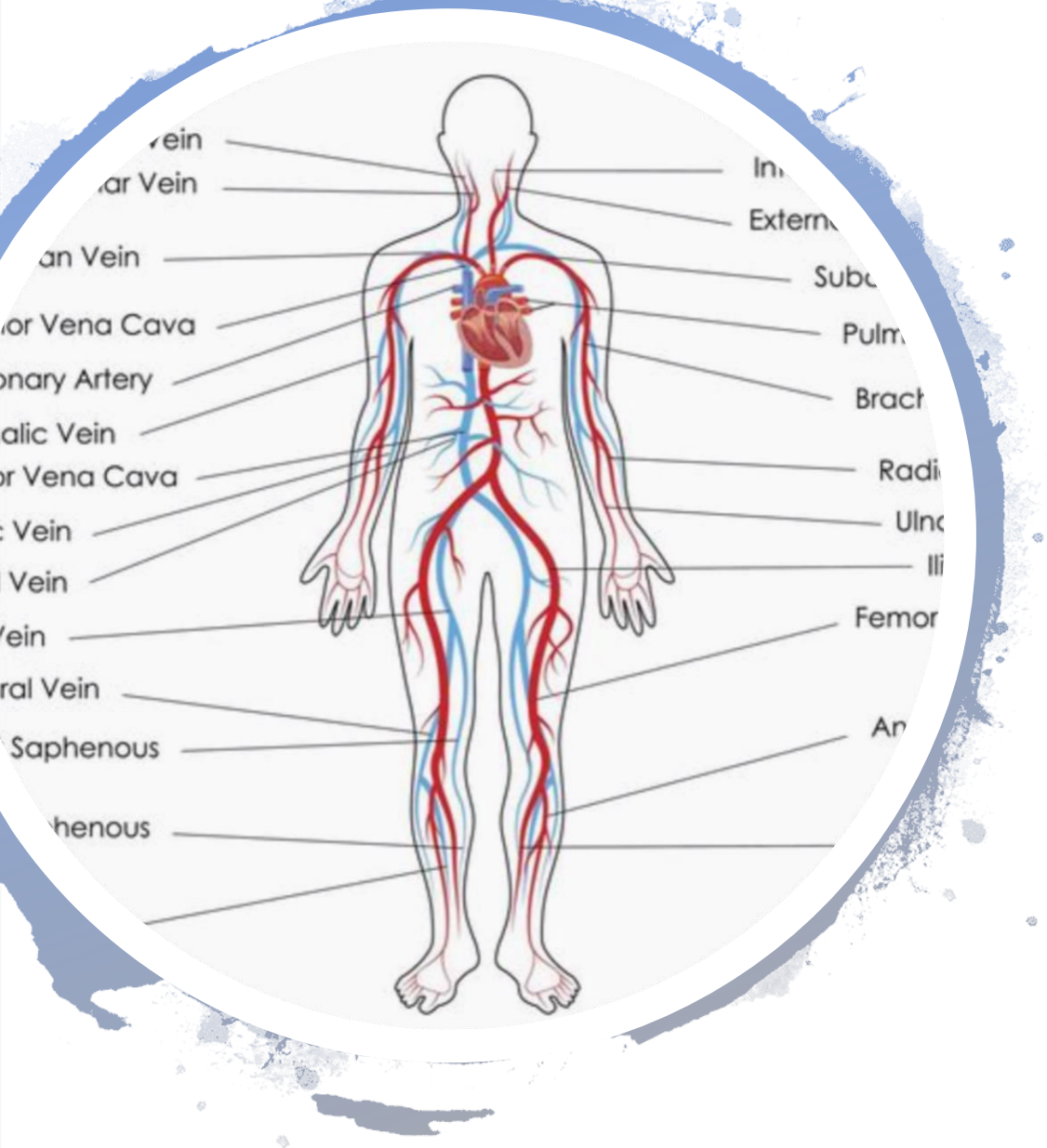

Heart, vessels and lymphatic system

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Learning Outcomes:

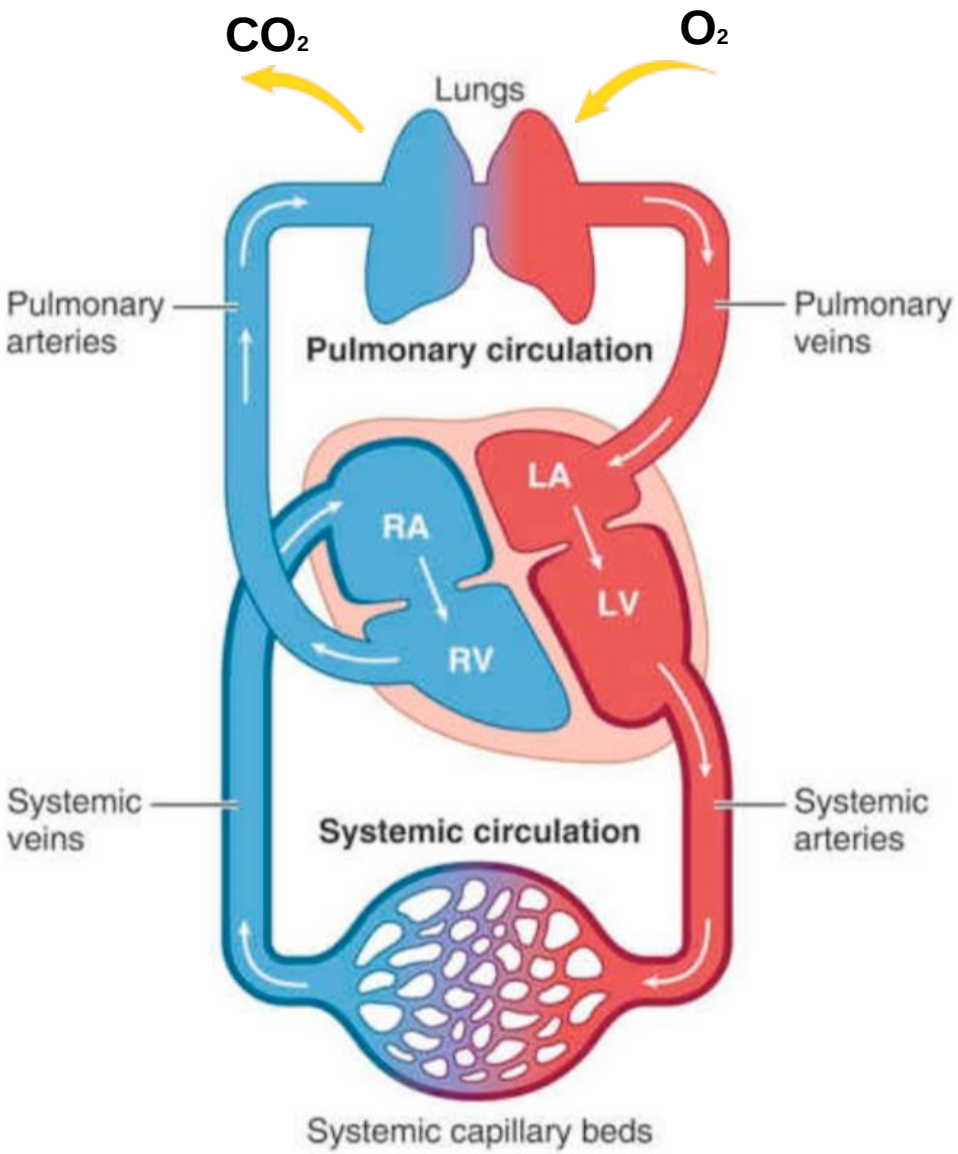
- Describe the general pattern of circulation in human.
- Explain the constitution of heart wall and pericardium.
- Describe the anatomical features of the heart.
- Outline the flow of blood through the heart.
- Describe the conducting and circulatory system of the heart.
- Describe the anatomical features of the lymphatic system.
- Outline the lymphatic circulation.

Circulatory system

The circulatory system transports fluids throughout the body.

1. Cardiovascular system
   blood transportation network

2. Lymphatic system
   lymph transportation network



Cardiovascular System

Cardiovascular system

Two major divisions

Pulmonary circuit

Carries deoxygenated blood from the heart to the lungs for gas exchange and returns oxygenated blood to the heart

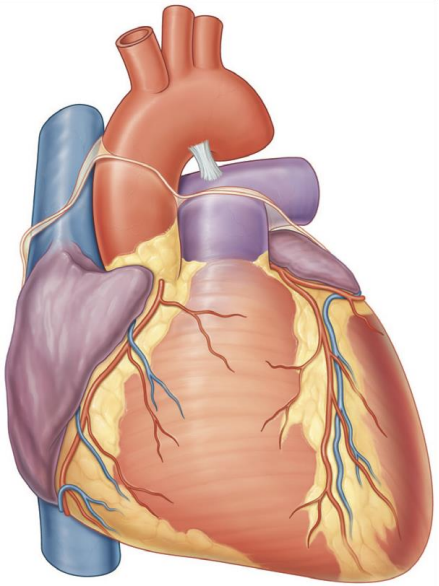
Systemic Circuit

Carries oxygenated blood from the heart to supply the whole body (including the lungs and the heart themselves) and returns deoxygenated blood back to the heart

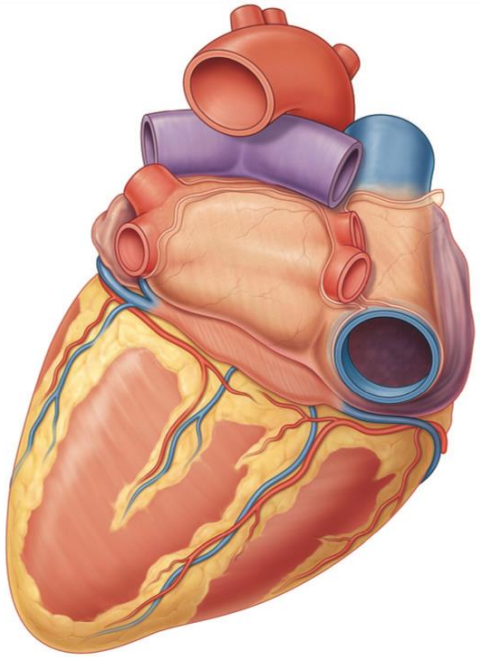
Functions

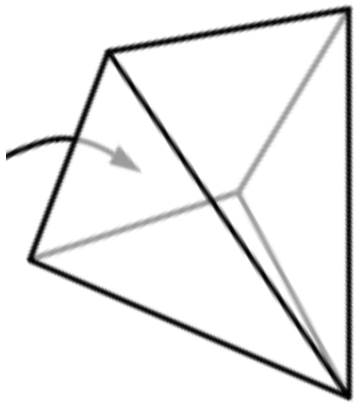
- pumps the blood through both pulmonary and systemic circuits
- generates and regulates blood pressure

