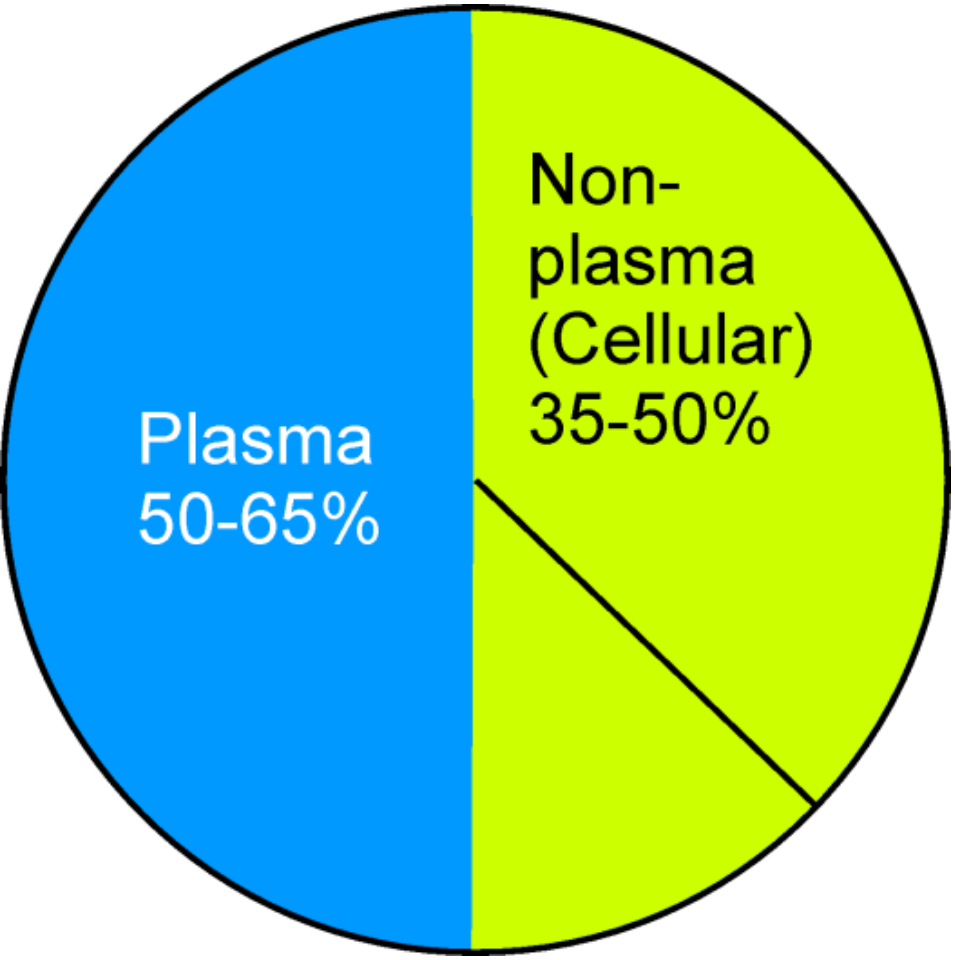
Components of Blood

composed of two portions:

(1) blood plasma,

(2) formed elements,

✓ Components of Blood



- formed elements:
  - more than 99 percent of red blood cells (RBCs).
- The rest are white blood cells (WBCs) and platelets

Blood Plasma

- *watery liquid extracellular matrix*
- *contains dissolved substances*
- is composed of 91.5 percent water and 8.5 percent solutes

solutes = Proteins 7% + Other solutes1.5%

- Albumins 54%
- Globulins 38%
- Fibrinogen 7%
- All others 1%

Proteins

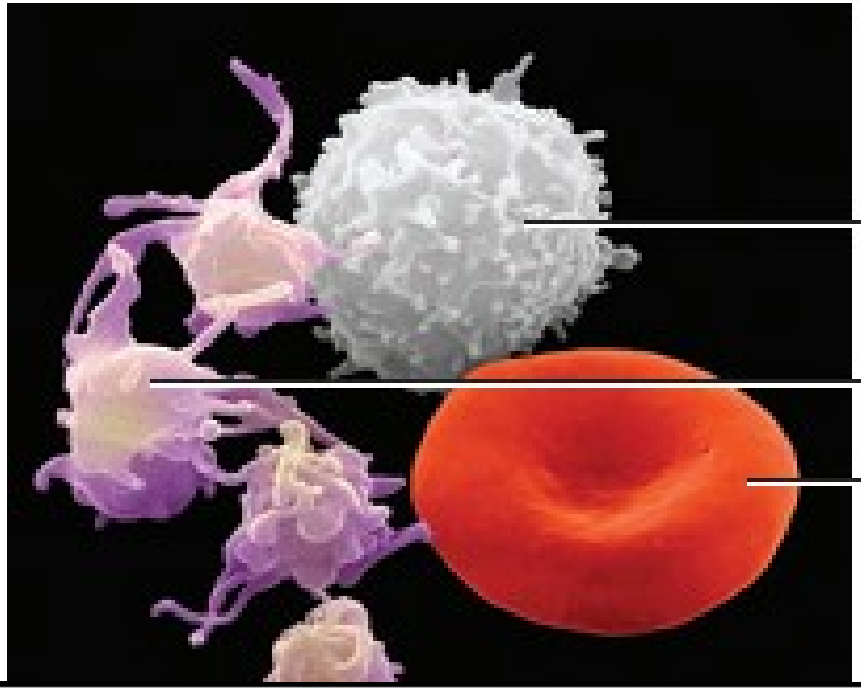
Other solutes: gases, waste products…

Formed Elements

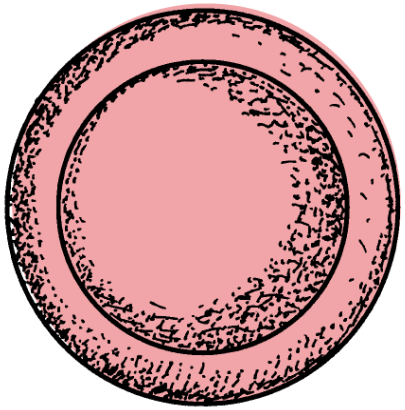
- *are cells and cell fragments.*
- Include:
  - red blood cells (RBCs),
  - white blood cells (WBCs),
  - and platelets.

Red blood cells(RBC): 4.8–5.4 million

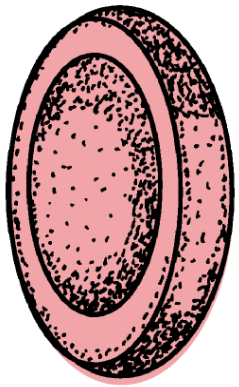
- contain the oxygen-carrying protein hemoglobin
- are produced in the red marrow of bones.
- are biconcave discs (7–8 μm), a shape that provides a large area for oxygen exchange.
- They do not possesses nucleus.



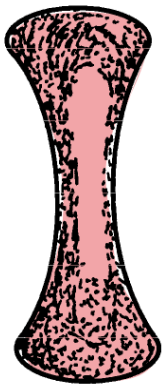
RED BLOOD CELLS



Viewed From Above



Viewed From An Angle

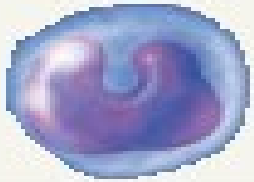


Cross Section

White blood cells (**leukocytes): 5,000–10,000**

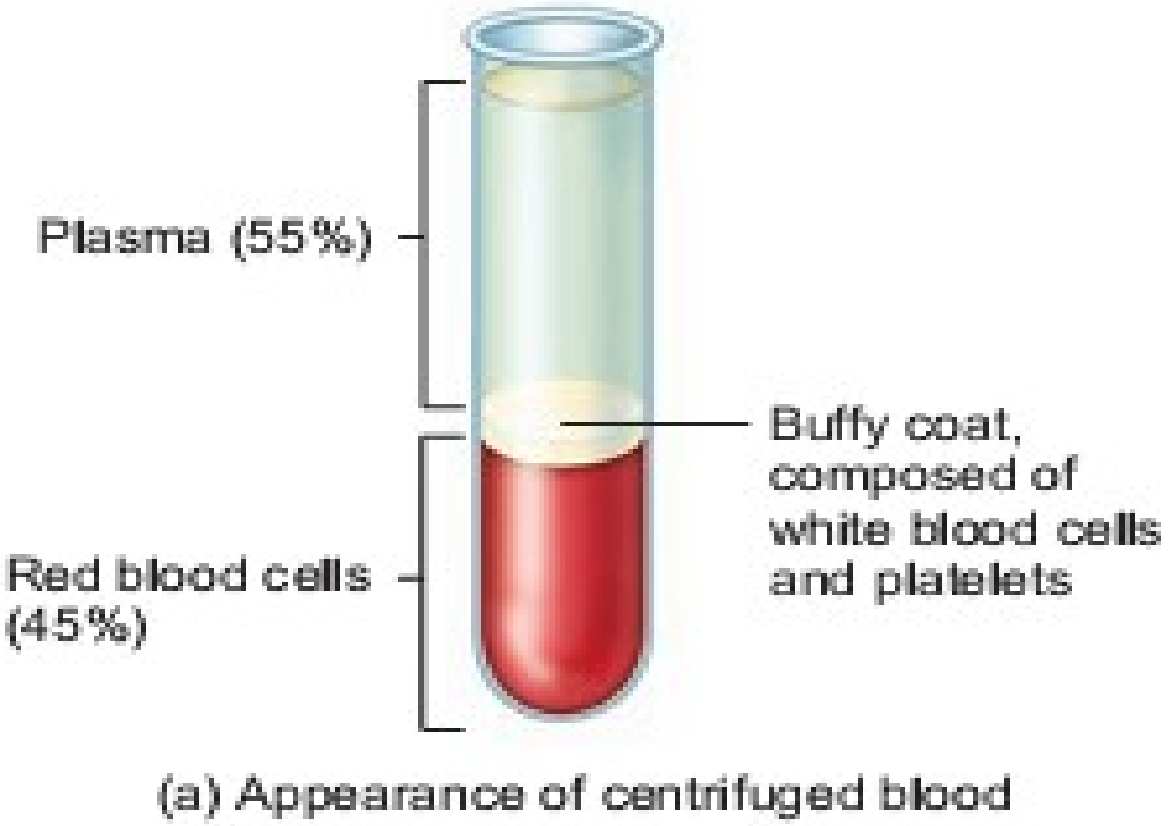
- have a nucleus but they do not contain hemoglobin.
- divided into two general categories:
  - **Agranulocytes- includes Lymphocytes & Monocytes.**
  - **Granulocytes**
    - are the category of leukocytes that contain **granules** within the cytoplasm.
- Granulocytes include:
  - **Neutrophils,**
  - **Eosinophils, and**
  - **Basophils**

Significance of *High* and *Low* White Blood Cell Counts

WBC TYPE	*HIGH* COUNT	*LOW* COUNT
Neutrophils 	Bacterial infection, burns, stress, inflammation	Radiation exposure, drug toxicity, vitamin B_{12} deficiency, systemic lupus erythematosus (SLE)
Lymphocytes 	Viral infections, some leukemias	Prolonged illness, immunosuppression, treatment with cortisol
Monocytes 	Viral or fungal infections, tuberculosis, some leukemias, other chronic diseases	Bone marrow suppression, treatment with cortisol
Eosinophils 	Allergic reactions, parasitic infections, autoimmune diseases	Drug toxicity, stress
Basophils 	Allergic reactions, leukemias, cancers, hypothyroidism	Pregnancy, ovulation, stress, hyperthyroidism

latelets (Thrombocytes) :150,000–400,000/µL

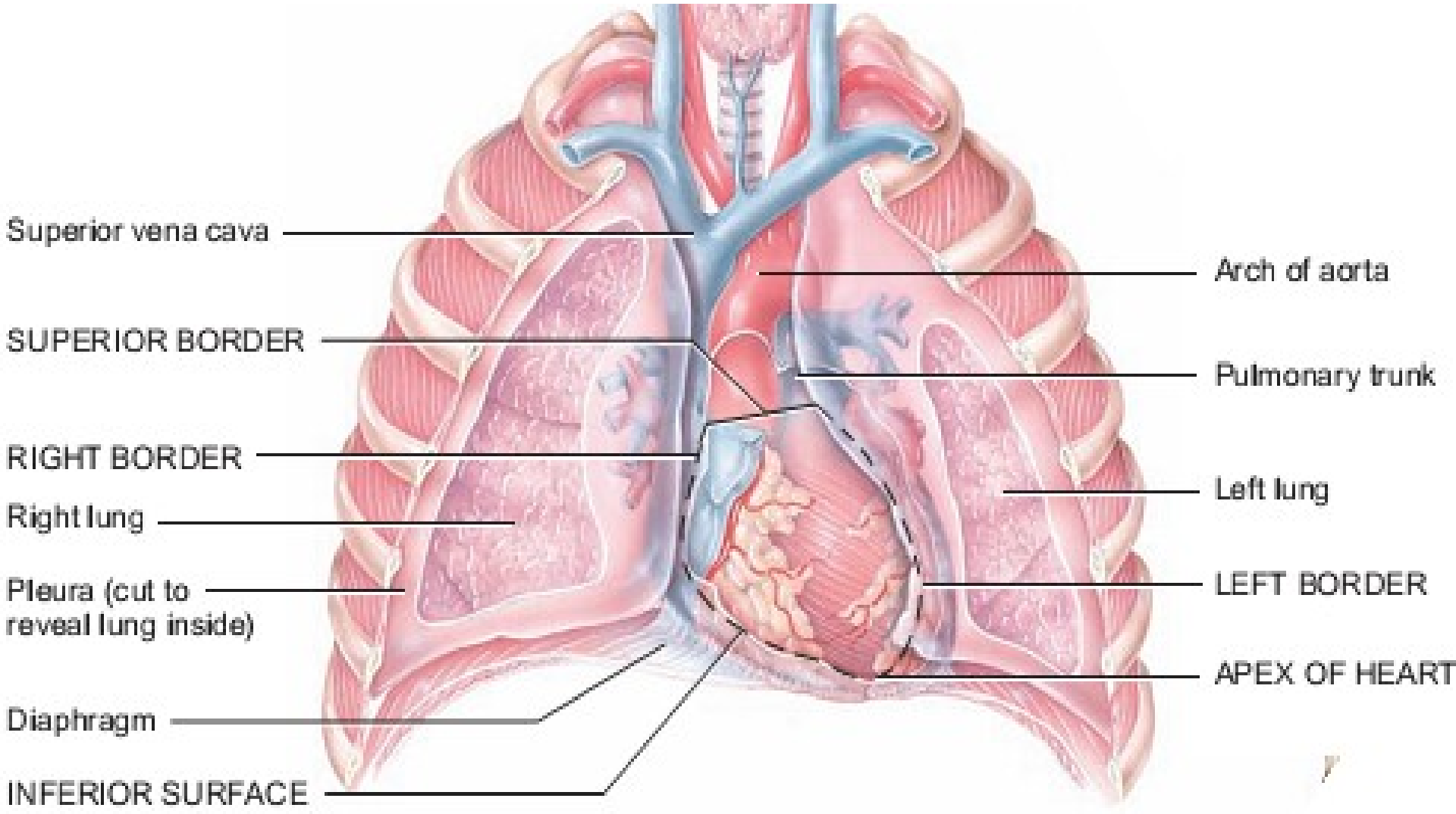
- 2–4 µm diameter
- live for 5–9 days; contain many vesicles but no nucleus
- Release chemicals that promote vascular spasm and blood clotting



(a) Appearance of centrifuged blood

The cardiovascular system

- **Heart**
  - hollow, muscular, 4 chambered organ
  - Weighs about 250 g in adult females and 300 g in adult males.
  - rests on the diaphragm, in the mediastinum.
  - About it's 2/3rd lies to the left of the body's midline.

