

Cardiovascular system

- ❖ The **cardiovascular system** (*Cardio* - heart; *vascular* - blood or blood vessels)
- ❖ Consists of three interrelated components:
 - Heart
 - Blood
 - Blood vessels

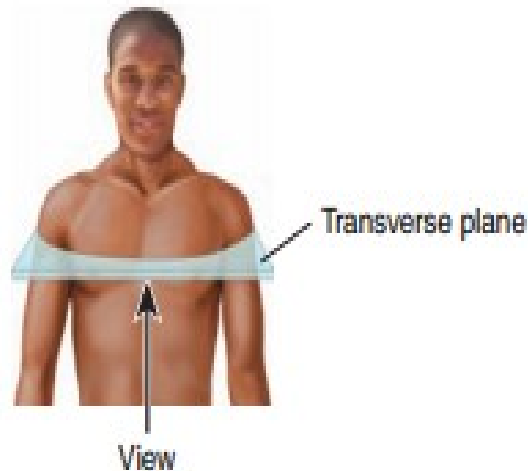
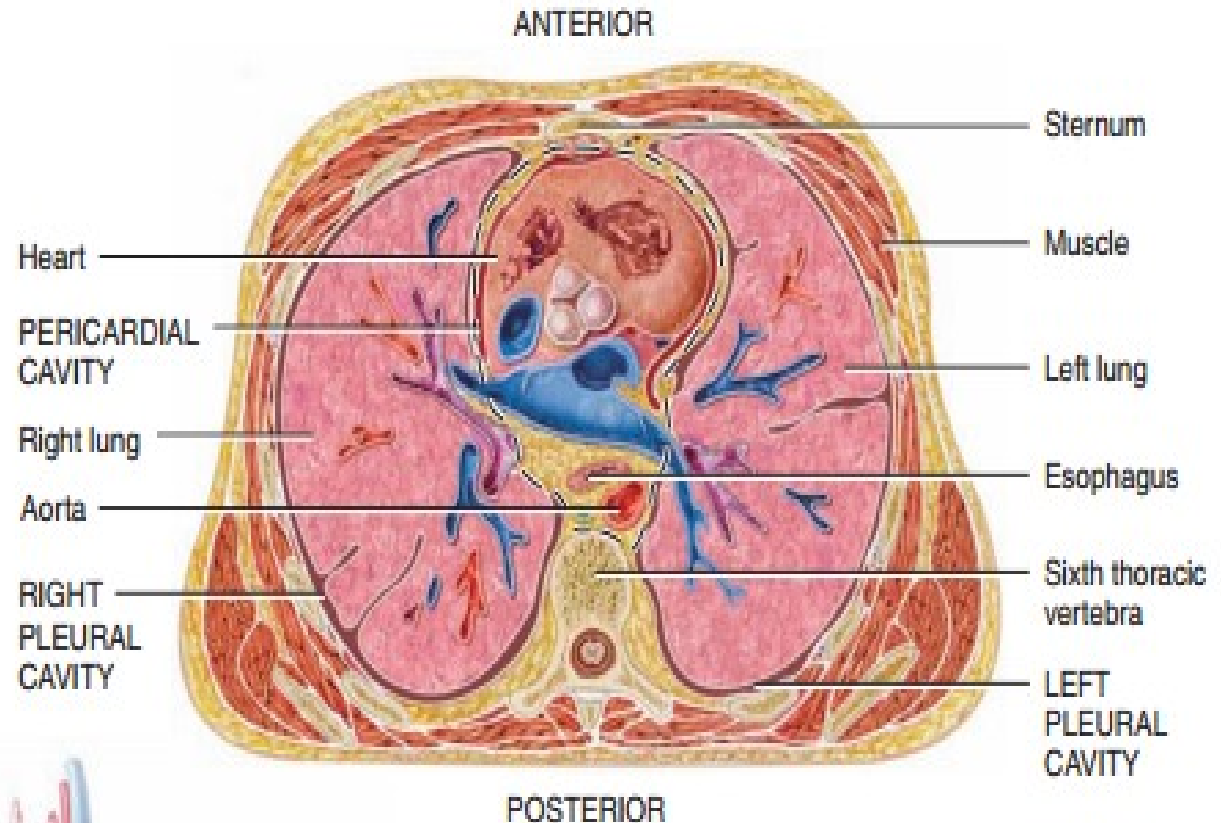
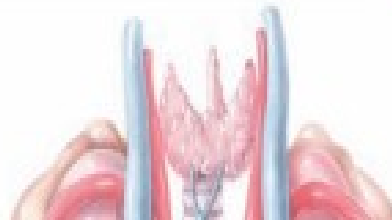
HEART

- For blood to reach body cells and exchange materials with them, it must be pumped continuously by the heart through the body's blood vessels.
- The heart beats about **100,000** times every **day**, which adds up to about 35 million beats in a **year**, and approximately **2.5 billion** times in an average **lifetime**.
- **Cardiology** is the scientific study of the normal heart and diseases associated with it.

HEART

- A four **chambered**, hollow muscular organ approximately the size of a closed fist.
- **Heart** pumps more than about 14,000 liters (3600 gal) of blood in a **day**, or **5 million** liters (1.3 million gal) in a **year**.
- Its mass averages **250g** in adult females and **300g** in adult males.

Position of the heart in mediastinum

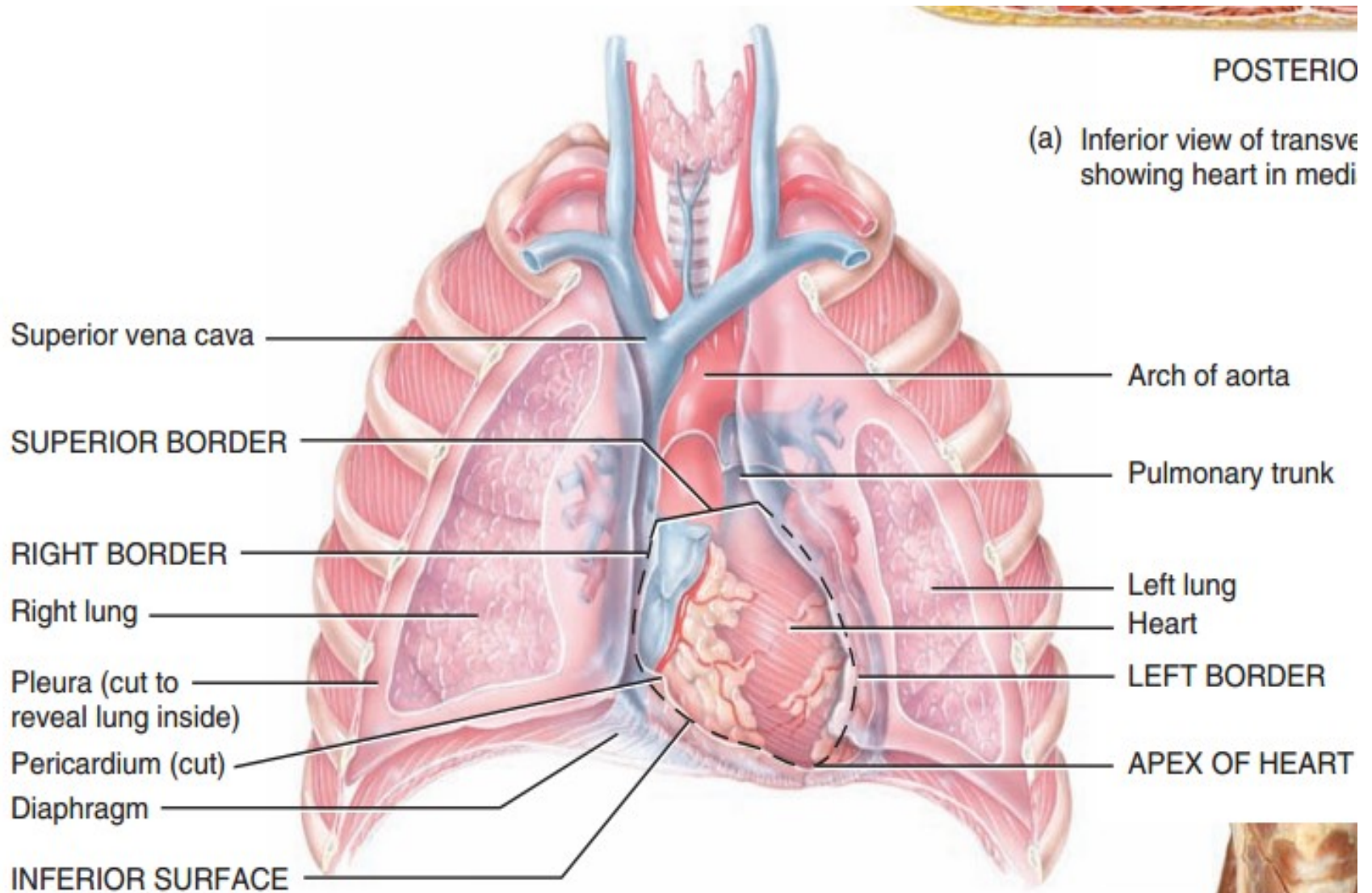


(a) Inferior view of transverse section of thoracic cavity showing heart in mediastinum

HEART

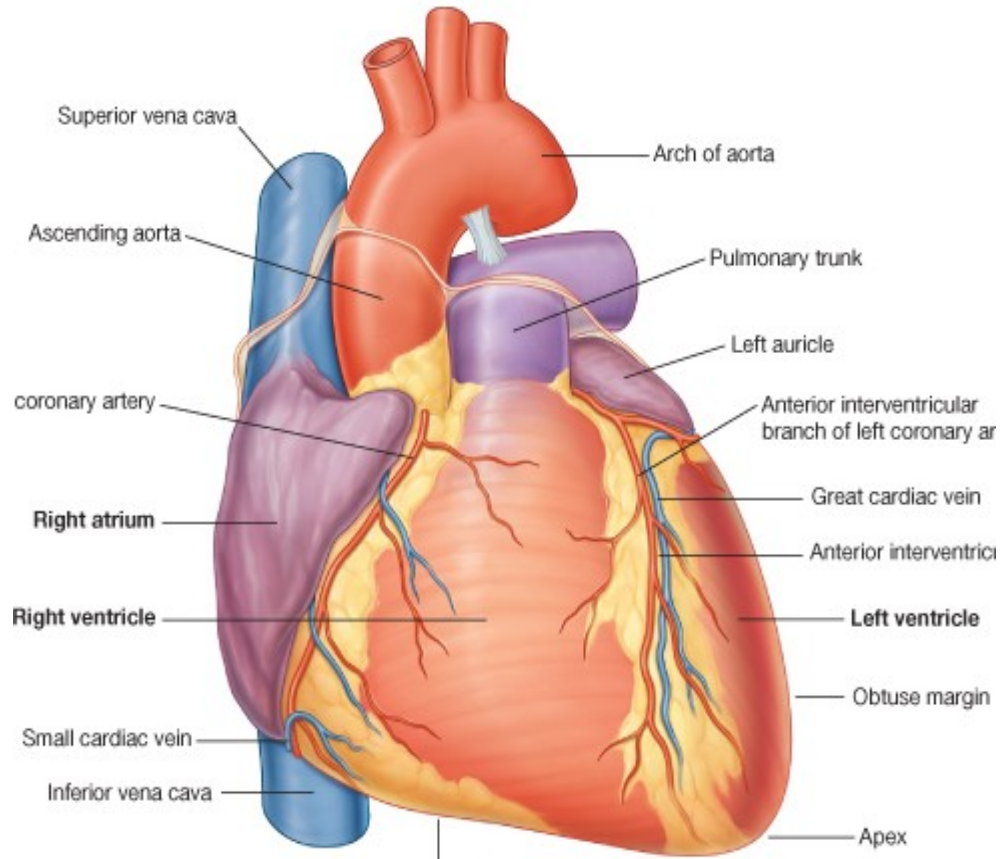
- The heart lies in the **mediastinum**, an anatomical region that extends from the **sternum** to the **vertebral column**, from the **first rib** to the **diaphragm**, and between the **lungs**.
- About **two-thirds** of the mass of the heart lies to the left of the body's midline.
- It rests on the **diaphragm**, near the midline of the thoracic cavity.

HEART



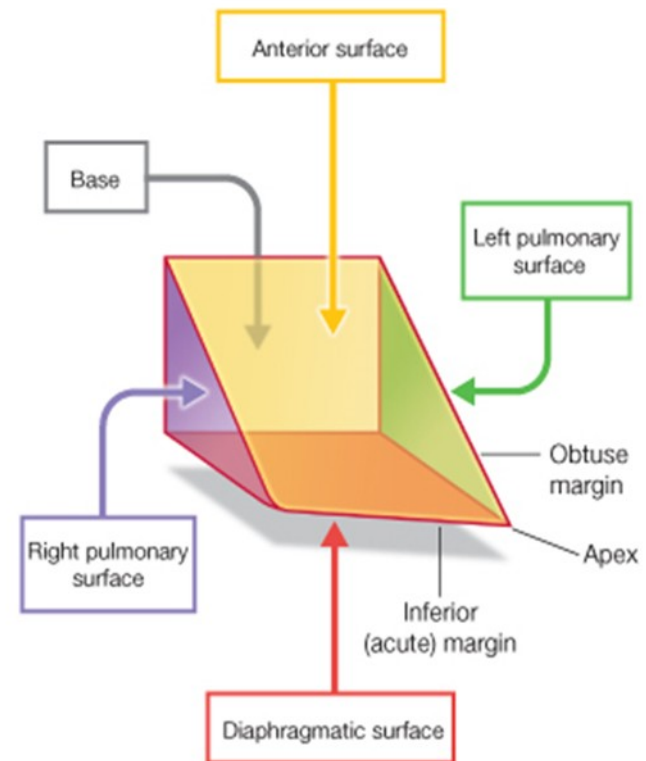
The four surfaces of the heart

- ✓ **Anterior (Sternocostal) surface:**
 - formed mainly by the right ventricle
- ✓ **Inferior (Diaphragmatic) surface:**
 - formed mainly by the left ventricle and partly by the right ventricle.
 - It is the area of the heart on which the pyramid rests.
- ✓ **Right pulmonary surface:**
 - formed mainly by the right atrium.
- ✓ **Left pulmonary surface:**
 - formed mainly by the left ventricle



The apex of the heart

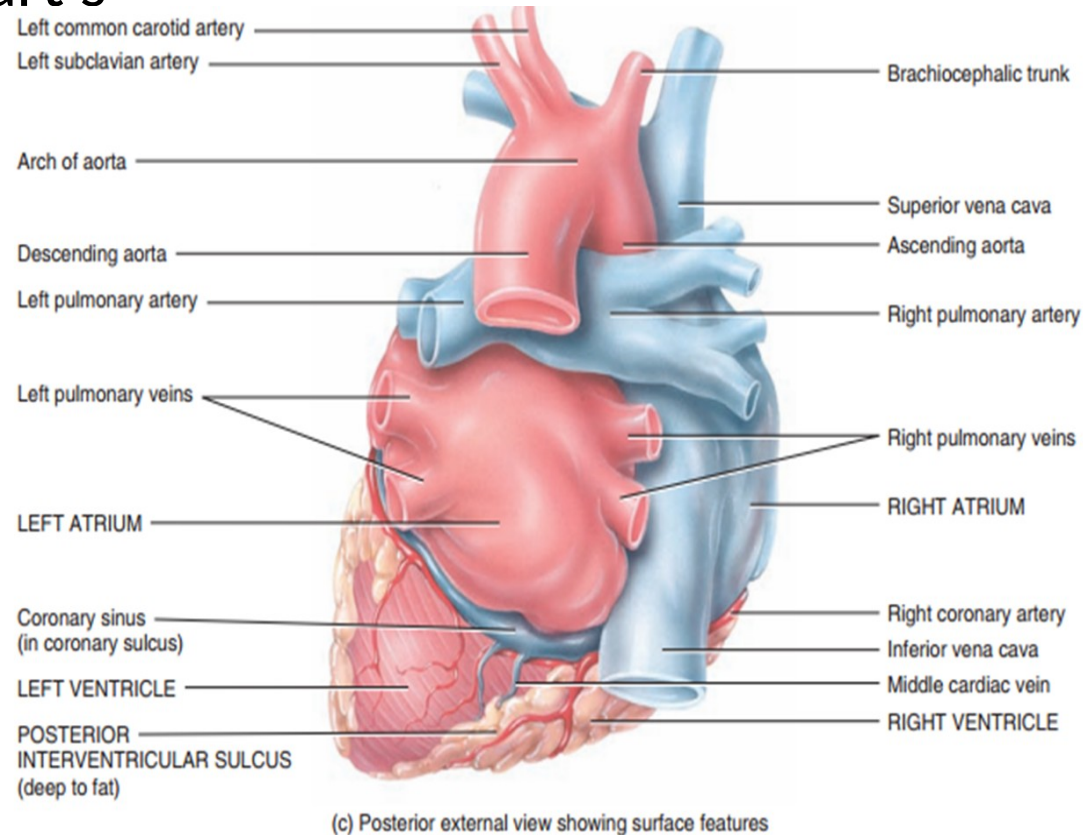
- **Apex** is formed by:
 - The inferolateral part of the left ventricle
 - It projects forward & downward.
- Lies posterior to the left 5th intercostal space, usually ~9 cm from the median plane.
- Apex is where the sounds of mitral valve closure are maximal (**apex beat**); the apex underlies the site where the heartbeat may be auscultated on the thoracic wall.