Anterior view



Posterior view

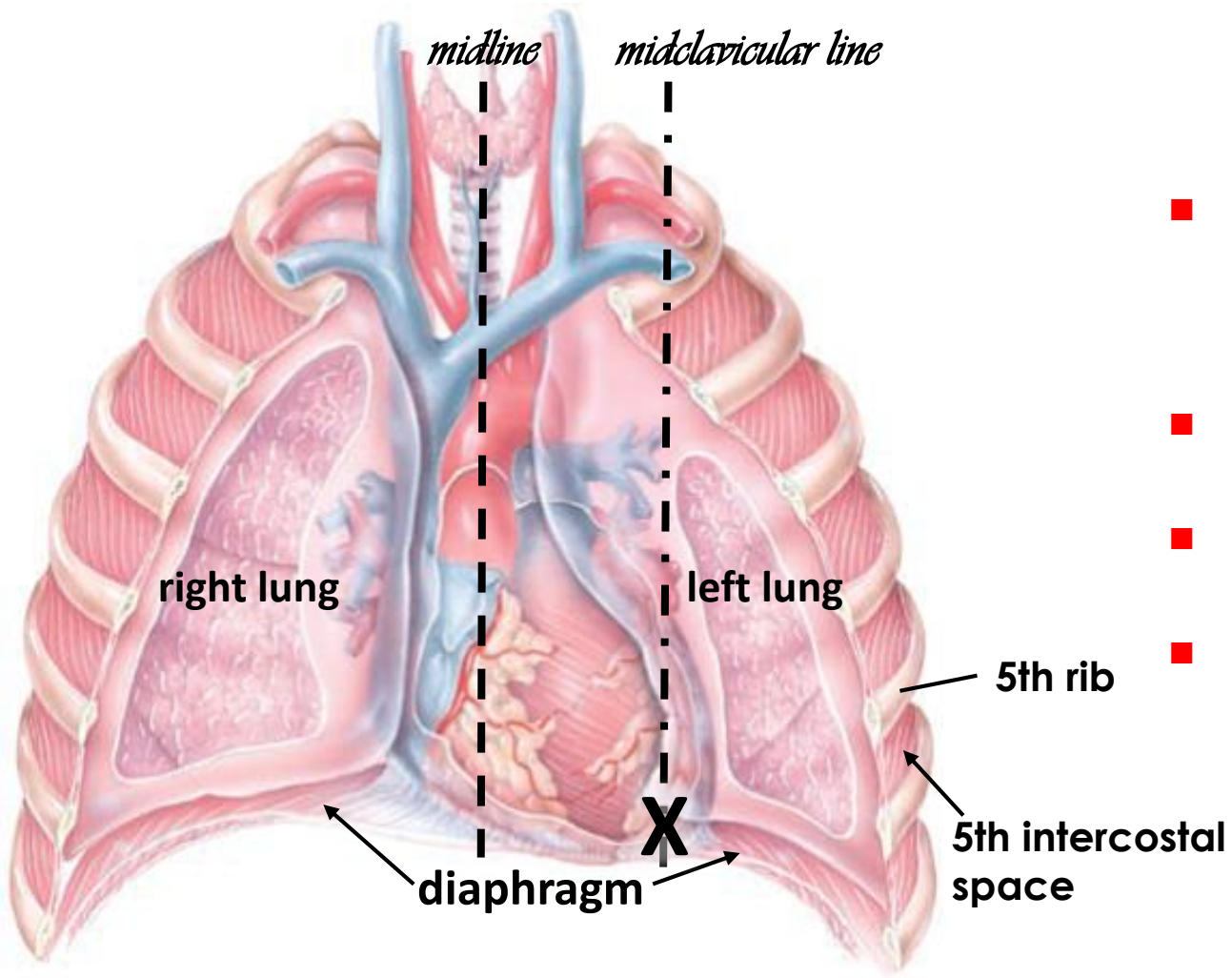




Size and Shape of the Heart

- about the size of one's loosely clenched fist
- tilted and inverted pyramid, pointing toward inferior left
- The apex of the heart is the inferior blunt tip, sit on the diaphragm
- The base of the heart is the broad superior portion facing the thoracic vertebrae, made up of right and left atrium

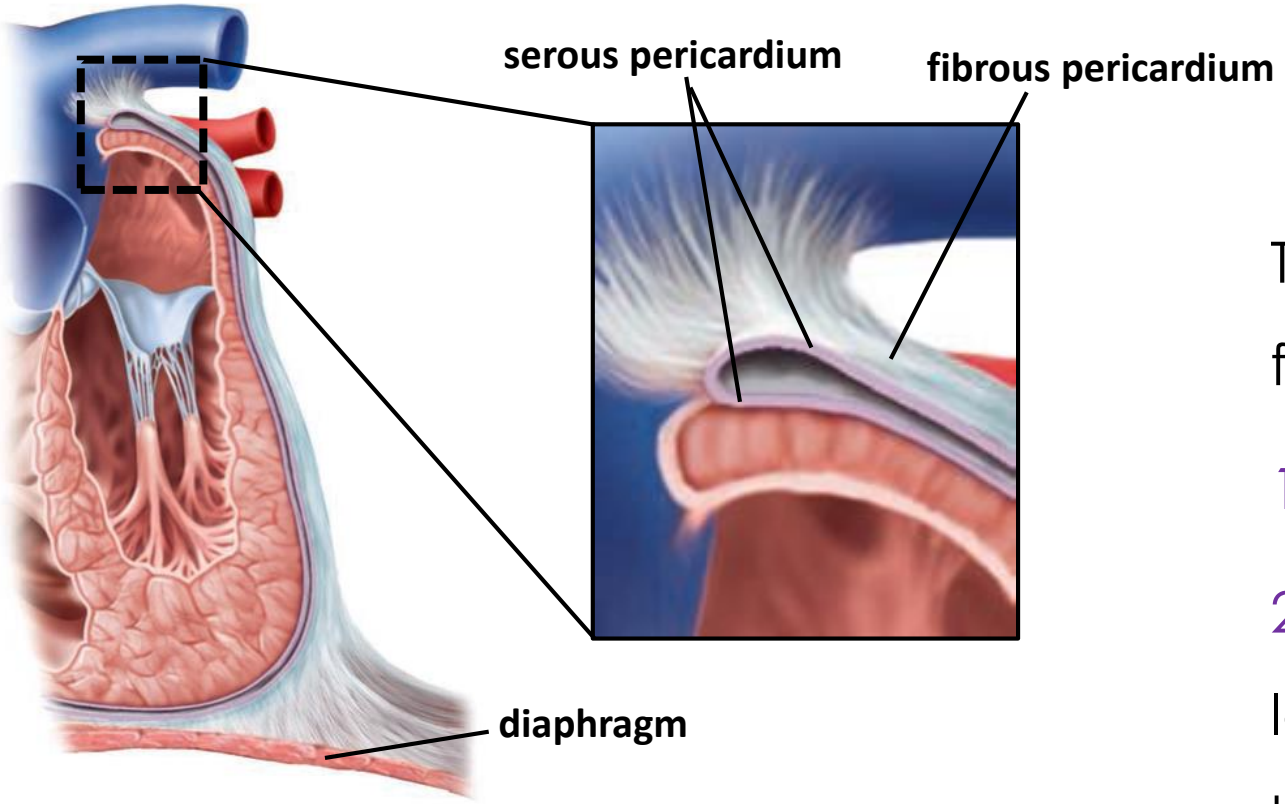
Location of the Heart

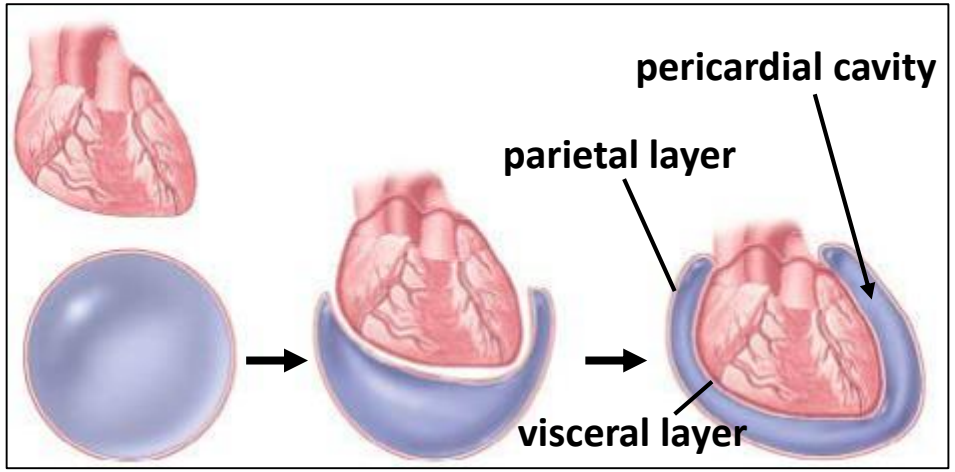


Anterior view

- in the mediastinum, between the lungs
- superior to the diaphragm
- posterior and to the left of the sternum
- apex locates at the left midclavicular line of the 5th intercostal space

Pericardium





Serous pericardium

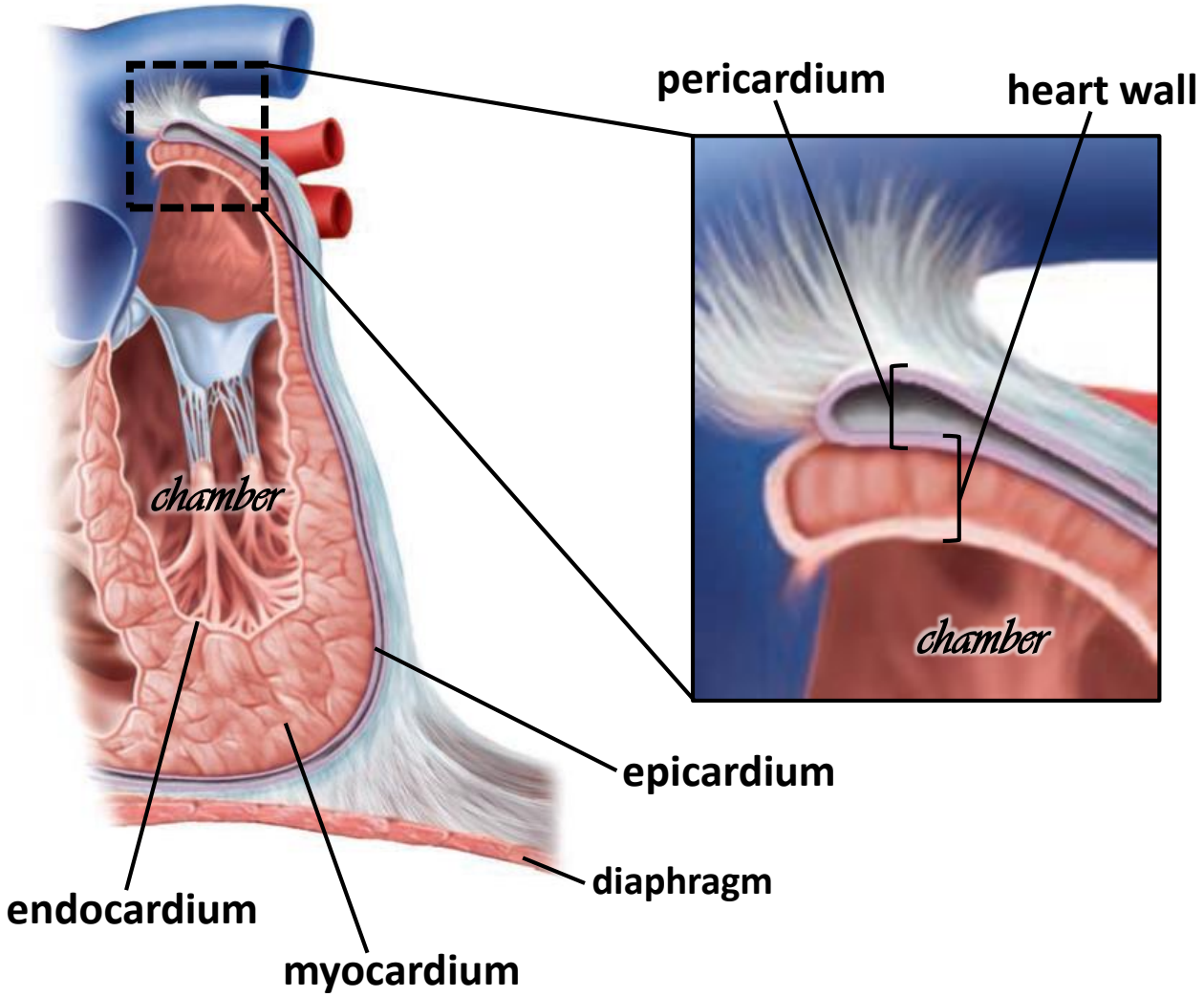
The pericardium surrounds the heart, from outer to inner:

1. fibrous pericardium

2. serous pericardium: formed by two layers with a pericardial cavity in between containing pericardial fluid