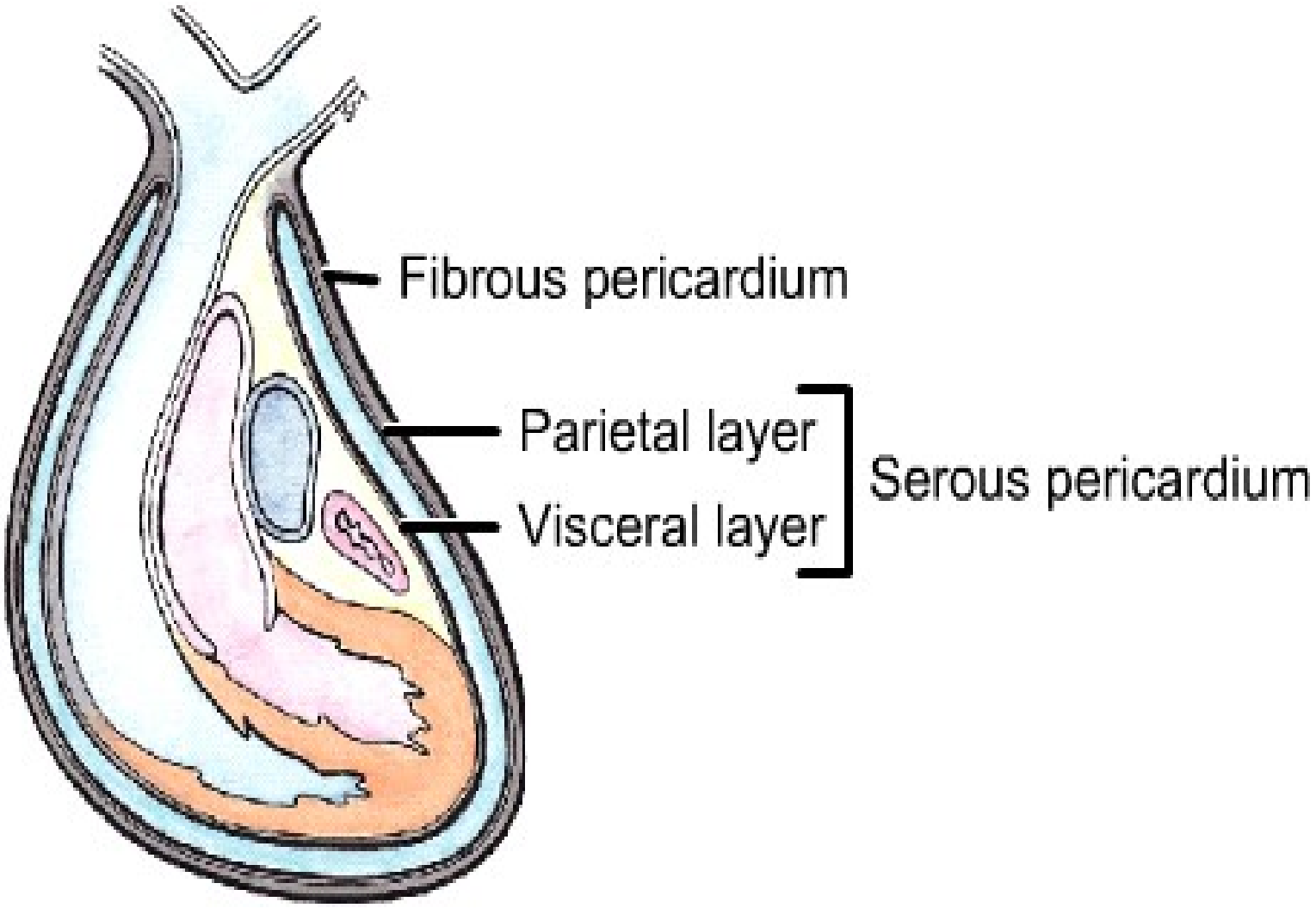

Superior vena cava
SUPERIOR BORDER
RIGHT BORDER
Right lung
Pleura (cut to reveal lung inside)
Diaphragm
INFERIOR SURFACE
Arch of aorta
Pulmonary trunk
Left lung
LEFT BORDER
APEX OF HEART

• *Pericardium*

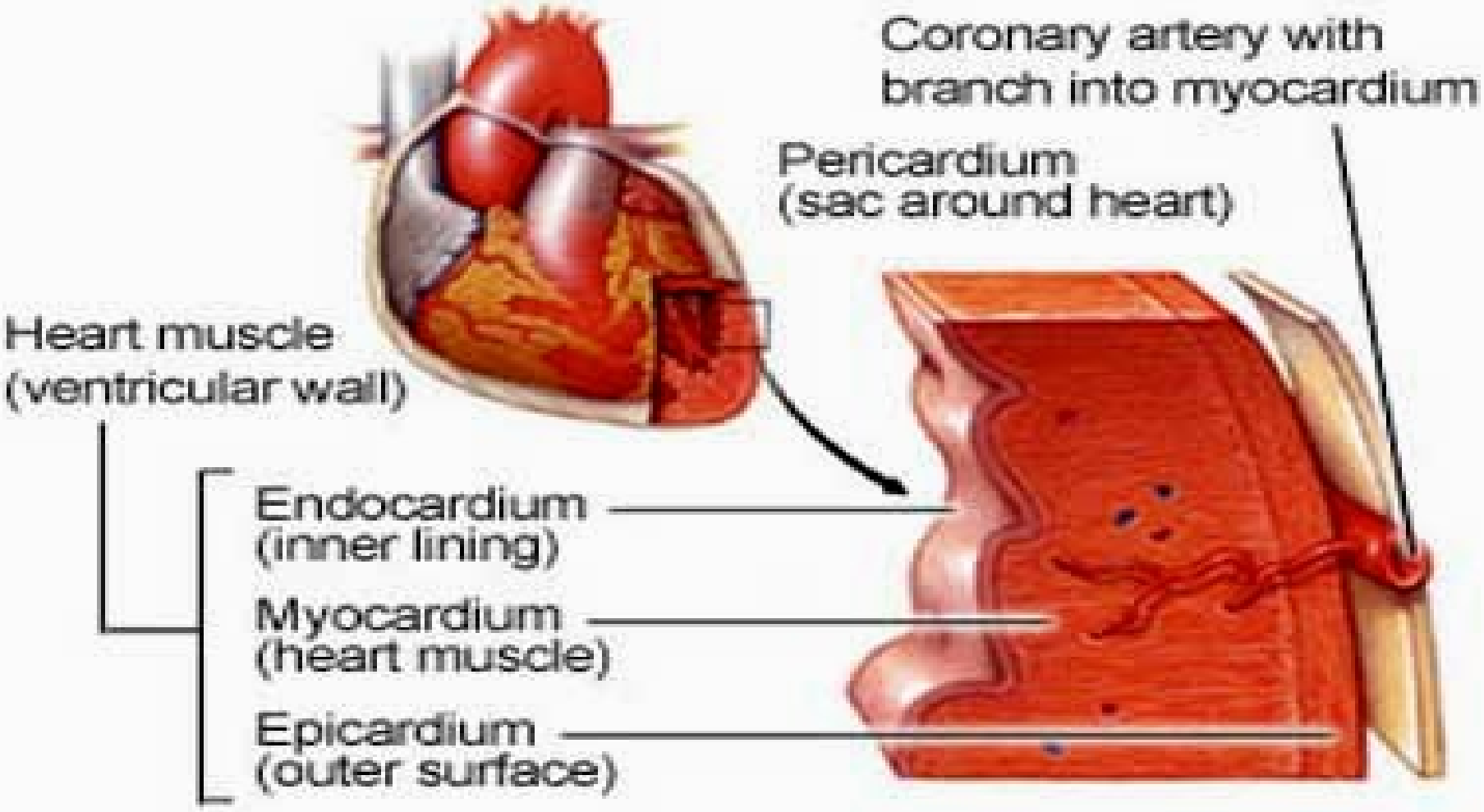
- is a fibroserous membrane that covers the heart and the beginning of its great vessels.
- is a closed sac composed of two layers.
- fibrous pericardium
  - tough external layer.
- ***Serous pericardium :*** is composed mainly of mesothelium.
  - Subdivided into two layers:
    - parietal layer
    - visceral layer : forms the epicardium, the outermost of three layers of the heart wall.

- ***Pericardial cavity :*** is the potential space between the parietal and visceral layers of serous pericardium.
  - contains a thin film of fluid that enables the heart to move and beat in a frictionless environment.
- Mesothelium : a single layer of flattened cells forming an epithelium
  - - lines both the internal surface of the fibrous pericardium and the external surface of the heart

-


Fibrous pericardium
Parietal layer
Visceral layer
Serous pericardium

- **Layers of the heart wall**
  - **contain** 3 distinct layers:
  - **Epicardium** –
    - thin, external membrane around the heart
  - **Myocardium** –
    - thickest layer; consists of cardiac muscle
    - responsible for the ability of the heart to contract.
    - makes up approximately 95% of the heart wall.
  - **Endocardium** – a thin innermost layer



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Apex of the heart:

- formed by the inferolateral part of the left ventricle.
- Lies posterior to the left 5th intercostal space in adults, usually approximately 9 cm from the median plane.
- Remains motionless throughout the cardiac cycle.
- Is where the sounds of mitral valve closure are maximal (apex beat).

Chambers of the heart

- RIGHT ATRIUM
  - receives venous blood from the SVC, IVC, and coronary sinus.
  - right auricle
    - is ear-like conical muscular pouch
    - increase the capacity of the atrium as it overlaps the ascending aorta.

- ***oval fossa*** : which is a remnant of the oval foramen.
- **Interatrial septum-** is a thin partition between right and left atriums

RIGHT VENTRICLE

- the right AV (tricuspid) orifice
  - located posterior to the body of the sternum at the level of the 4^{th} and 5^{th} intercostal spaces.
  - tricuspid valve guards the right AV orifice.

Interventricular septum (IVS)

- is a strong, obliquely placed partition between the right and left ventricles
- composed of muscular forms the majority of the septum
  - and membranous part.

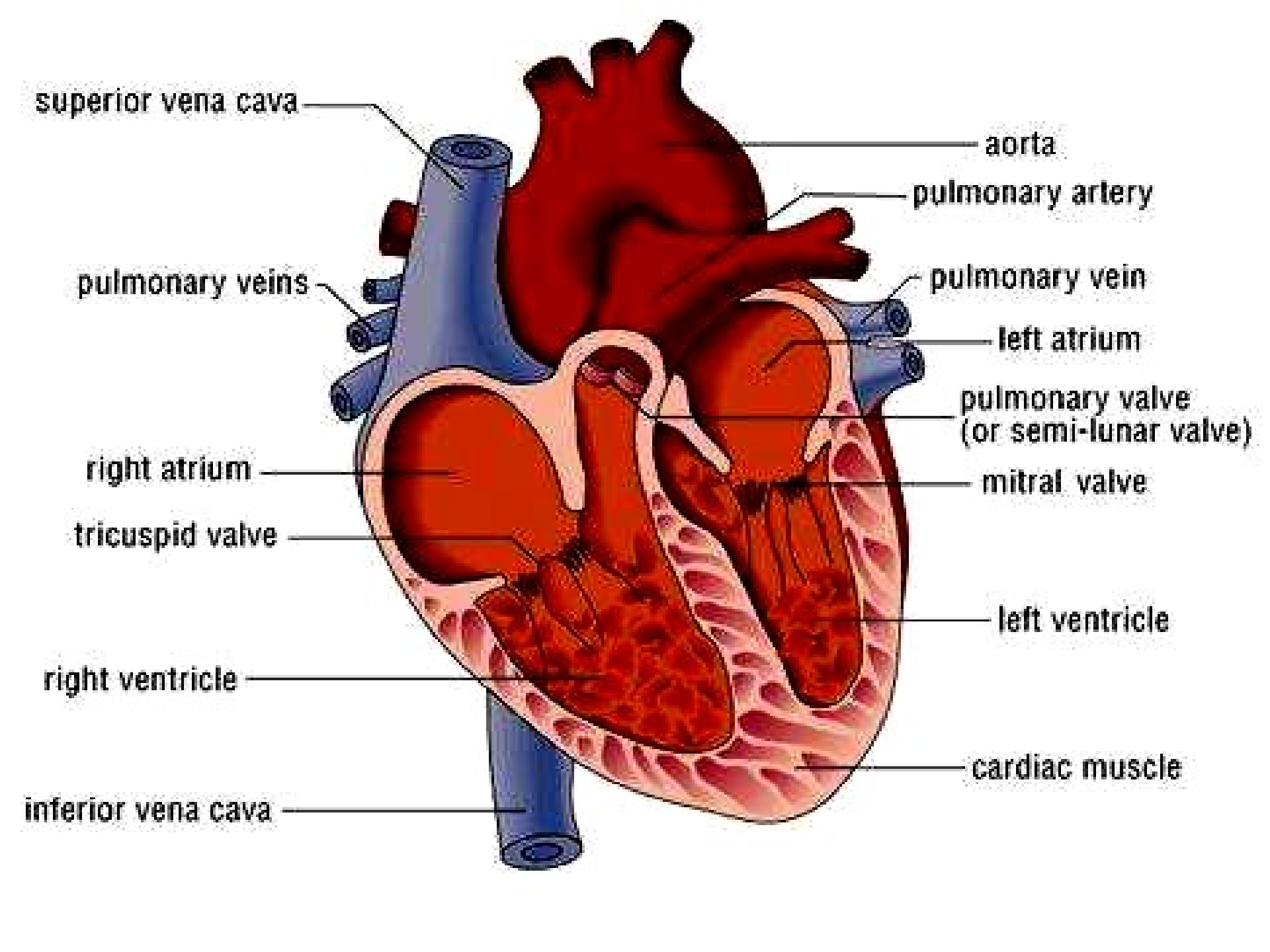
- Pulmonary valve :
  - is at the level of the left 3rd costal cartilage.

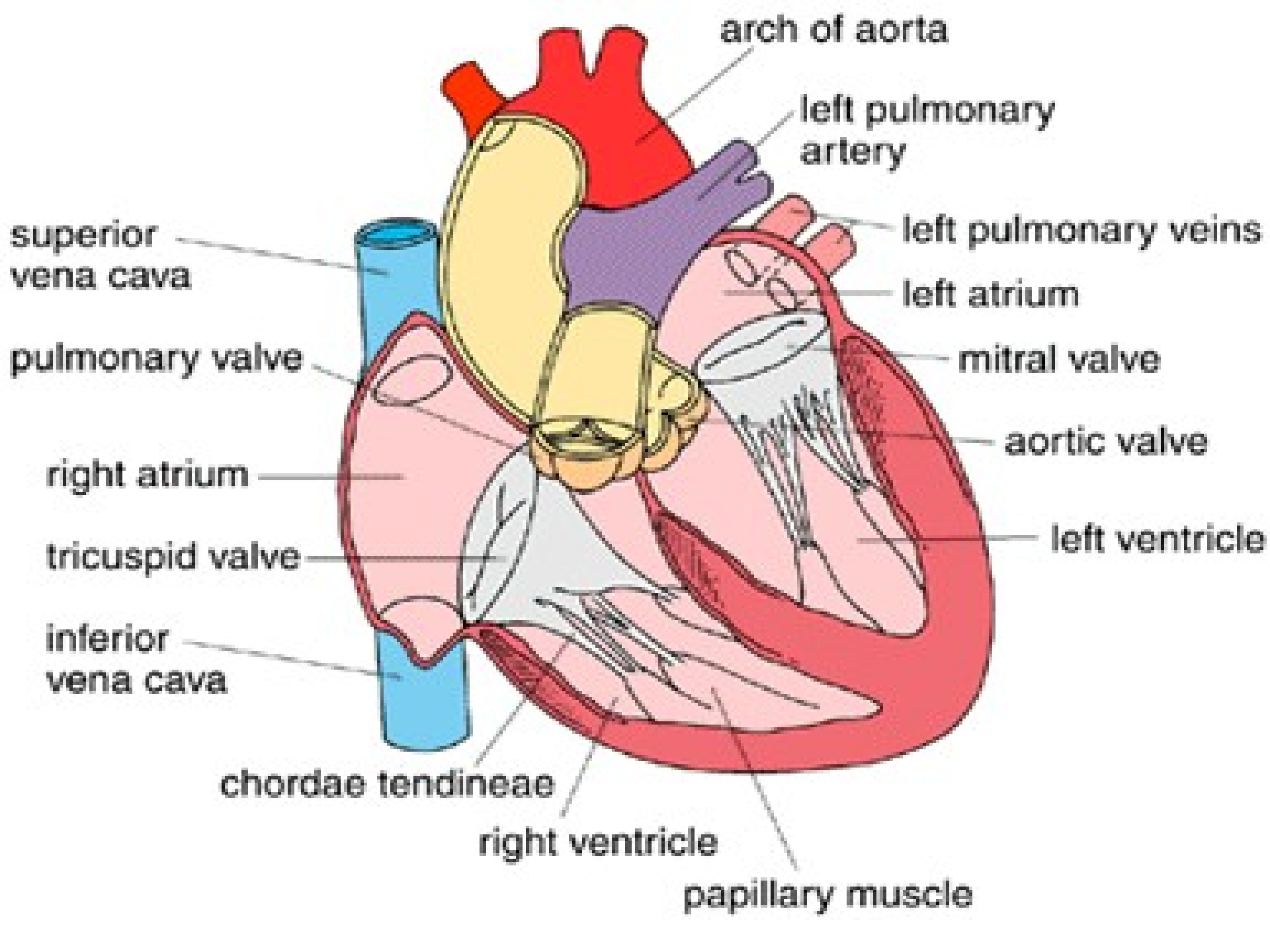
- ***LEFT ATRIUM***

- forms most of the base of the heart.
  - Four valve less pulmonary veins entering its smooth posterior wall.
  - A slightly thicker wall than that of the right atrium.
- ***left auricle :*** tubular and muscular,

LEFT VENTRICLE

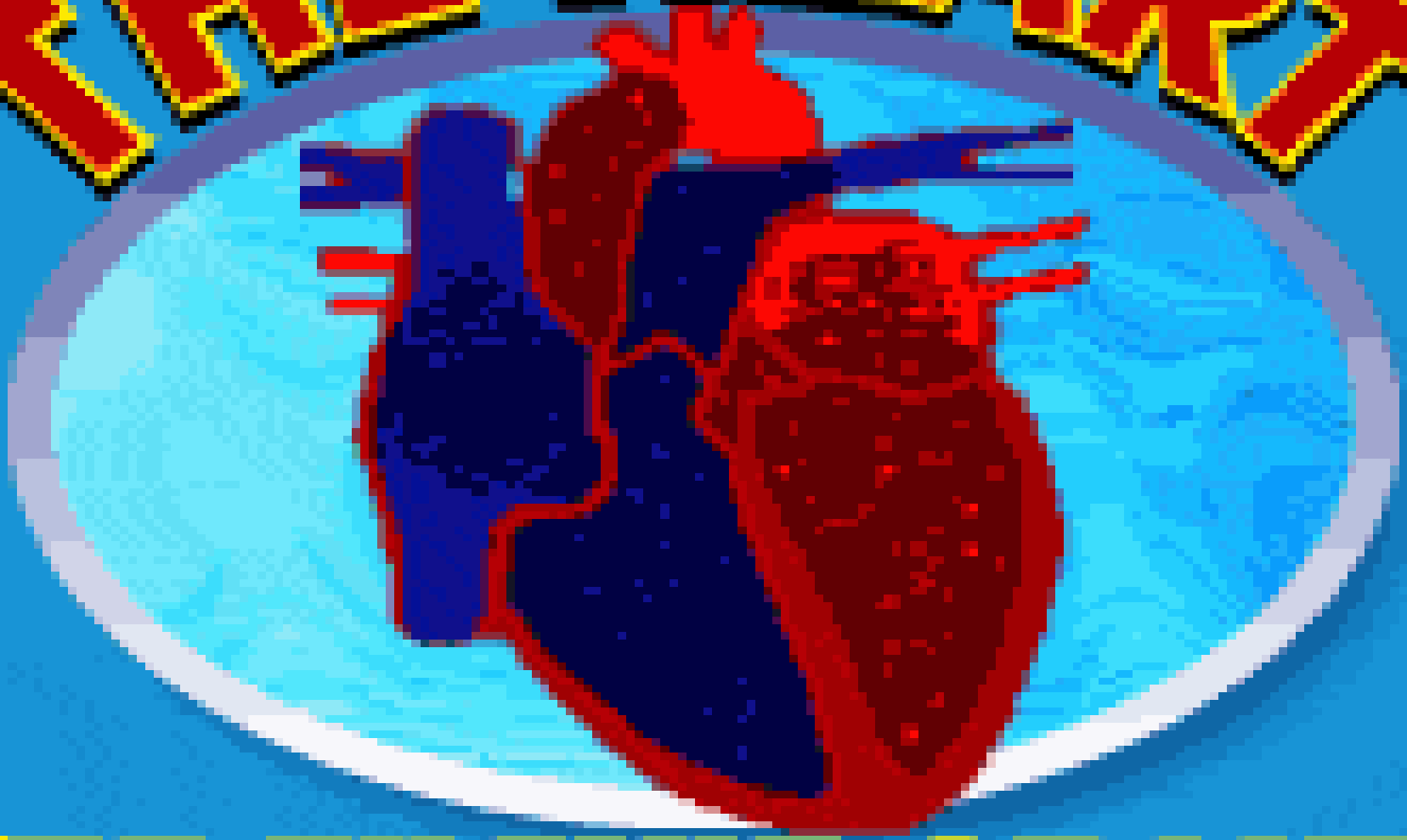
- forms the apex of the heart.
- performs more work than the right ventricle :
  - ***Walls*** : are two to three times as thick as those of the right ventricle.
  - mitral valve : a double-leaflet that guards the left AV orifice.
  - ***aortic vestibule :***
    - is a smooth-walled, non-muscular, superoanterior outflow part.
    - leading to the aortic orifice and aortic valve.