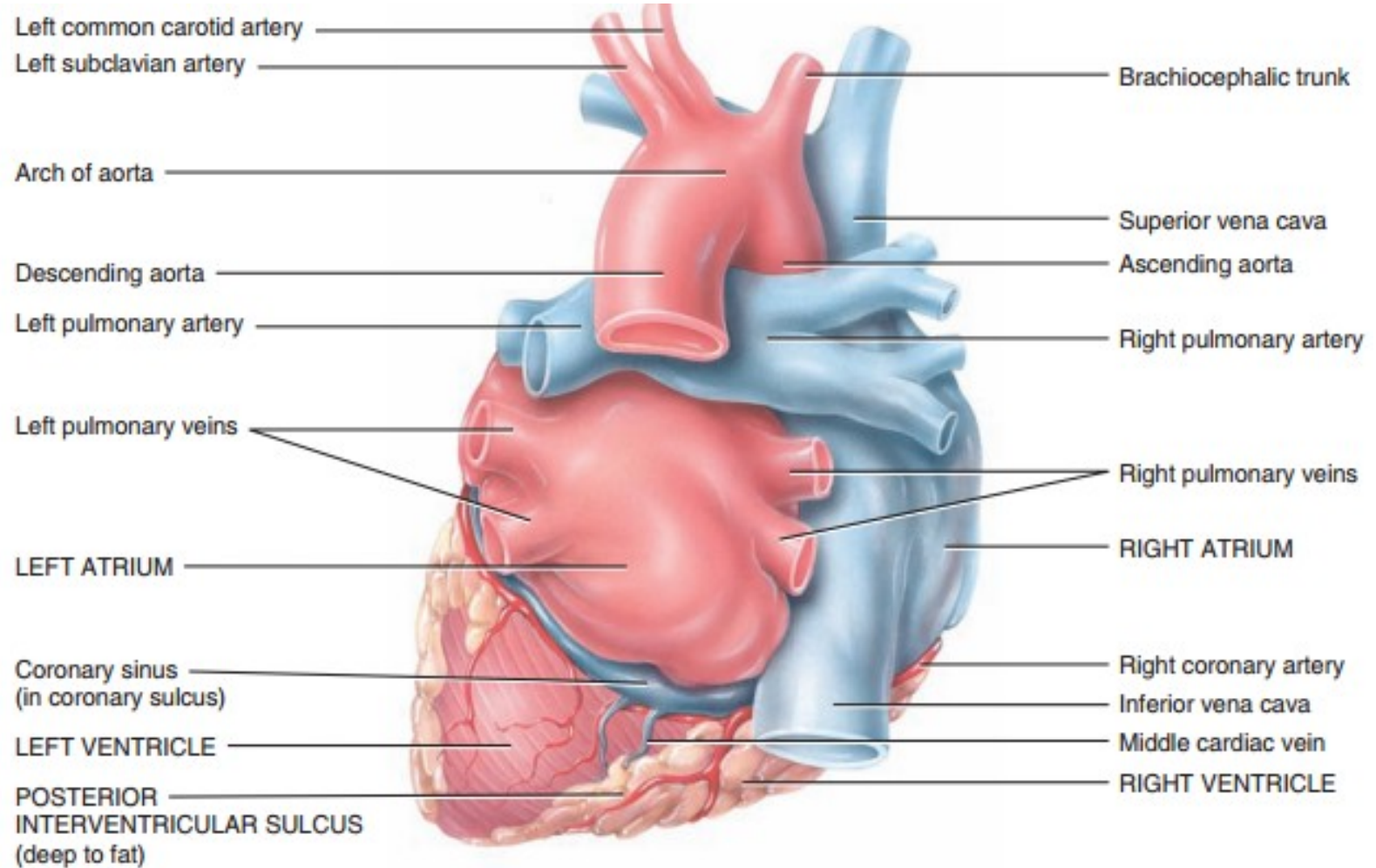
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The base of the heart

- Posterior aspect of the heart's (opposite of the **apex**).
- formed mainly by the **left atrium**, with a lesser contribution by the **right atrium**.
- It is posterior toward vertebrae of **T6-T9**.
- Extends superiorly to the bifurcation of the pulmonary trunk and inferiorly to the coronary groove.



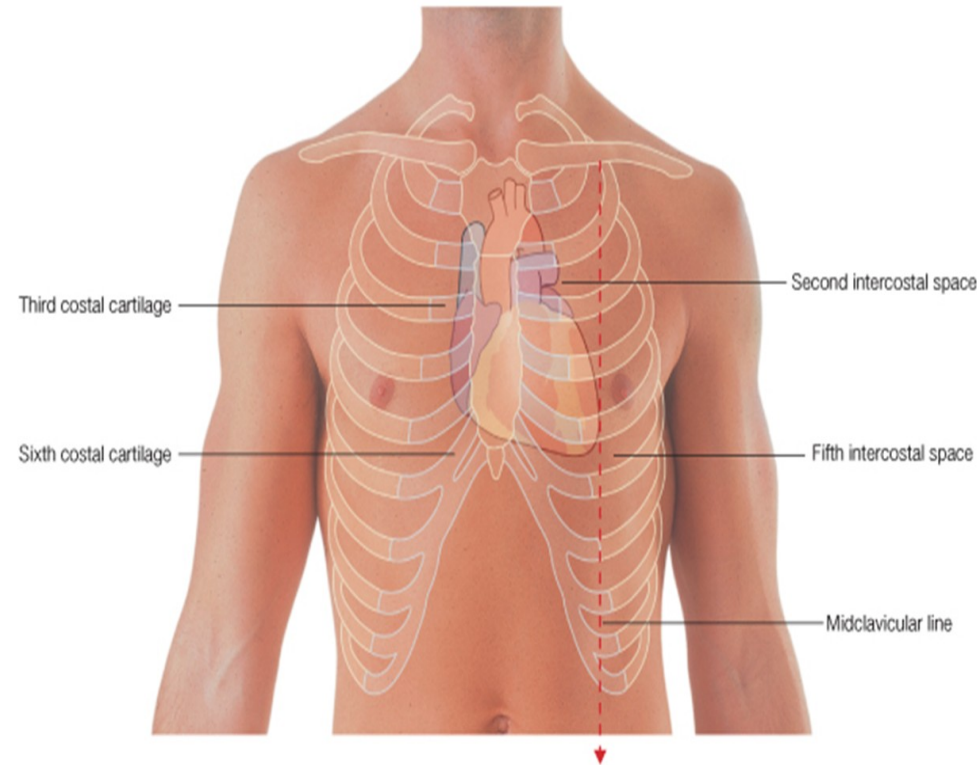
Base of the heart



(c) Posterior external view showing surface features

Surface anatomy of the Heart

- Knowledge of the surface anatomy of the **thorax** is particularly important .
- B/c it is one of the areas most frequently subjected to physical examination, like **auscultation** and **percussion**.



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Surface landmarks of the heart

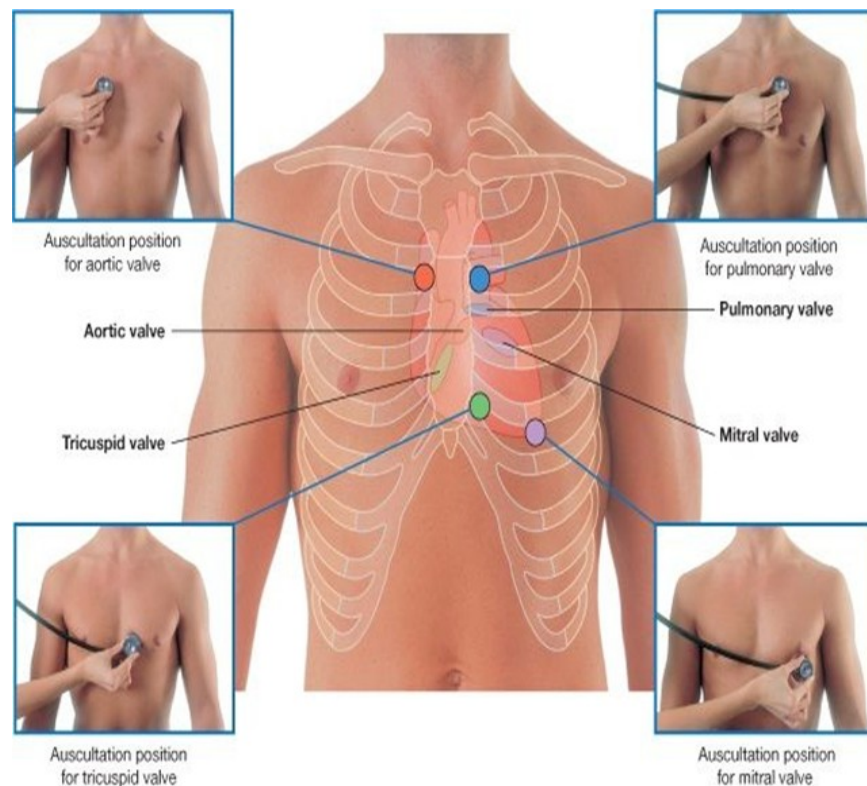
- The **upper limit** of the heart reaches as high as the **3rd costal cartilage** on the right side of the sternum and the **2nd intercostal space** on the left side of the sternum.
- The **lower margin** of the heart extends from the sternal end of the right **6th costal cartilage** to the apex in the **5th intercostal space** near the MCL.

Surface landmarks of the heart

- The **right margin** of the heart extends from the right 3rd costal cartilage to near the right 6th costal cartilage.
- The **left margin** of the heart descends laterally from the 2nd intercostal space to the apex located near the midclavicular line in the 5th intercostal space.

Listening sites for heart sounds

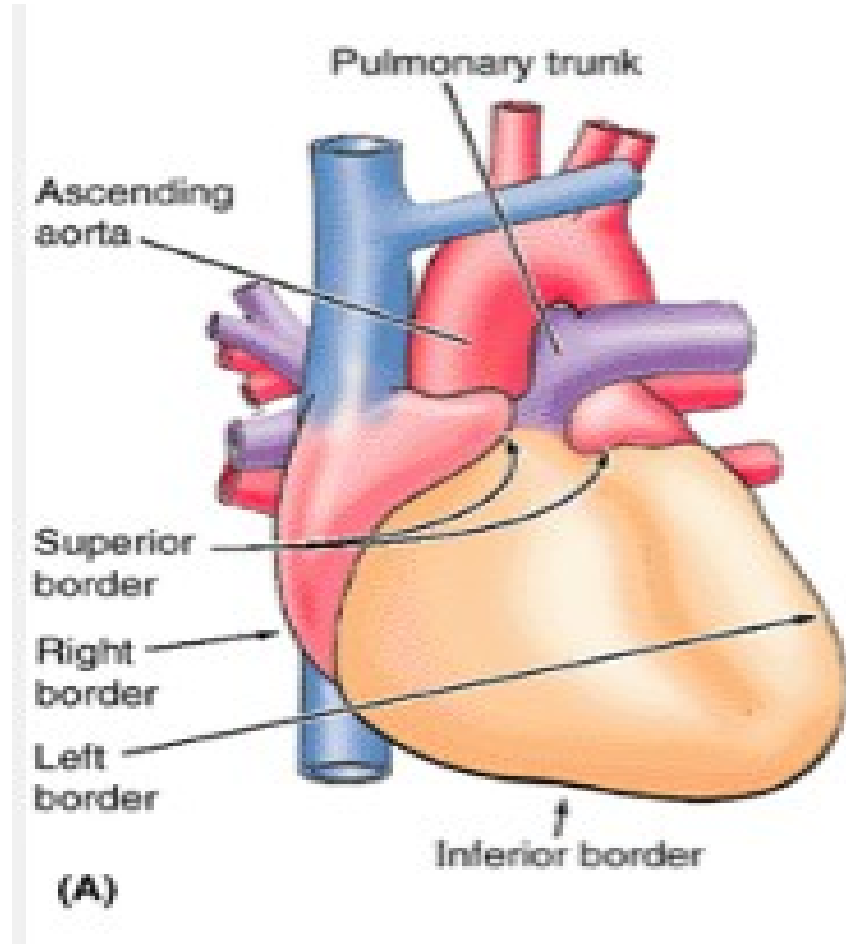
- The **tricuspid valve** is heard just to the left of the lower part of the sternum near the 5th intercostal space.
- The **mitral valve** is heard over the apex of the heart in the left 5th intercostal space at the **MCL** line.
- The **pulmonary valve** is heard over the medial end of the left 2nd intercostal space.
- The **aortic valve** is heard over the medial end of the right 2nd intercostal space.



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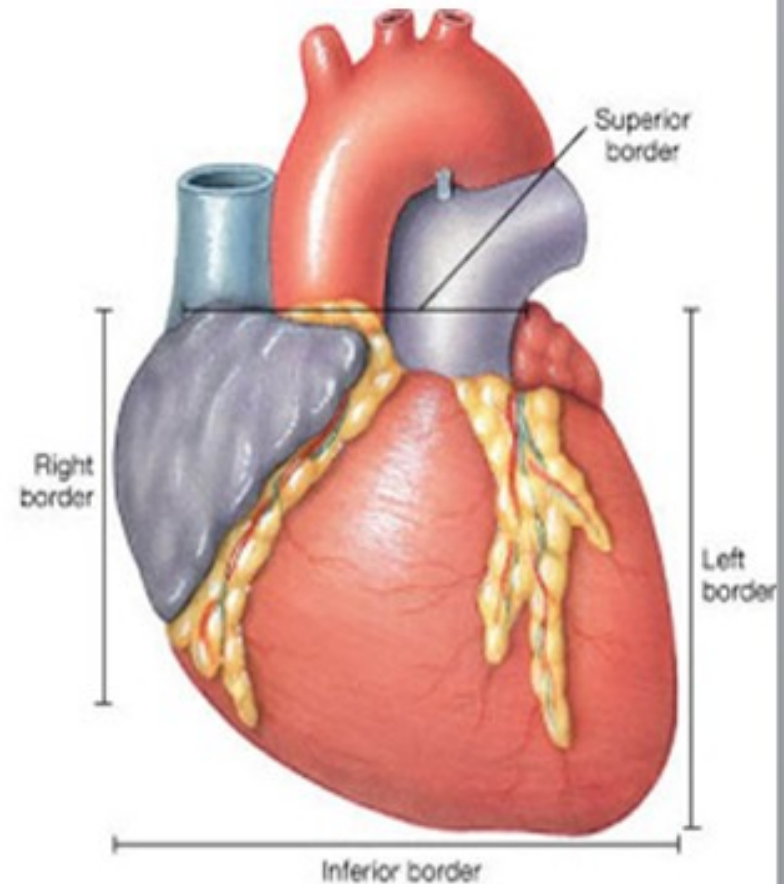
Borders of the heart

- ✓ **Right border:**
 - formed by the right atrium and extending between the SVC and the IVC.
- ✓ **Inferior border**
 - formed mainly by the right ventricle and slightly by the left ventricle.
- ✓ **Left border**
 - formed mainly by the left ventricle and slightly by the left auricle.