- parietal layer
- visceral layer

Heart wall



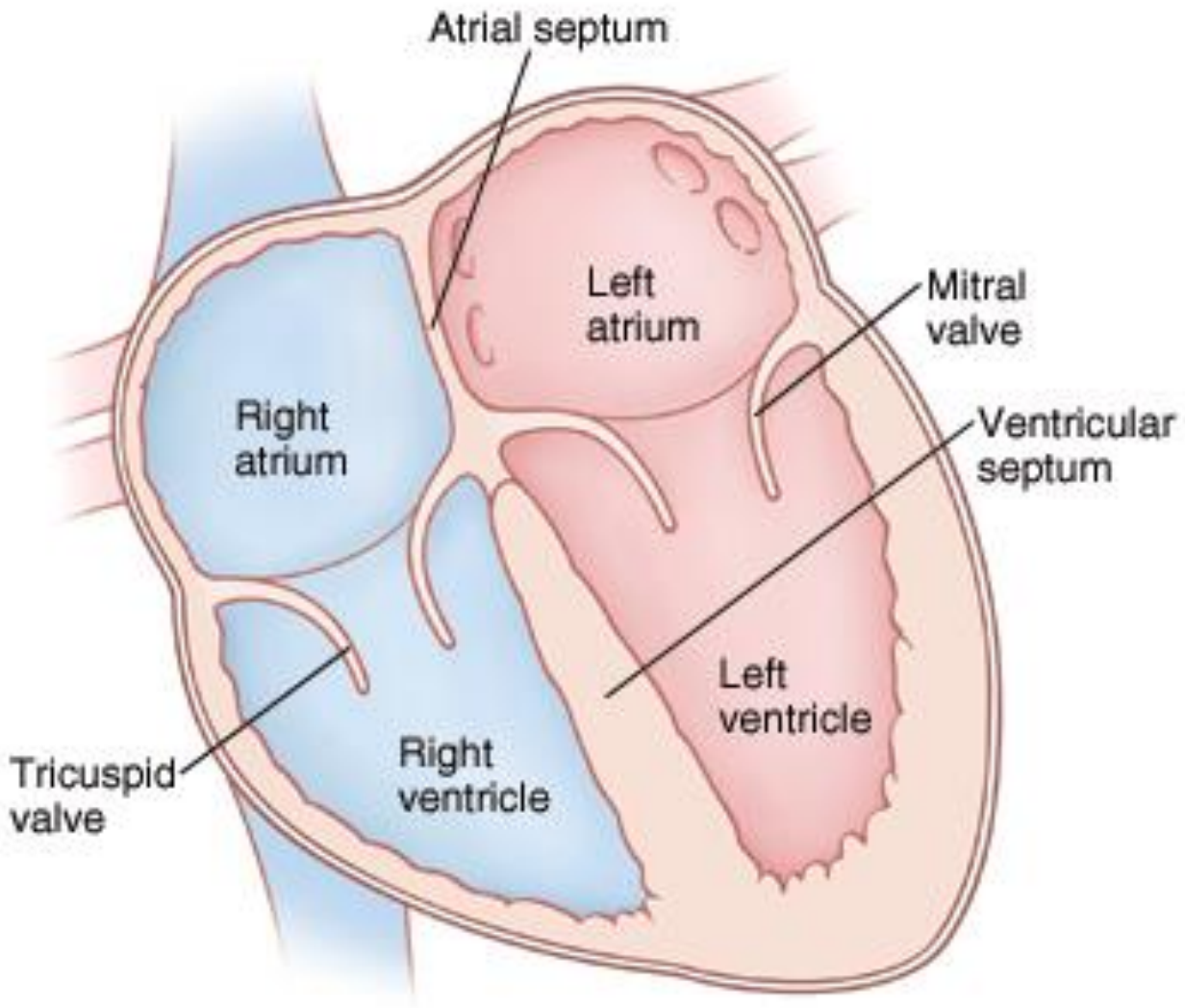
The wall of the heart have 3 layers, from innermost to outermost:

endocardium: lines the chambers of the heart by a layer of simple epithelium

myocardium: thickest layer, formed by cardiac muscle cells

epicardium (visceral layer of serous pericardium): contains coronary vessels

Heart chambers



The heart has four chambers:

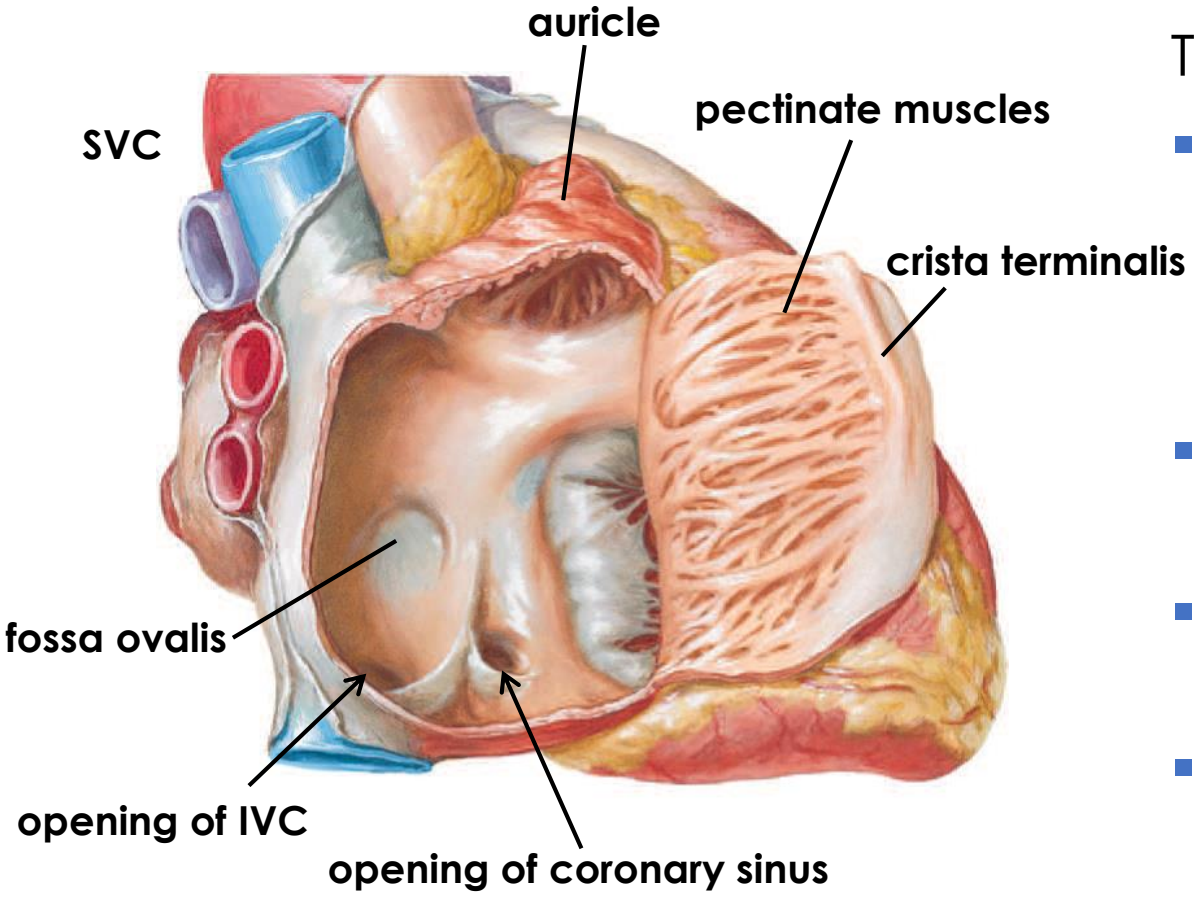
Right and left **atria**:

- 2 upper chambers
- thin walled, receiving chambers

Left and right **ventricles**:

- 2 lower chambers
- thick walled, pumping chambers

Right atrium(RA)

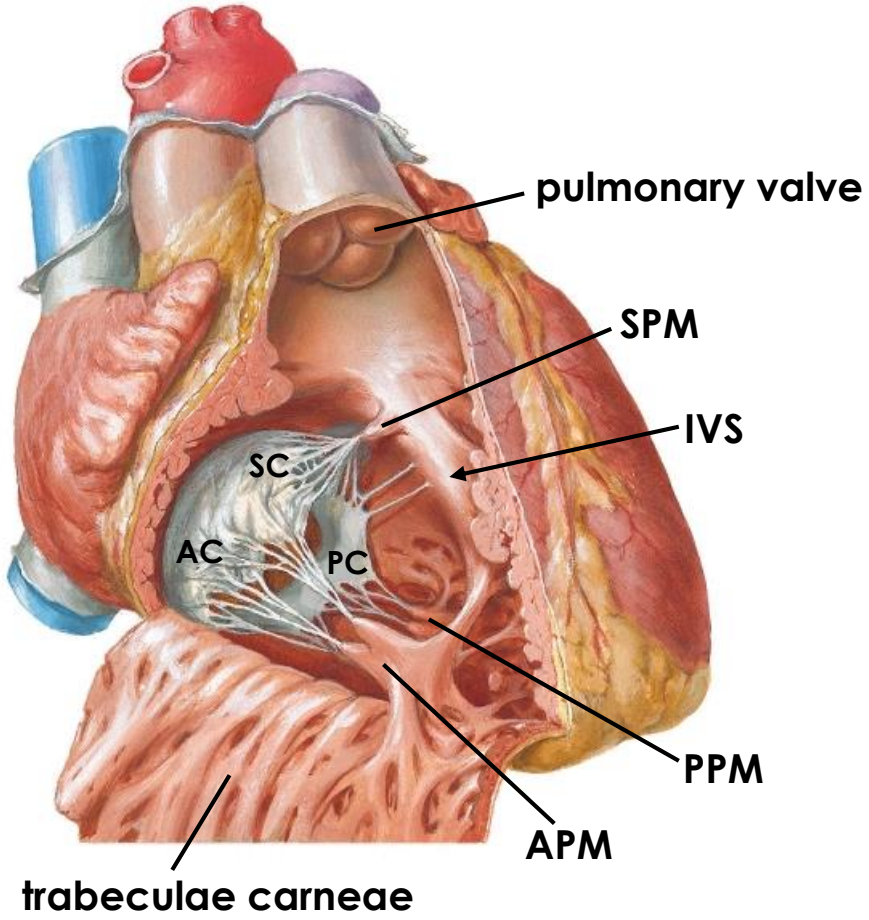


Right atrium forms the right border of the heart.

The interior of the RA has:

- a smooth wall posteriorly containing
  - opening of SVC
  - opening of IVC
  - opening of the coronary sinus
- a rough, muscular wall anteriorly
  - pectinate muscles
- crista terminalis separating smooth and rough wall
- an oval, thumbprint-sized depression, called fossa ovalis, in the interatrial septum
- an ear-like right auricle projected superiorly and anteriorly

Right ventricle(RV)



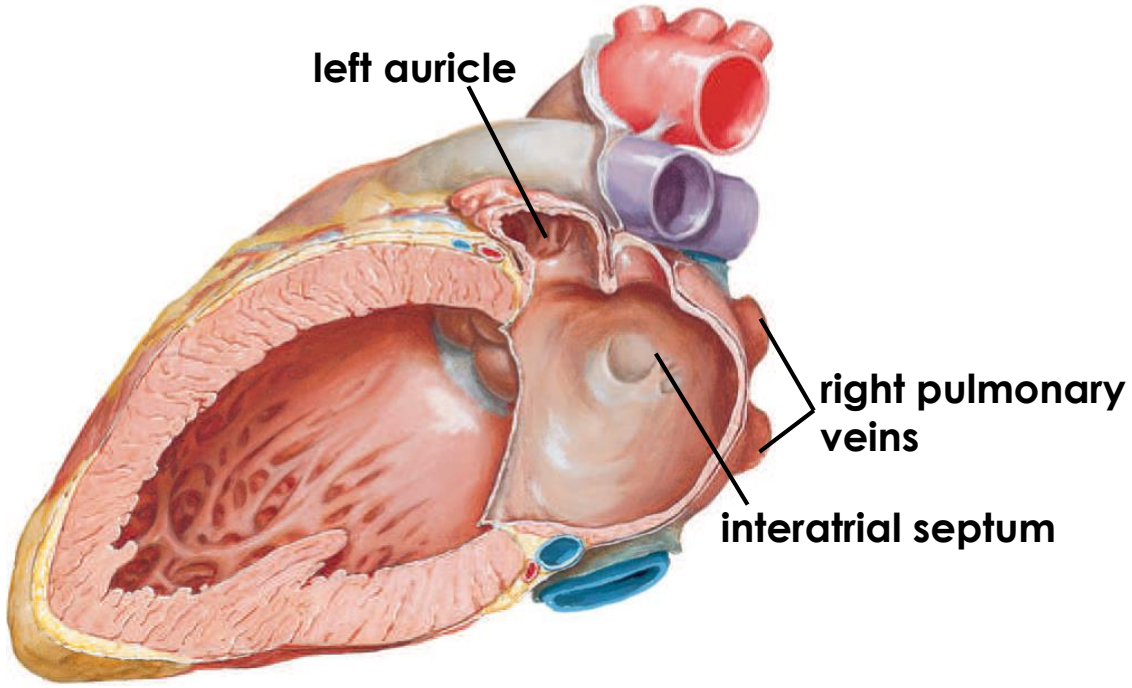
Right ventricle forms the anterior surface and the inferior border of the heart.