superior vena cava
aorta
pulmonary artery
pulmonary veins
pulmonary vein
left atrium
pulmonary valve
(or semi-lunar valve)
right atrium
mitral valve
tricuspid valve
left ventricle
right ventricle
cardiac muscle
inferior vena cava


arch of aorta
left pulmonary artery
left pulmonary veins
superior vena cava
left atrium
pulmonary valve
mitral valve
aortic valve
right atrium
left ventricle
tricuspid valve
inferior vena cava
chordae tendineae
right ventricle
papillary muscle

- **Heart Valves:**
  - prevent back flow of blood and ensure that blood flows in the proper direction through the heat.
  - The valves function to maintain blood flow in one direction.
  - Valves open and close in response to changes in pressure
- **4 heart valves**
  - **Atrioventricular (AV) valves**
    - **tricuspid and**
    - **bicuspid valves**
  - **Semilunar valves- prevent back flow of blood form arteries to ventricles during ventricular diastole.**
    - **Aortic valve**
    - **Pulmonary valve**

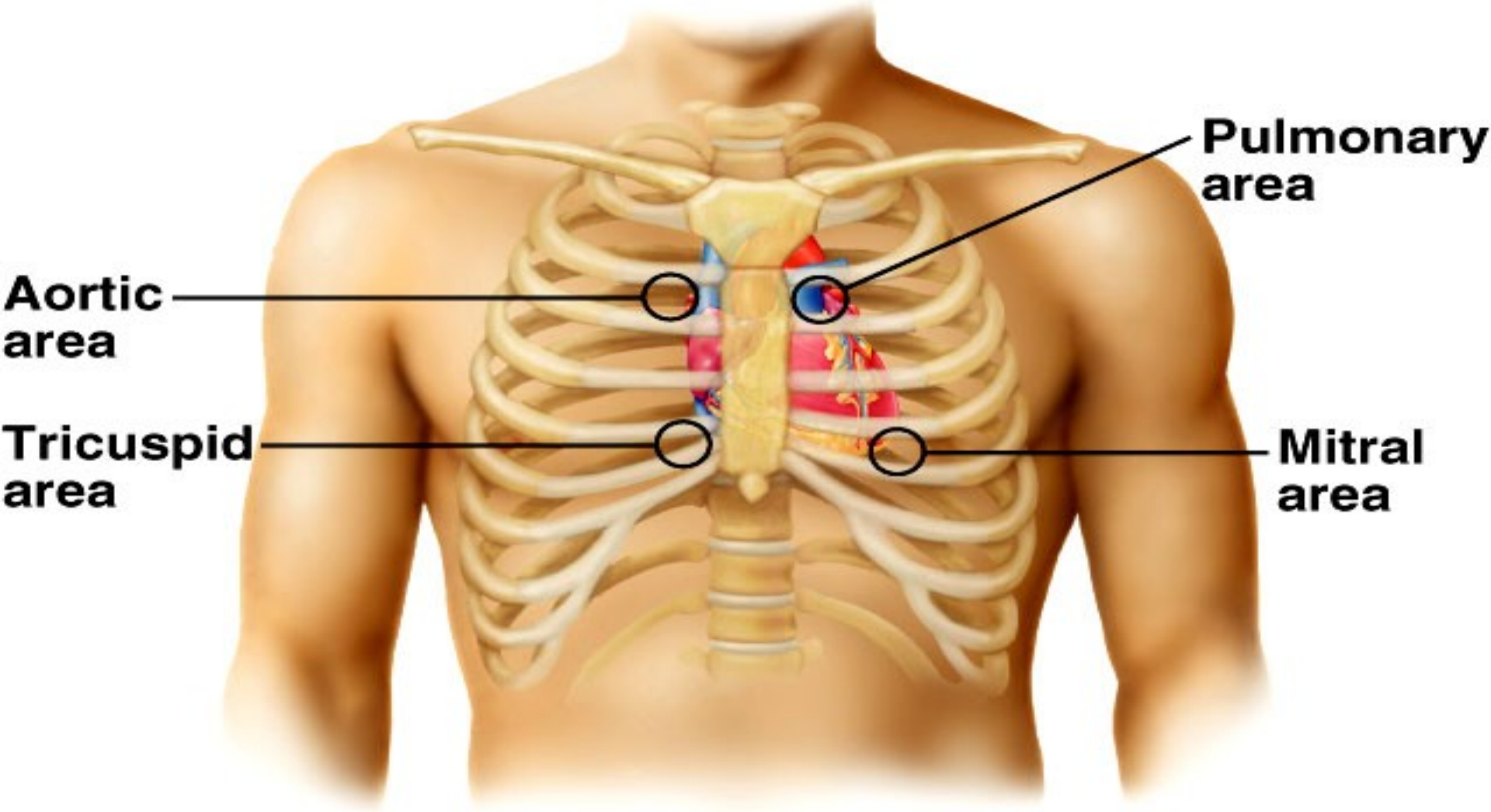
THE HEART



THE ENGINE OF LIFE

Location of Heart in the thoracic cavity

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Stimulating and Conducting System of the Heart.

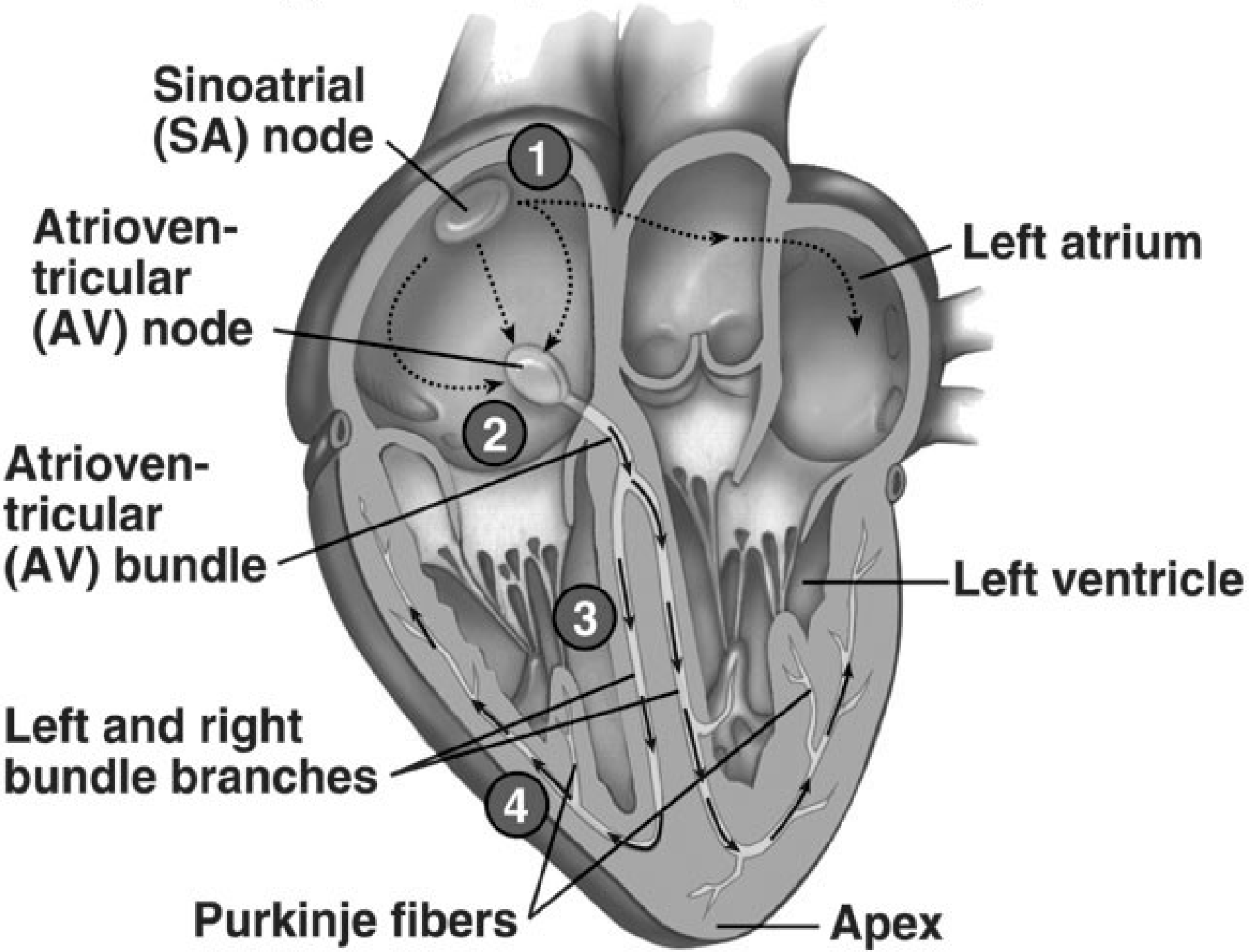
- conducting system of the heart:
  - generates and transmits the impulses that produce the coordinated contractions of the cardiac cycle.
  - consists of nodal tissue :
    - initiates the heartbeat and coordinates contractions of the four heart chambers.

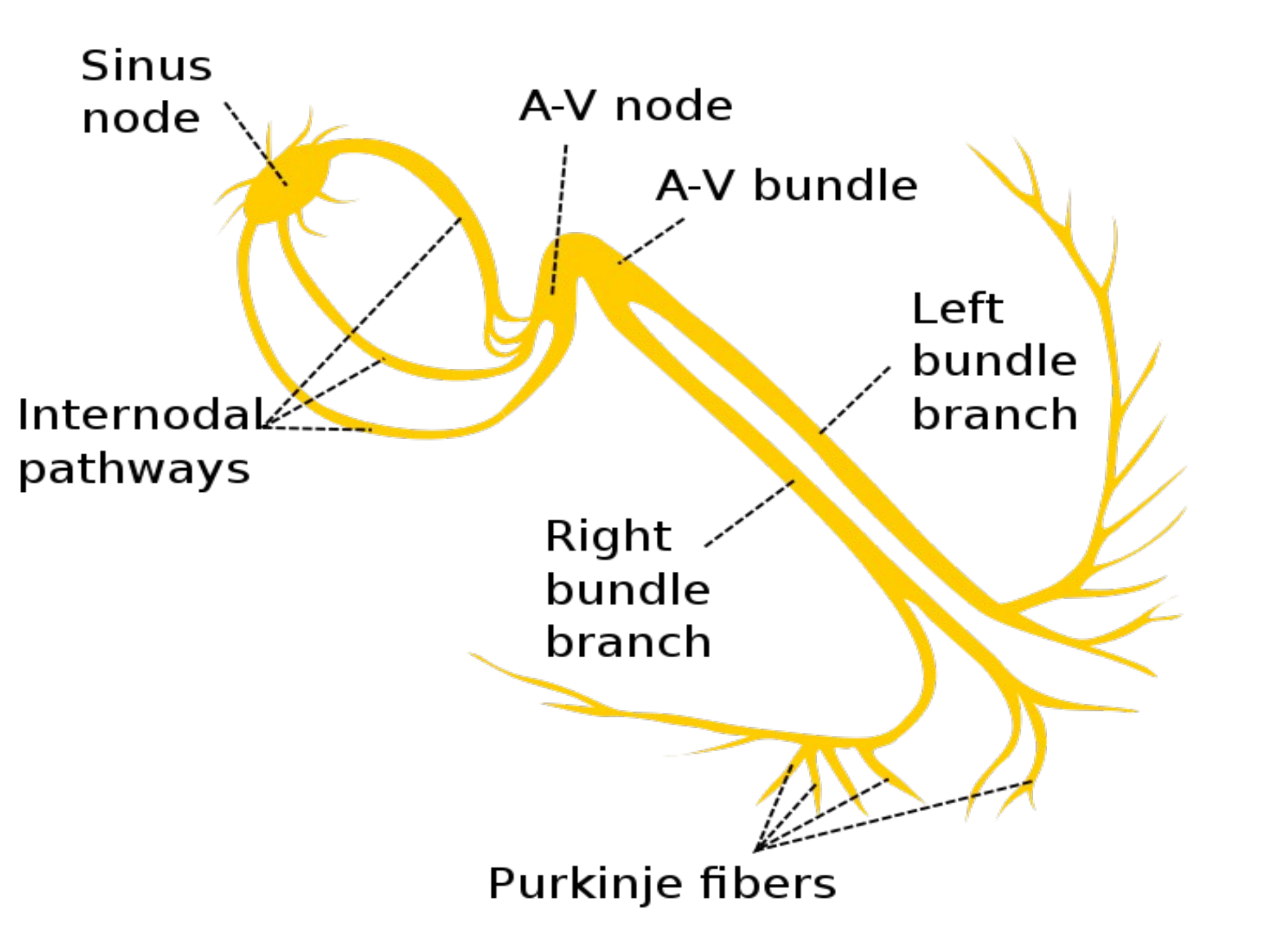
- Consists
  1. Sinuatrial (SA) node :
     - located at the junction of the SVC and right atrium.
     - Is small collection of nodal tissue, specialized cardiac muscle fibers
- is the pacemaker of the heart.
  - initiates and regulates the impulses for the contractions of the heart.

- The contraction signal from it spreads myogenically (through the musculature) of both atria.
- is stimulated by the sympathetic division of the ANS to accelerate the heart rate and is inhibited by the parasympathetic division to return to or approach its basal rate.

2. Atrioventricular (AV) node :
   - is a smaller collection of nodal tissue than the SA node.
   - located near the opening of the coronary sinus.
   - signal is transmitted rapidly from the SA node to the AV node.

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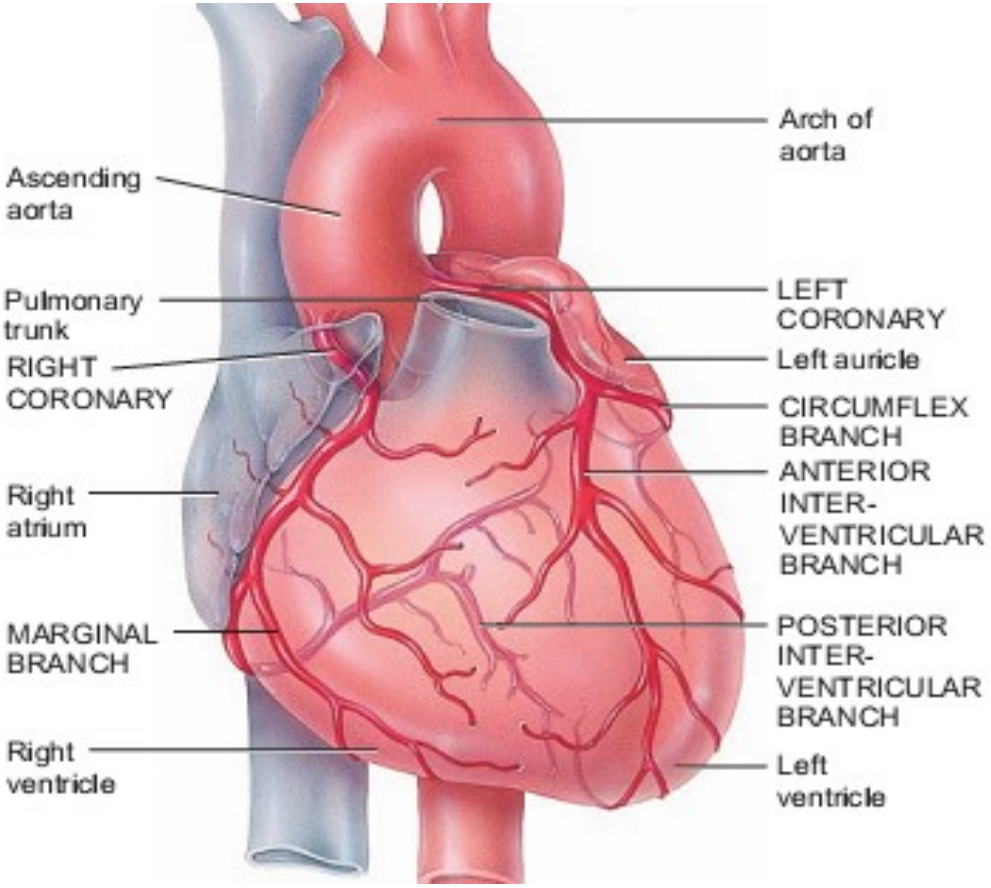