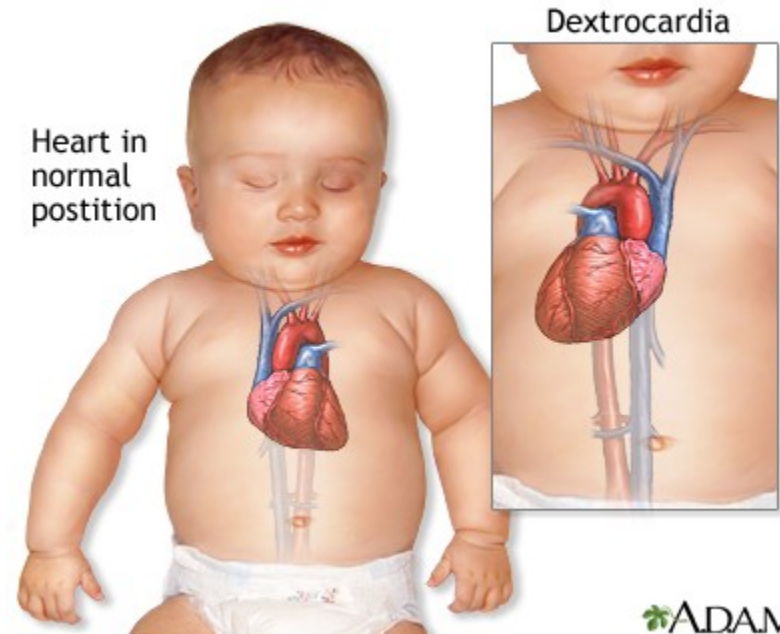
Borders of the heart

- ✓ **Superior border;**
 - formed by the right and left atria and auricles in an anterior view.
 - ascending aorta and pulmonary trunk emerge from this border and the SVC enters its right side.



Positional Abnormalities of the Heart

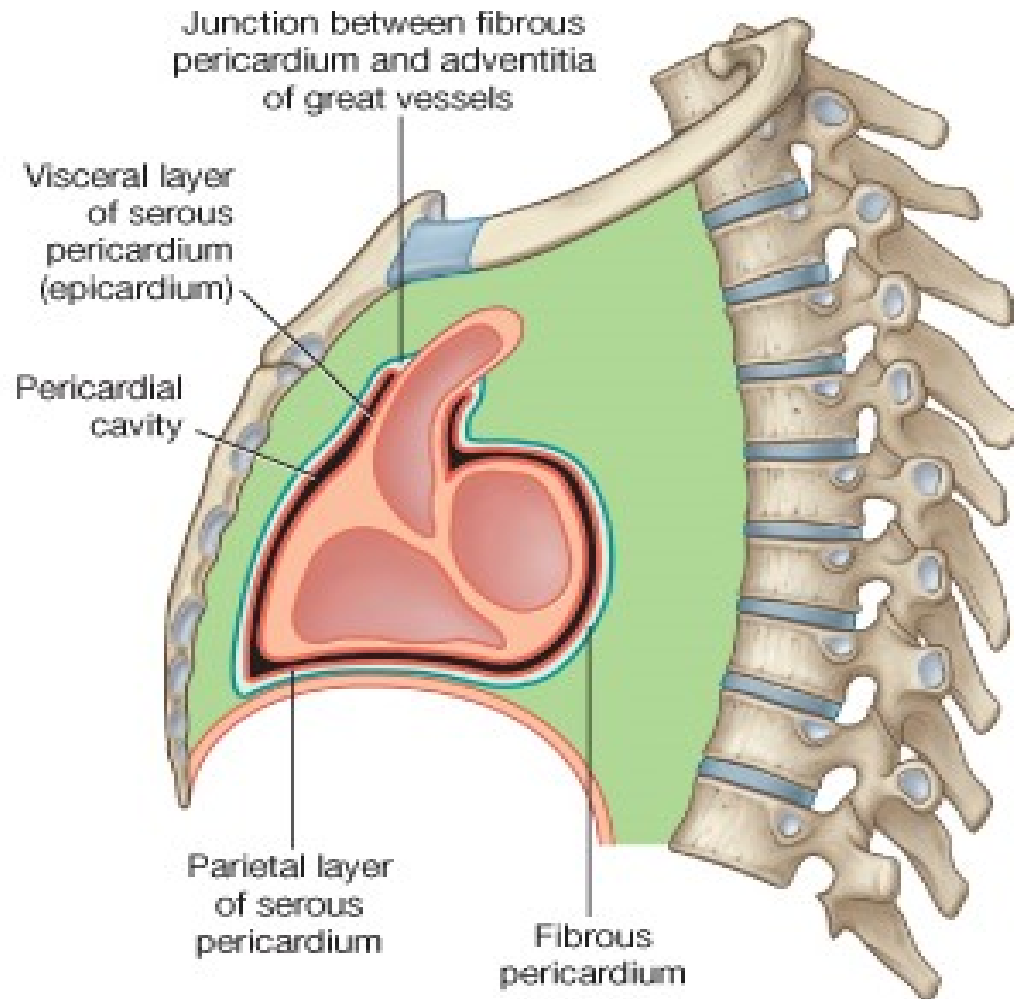
- Abnormal folding of the embryonic heart may cause the position of the heart to be completely reversed.
- So that the **apex** is directed to the right instead of to the left- which is called **Dextrocardia**.
- This congenital anomaly is the most common positional abnormality of the heart, but it is still relatively uncommon



Dextrocardia

- Two types:
 1. **Situs inversus**; is anomaly of a general transposition of the thoracic and abdominal viscera
 2. **Isolated dextrocardia**
 - When the transposition may affect only the heart
 - In **situs inversus**, the incidence of accompanying cardiac defects is low, and the heart usually functions normally.
 - In **isolated dextrocardia**, however, the congenital anomaly is complicated by severe cardiac anomalies, such as transposition of the great arteries.

Coverings of the Heart (Pericardium)



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Pericardium

- The **pericardium** is a **fibro-serous** membrane that covers the heart and the beginning of its great vessels.
- It confines the heart to its position and allowing sufficient freedom of movement for vigorous and rapid contraction.
- The **pericardium** is a closed sac composed of two layers;
 - the external layer, **fibrous** pericardium and
 - the internal layer, **Serous** pericardium
- Protects the **heart** against sudden overfilling and anchors the heart in the mediastinum.

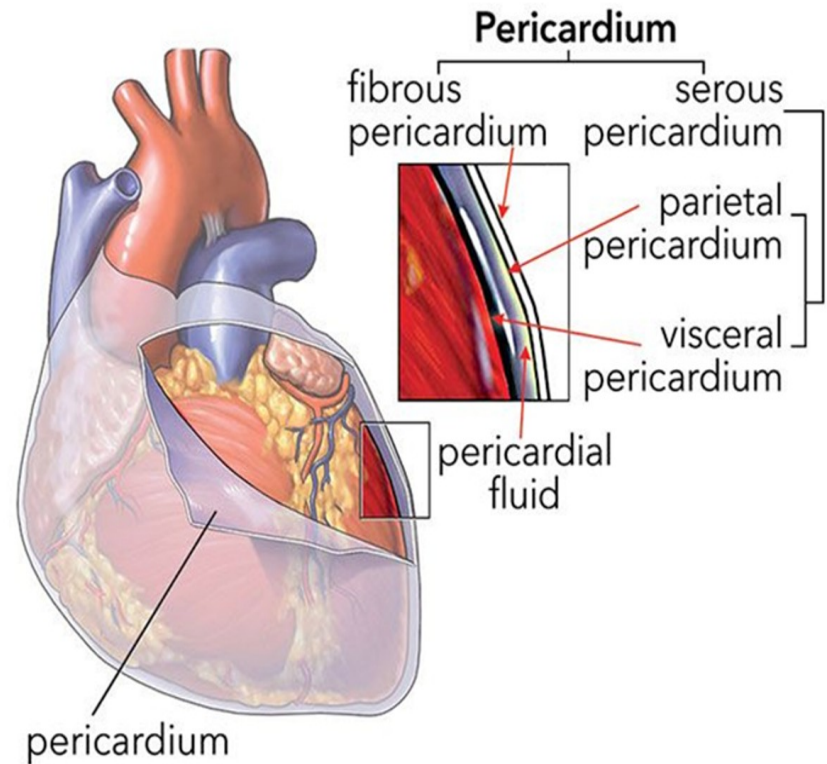
Pericardium

- ❖ The deeper **serous pericardium** is a thinner, more delicate membrane that forms a double layer around the heart ;
- The outer **parietal layer** of the serous pericardium is fused to the fibrous pericardium.
- The inner **visceral layer** of the serous pericardium, also called the **epicardium** when combined with the underlying areolar or adipose tissue, adheres tightly to the surface of the heart.

Pericardium

➤ Pericardial cavity

- Is the potential space b/n the parietal and visceral layers of serous pericardium.
- It normally contains a thin film of fluid that enables the heart to move and beat in a frictionless environment.



The wall of each heart chamber

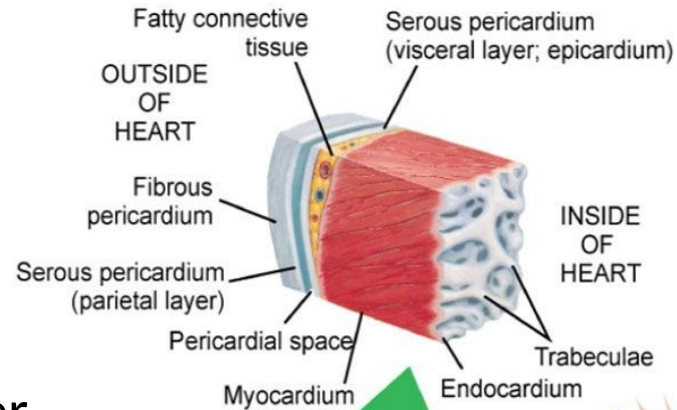
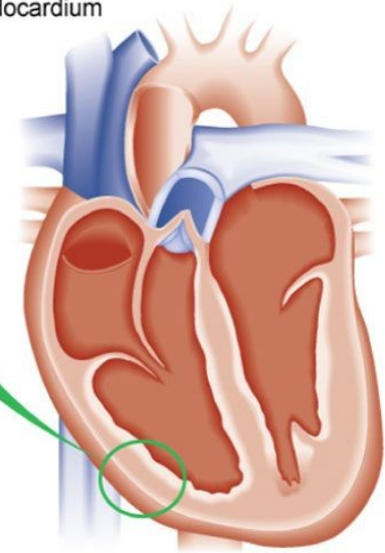
❖ The heart wall consists of three layers;

1. Endocardium : a thin internal layer lining membrane of the heart that also covers its valves.

2. Myocardium - a thick, helical middle layer composed of cardiac muscle.

3. Epicardium - a thin external layer (mesothelium) formed by the visceral layer of serous pericardium.

❖ The walls of the heart consist mostly of **myocardium**, especially in the **ventricles**.

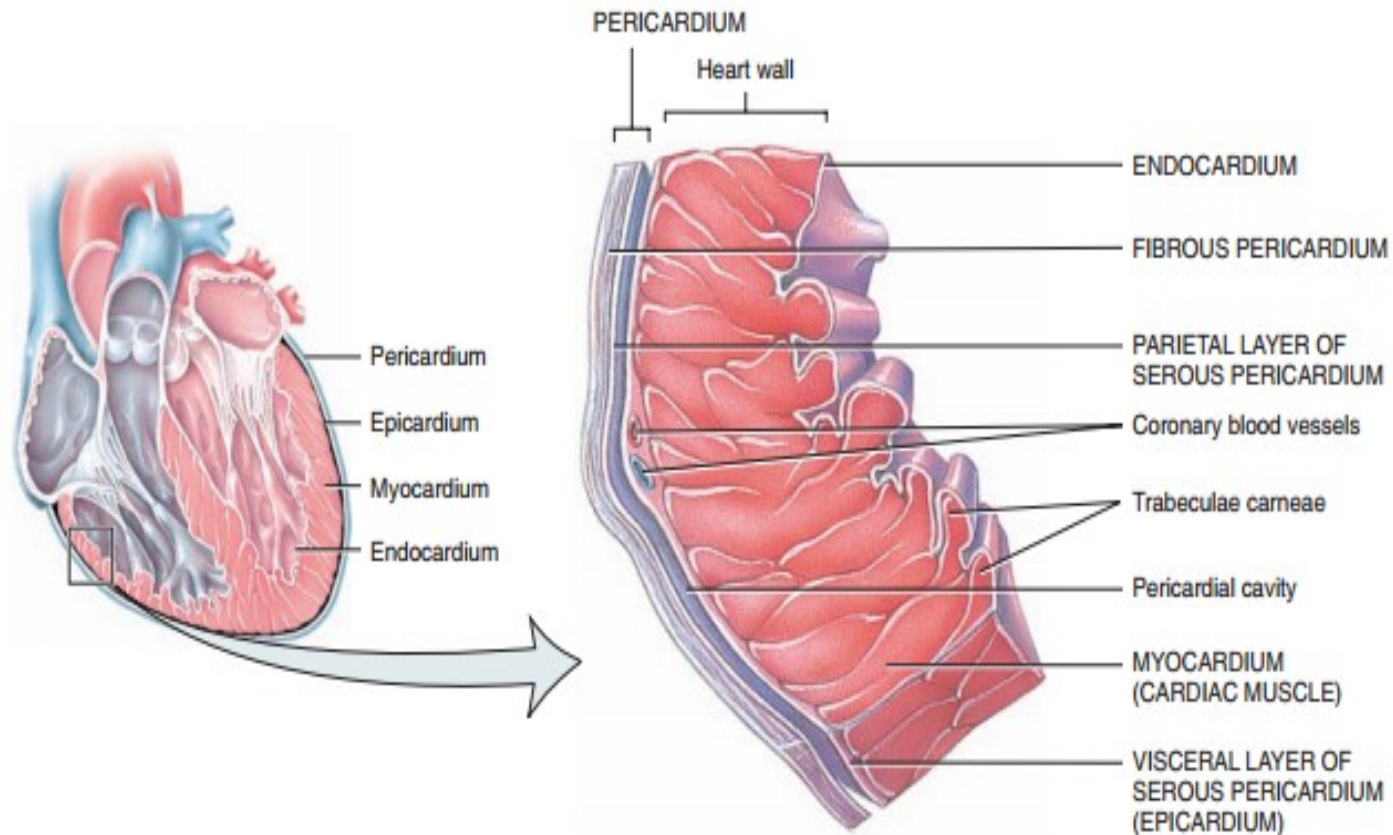


Source: Modified from Patton & Thibodeau, 2010.

Heart wall

Figure 20.2 Pericardium and heart wall.

 The pericardium is a triple-layered sac that surrounds and protects the heart.