- guarded by tricuspid valve at right AV orifice

anterior cusp (**AC**)
posterior cusp (**PC**)
septal cusp (**SC**)
→ tendinous cords (chordae tendineae) →
anterior papillary muscle (**APM**)
posterior papillary muscle (**PPM**)
septal papillary muscle (**SPM**)

- separated from left ventricle by interventricular septum(IVS)
- communicates with the pulmonary trunk through pulmonary valve(semilunar valve)
- contains a rough, muscular wall
  - trabeculae carneae

Left atrium(LA)

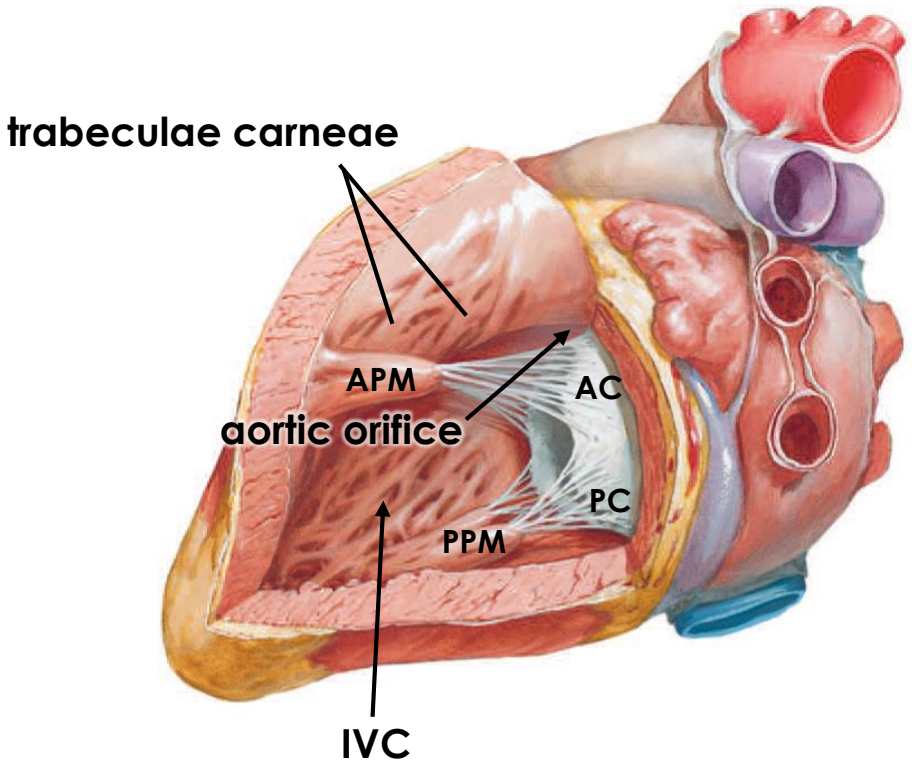


Left atrium forms most of the base of the heart.

The interior of the left atrium has:

- a large smooth-walled part and a smaller muscular left auricle containing pectinate muscles
- opening of four pulmonary veins
- smooth-walled interatrial septum

Left ventricle(LV)



The left ventricle forms the apex of the heart, nearly all its left surface and border.

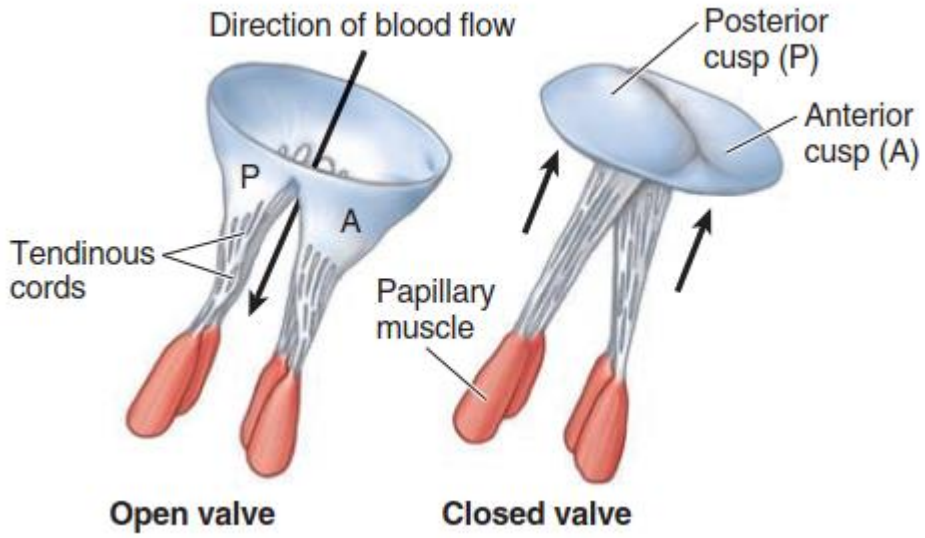
The interior of the left ventricle has:

- guarded by bicuspid valve at the left AV orifice

anterior cusp (**AC**) / posterior cusp (**PC**) → tendinous cords (chordae tendineae) → anterior papillary muscle (**APM**) / posterior papillary muscle (**PPM**)

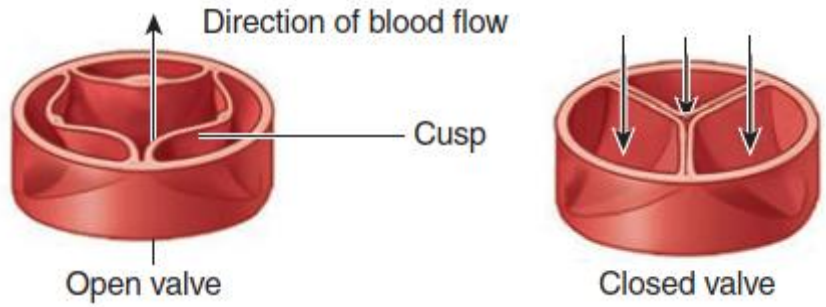
- separated from right ventricle by IVS
- communicates with the ascending aorta via aortic valve(semilunar valve) at aortic orifice
- contains a thick, rough, muscular wall
  - trabeculae carneae

Blood flow through valves



Bicuspid/tricuspid valves:

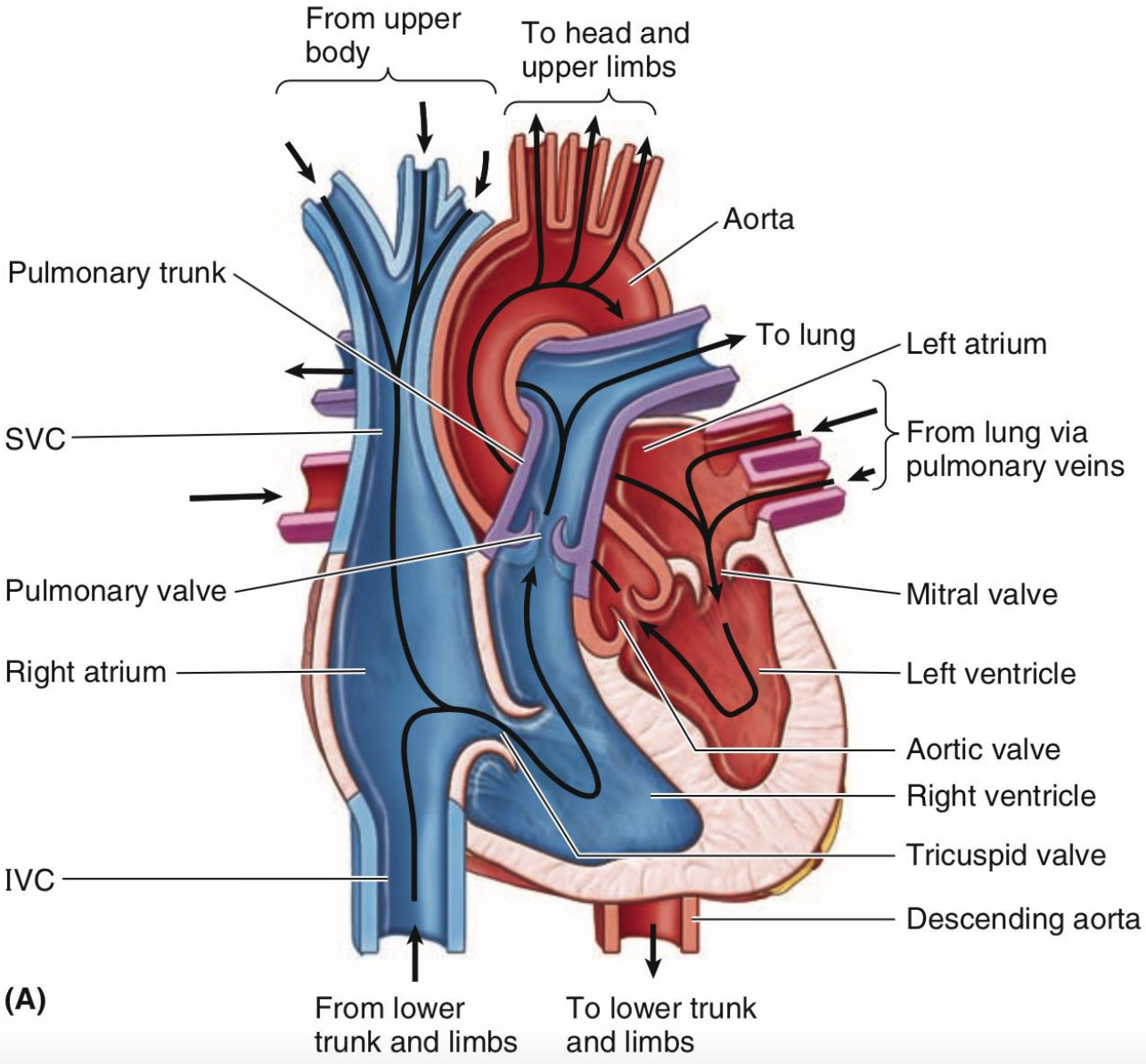
- Atrial pressure increases → blood flow pushes through → tendinous cords loose and papillary muscles relax → **valves open**
- Ventricular pressure increases→ blood flow pushes back → tendinous cords tighten and papillary muscles contract → **valves close**



Semilunar valves:

- Ventricular pressure increases → blood flow pushes the cusps aside → **valves open**
- Ventricular pressure decreases → reflux of blood enter pulmonary sinuses → **valves close**