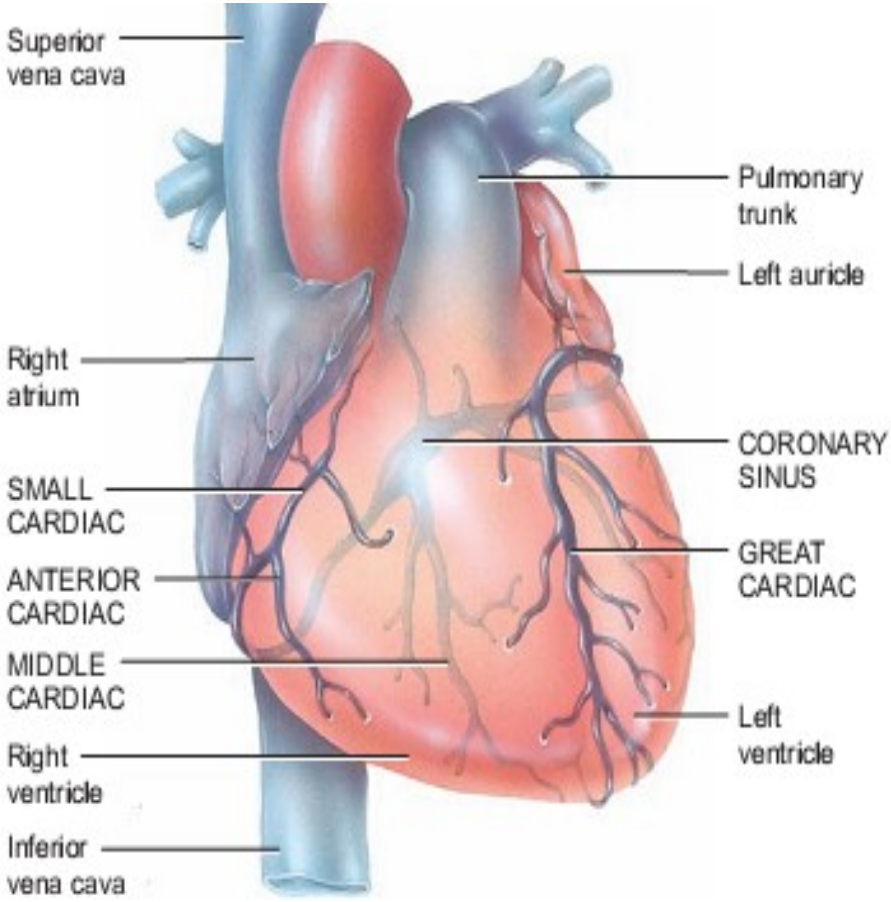

Sinus node
A-V node
A-V bundle
Left bundle branch
Internodal pathways
Right bundle branch
Purkinje fibers

- then distributes the signal to the ventricles through the AV bundle.
- Is the only bridge between the atrial and ventricular myocardium.
- AV bundle divides into right and left bundles

- **Innervation of the Heart**
  - **Autonomic Innervation (*cardiac plexus*)**
    - **Vagus Nerve (parasympathetic)**
    - **cardioinhibitory center**
  - **Sympathetic trunks**
    - **cardioaccelatory center**

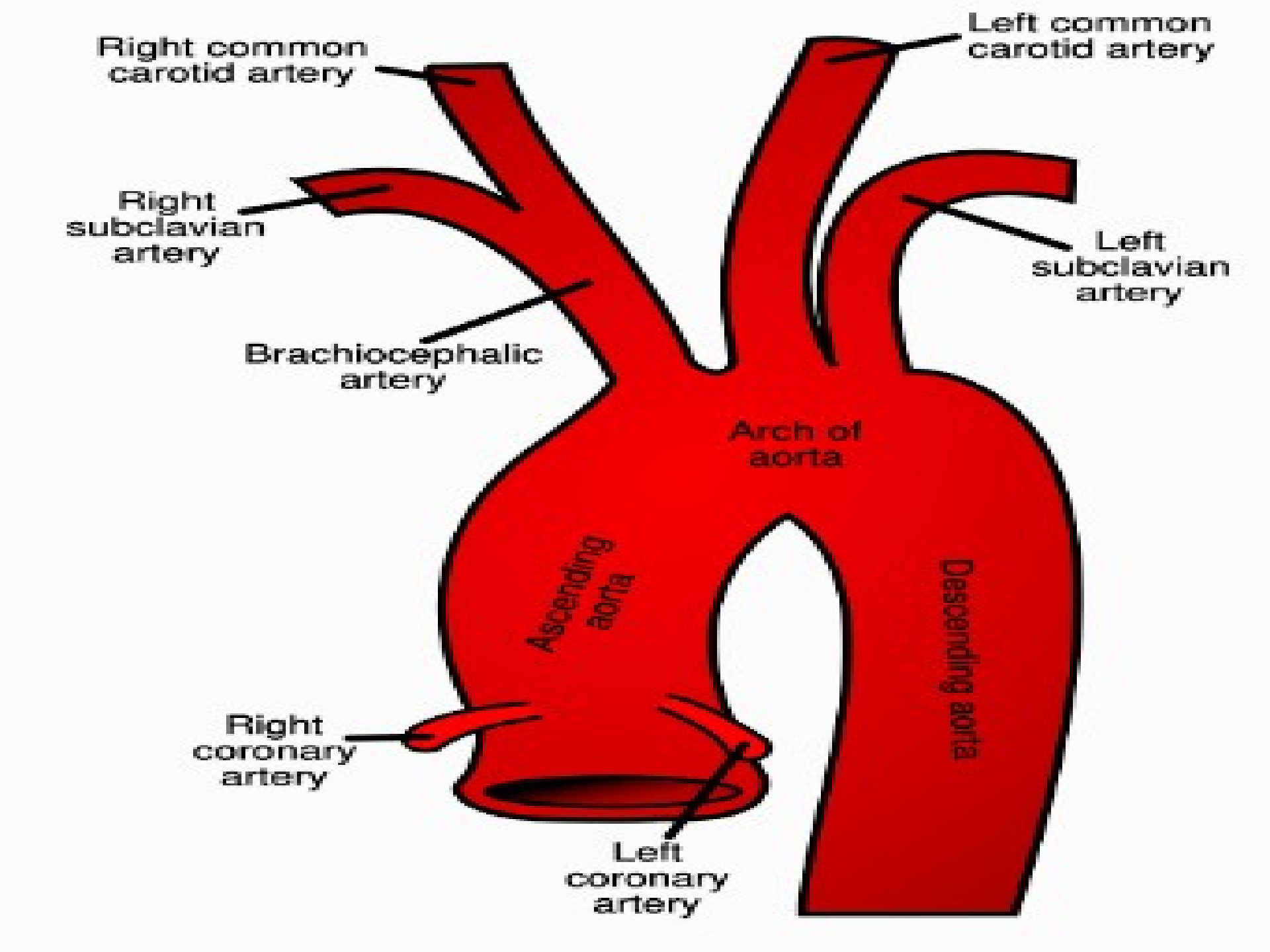
- **Two circulatory routes**:
  - *pulmonary circulation*:
    - right ventricle ----pulmonary artery---- lungs----pulmonary vein----- left atrium
  - *systemic circulation*:
    - left ventricle ----- aorta-----body------ superior and inferior vena cava------right atrium
    - **Coronary circulation:**
      - is part of the systemic circulation
      - supplies blood to the heart tissues via coronary arteries and drains via veins.


Arch of aorta
Ascending aorta
Pulmonary trunk
LEFT CORONARY
RIGHT CORONARY
Left auricle
CIRCUMFLEX BRANCH
ANTERIOR INTER-VENTRICULAR BRANCH
Right atrium
MARGINAL BRANCH
POSTERIOR INTER-VENTRICULAR BRANCH
Right ventricle
Left ventricle


Superior vena cava
Pulmonary trunk
Left auricle
Right atrium
CORONARY SINUS
SMALL CARDIAC
GREAT CARDIAC
ANTERIOR CARDIAC
MIDDLE CARDIAC
Left ventricle
Right ventricle
Inferior vena cava

Principal Arteries of the body

- **aorta**
- **ascending aorta**
  - ascends from the heart (left ventricle)
  - The coronary arteries are the only branch of the ascending aorta
- Aortic arch
  - Three vessels arise from the aortic arch:
    - the brachiocephalic artery–supplies the upper limbs and head regions
    - left common carotid artery
    - left subclavian artery


Right common carotid artery
Left common carotid artery
Right subclavian artery
Left subclavian artery
Brachiocephalic artery
Arch of aorta
Ascending aorta
Descending aorta
Right coronary artery
Left coronary artery

- Brachiocephlic trunk:
  - bifurcates into:
    - the right common carotid artery
      - supplies the right side of hand and neck.
    - subclavian artery
      - supplies the right upper limb
- Left common carotid artery and the left subclavian artery
  - branch directly from the aortic arch.

- **Arteries of the neck and head**
- Common carotid artery
  - ascends upwards in the neck lateral to trachea
  - Divides slightly below the angle of the mandible into
    - the internal carotid artery and
    - the external carotid artery

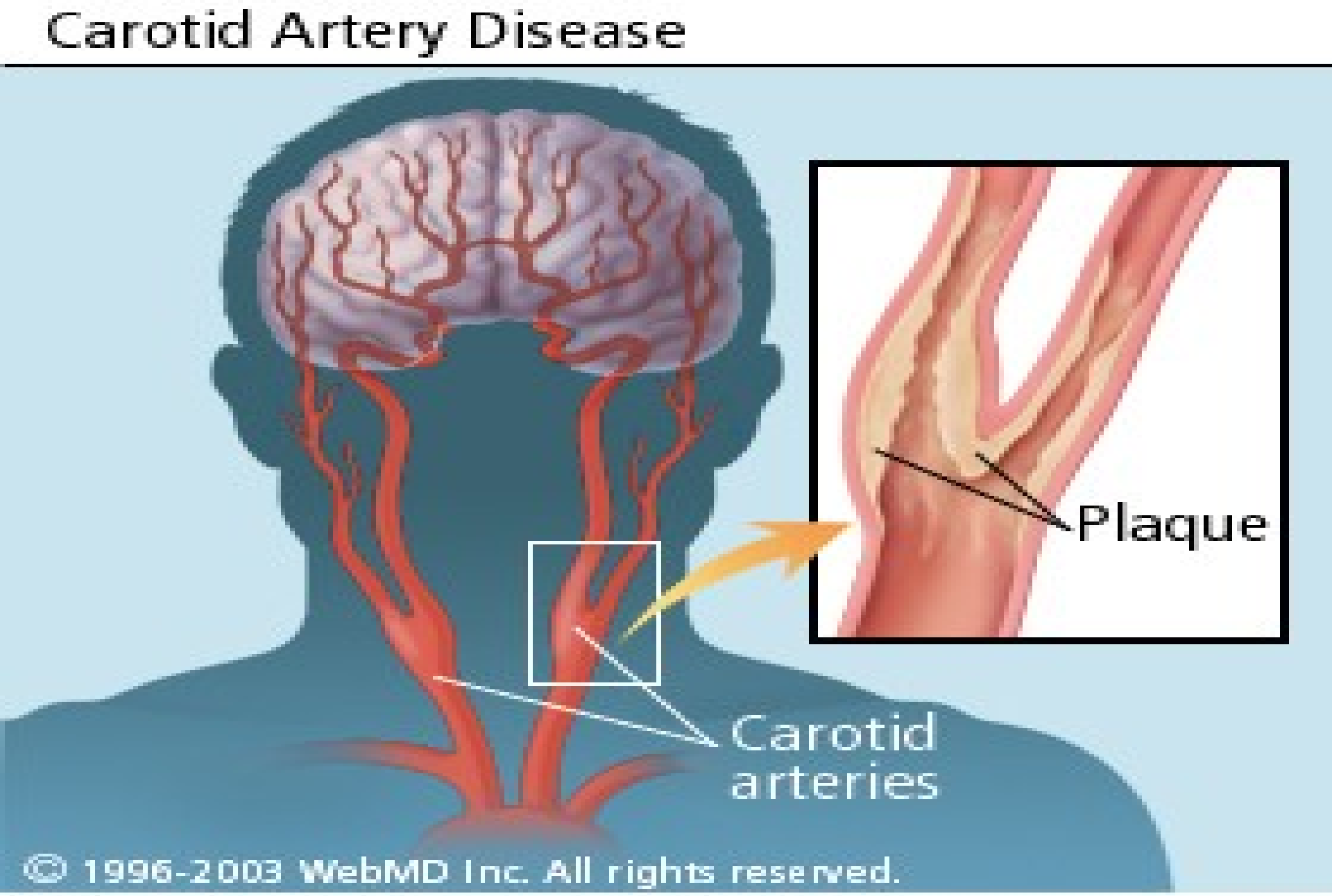
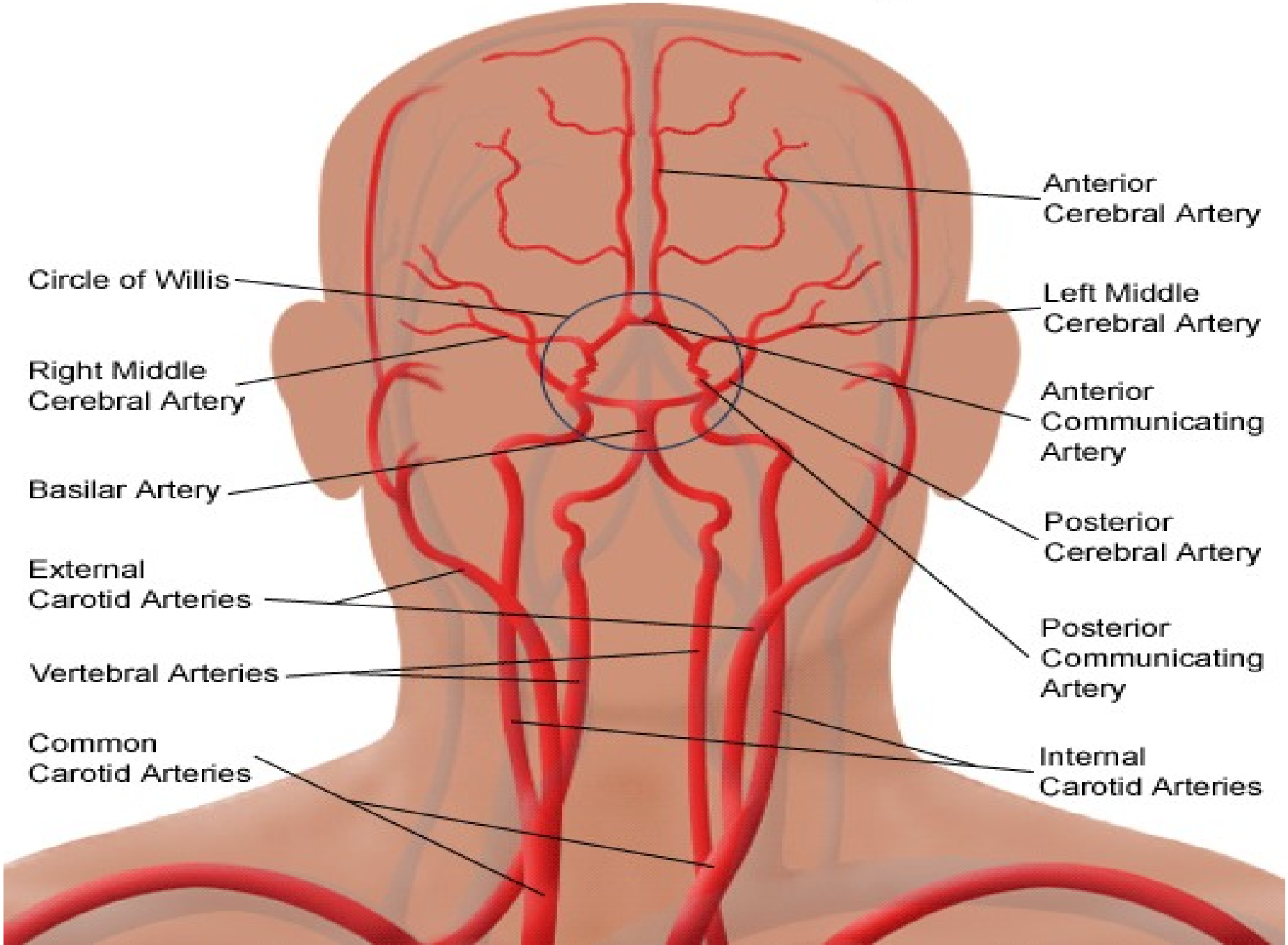


Illustration of Carotid Artery Stenosis

- The brain is supplied by four arteries:
  - paired vertebral arteries (i.e., right and left) and
  - paired internal carotid arteries.

1. The vertebral artery
   - arises from the subclavian artery
   - enters the cranial cavity through the foramen magnum.
   - The right and left vertebral arteries unite to form the basilar artery.

Arterial Circulation of the Brain, Including Carotid Arteries



✓Arteries of the upper limbs

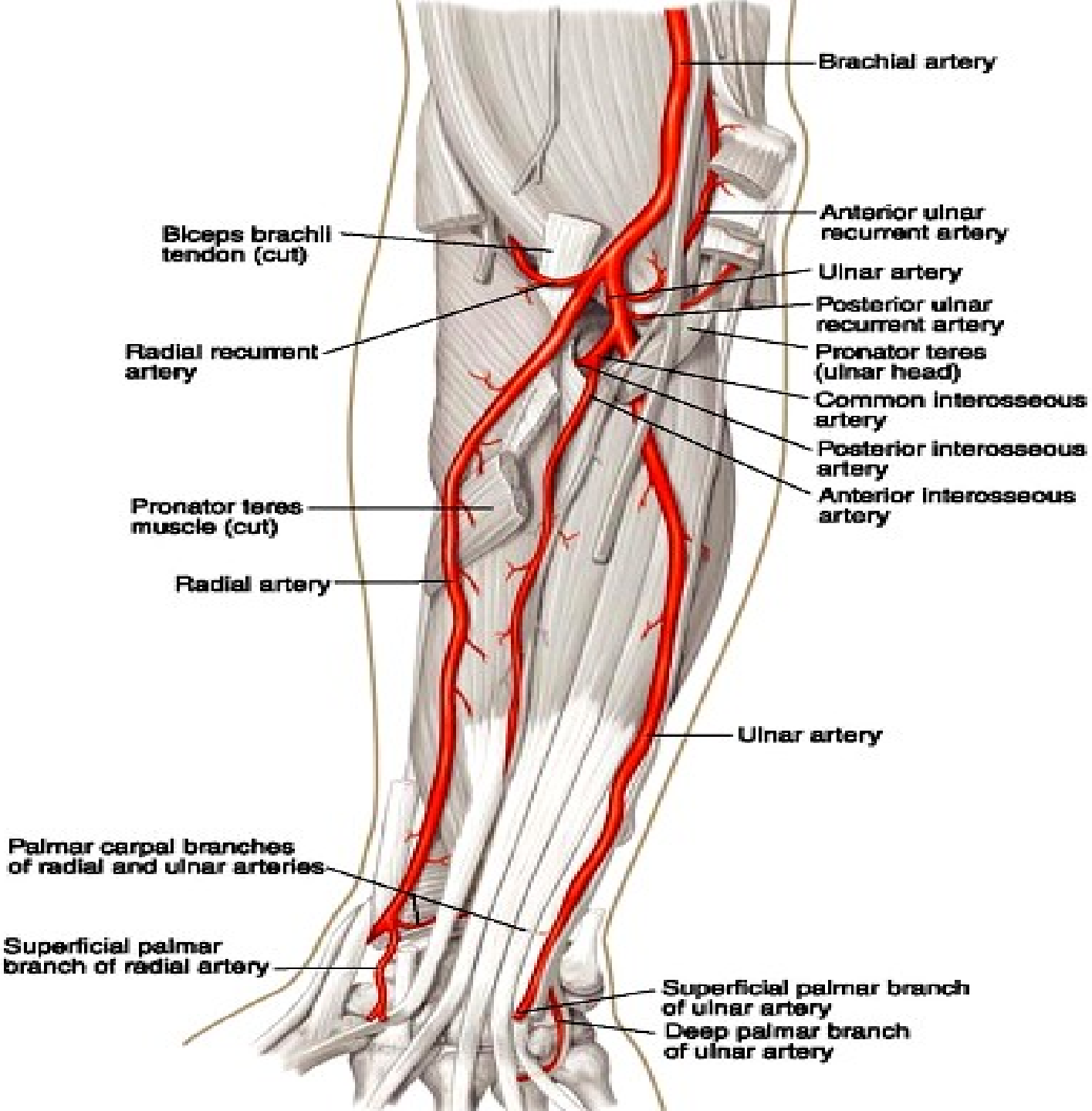
- subclavian
  - Right subclavian- from brachiocephalic.
  - left subclavian- from aortic arch.
- becomes the axillary artery as it passes lateral border of 1st rib into the axilla.