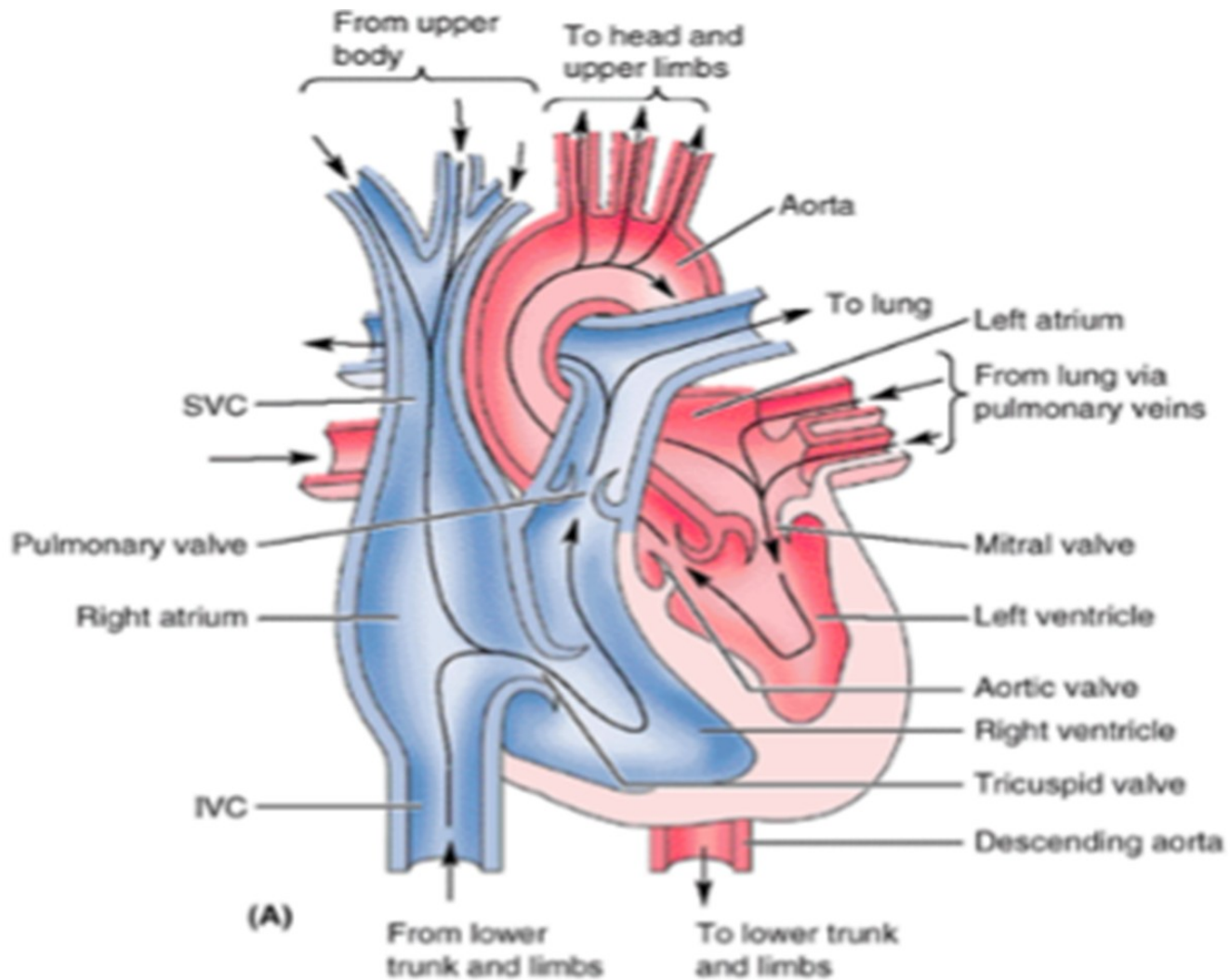


(a) Portion of pericardium and right ventricular heart wall showing divisions of pericardium and layers of heart wall

The Heart

- ✓ The **right** side (right heart):
 - receives poorly oxygenated (**venous**) blood from the body through the **SVC** and **IVC** and pumps it through the pulmonary trunk to the lungs for oxygenation.
- ✓ The **left** side (left heart):
 - receives well-oxygenated (**arterial**) blood from the lungs through the pulmonary veins and pumps it into the aorta for distribution to the body.

The heart

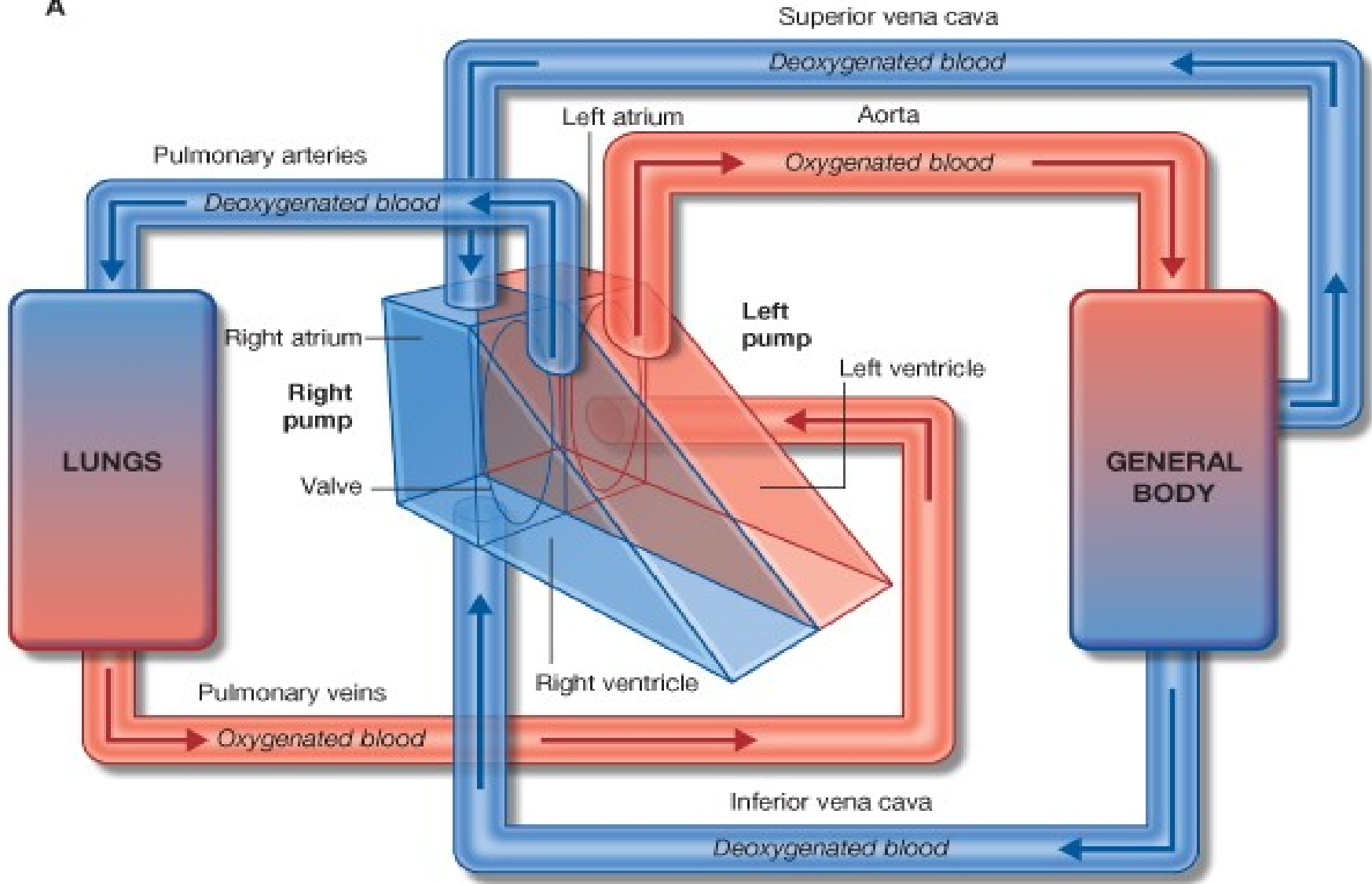


Chambers of the heart

- The heart has **four** chambers;
- Right and left **atria & ventricles**
 - the atria are **receiving** chambers
 - the ventricles are **discharging** chambers

Cardiac cycle

A

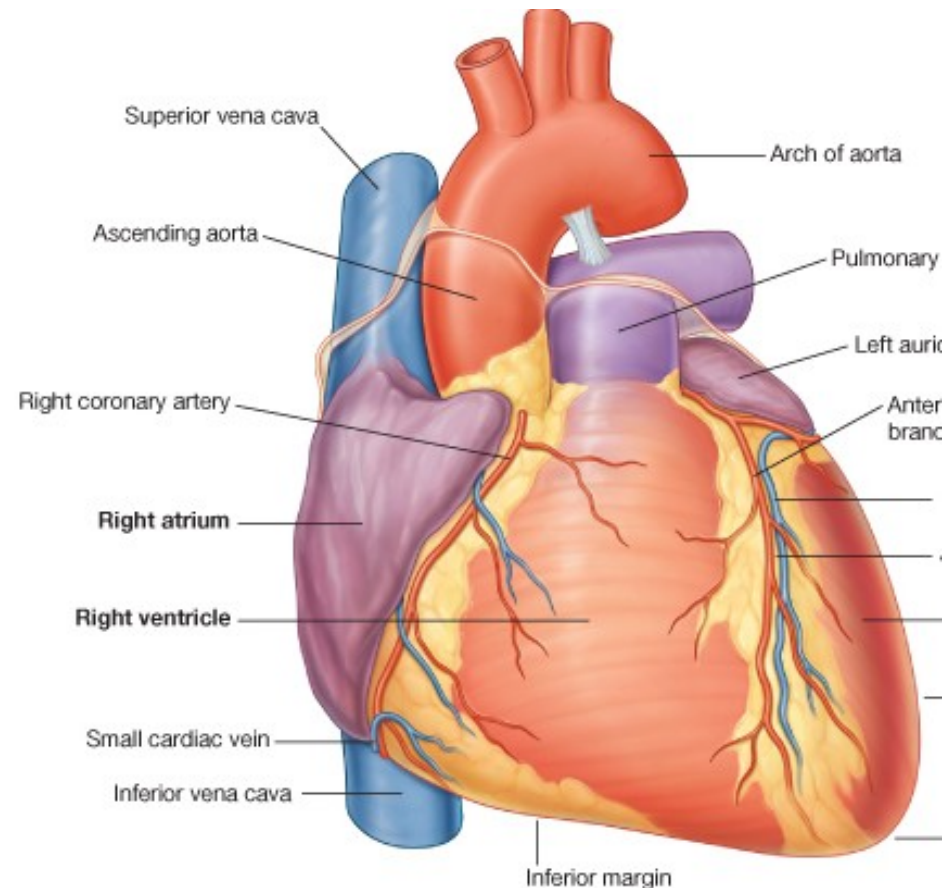


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Chambers of the Heart

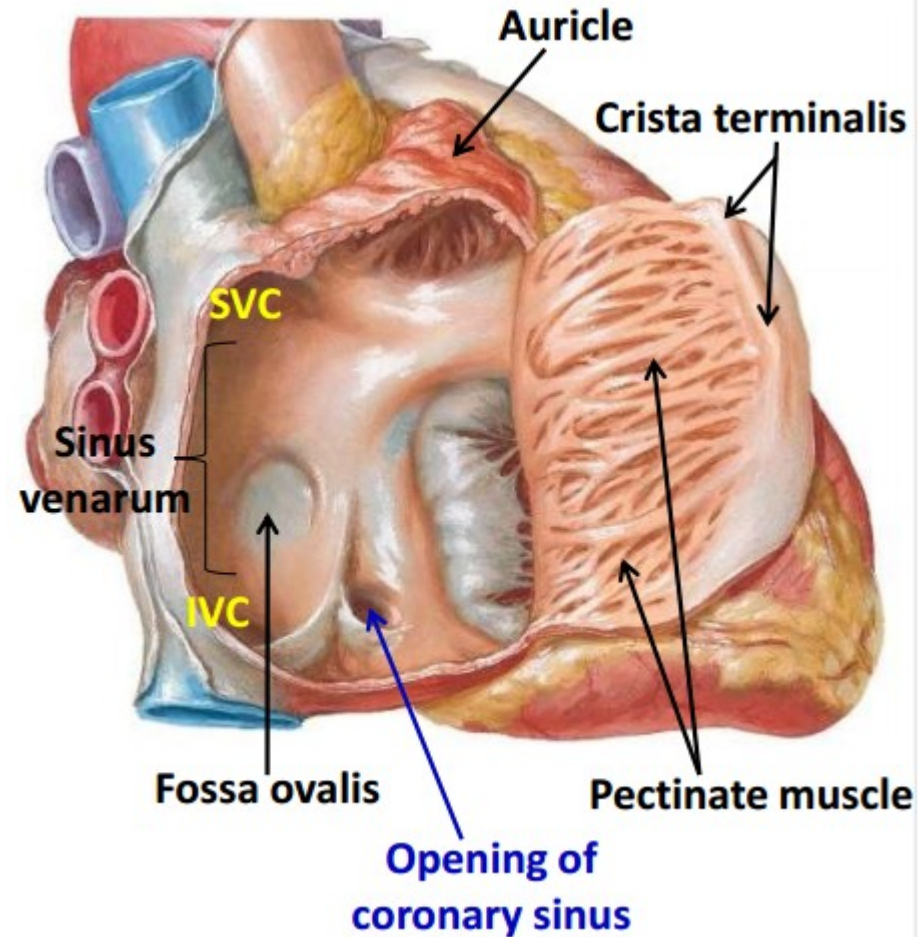
Right atrium

- ✓ **Right auricle**
- Is a conical muscular pouch which is an **add-on room**, increasing the capacity of the atrium as it overlaps the ascending aorta.



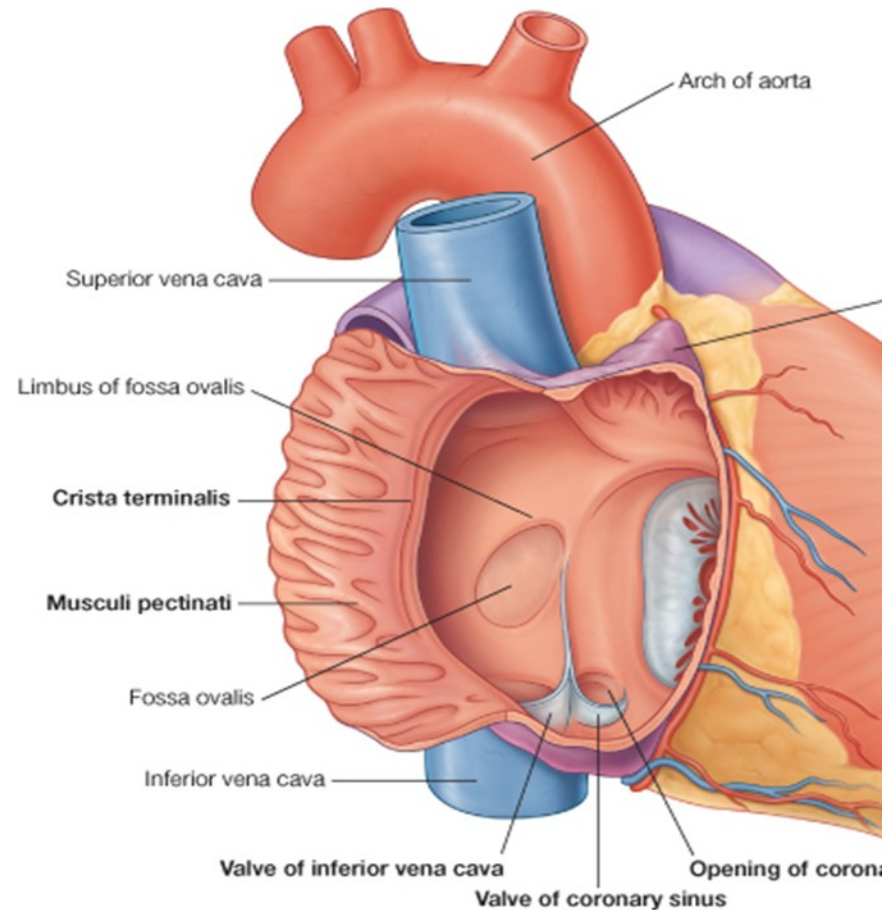
Right atrium

- ❖ The interior of the right atrium has a:
 - ✓ **Sinus venarum/ venae cavae**
 - A smooth, thin-walled, posterior part of the atria which SVC & IVC and coronary sinus open.
 - ✓ **Pectinate muscles**
 - A rough, anterior muscular wall



Right atrium

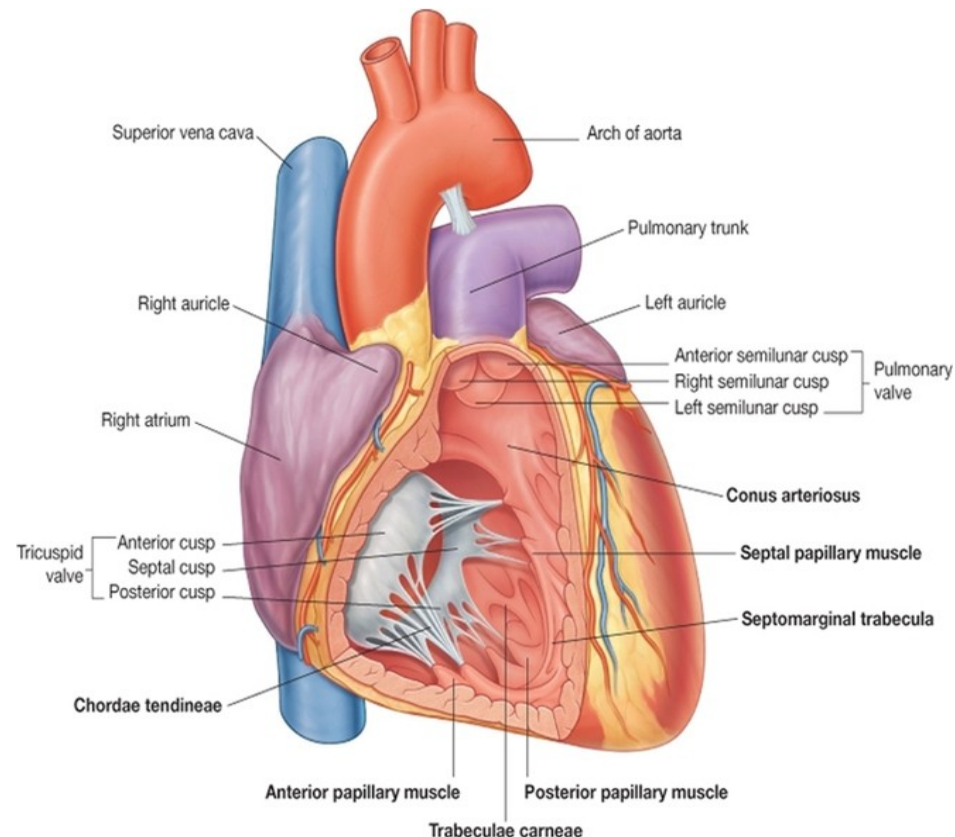
- ✓ **Fossa ovalis**
 - A depression in the interatrial septum, which is the fetal embryonic remnant of **foramen ovale**.