The flow of the blood in heart



Systemic circuit

↓

Right atrium

↓

Tricuspid valve

↓

Right ventricle

↓

Pulmonary valve

↓

Pulmonary circuit

↓

Left atrium

↓

Bicuspid valve

↓

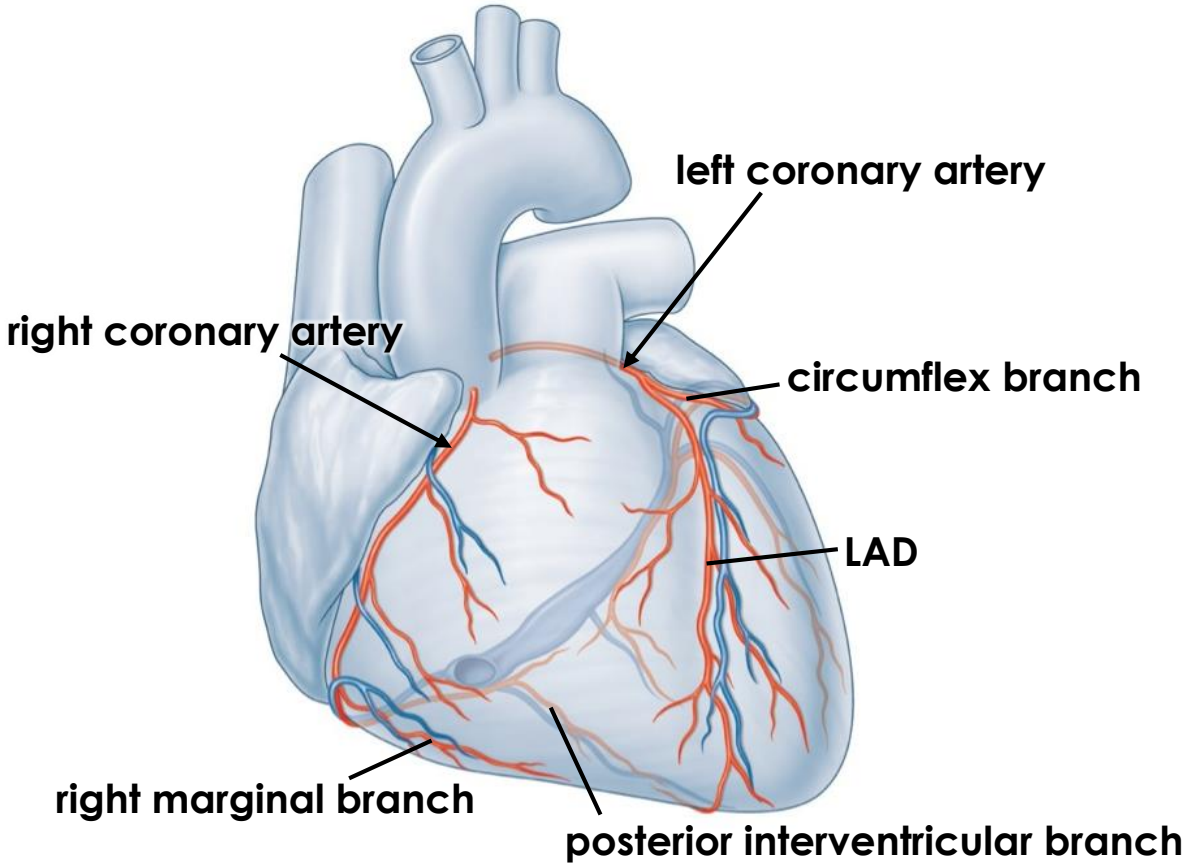
Left ventricle

↓

Aortic valve

→ Systemic circuit

Coronary Circulation

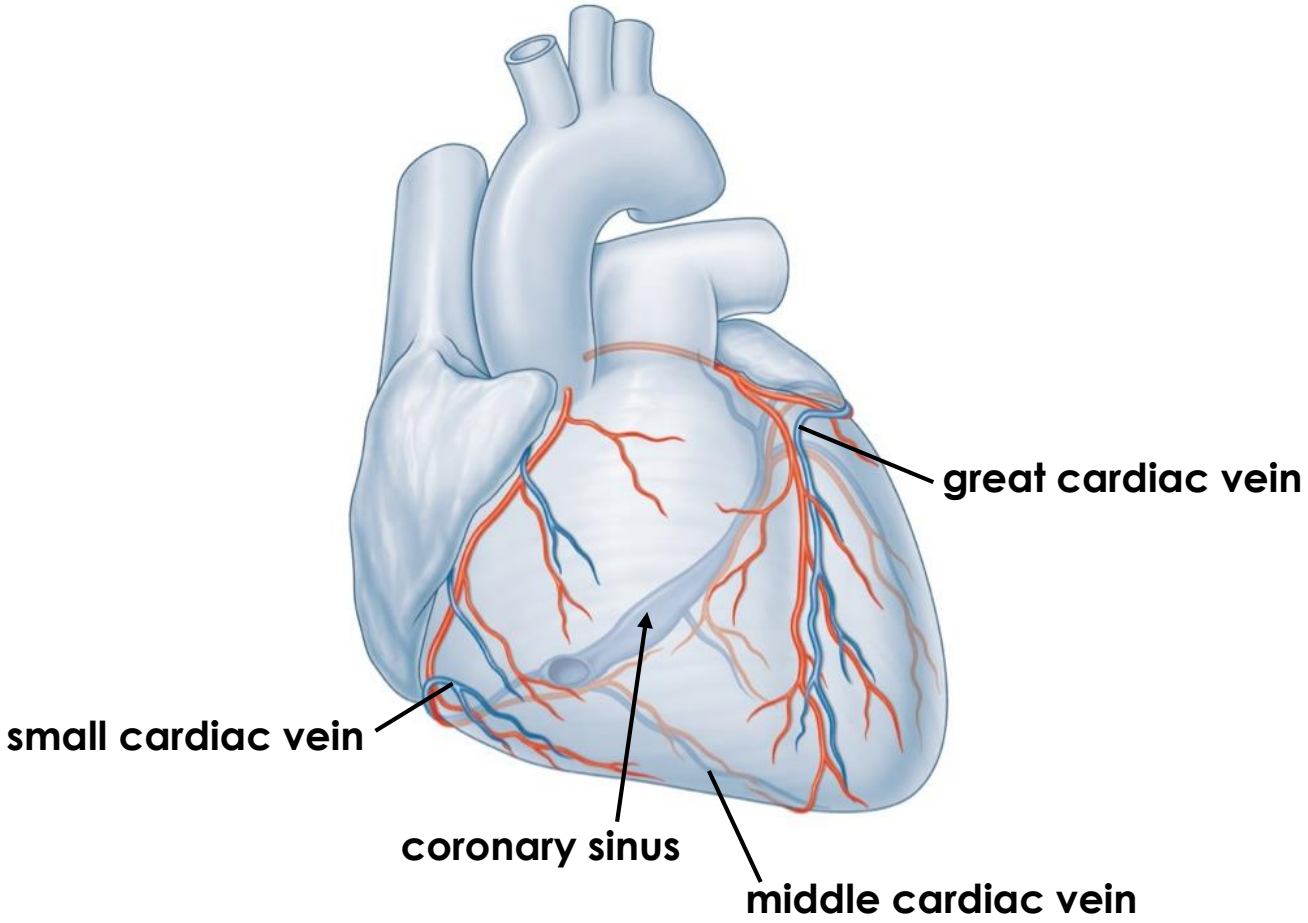


Coronary arteries supply blood to the heart muscle.

Two main coronary arteries arise from the corresponding aortic sinuses at the initial portion of ascending aorta:

- the right coronary artery
  - right marginal branch
  - posterior interventricular branch
- the left coronary artery
  - anterior interventricular branch (LAD)
  - circumflex branch

Coronary Circulation



Cardiac veins collect and return blood to the right atrium through the **coronary sinus**.

- great cardiac vein

  - accompanied with LAD

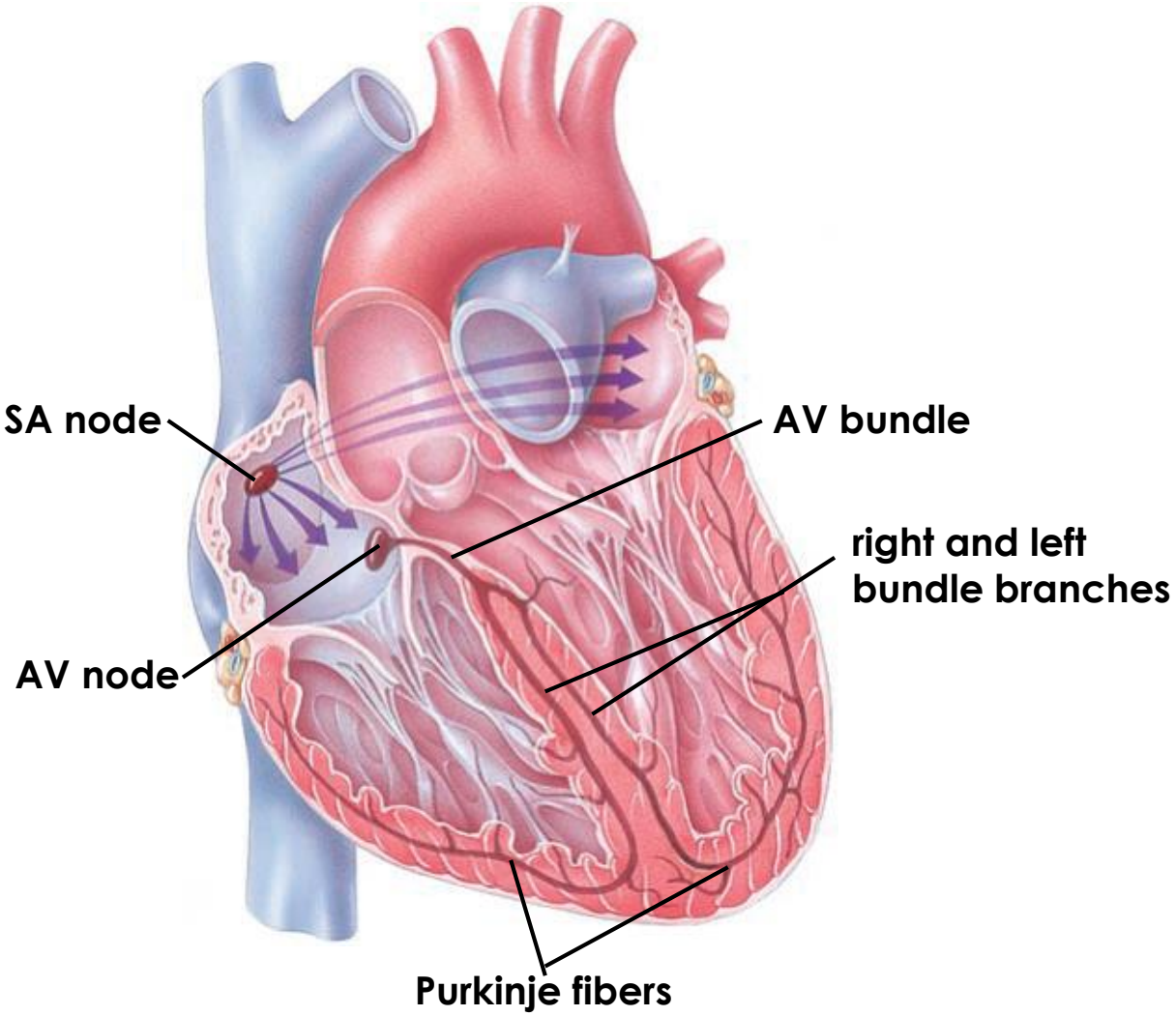
- middle cardiac vein

  - accompanied with posterior interventricular branch

- small cardiac vein

  - accompanied with right marginal branch

Conducting System of the Heart



Specialized cardiac conducting cells initiate and conduct the electrical signals locally, ensure that the four heart chambers are coordinated with each other.

sinoatrial (SA) node (pacemaker)

↓ spread throughout the atria

atrioventricular (AV) node

↓

AV Bundle (Bundle of His)

↓ through interventricular septum

right and left bundle branches

↓

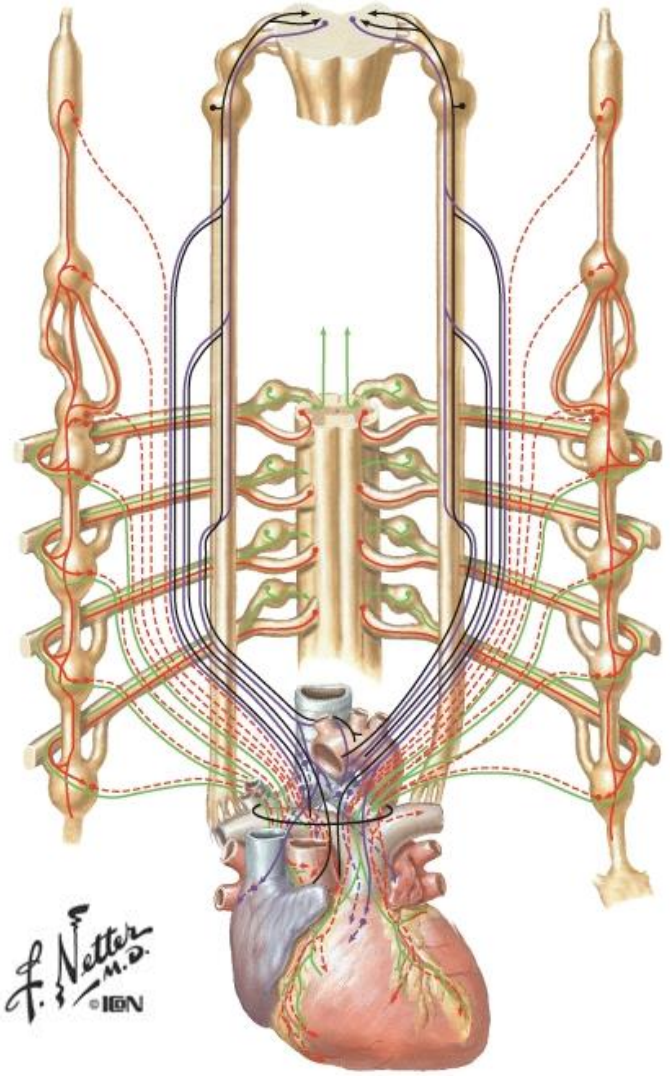
Purkinje fibers spread throughout the ventricular myocardium