Axillary artery

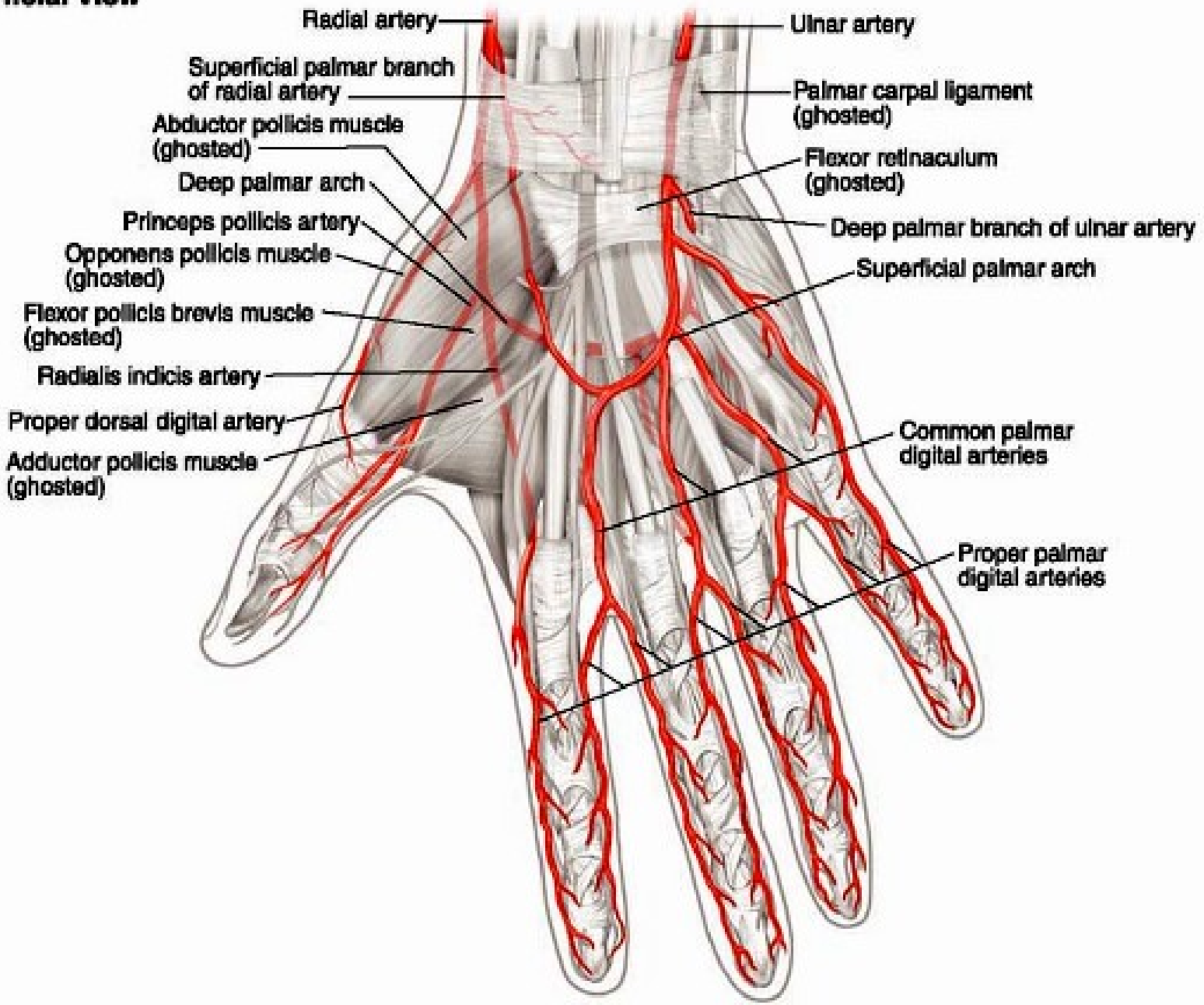
- direct continuation of subclavian artery.
- It becomes the brachial artery in the arm.
  - **Site for BP(blood pressure measurement)**

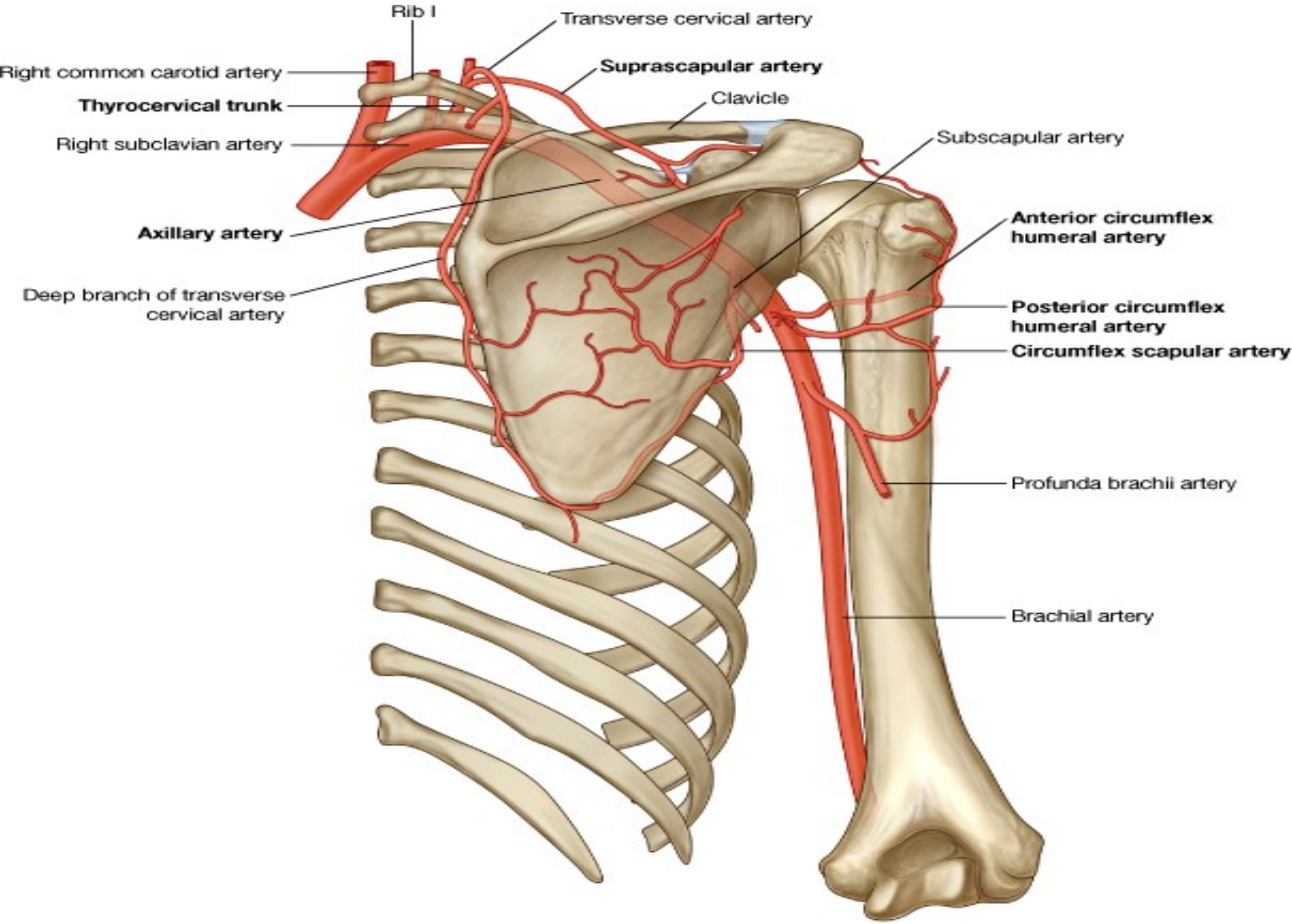
Brachial artery

- direct continuation of axillary artery.
- Branches:
  - Profunda brachii (deep artery of arm) in the arm
  - Radial and ulnar terminal branches in cubital fossa
- Radial artery-
  - supplies muscles on the radial side of the forearm.
  - is the site of measuring pulse.
- Ulnar artery –
  - supplies muscles on the ulnar side of the forearm.
- Both arteries form
  - palmar arch in the palm and
  - digital arteries supplying the digits.

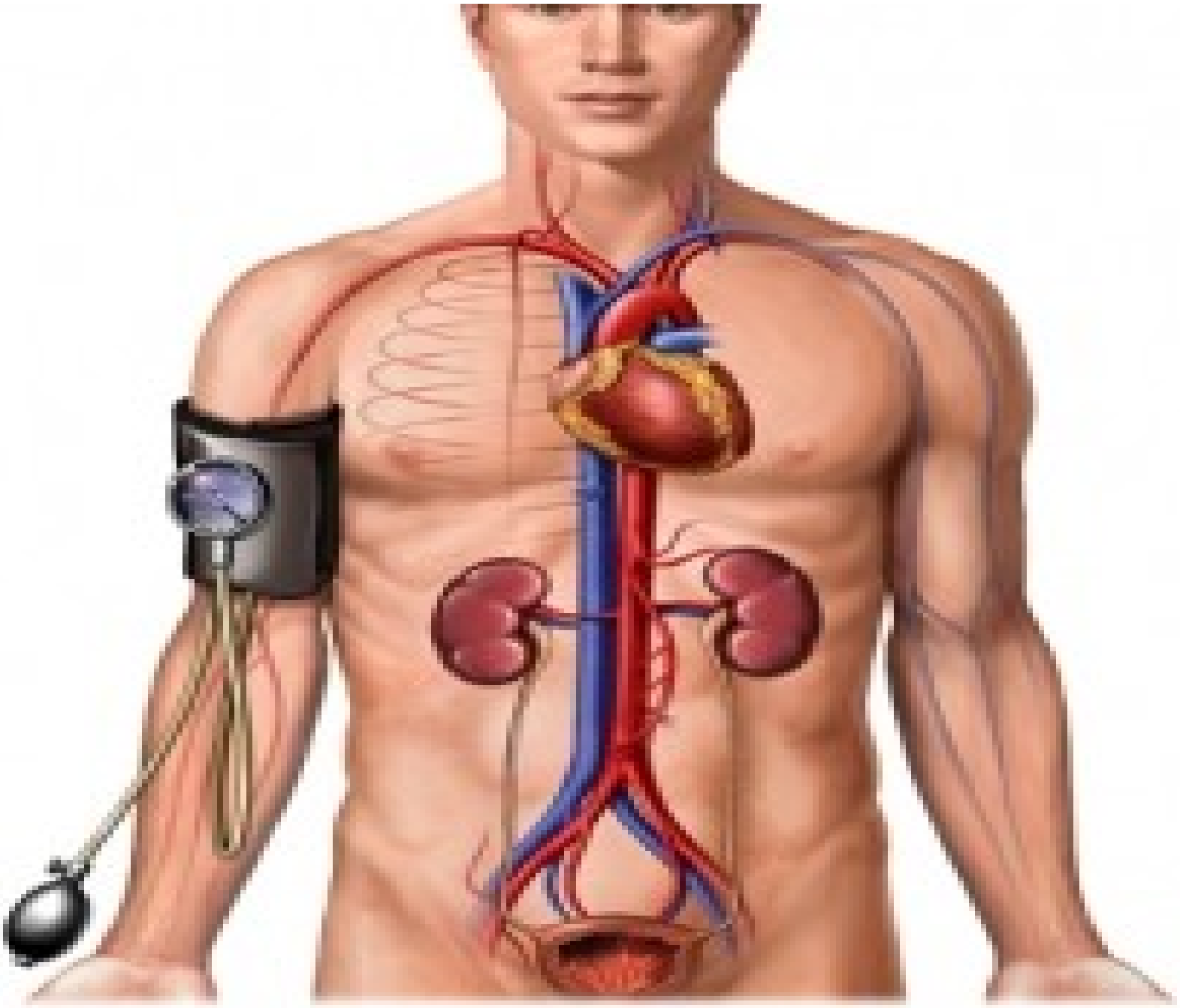

Brachial artery
Anterior ulnar recurrent artery
Biceps brachii tendon (cut)
Ulnar artery
Posterior ulnar recurrent artery
Radial recurrent artery
Pronator teres (ulnar head)
Common interosseous artery
Posterior interosseous artery
Anterior interosseous artery
Pronator teres muscle (cut)
Radial artery
Ulnar artery
Palmar carpal branches of radial and ulnar arteries
Superficial palmar branch of radial artery
Superficial palmar branch of ulnar artery
Deep palmar branch of ulnar artery

A. Superficial view





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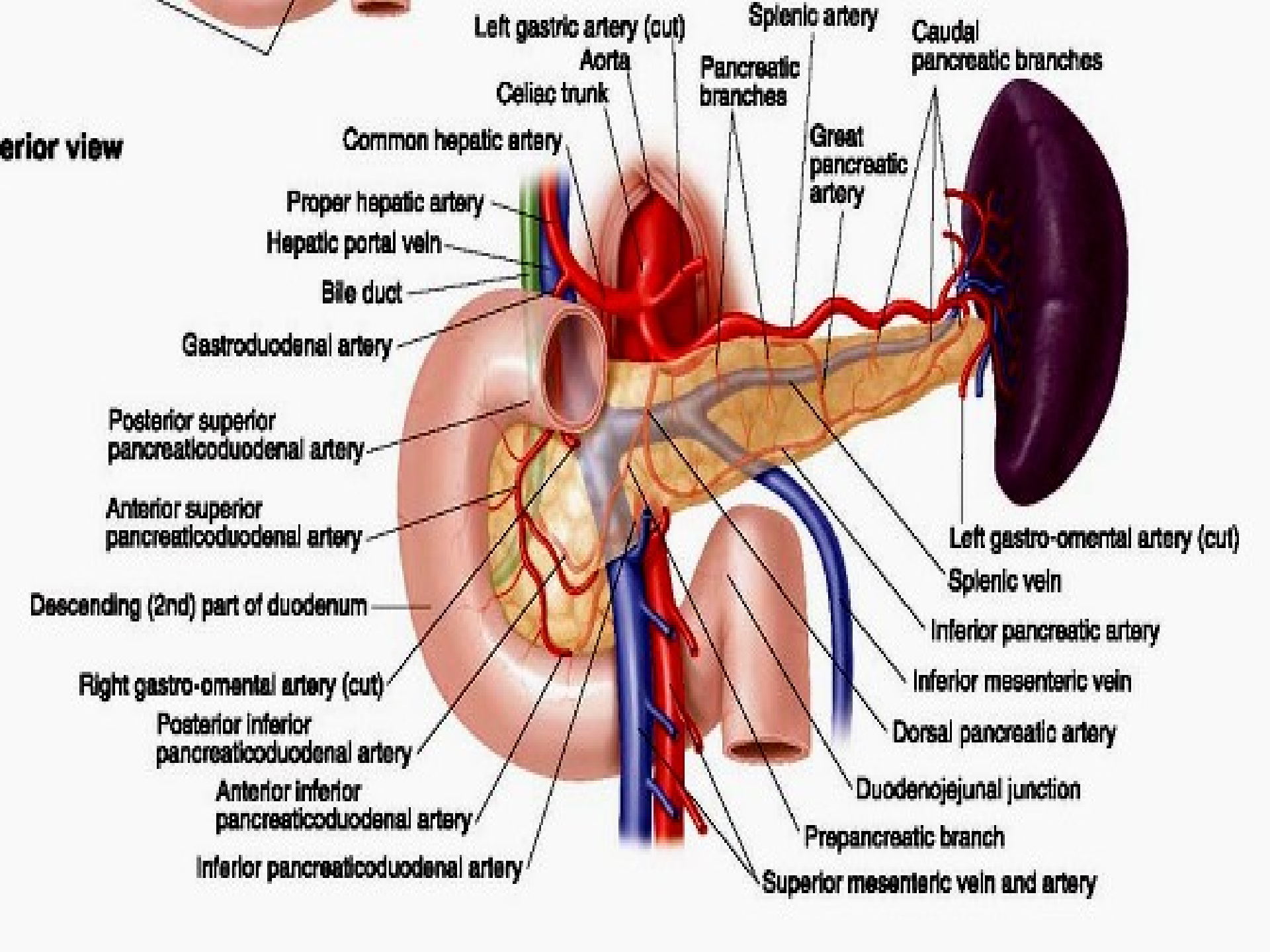