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Right Ventricle

- ✓ The **right ventricle**;
- Forms the largest part of the **anterior** surface of the heart.
- ❖ The interior of the right ventricle has;
 1. **Trabeculae carneae**;
 - Irregular muscular elevations.



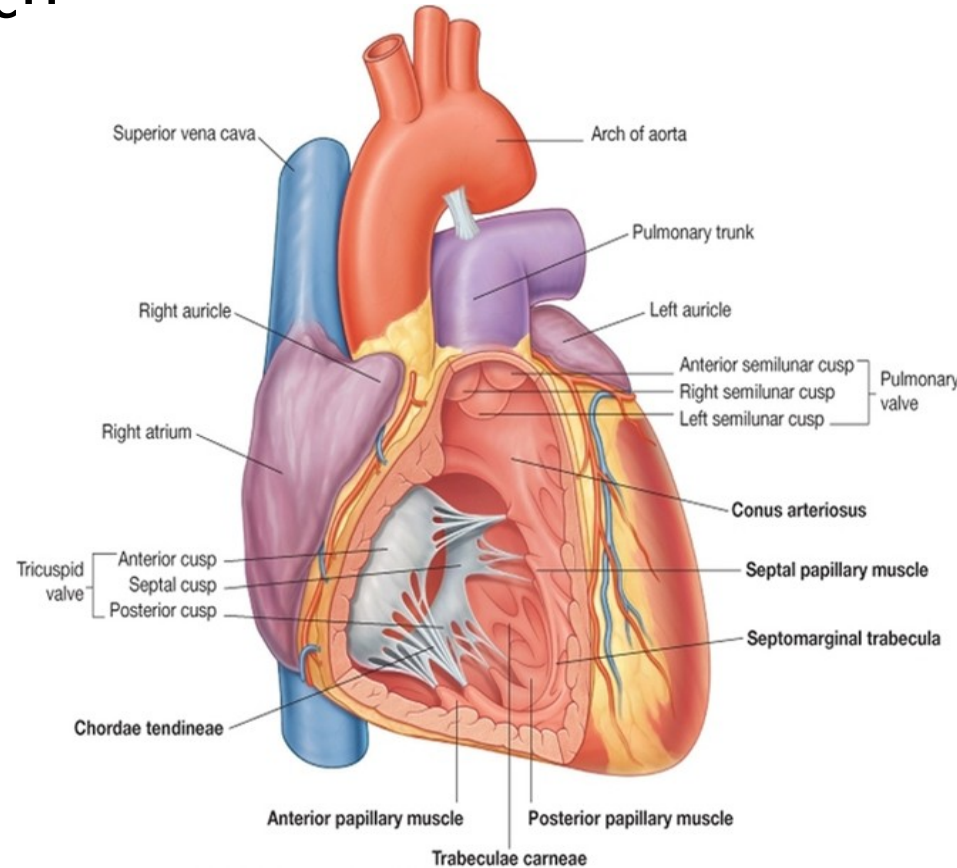
Right Ventricle

3. Pupillary muscle;

- Is cardiac muscle which attach to tendinous cords.

4. Chordae tendineae;

- a tendon attach to the free edges and ventricular surfaces of the cusps.

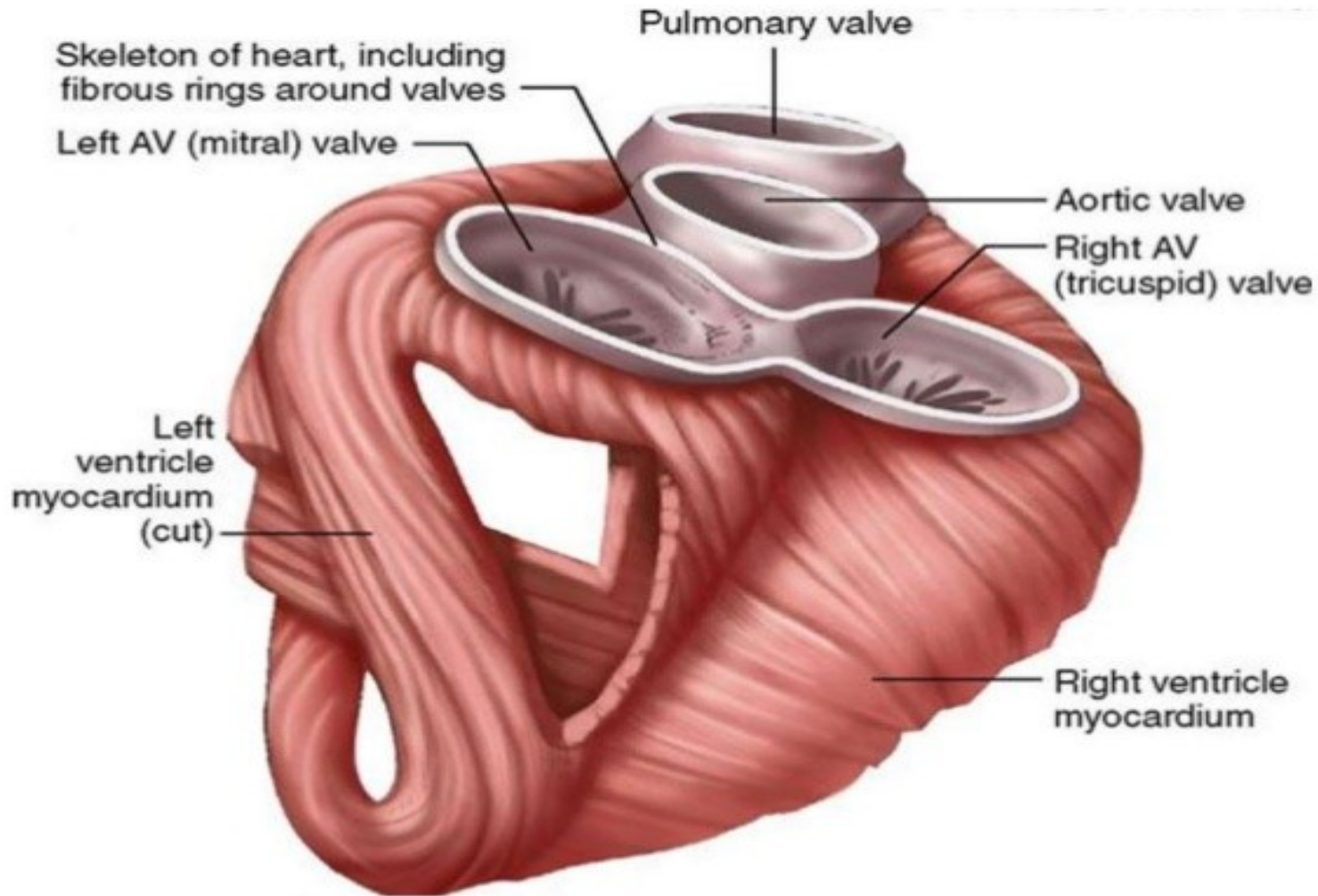


Right Ventricle

5. Tricuspid valve

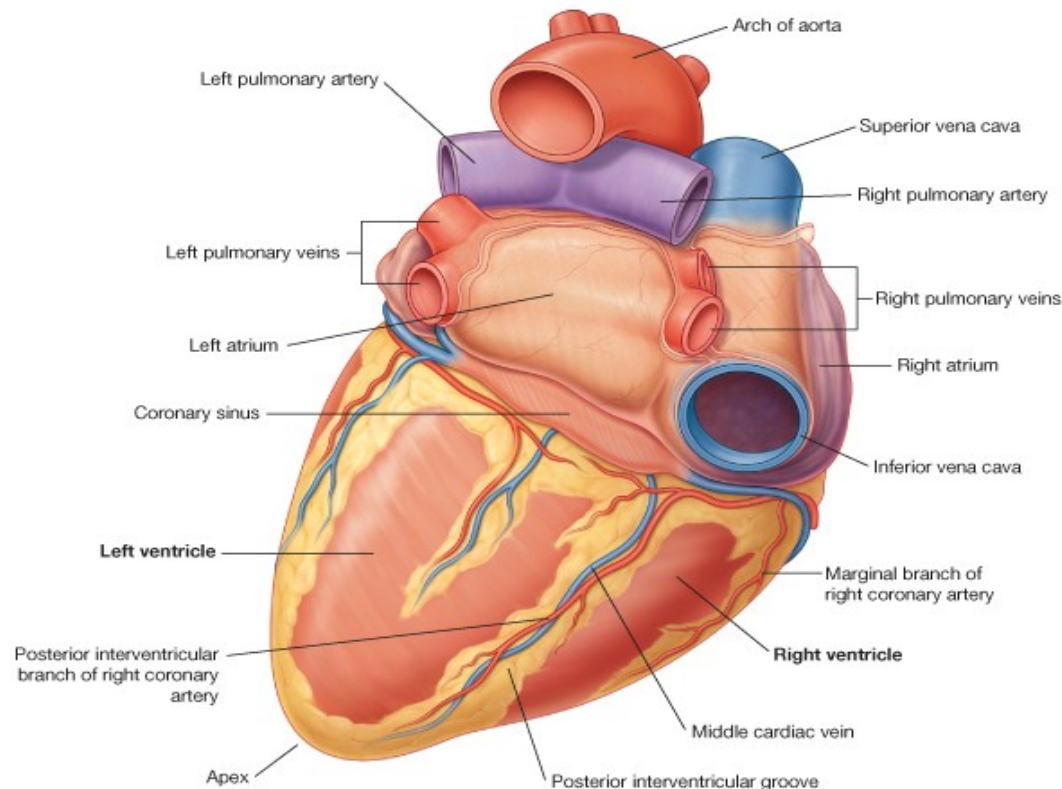
- Guards the right AV orifice.
- The bases of the valve cusps are attached to the fibrous ring around the orifice.
- The **inflow** part of the ventricle receives blood from;
- The right atrium through the **right AV orifice**

Fibrous ring and Valves of the Heart



Left Atrium

- ✓ **Left Atrium**
 - forms most of the base or posterior surface of the heart.
- ✓ **left auricle;**
 - Is the tubular, muscular wall which trabeculated with **pectinate muscles**.
- A **semilunar depression** in the interatrial septum indicates the floor of the **foramen ovalis**.

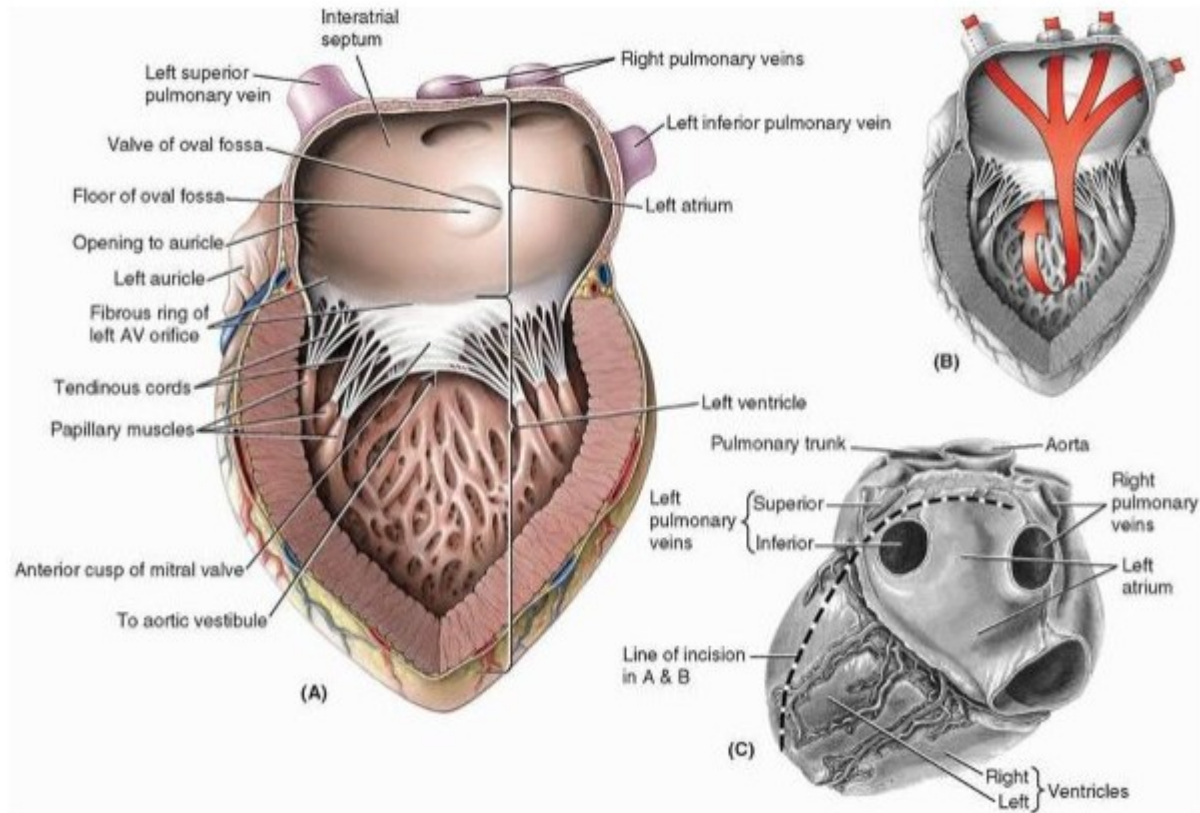


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The interior of the left atrium

- ✓ **Pectinate muscles**
 - A larger smooth-walled part and a smaller muscular **auricle** containing.
- ✓ **Four pulmonary veins**
 - **Rt** and **Lt** pulmonary veins entering its smooth posterior wall.
- **LA** discharges the oxygenated blood that it received from the pulmonary veins into the left ventricle through **left AV** orifice.