Innervation of the heart

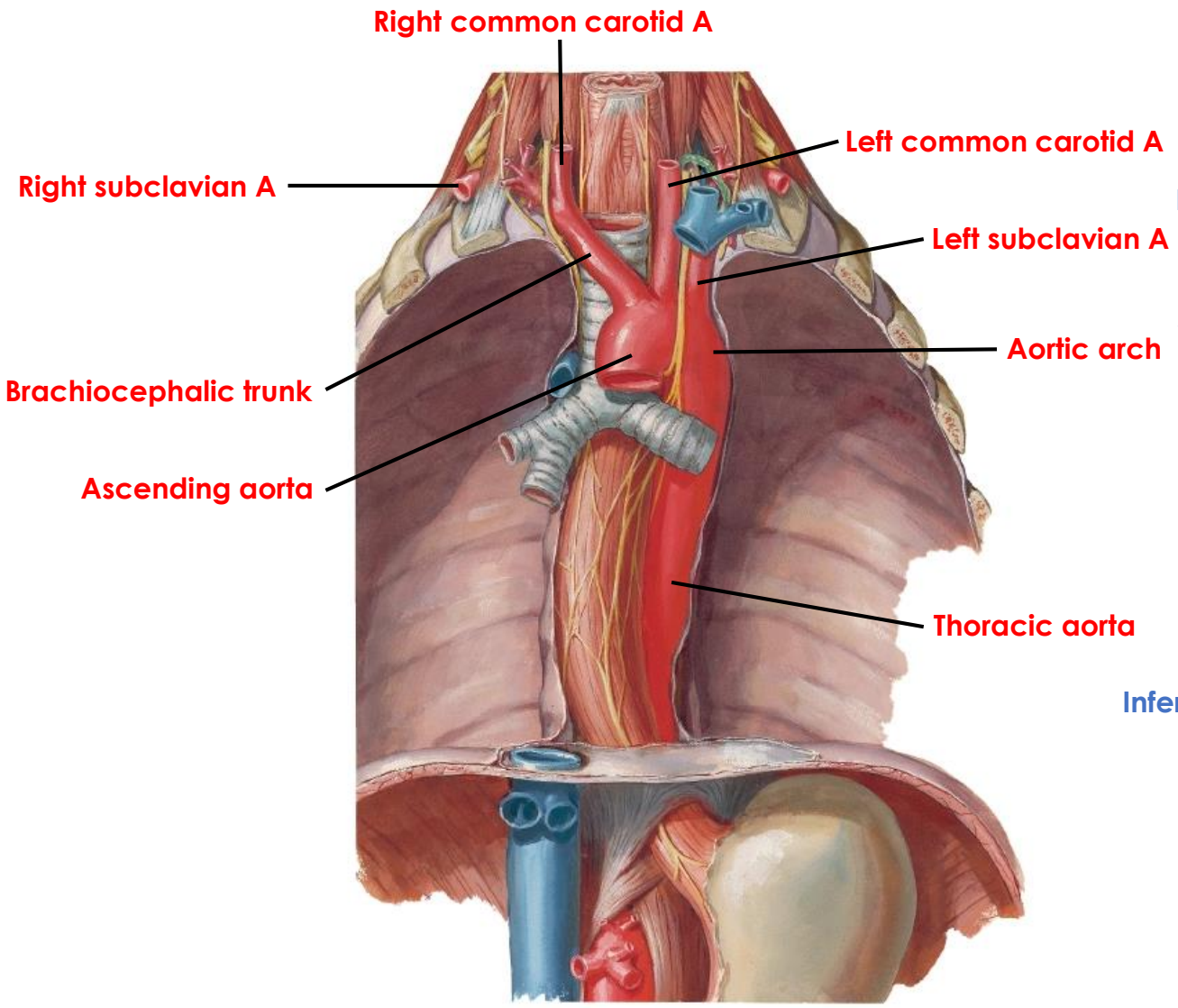
The heart is supplied by cardiac plexus formed of sympathetic and parasympathetic fibers, part of the autonomic nervous system.

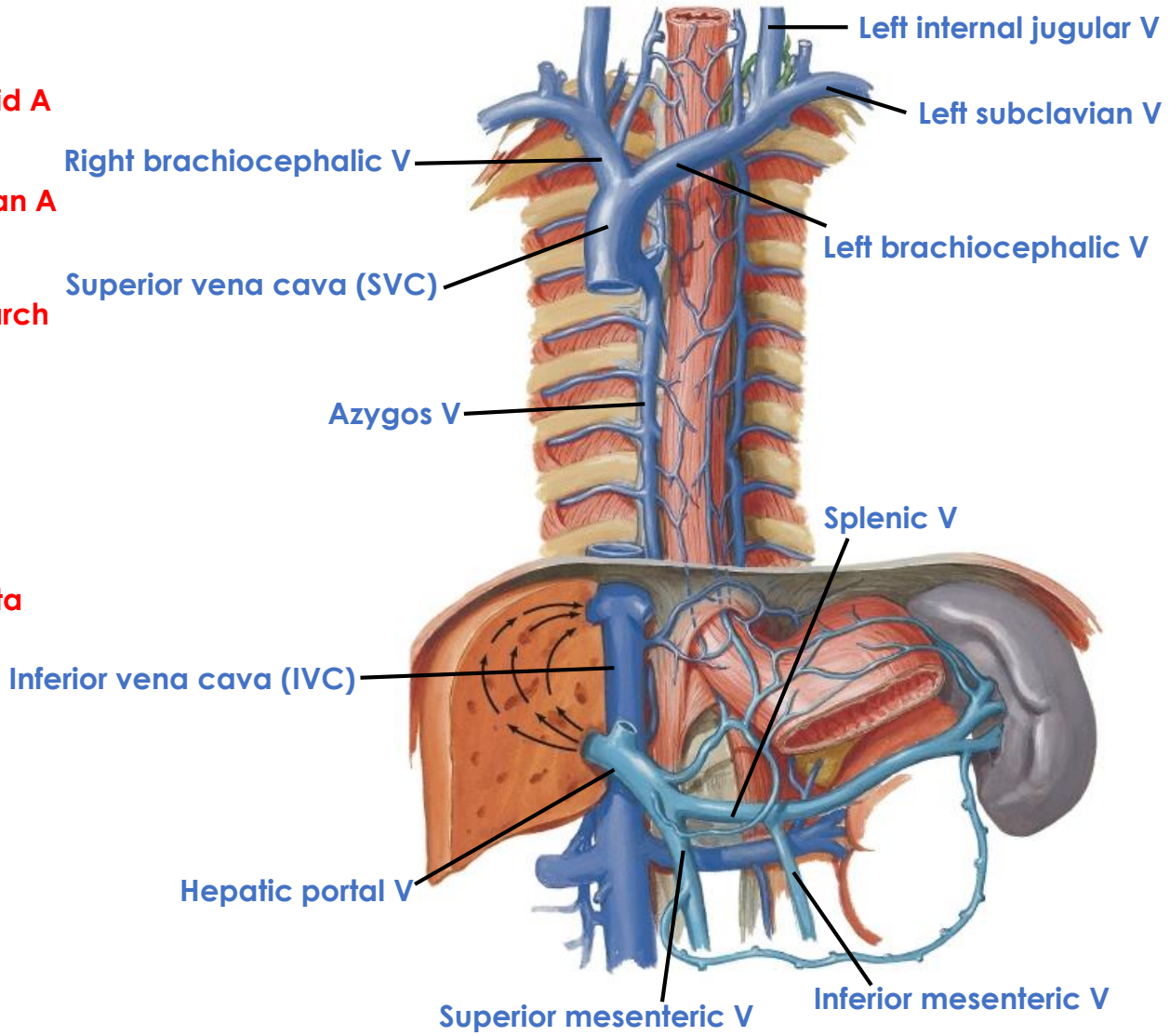
- sympathetic stimulation(sympathetic trunk):
  - increase heart rate
  - increase force of contraction
  - dilation of coronary arteries

- parasympathetic stimulation(vagus nerve):
  - decrease heart rate
  - decrease force of contraction
  - constriction of coronary arteries