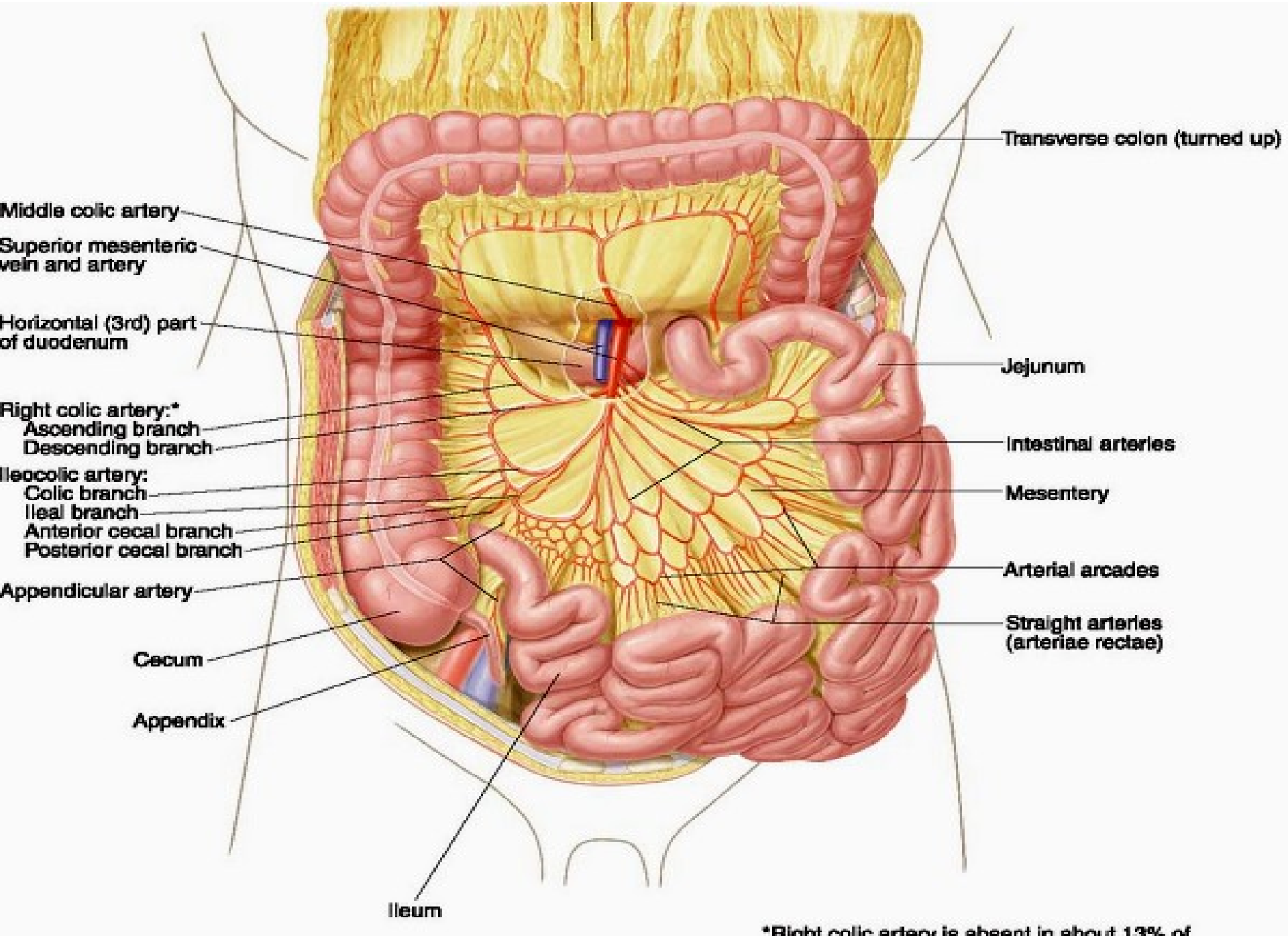
- **Thoracic aorta:**
  - It is a continuation of the aortic arch
  - descends though the thoracic cavity to diaphragm
- **Branches :**
  - gives branches to the muscles and organs of thoracic region.

- **<u>Abdominal aorta</u>**
  - is the continuation of the thoracic aorta
  - begins at the aortic hiatus in the diaphragm and ends fourth lumbar vertebra,
  - it divides into the right and left common iliac arteries.

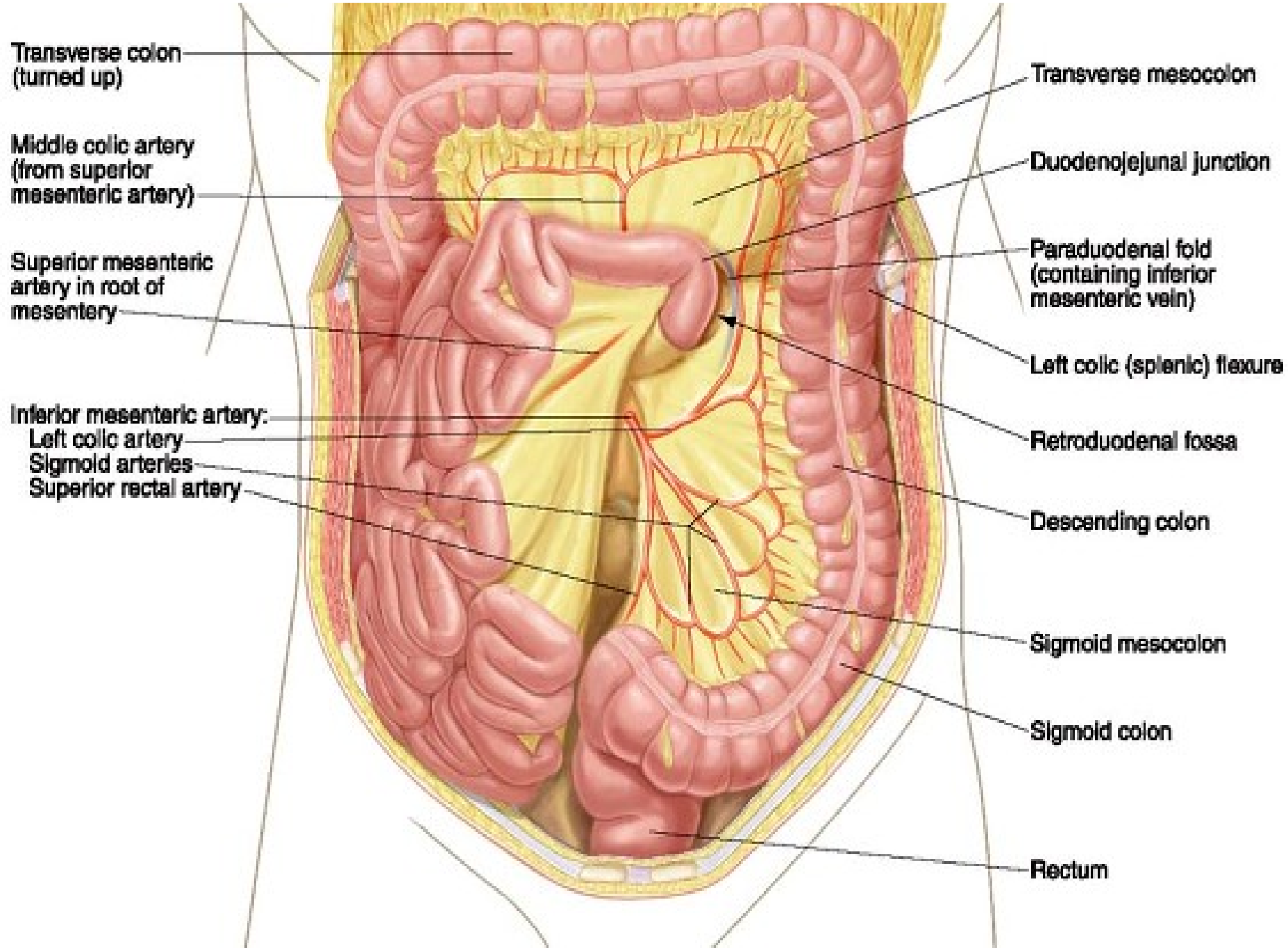
- **Unpaired branches**
- **Celiac trunk** –
  - short, thick, branch, which divides into three vessels:
    - Splenic artery (to spleen)
    - Left gastric artery (to stomach)
    - Common hepatic (to liver)
- Superior mesenteric artery-
  - to the small intestine (except the proximal part of duodenum), cecum, appendix, ascending , and transverse colons.


erior view
Left gastric artery (cut)
Aorta
Celiac trunk
Splenic artery
Pancreatic branches
Caudal pancreatic branches
Common hepatic artery
Great pancreatic artery
Proper hepatic artery
Hepatic portal vein
Bile duct
Gastroduodenal artery
Posterior superior pancreaticoduodenal artery
Anterior superior pancreaticoduodenal artery
Descending (2nd) part of duodenum
Right gastro-omental artery (cut)
Posterior inferior pancreaticoduodenal artery
Anterior inferior pancreaticoduodenal artery
Inferior pancreaticoduodenal artery
Left gastro-omental artery (cut)
Splenic vein
Inferior pancreatic artery
Inferior mesenteric vein
Dorsal pancreatic artery
Duodenojejunal junction
Prepancreatic branch
Superior mesenteric vein and artery

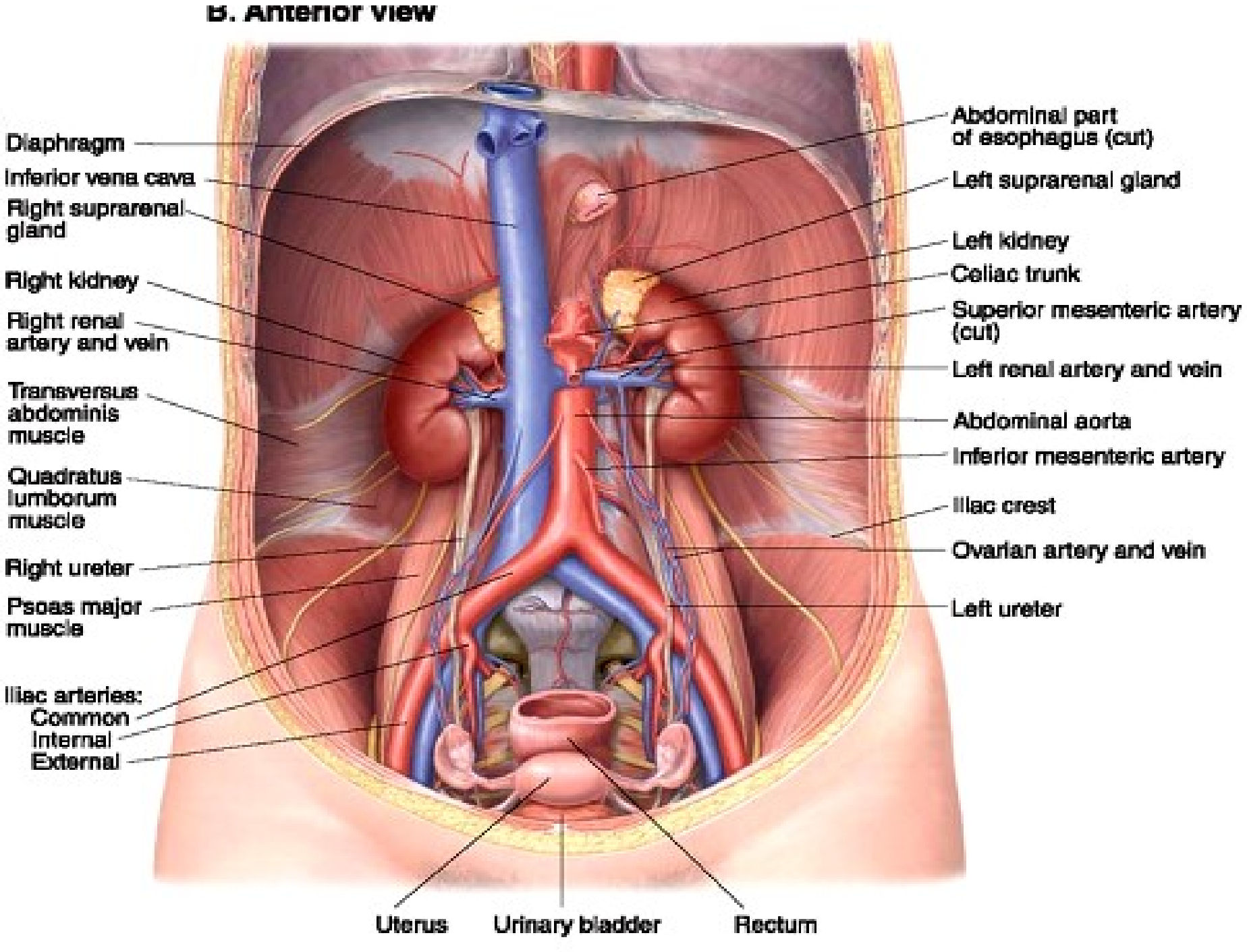
- Inferior mesenteric artery –
  - last major, anterior, unpaired branch.
    - Supplies the descending, and sigmoid colons, rectum.
- Paired branches
  - Renal artery– to kidney
  - Suprarenal artery - to adrenal glands
  - Gonadal: to testes(male) and to ovaries(female)

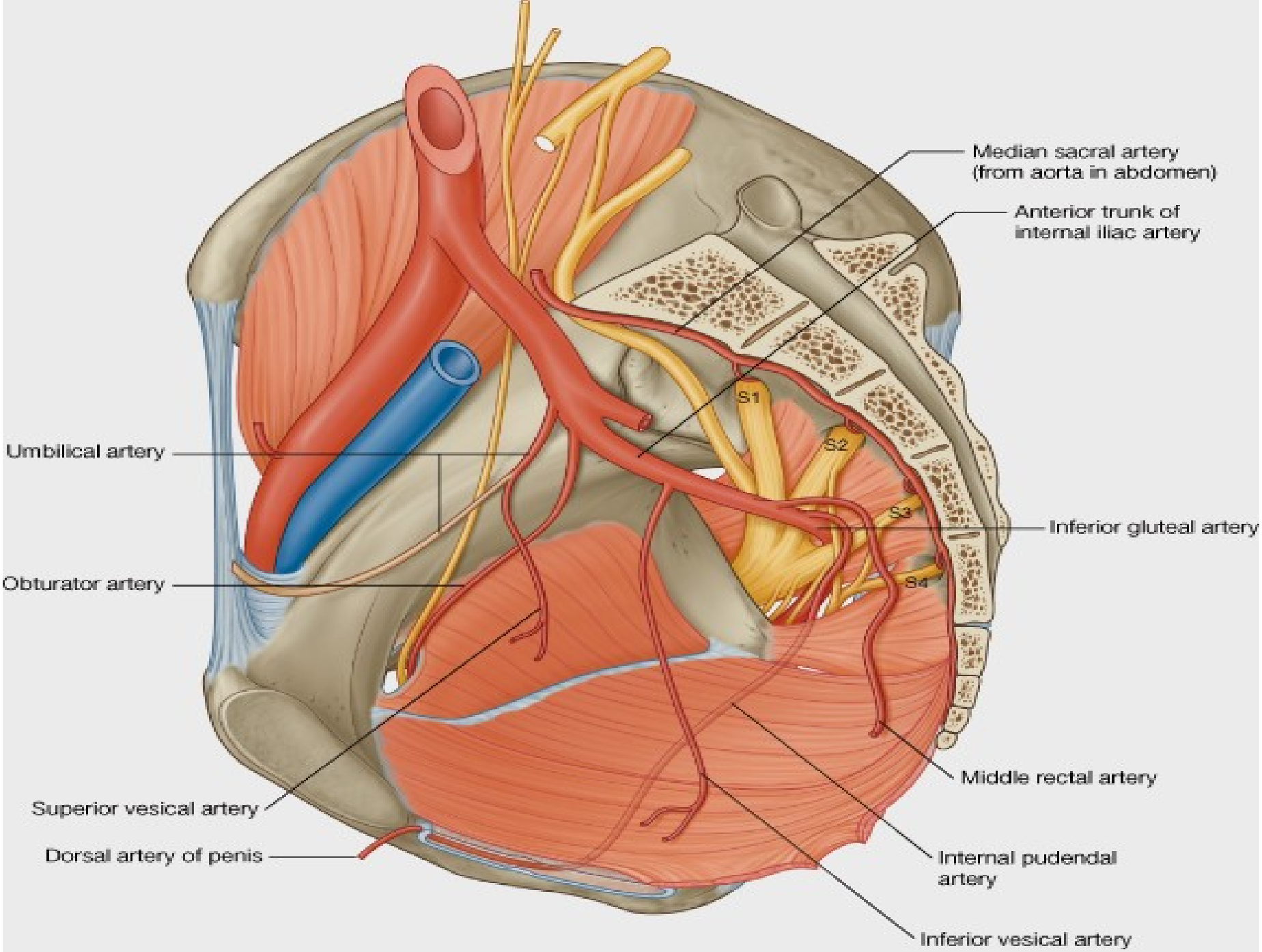


*Right colic artery is absent in about 13% of


Transverse colon (turned up)
Middle colic artery (from superior mesenteric artery)
Superior mesenteric artery in root of mesentery
Inferior mesenteric artery:
Left colic artery
Sigmoid arteries
Superior rectal artery
Transverse mesocolon
Duodenojejunal junction
Paraduodenal fold (containing inferior mesenteric vein)
Left colic (splenic) flexure
Retroduodenal fossa
Descending colon
Sigmoid mesocolon
Sigmoid colon
Rectum