The interior of the left atrium



The interior of the left ventricle

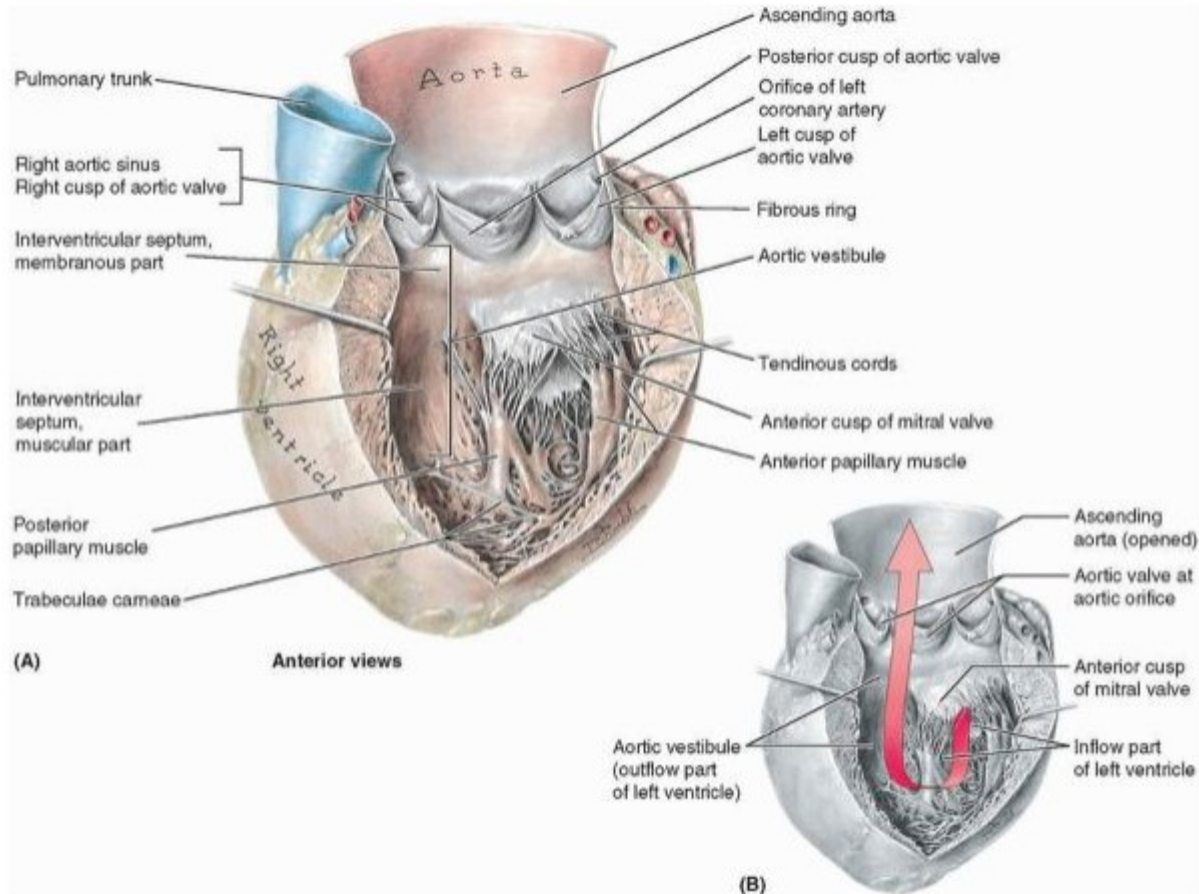
✓ Trabeculae carneae

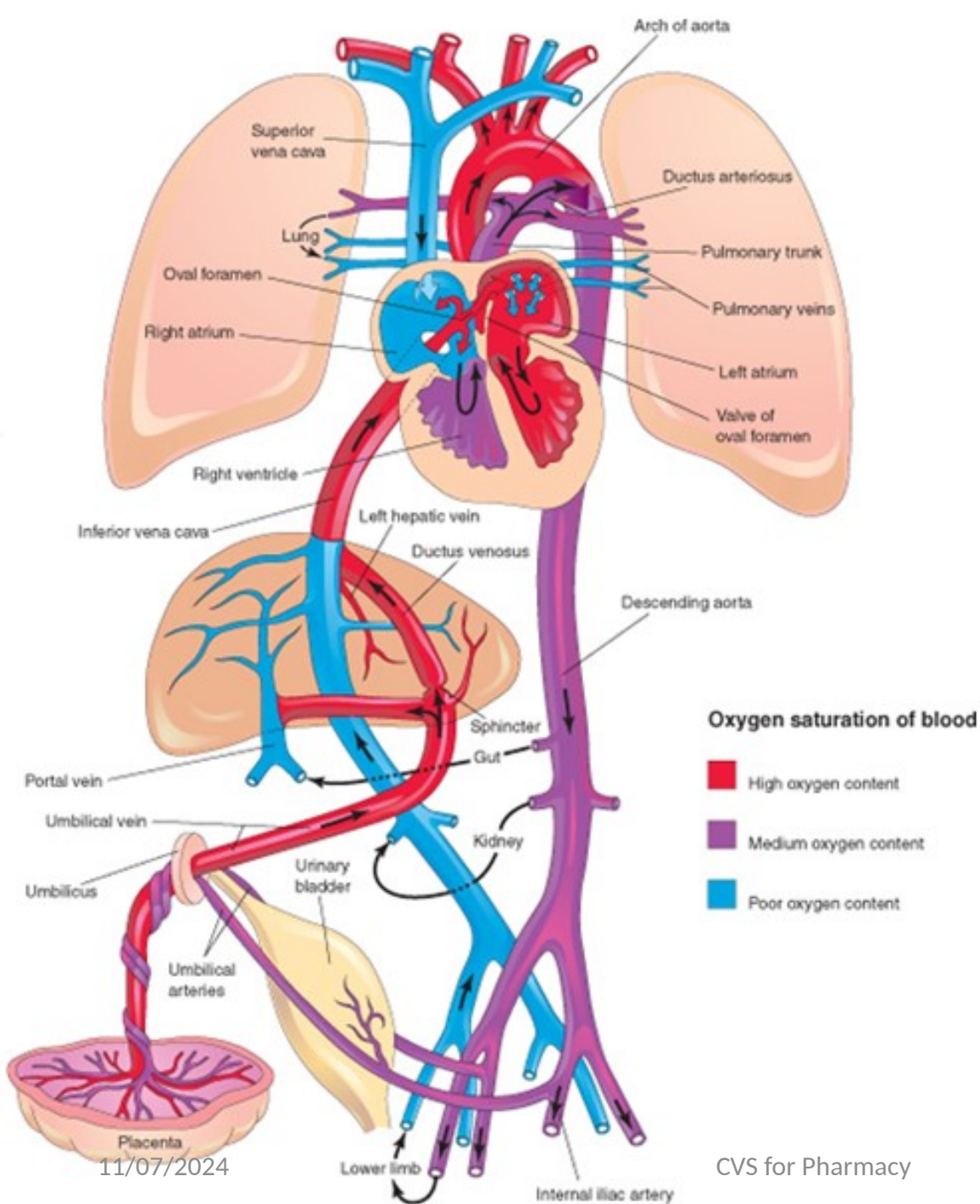
- are finer and more numerous than those of the right ventricle.
- Walls that are two to three times as thick as that of the right ventricle.

The interior of the left ventricle

- ✓ **Aortic vestibule or outflow tract of the left ventricle**
- **Aortic valve** - the opening from the left ventricle into the aorta.
- B/n the cusps and the wall of the ascending aorta there are **pocket-like sinuses**- the right, left, and posterior aortic sinuses, which right and **left coronary** arteries originate.
- ✓ **Mitral valve**

The interior of the left ventricle





Fetal circulation.

The colors indicate the oxygen saturation of the blood, and the *arrows* show the course of the blood from the placenta to the heart.

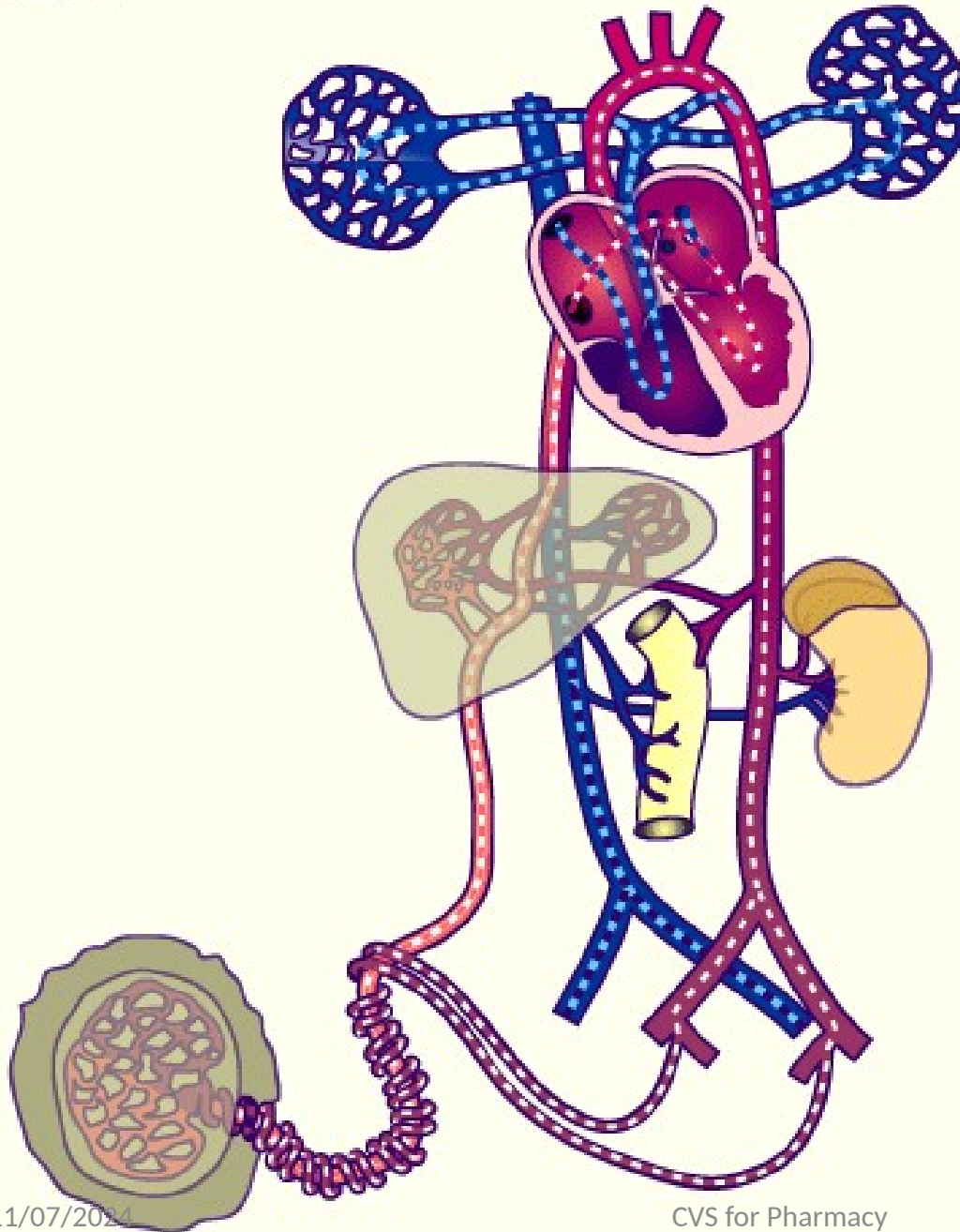
The organs are not drawn to scale. Observe that three shunts permit most of the blood to bypass the liver and lungs:

- (1) ductus venosus,
- (2) oval foramen, and
- (3) ductus arteriosus.

The poorly oxygenated blood returns to the placenta for oxygen and nutrients through the umbilical arteries.

before birth

The blood circulation system
situation at the end of pregnancy



In the placenta the blood becomes enriched with nutrients and oxygen and gets via the unpaired umbilical vein into the fetal blood circulation system.

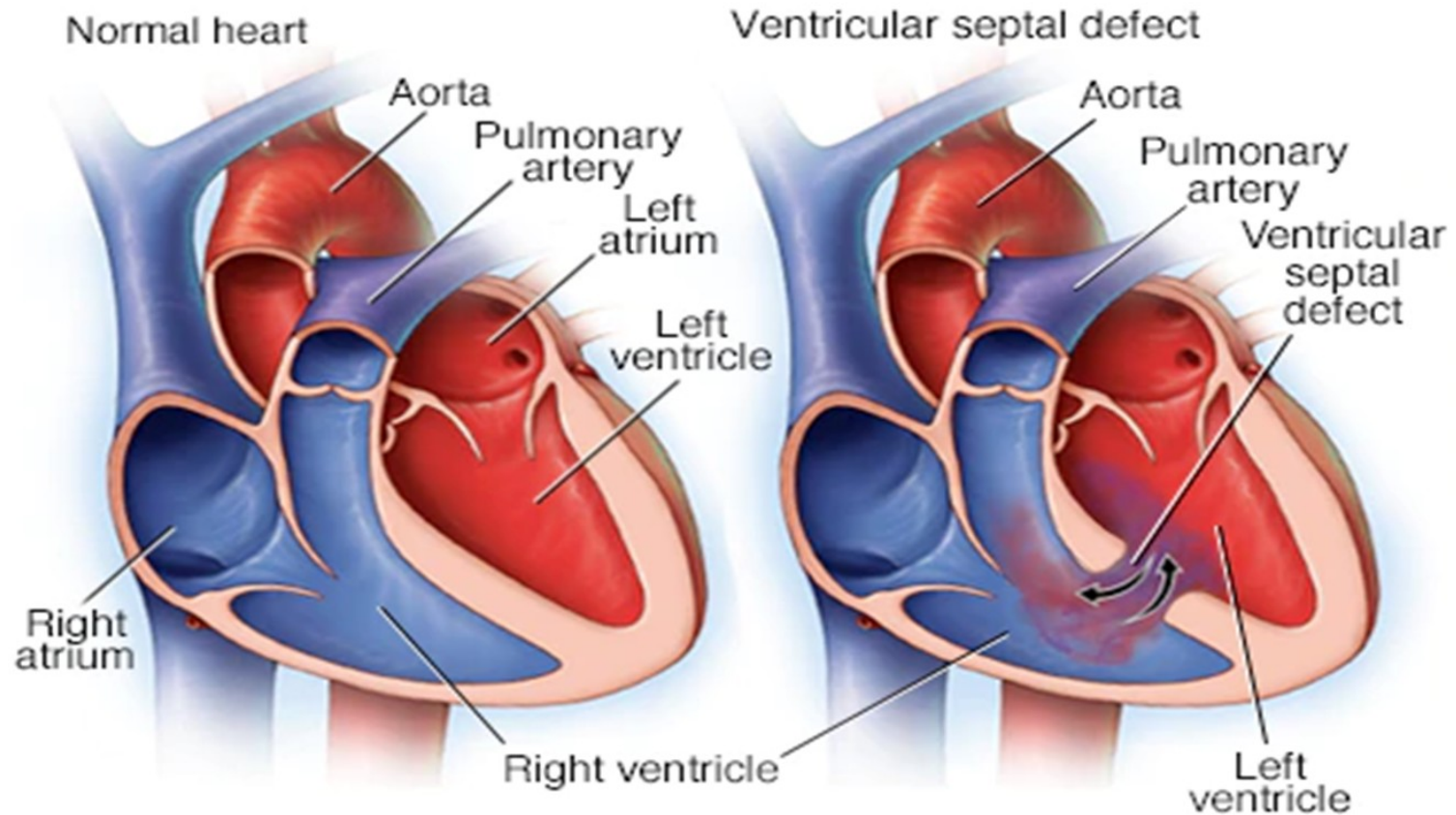
Atrial Septal Defects (ASD)

- A congenital anomaly of the **interatrial septum**, usually incomplete closure of the **foramen ovale**.

Ventricular Septal Defects

- A VSD causes a **left to right shunt** of blood through the defect.

Ventricular Septal Defects



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Patent or persistent ductus arteriosus

- ✓ **Patent or persistent ductus arteriosus**
- Is when the ductus arteriosus, which connects the left branch of the pulmonary artery to the inferior aspect of the aortic arch, fails to close at birth.