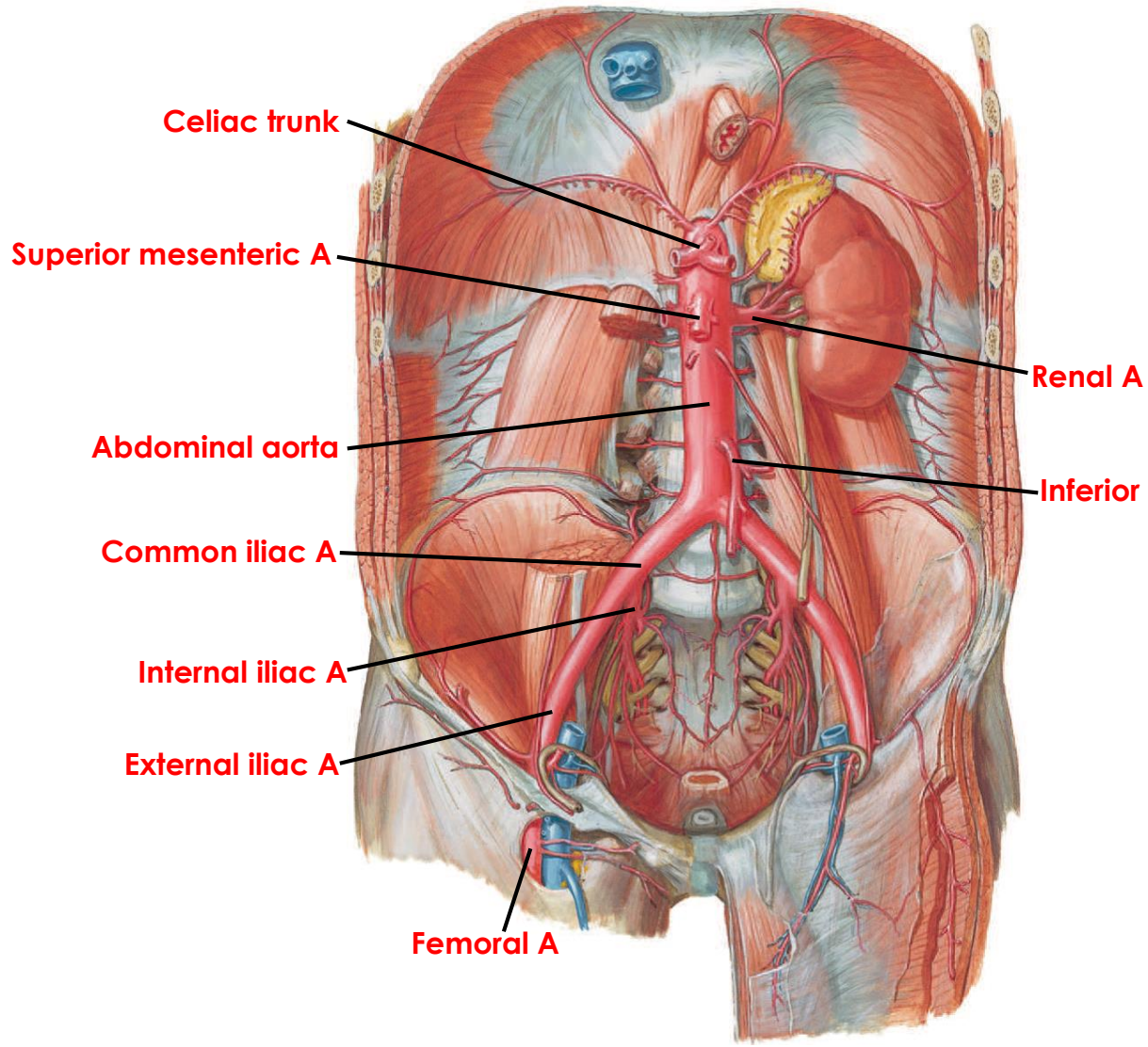


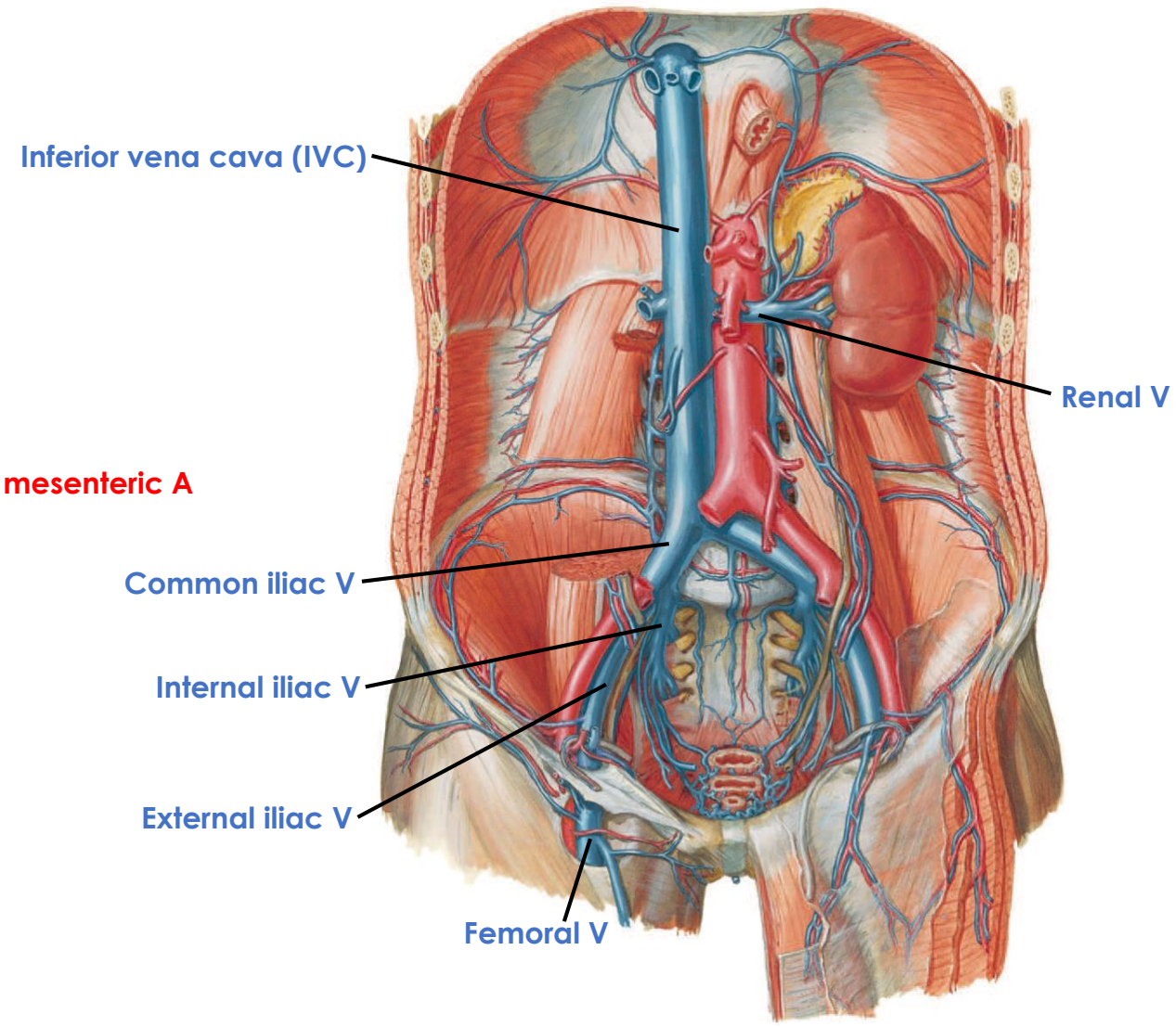
Great Vessels

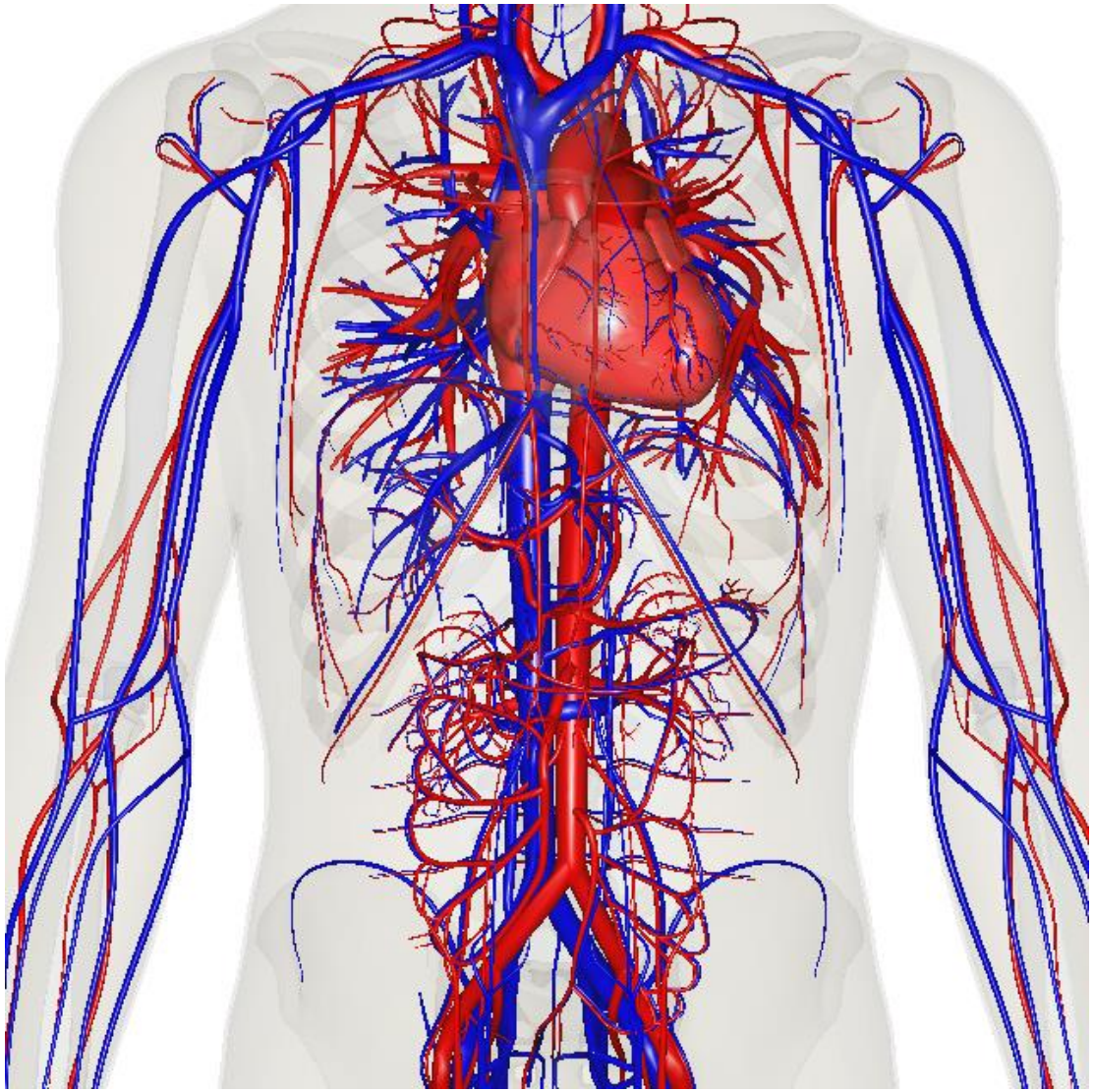




Great Vessels





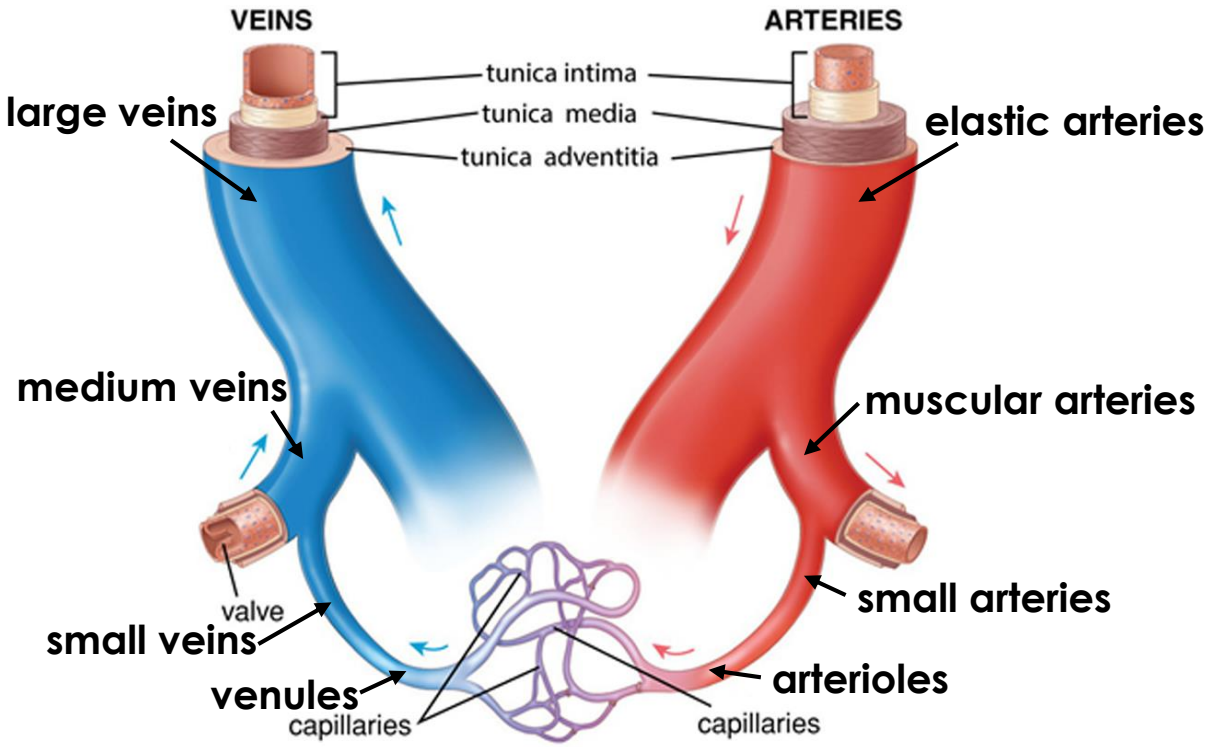


Blood Vessels

Three principal categories of blood vessels: arteries, veins, and capillaries

- Arteries are the vessels carry blood away from the heart
- Veins are the vessels carry blood back to the heart
- Capillaries are microscopic, thin-walled vessels, forming capillary bed connecting arteries and veins

Structure of Blood Vessels

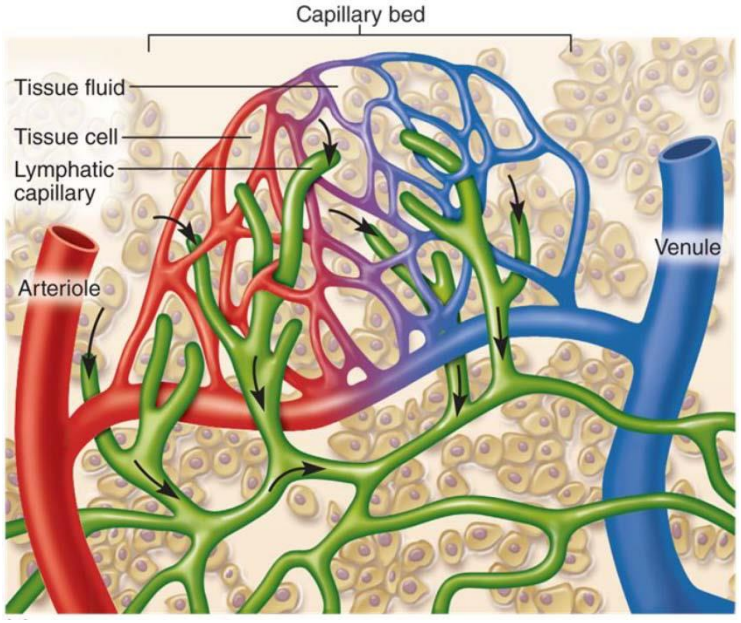


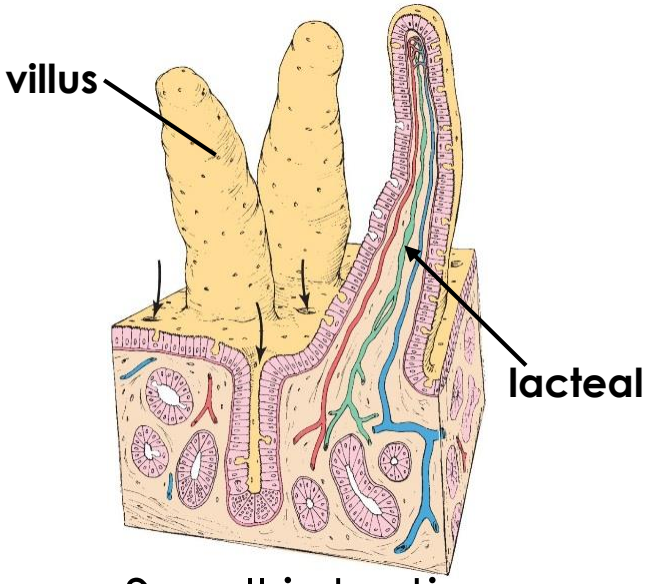
The walls of arteries and veins are composed of 3 layers, from innermost to outermost:

- tunica intima
  - endothelial lining
  - elastic tissues
- tunica media
  - elastic fibers
  - smooth muscles
- tunica externa (adventitia)
  - connective tissues

	Tunica intima	Tunica media	Tunica externa
Arteries	most elastic tissue	varies	relatively thick
Veins	very little tissue	thin layer	relatively thick
Capillaries	simple endothelial lining	absent	very delicate