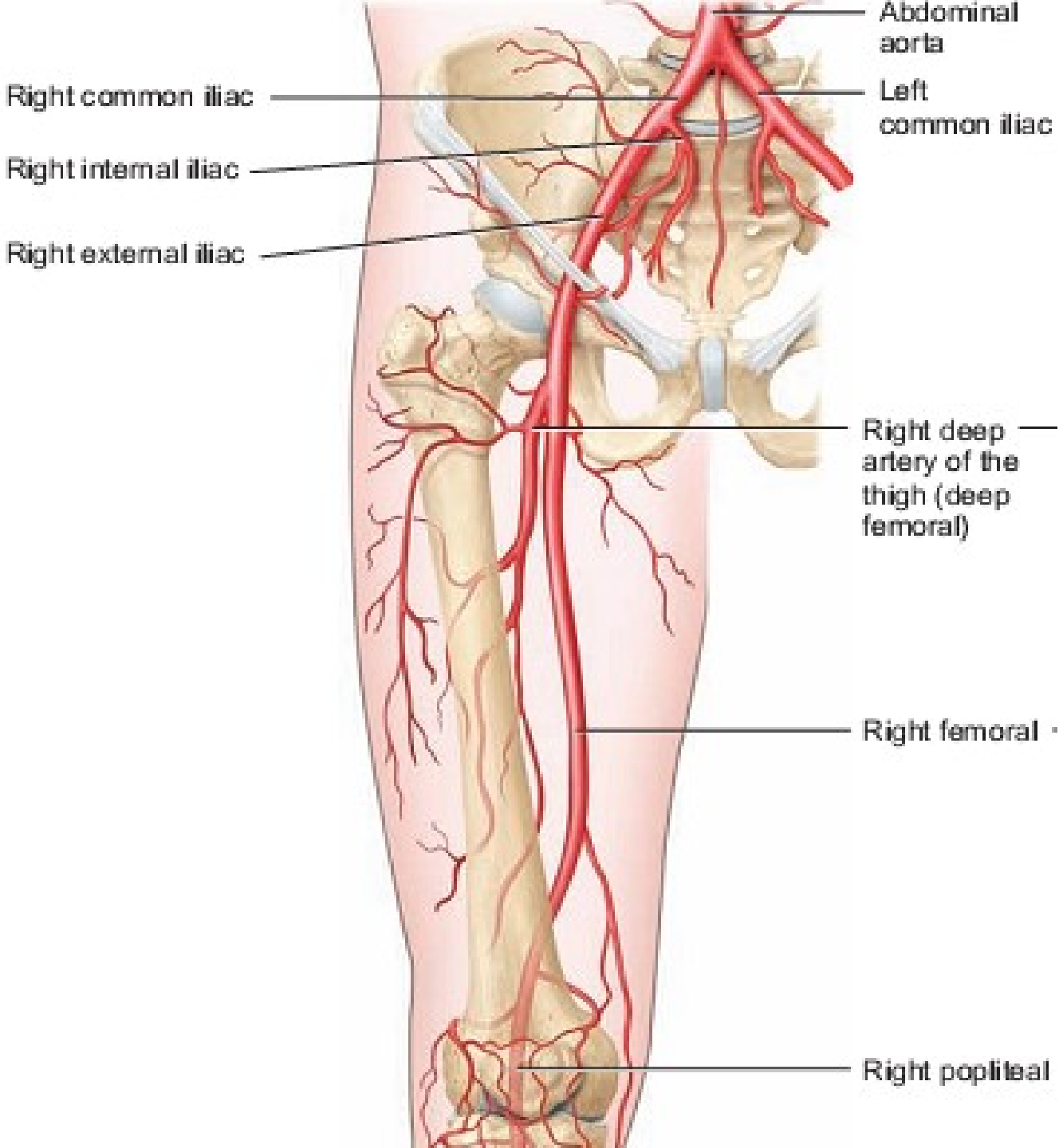
- **Arteries of the pelvis and lower limbs_**
  - The common iliac divides into
    - the internal iliac and
    - external iliac.
- The internal iliac artery
  - supply gluteal muscles and organs of the pelvic region
- The external iliac artery–
  - passes out of pelvis beneath the inguinal ligament to become the femoral artery


B. Anterior view
Diaphragm
Inferior vena cava
Right suprarenal gland
Right kidney
Right renal artery and vein
Transversus abdominis muscle
Quadratus lumborum muscle
Right ureter
Psoas major muscle
Iliac arteries:
Common
Internal
External
Abdominal part of esophagus (cut)
Left suprarenal gland
Left kidney
Celiac trunk
Superior mesenteric artery (cut)
Left renal artery and vein
Abdominal aorta
Inferior mesenteric artery
Iliac crest
Ovarian artery and vein
Left ureter
Uterus
Urinary bladder
Rectum



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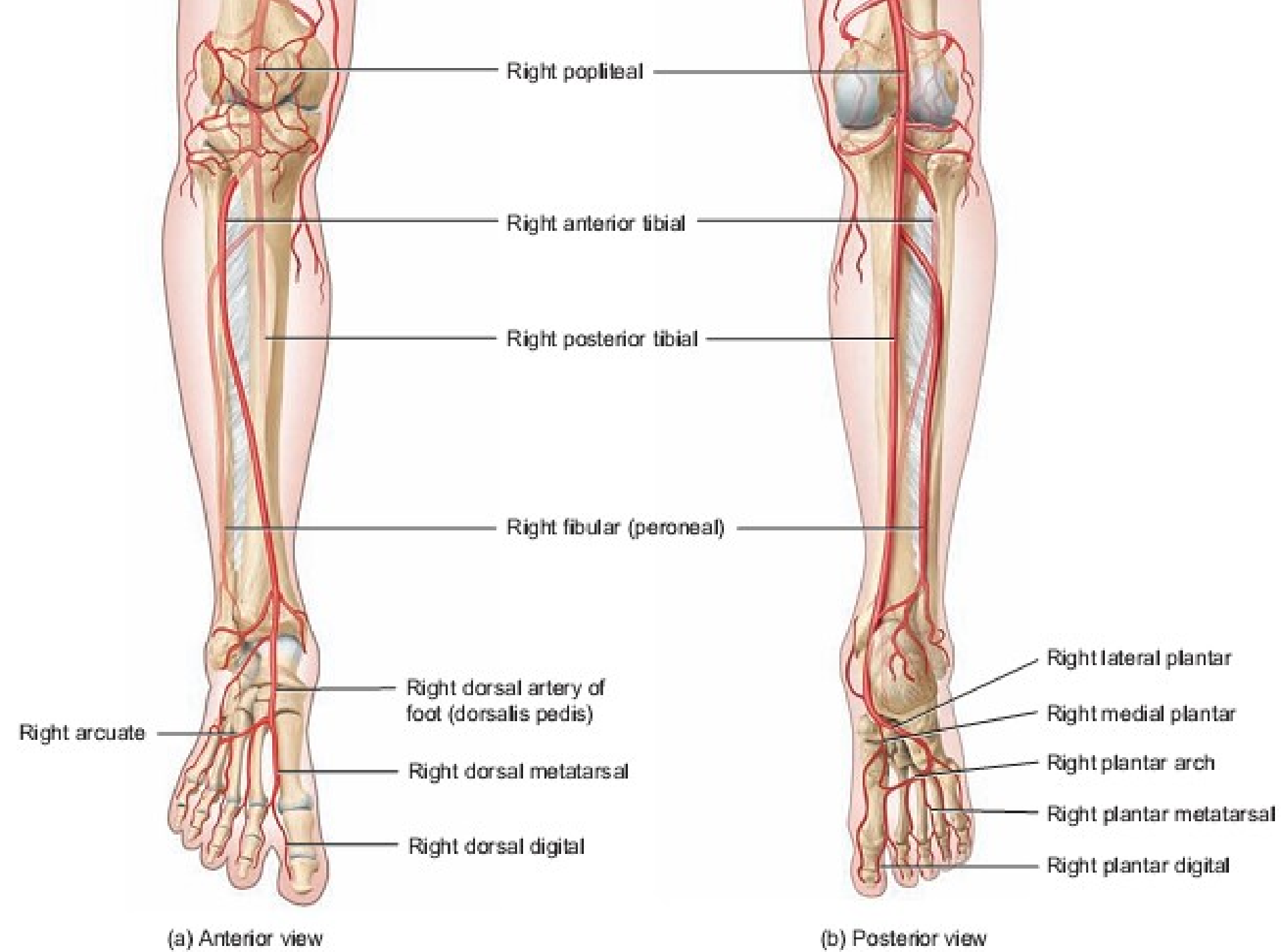
- *Femoral artery* –
  - Is direct continuation of EIA
  - passes through the femoral triangle on the upper medial portion of the thigh.
  - At this point it is close to the surface, hence for pulpation.
  - the femoral artery becomes the popliteal artery as it passes across the posterior aspect of the knee.


Abdominal aorta
Right common iliac
Left common iliac
Right internal iliac
Right external iliac
Right deep artery of the thigh (deep femoral)
Right femoral
Right popliteal

The popliteal artery:

- Is direct continuation of femoral artery
- Passes through popliteal fossa
  - divides into the
    - anterior tibial and
    - the posterior tibial arteries

    Anterior tibial artery:
  - Is terminal branch of popliteal artery.
  - Supplies anterior compartment of leg
  - at the ankle, becomes
    - the dorsal pedal artery (dorsalis pedis)


Right popliteal
Right anterior tibial
Right posterior tibial
Right fibular (peroneal)
Right dorsal artery of foot (dorsalis pedis)
Right arcuate
Right dorsal metatarsal
Right dorsal digital
Right lateral plantar
Right medial plantar
Right plantar arch
Right plantar metatarsal
Right plantar digital
(a) Anterior view
(b) Posterior view

Dorsalis pedis

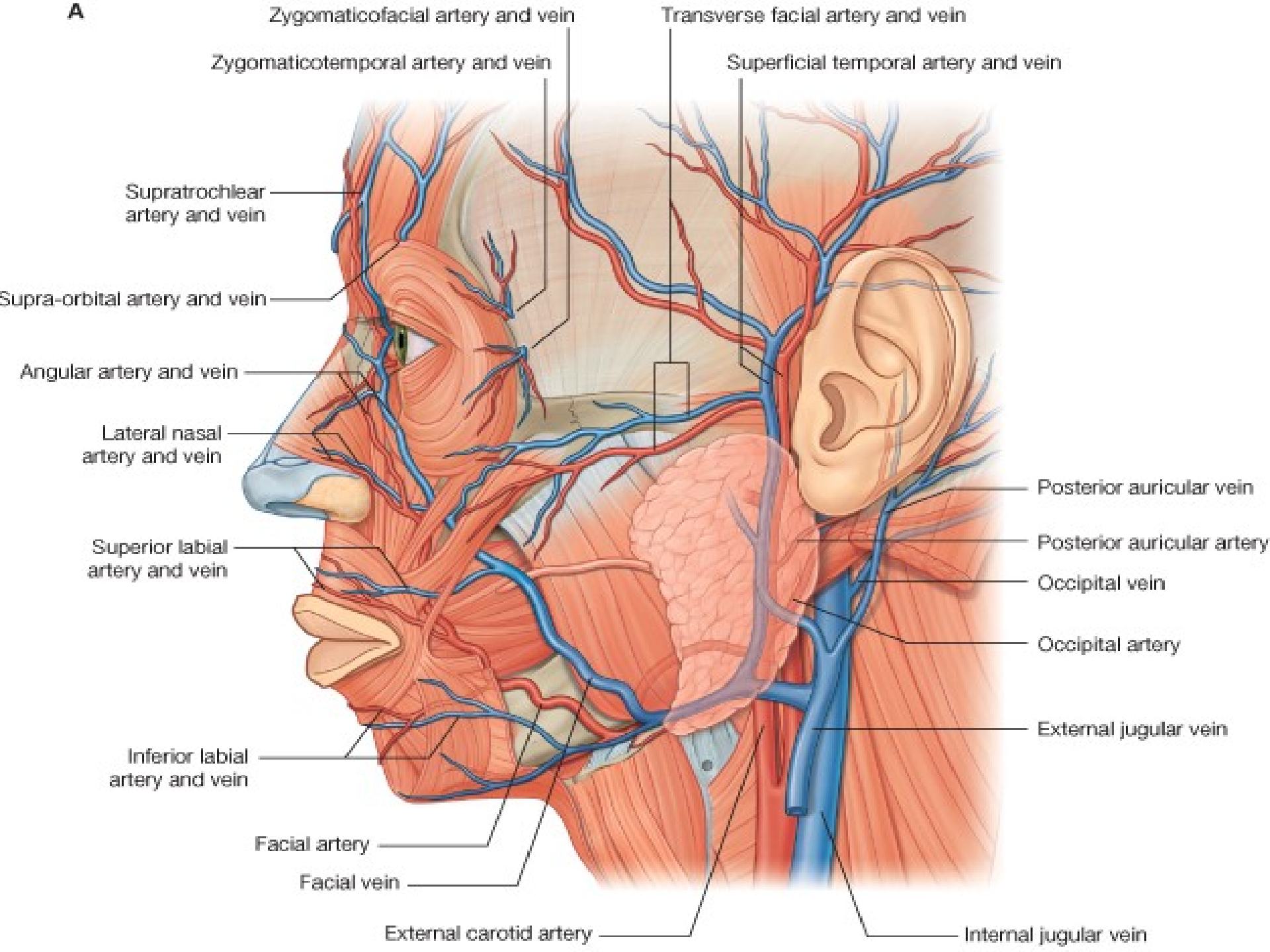
- On dorsum of foot
- is the site from which the most distal pulse is recorded.

The posterior tibial artery

- is another terminal branch of PA.

Venous drainage of the body

- **Veins Draining the neck and head**
  - External jugular vein (EJV)
    - from scalp, portions of face, superficial neck region
    - drain into right and left subclavian vein.
  - Internal jugular vein (IJV)
    - from brain, meninges, deep regions of face and neck


A
Zygomaticofacial artery and vein
Transverse facial artery and vein
Zygomaticotemporal artery and vein
Superficial temporal artery and vein
Supratrochlear artery and vein
Supra-orbital artery and vein
Angular artery and vein
Lateral nasal artery and vein
Posterior auricular vein
Superior labial artery and vein
Posterior auricular artery
Occipital vein
Occipital artery
External jugular vein
Inferior labial artery and vein
Facial artery
Facial vein
External carotid artery
Internal jugular vein

- larger and deeper than the EJV
- passes in carotid sheath with the common carotid, internal carotid, and vagus nerve beneath sternocleidomastoid muscle.

– subclavian vein and internal jugular: unite to form the brachiocephalic vein just posterior to SC joint.

– the two brachiocephalic veins: merge to form the superior vena cava, which empties into the right atrium

Veins of the upper extremity

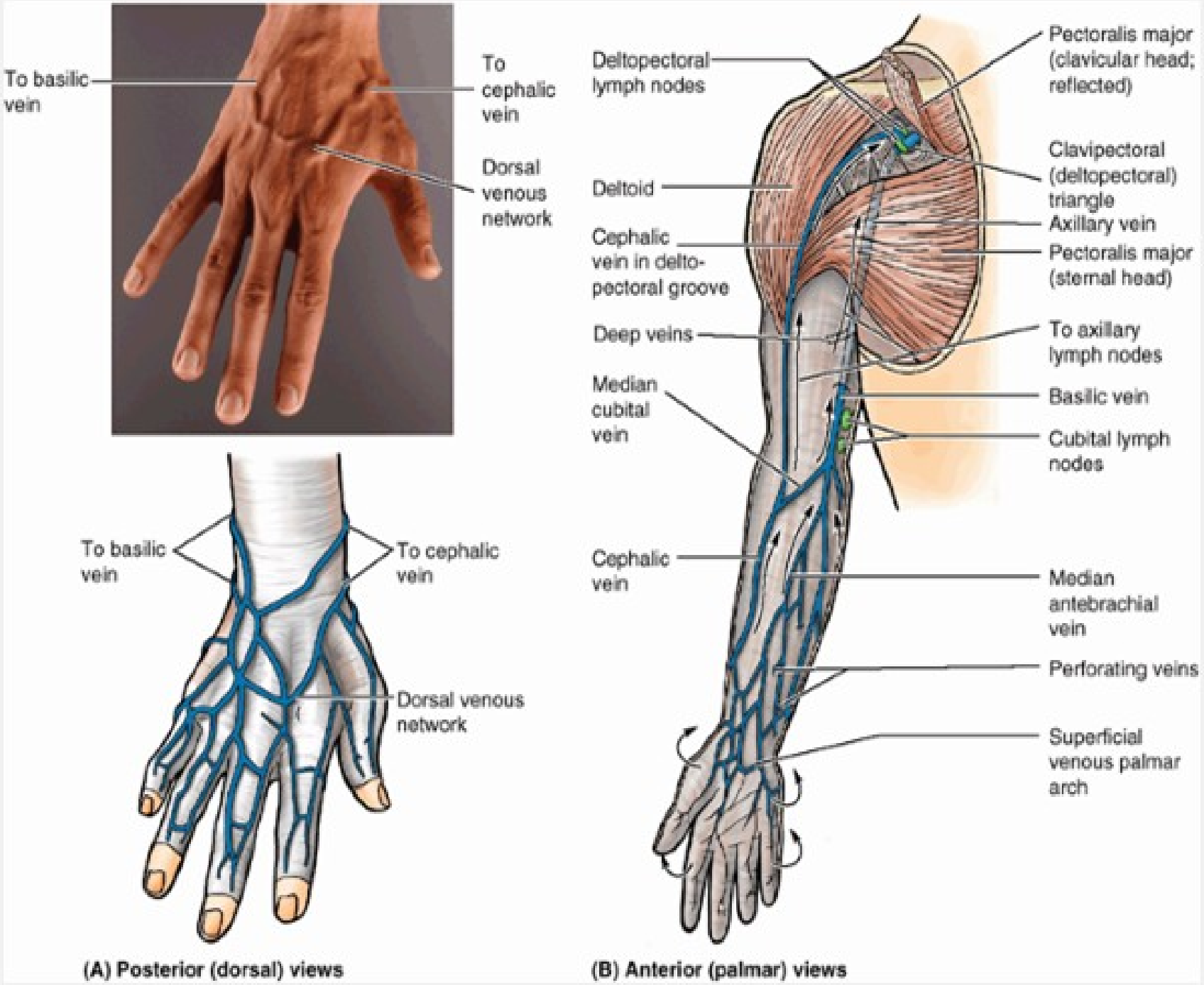
- Consists of superficial and deep venous drainage

Deep veins

- accompany the arteries and bear their names / region
  - radial vein + ulnar vein
    - both drain from deep and superficial palmar arches
    - radial and ulnar veins join in the cubital fossa.
    - form the brachial vein, which continues up on the medial side of the arm.
  - Brachial vein -axiliary → subclavian + internal jugular → brachiocephalic.