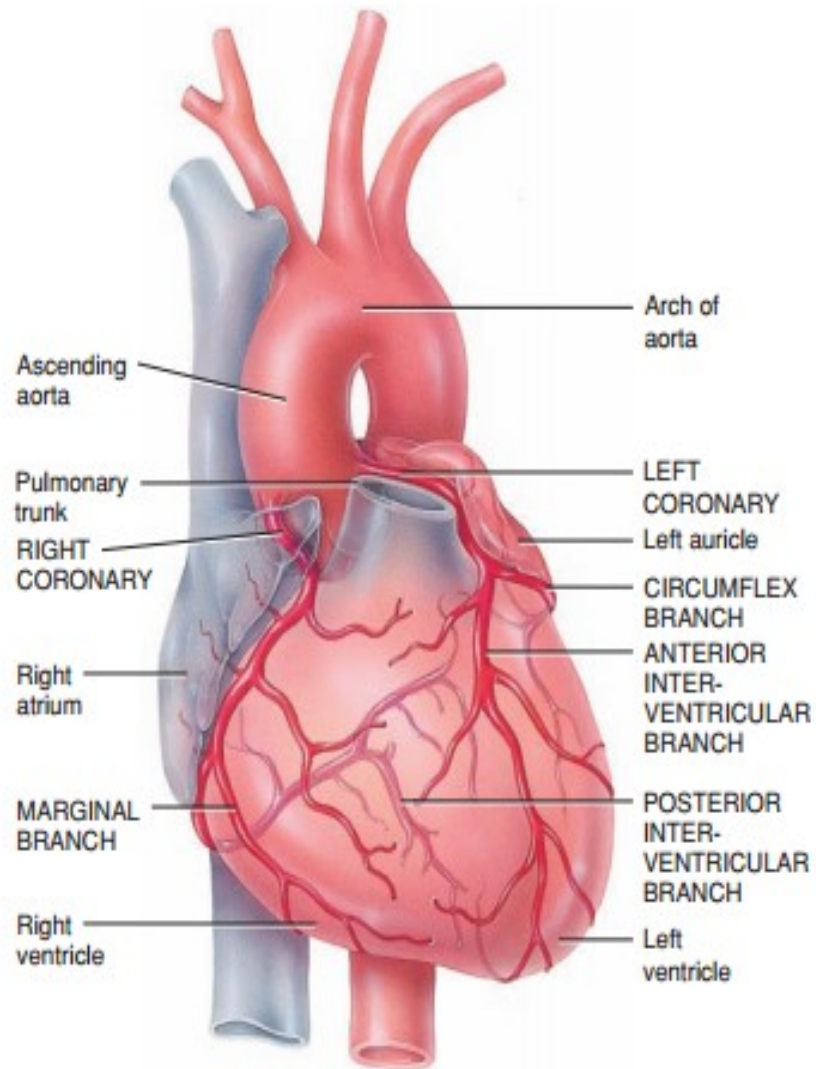
Vasculature of the Heart

- ❖ The **heart** is supplied by
 - ✓ Coronary arteries which arise from:
 - **The aortic sinus** of ascending aorta
 - ✓ it's drained is by **cardiac veins**

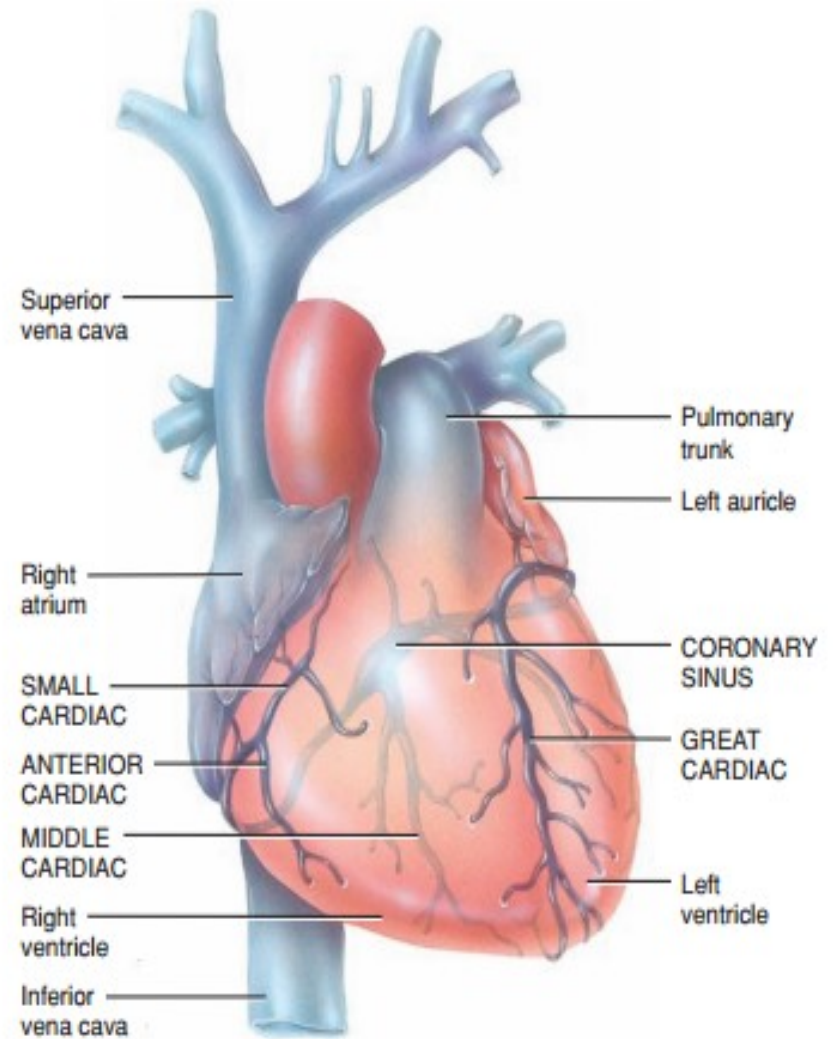
Coronary arteries

- ✓ There are two major branches of coronary artery:
 - **Left coronary artery (LCA):**
 1. Anterior interventricular artery(AIVA):
 2. Coronary circumflex artery

Coronary circulation



(a) Anterior view of coronary arteries

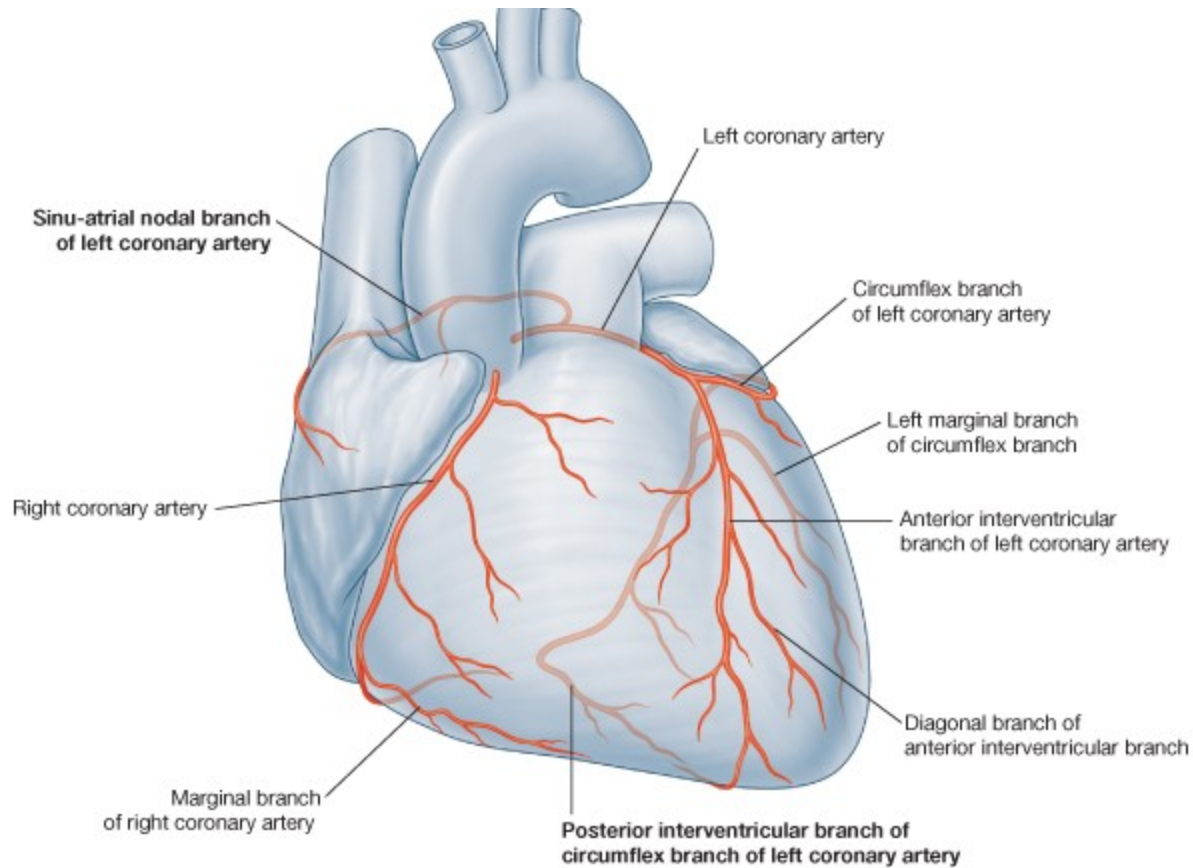


(b) Anterior view of coronary veins

Coronary arteries

- **Right coronary artery (RCA):**
 1. **A right marginal branch**
 2. **Posterior interventricular artery**

Vasculature of the Heart



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Venous Drainage of the Heart

- The heart is drained mainly by cardiac veins that empty into the **coronary sinus** and partly by small veins that empty into the right atrium directly.

The coronary sinus:

- a wide venous channel that runs from left to right in the posterior part of the coronary groove.

Venous Drainage of the Heart

❑ Great Cardiac Vein;

- Is the main tributary of the coronary sinus
- It drains the areas of the heart supplied by the **LCA**.

❑ The middle cardiac vein

- accompanies the **posterior interventricular artery** (usually arising from the RCA).

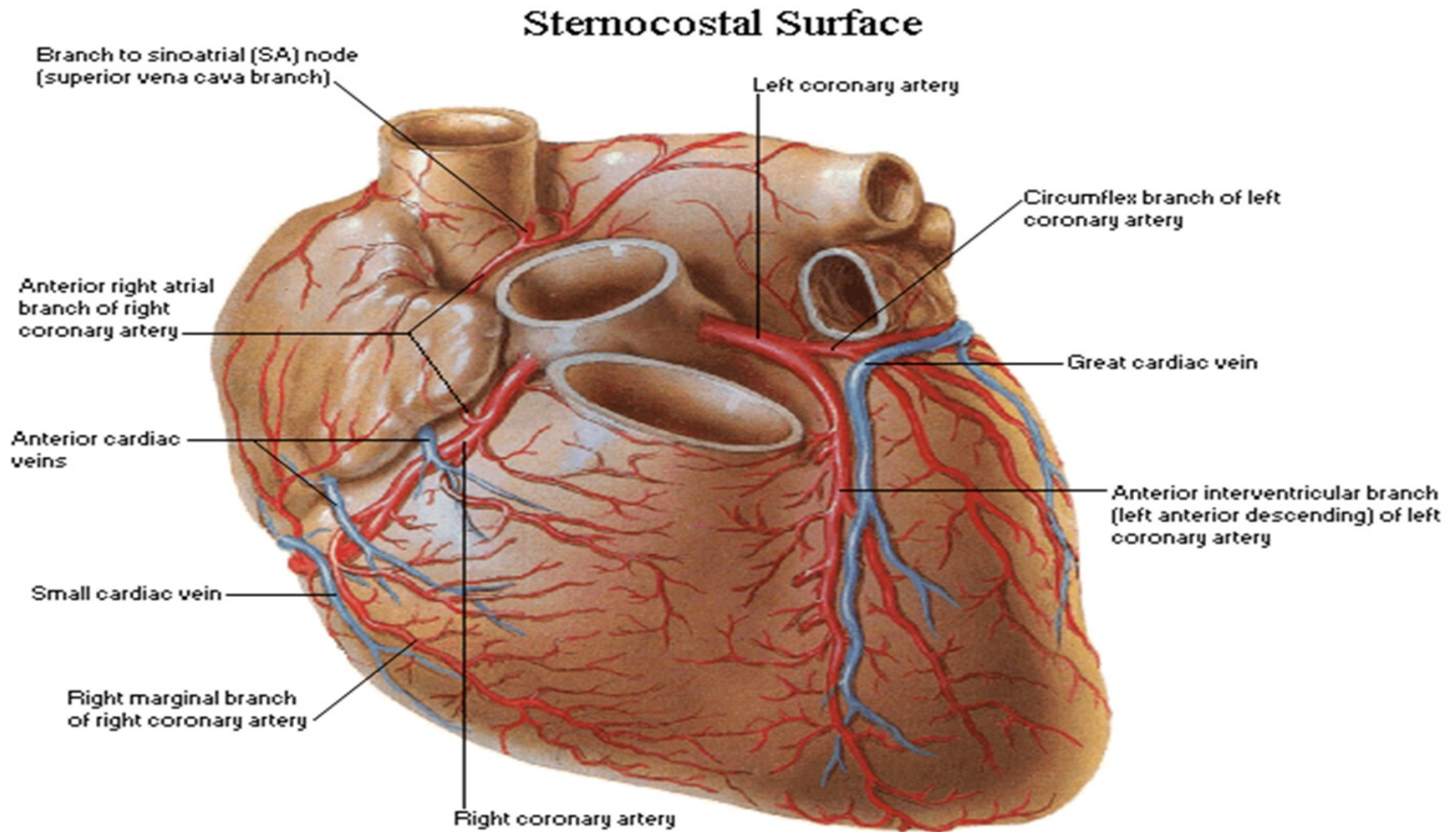
❑ A small cardiac vein

- accompanies the **right marginal branch of the RCA**.

❑ Smallest veins of heart/ Cordis minimae

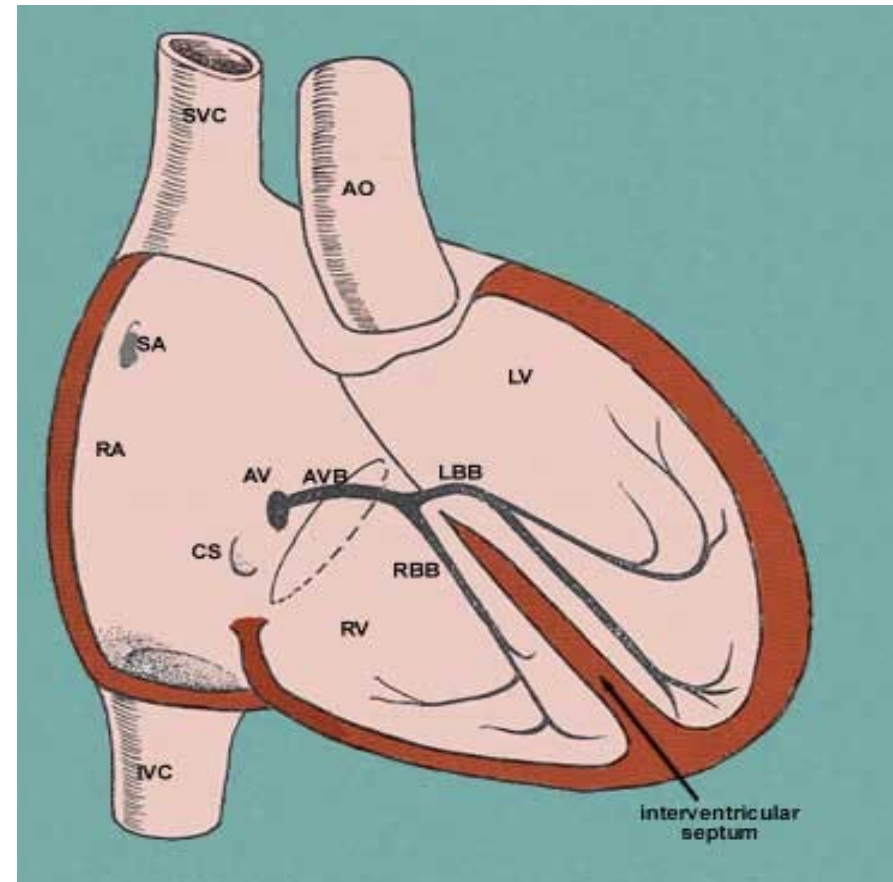
- ❖ Are the smallest cardiac veins which open directly into the chambers of the heart, chiefly the atria.