Organization of Lymphatic System





Small intestine

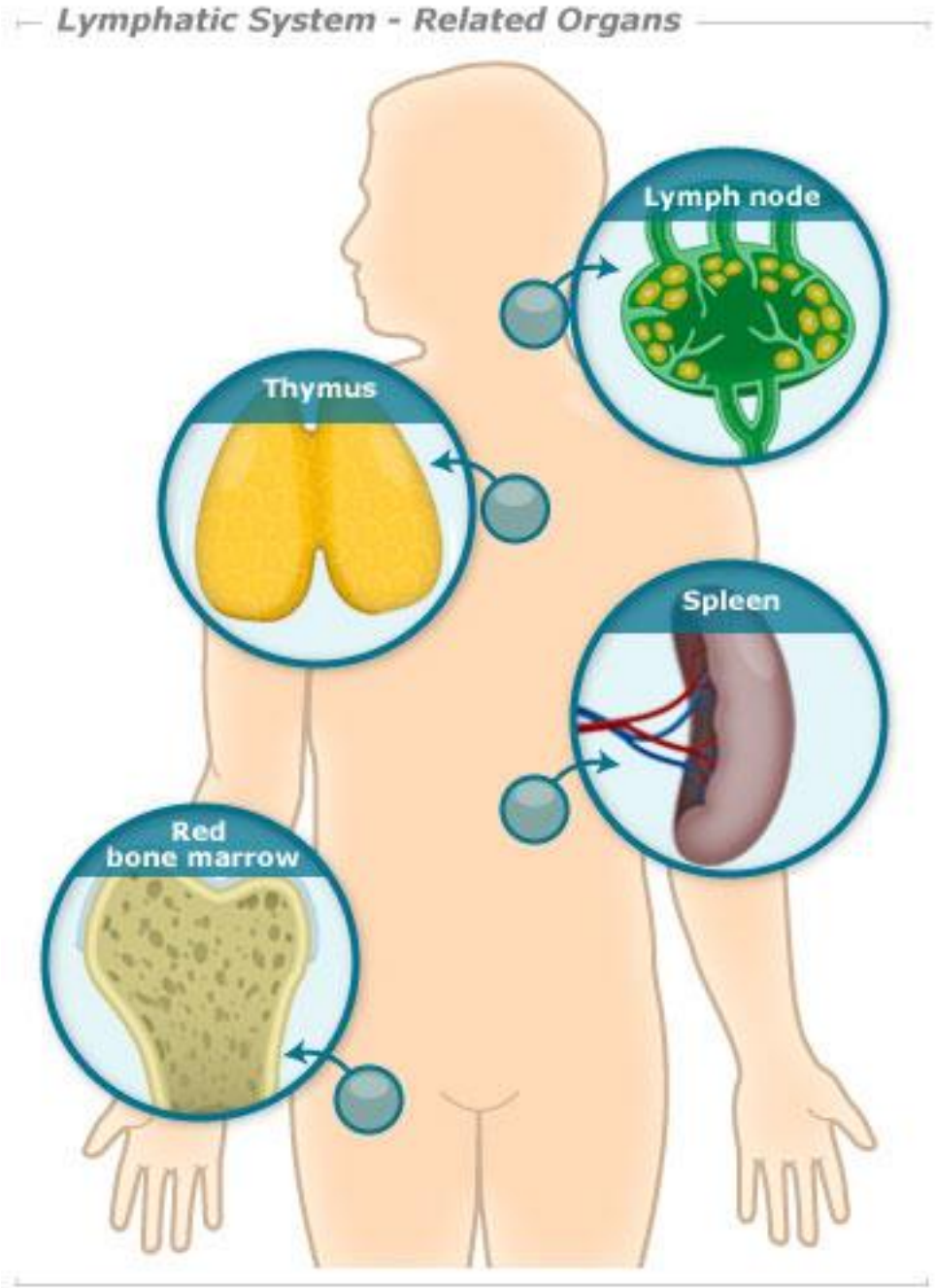
The lymphatic system consists of **lymphoid organs**, the network of **lymphatic vessels**, and **lymph.**

Function of lymphatic system

1. fluid balance (maintain homeostasis)
   - recover fluid lost from blood capillaries

2. defense (immunity)
   - guard against pathogens

3. fat absorption via intestinal lacteals
   - chyle (lymph + lipids) is absorbed through lacteal located in the core of the villus of small intestine



The Pennsylvania State University

Major lymphatic tissue and organs

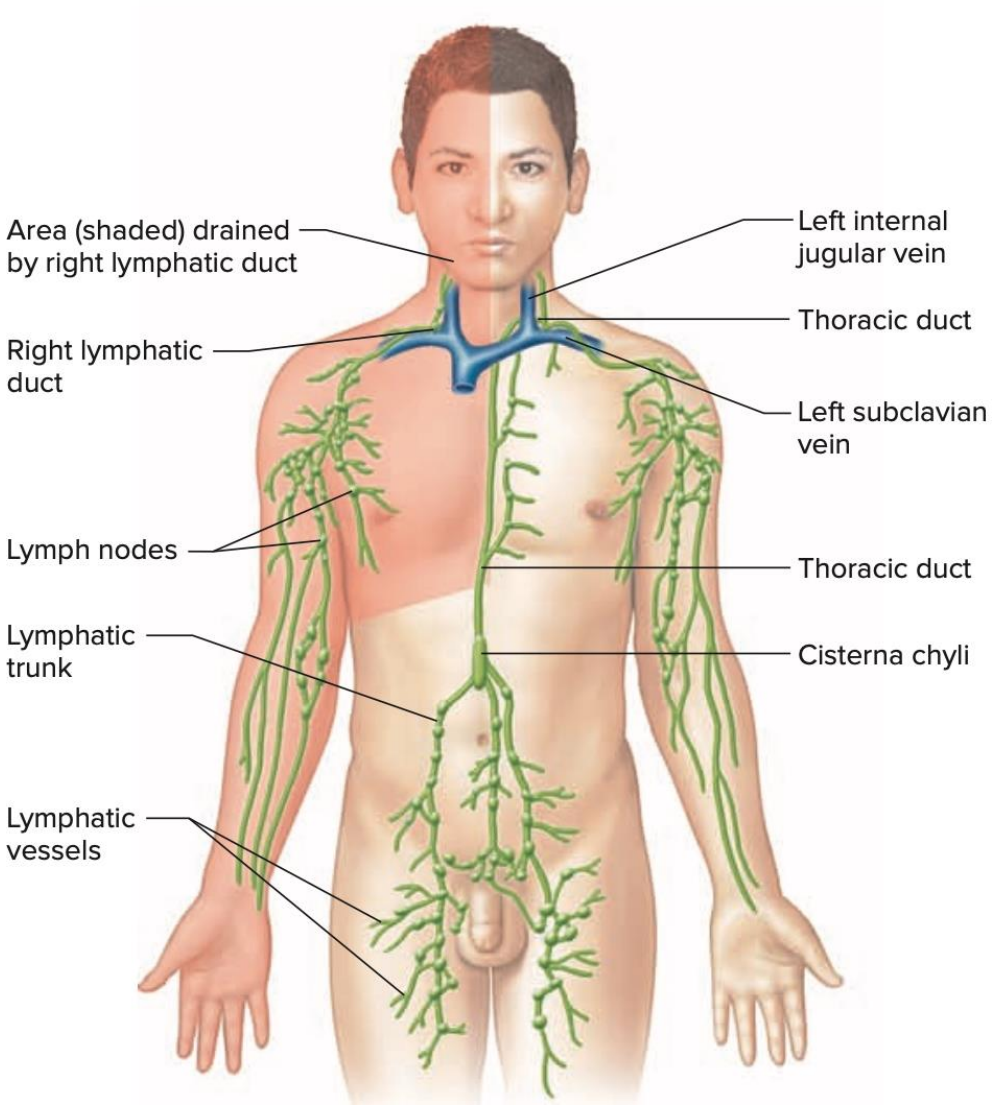
Primary organs: Sites where lymphoid stem cells are divided and matured into immunocompetent T and B cells

- thymus (T cells)
- bone marrow (B cells)

Secondary organs: Immunocompetent cells populate these tissues and initiate immune responses to foreign antigen

- lymph nodes
- spleen
- tonsils

Lymphatic circulation



interstitial fluid (**lymph**)

↓

lymph capillaries

↓

lymphatic vessels

- afferent vessels
- ↓
- lymph nodes
- ↓
- efferent vessels

↓

lymphatic trunks

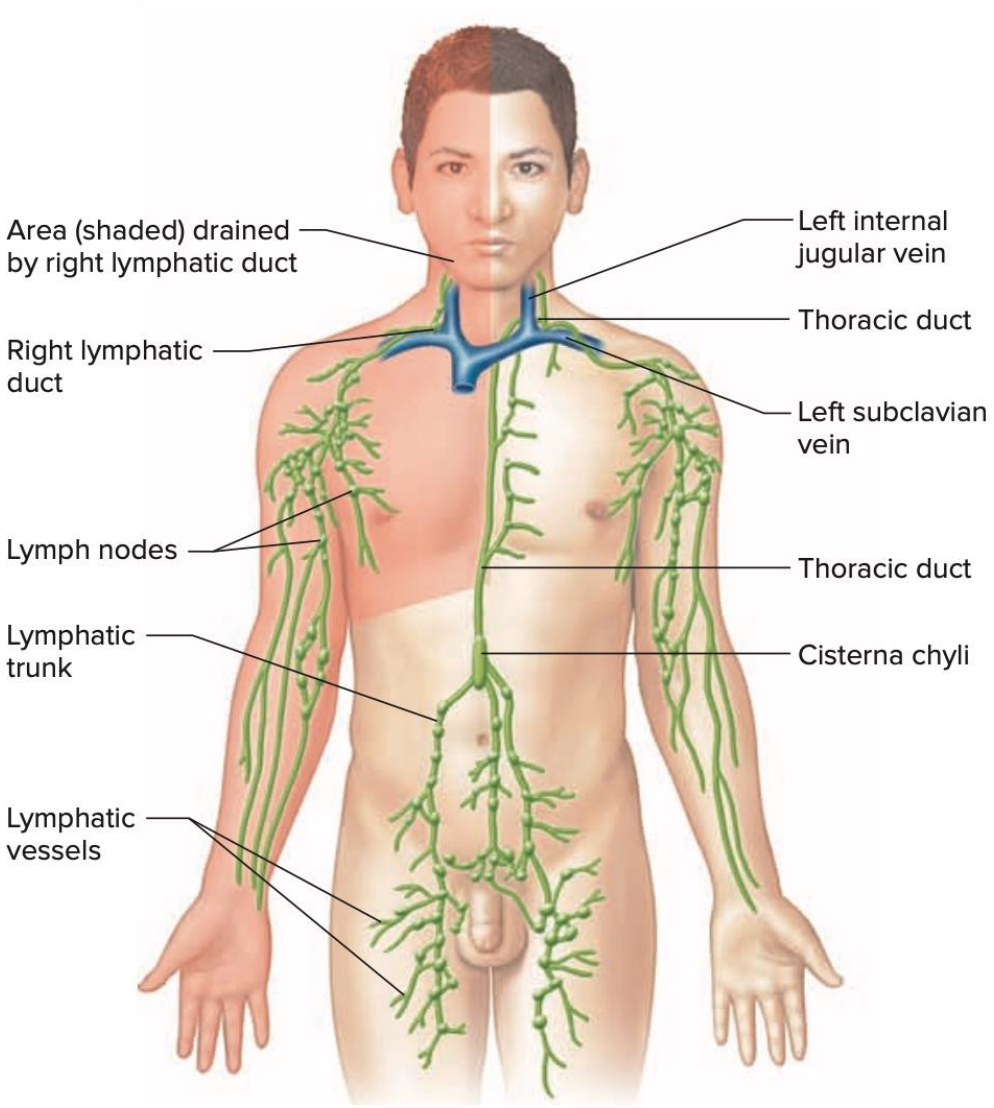
↓

TWO lymphatic ducts

↓

blood stream (through the **venous angles**)

Lymphatic circulation



Two lymphatic ducts

- right lymphatic duct (right upper 1/4)
  - from the union of right jugular, subclavian, and bronchomediastinal trunks to right venous angle
- thoracic duct (left upper 1/4 + lower 1/2)
  - from cisterna chyli to left venous angle

Venous angles

- the junction where internal **jugular veins** and **subclavian veins** merge to form the brachiocephalic vein
- lymph drains back from lymphatic circulation to cardiovascular circulation

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