Superficial veins:

- do not accompany the arteries.
- are in subcutaneous tissue with cutaneous nerves.
- are two:
  - basilic vein
    - drains blood from ulnar side of forearm, medial side of arm
    - merges with brachial vein near the head of the humerus to form the axillary vein
  - cephalic vein
    - drains superficial region of hand and forearm on radial side
    - joins axillary vein in the shoulder region


To basilic vein
To cephalic vein
Dorsal venous network
To basilic vein
To cephalic vein
Dorsal venous network
(A) Posterior (dorsal) views
Deltopectoral lymph nodes
Deltoid
Cephalic vein in delto-pectoral groove
Deep veins
Median cubital vein
Cephalic vein
Pectoralis major (clavicular head; reflected)
Clavipectoral (deltopectoral) triangle
Axillary vein
Pectoralis major (sternal head)
To axillary lymph nodes
Basilic vein
Cubital lymph nodes
Median antebrachial vein
Perforating veins
Superficial venous palmar arch
(B) Anterior (palmar) views

- *median cubital vein:*
  - ascends from the cephalic vein to join basilic vein on radial side.
  - It is a site of *venipuncture*

Veins of the thorax

- *Superior vena cava*
  - receives blood from the:
    - right and left brachiocephalic veins
  - lacks valves which are characteristics of most veins

Veins of the lower extremity

- deep and a superficial group

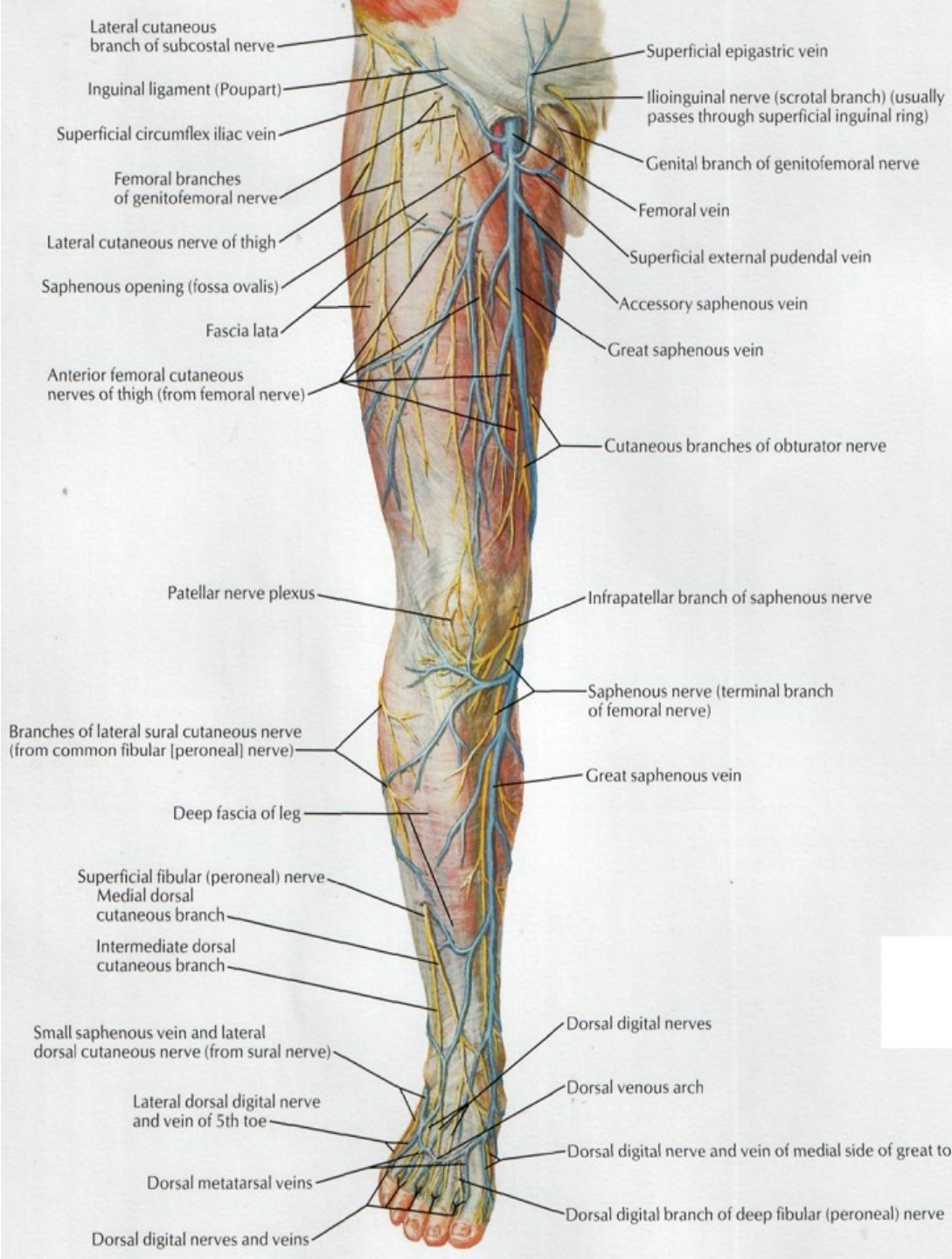
The deep veins

- accompany the corresponding arteries
- These include:
  - posterior and anterior tibial veins
    - originate in the foot
    - ascend upwards in front of the tibia to the back of the knee
    - they merge to form the popliteal vein.
  - Popliteal vein
    - drains blood from the knee region and above the knee,
    - it becomes the femoral vein

- the femoral vein
  - receives blood from the:
    - deep femoral vein
    - the great saphenous vein
    - becomes the external iliac vein (as it passes under the inguinal ligament).
- the external iliac vein
  - merges with the internal iliac vein to form the common iliac vein

- *Superficial vein include*
  - *small saphenous vein* :
    - arises from the lateral side of the foot,
    - courses posteriorly along the surface of the leg
    - enters deep into the popliteal vein behind the knee.

- *Great saphenous vein :*
  - longest vessel in the body
  - originates form dorsal venous arch of the foot.
  - ascends superiorly along the medial aspect of the leg and thigh.
  - ends draining into the femoral vein.

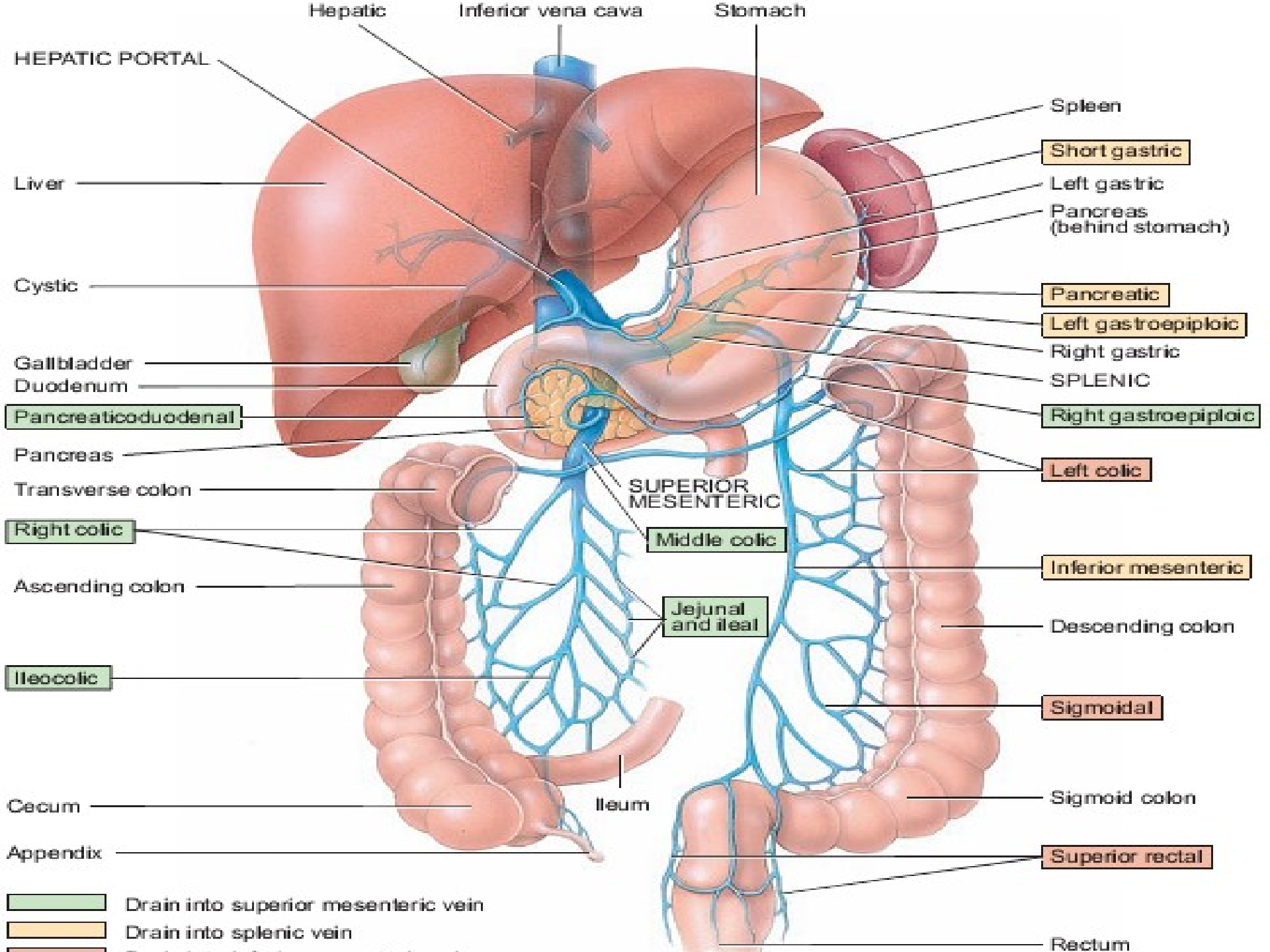


✓ Veins of the Abdominal Region

- inferior vena cava
  - parallels the abdominal aorta on the right.
  - Passes in caval opening (TV VIII) through diaphragm
  - empties into the right atrium
  - largest in diameter of all vessels in the body
  - has tributaries corresponding to the branches of the abdominal aorta .
  - (***Exceptions:*** the left gonadal veins and the left suprarenal vein drain into the left renal vein)

Hepatic portal system

- is one in which the veins that drain one group of capillaries delivers blood to another group of capillaries,
- which in turn are drained by systemic veins that carry blood to the vena cava and then into the right atrium of heart.
- two capillary beds in series:
  - veins that drain blood from capillaries in the GIT, pancreas, spleen, gallbladder into the capillaries in the liver (sinusoids)
  - right and left hepatic veins that drain the liver into the inferior vena cava


Hepatic
Inferior vena cava
Stomach
HEPATIC PORTAL
Liver
Cystic
Gallbladder
Duodenum
Pancreaticoduodenal
Pancreas
Transverse colon
Right colic
Ascending colon
Ileocolic
Cecum
Appendix
Spleen
Short gastric
Left gastric
Pancreas (behind stomach)
Pancreatic
Left gastroepiploic
Right gastric
SPLENIC
Right gastroepiploic
Left colic
SUPERIOR MESENTERIC
Middle colic
Inferior mesenteric
Jejunal and ileal
Descending colon
Sigmoidal
Ileum
Sigmoid colon
Superior rectal
Rectum
Drain into superior mesenteric vein
Drain into splenic vein

Hepatic portal vein

- drains blood from digestive organs
- enters liver via porta hepatis with hepatic arteries.
- Is the principal supply for liver.
- formed by union of:
  - SMV (from small intestine)
  - and splenic vein (from spleen) posterior to neck of pancreas.

Lymphatic system:

- consists of four elements:
  - a fluid called lymph,
  - lymphatic vessels that transport the lymph,
  - lymphatic tissue,
  - and red bone marrow

FUNCTIONS

1. Drains excess interstitial fluid.
2. Transports dietary lipids from the gastrointestinal tract to the blood.
3. Protects against invasion through immune responses.

lymph (LIMF: clear fluid)

- are derived from interstitial fluid
- are in lymphatic vessels.
- **Edema** – accumulation of tissue fluid

Lymphatic Vessels

- begin as lymphatic capillaries.

Lymphatic Capillaries

- are closed at one end
- made of endothelium (simple squamous epithelium)
- have greater permeability than blood capillaries
- can absorb large molecules such as proteins and lipids.
- slightly larger in diameter than blood capillaries
- have a unique structure that permits interstitial fluid to flow into them but not out.

- ***Lacteals:***
  - are specialized lymphatic capillaries
  - carry dietary lipids into lymphatic vessels.

Lymph Trunks and Ducts

Lymph trunks:

- formed by united lymphatic vessels in a particular region of the body.
- Principal lymph trunks are:
  - Lumbar trunks drain lymph from:
    - the free lower limbs,
    - the wall and viscera of the pelvis,
    - the kidneys, the adrenal glands, and the abdominal wall.
  - Intestinal trunk drains lymph from:
    - the stomach, intestines, pancreas, spleen, and part of the liver.
  - Bronchomediastinal drain lymph from:
    - thoracic wall, lung, and heart.
  - Subclavian trunks: drain the free upper limbs.
  - Jugular trunks: drain the head and neck.

Lymphatic ducts:

- formed by united lymphatic trunks.
- Principal ducts are:
  - a. Right lymphatic duct
  - b. Thoracic duct

Thoracic (left lymphatic) duct:

- is about 38–45 cm long
- begins as a dilation called the cisterna chyli anterior to the LV II.
- drains remainder part of the body
- empties into left subclavian vein.
- is the main duct for the return of lymph to blood.

Cisterna chyli: receives lymph from:

- the right and left lumbar trunks
- the intestinal trunk
- left jugular, left subclavian, and left bronchomediastinal trunks.

Right lymphatic duct:

- is about 1.2 cm long
- drains upper right part of the body
- empties in to right subclavian vein
- receives lymph from:
  - the right jugular, right subclavian, and right bronchomediastinal trunks.

Lymphatic Organs and Tissues

- are classified into two groups based on their functions.
- Primary lymphatic organs:
  - are the sites where stem cells divide and become immunocompetent.
  - Includes: red bone marrow and thymus.

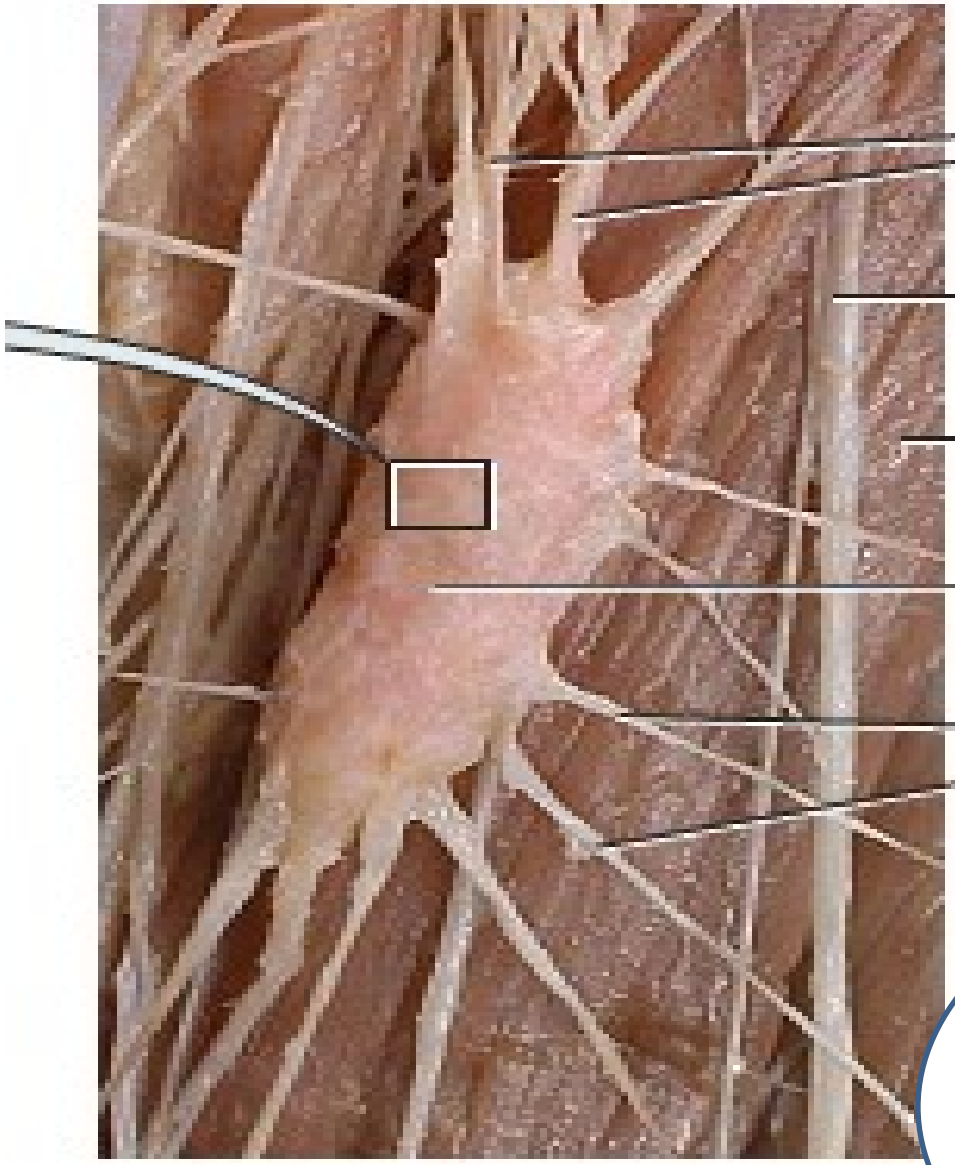
Thymus

- is a bilobed organ
- located in the mediastinum between the sternum and the aorta.
- extends from the top of the sternum to the top of the heart and its great vessels .

- secondary lymphatic organs:
  - are the sites where most immune responses occur.
  - Include: lymph nodes, the spleen.

Lymph Nodes

- Located along lymphatic vessels
- are about 600 bean-shaped along lymphatic vessels.
- are scattered throughout the body,
- help for filtration of lymph
- usually occur in groups.
- Some of the principal groups of lymph nodes are:
  - Popliteal and inguinal lymph nodes of lower limb
  - Lumbar lymph nodes pelvic region
  - Cubital and axillary lymph nodes – upper limb
  - Thoracic lymph nodes – chest
  - Cervical lymph nodes – neck



Anterior view of an inguinal lymph n

- ***Afferent lymphatic vessels:*** to the lymph nodes,
- ***efferent lymphatic vessels:*** away from the lymph

Spleen

- helps for filtration of blood, and destruction of old red cells.
- Is the largest single mass of lymphatic tissue.
- is a soft, encapsulated organ of variable size,
- Is about 12 cm in length.
- located in the left hypochondriac region between the stomach and diaphragm.
- It’s superior surface is smooth and convex .

- in the visceral surface of the spleen—are the:
  - gastric impression (stomach),
  - the renal impression (left kidney),
  - and the colic impression (left colic flexure of the large intestine).
- Spleenic hilum:
  - Which passes the:
    - large, tortuous splenic artery and splenic vein,
    - along with efferent lymphatic vessels.