Cardiac veins

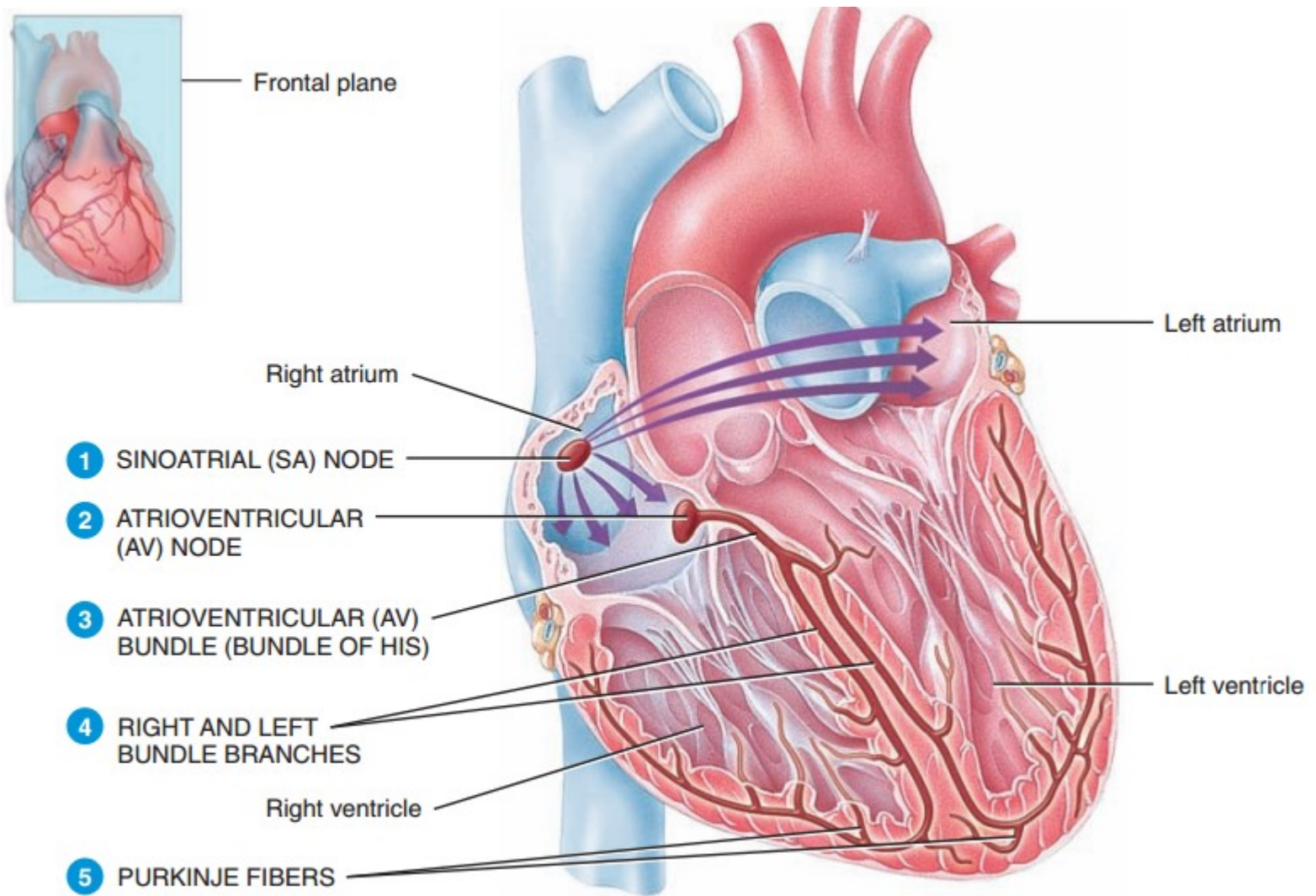


Innervation of the Heart

- The heart has an **internal nervous system (Conducting System of the Heart)** made up of the **SA (sinuatrial node)** & the **AV (atrioventricular) nodes**.
- The **AV bundle (His)** leaves the **AV node** near the lower part of **interatrial septum** & splits over upper part of **interventricular septum** into a **left bundle branch (LBB)** & a **right bundle branch (RBB)**.
- cardiac muscle is then supplied by branches of the two bundles.



Conduction system of the Heart

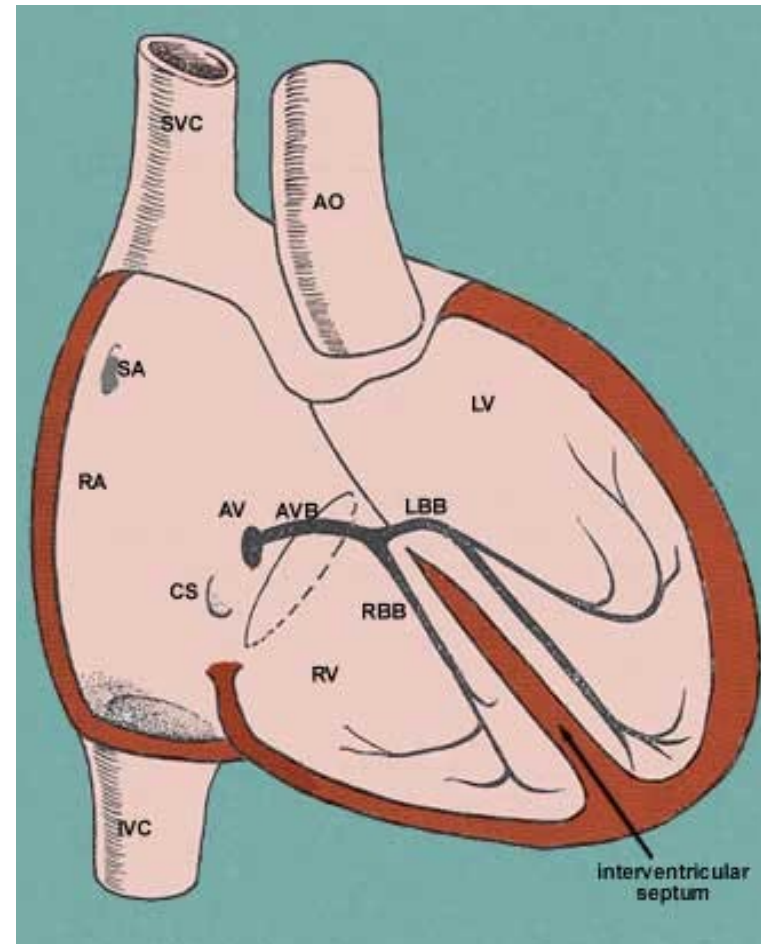


(a) Anterior view of frontal section

Innervation of the Heart

Conducting system:

- Consists of specialized muscle fibers in the: ***Sino-atrial node, Atrio-ventricular node, atrio - ventricular bundle (of His) & Purkinje fibers.***
- Sino-atrial node lies at the upper end of the sulcus terminalis, just to the right of opening of the SVC.
- II This is the pace-maker (where contraction of heart muscle is initiated)
- **Atrio-ventricular node:** lies in the lower part of the inter-atrial septum, just above attachment of cusps of Tricuspid Valve, just above the coronary sinus orifice.
- **Purkinje fibers** – larger than ordinary cardiac muscle fibers.



Blood Vessels

- The **cardiovascular system** contributes to **homeostasis** of other body systems by **transporting** and **distributing** blood throughout the body to deliver **oxygen**, **nutrients**, and **hormones** and carry away **wastes**.
- The structures involved in these important tasks are the **blood vessels**.
- It is a **closed** system: blood never leaves the network of arteries, veins and capillaries.

Blood Vessels

❖ Blood Vascular System:

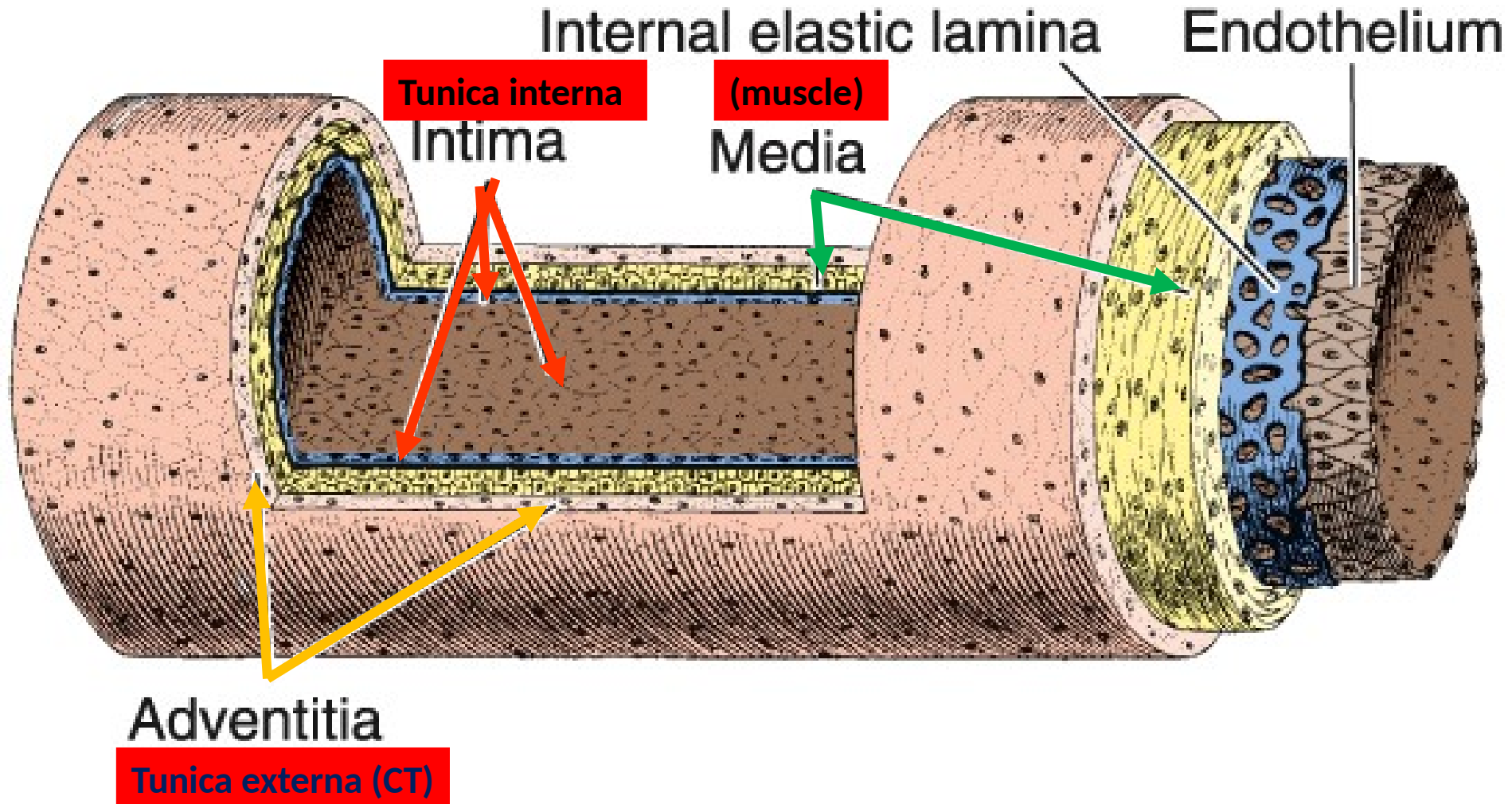
- **Pulmonary & Systemic closed circulation**
 1. heart, arteries, capillaries, veins.
 2. transports O_2 and nutrients to the tissues.
 3. carries away CO_2 and waste products from the tissues.
 4. circulates hormones to target cells.

Blood Vessels

- Blood vessels are made of 3 concentric layers, called from the luminal side outward.
 1. Tunica **intima**
 2. Tunica **media** &
 3. Tunica **adventitia**
- These three layers are analogous to the
 1. **Endocardium**,
 2. **Myocardium** and
 3. **Epicardium**, of the heart.

Structural Plan of Blood Vessels

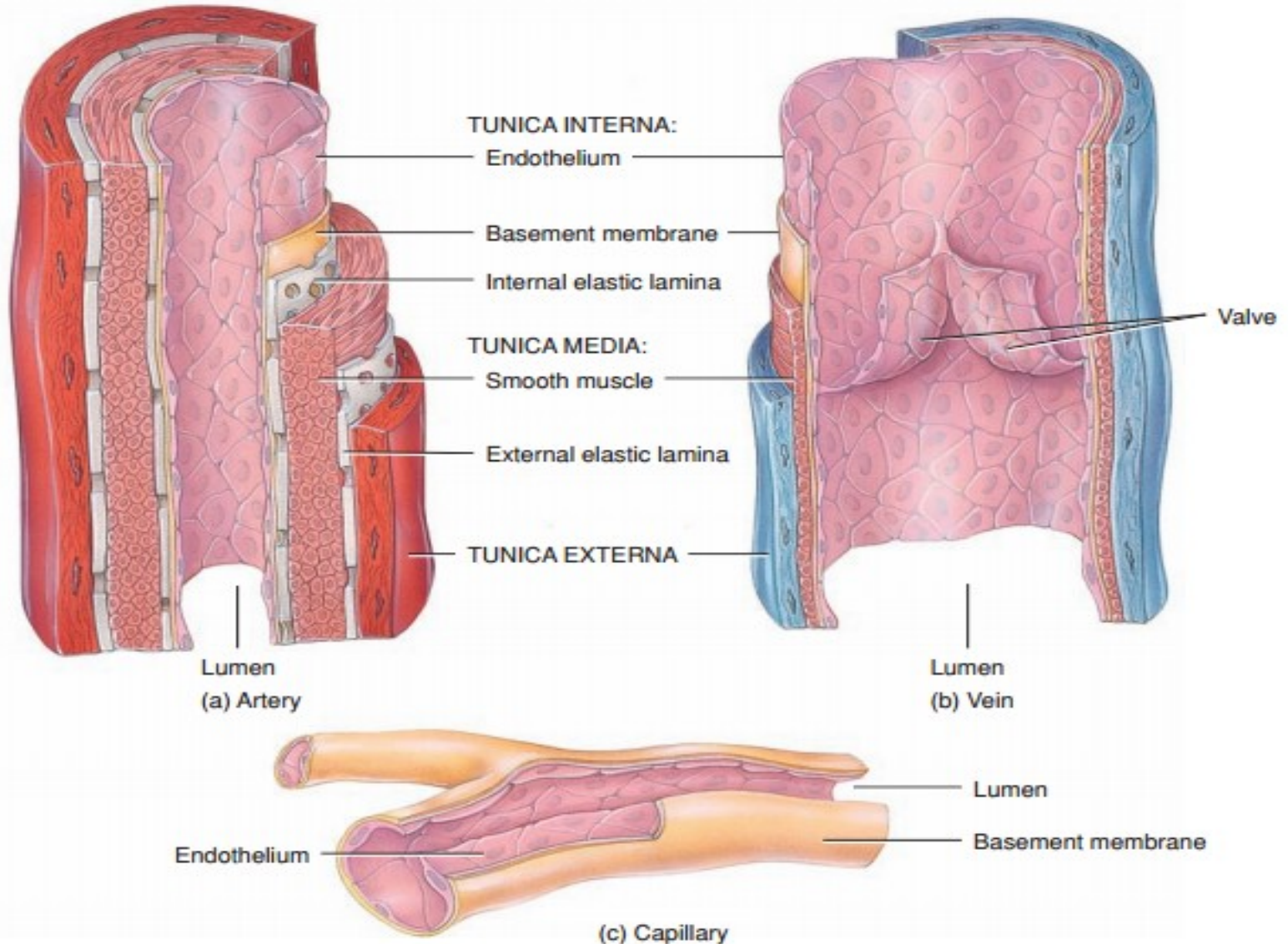
consist of concentric layers or "tunics" of different tissue types



Blood vessels

Figure 21.1 Comparative structure of blood vessels. The capillary (c) is enlarged relative to the artery (a) and vein (b).

6 Arteries carry blood from the heart to tissues; veins carry blood from tissues to the heart.



Tunica Adventitia (Tunica Externa)

- Consists of elastic and collagen fibers
- ✓ In large vessels contains:
 1. **Vasa vasorum** ("vessels of the vessel") → tiny vessels of the blood vessels, supply the vessel wall.
 2. **Nervi vascularis** → nerves of the blood vessels, supply the vessel wall.
- *The tunica adventitia tends to be much larger in veins than arteries.*
- It also helps anchor the vessels to surrounding tissues.

Anastomoses

- Most tissues of the body receive blood from more than one artery.
- The **union** of the branches of two or more arteries supplying the same body region is called an **anastomosis**.
- Anastomoses between arteries provide alternative **routes** for blood to reach a tissue or organ.
- The alternative route of blood flow to a body part through an anastomosis is known as **collateral circulation**.

Posterior View

Superior transverse scapular ligament and scapular notch

Suprascapular artery

Acromial branch of thoracoacromial artery

Omohyoid muscle (inferior belly)

Acromion and acromial plexus

Levator scapulae muscle

Dorsal scapular artery

Supraspinatus muscle (cut)

Infraspinous branch of
suprascapular artery

Spine of scapula

Posterior circumflex
humeral artery (in
quadrangular space)
and ascending and
descending branches

Infraspinatus muscle (cut)

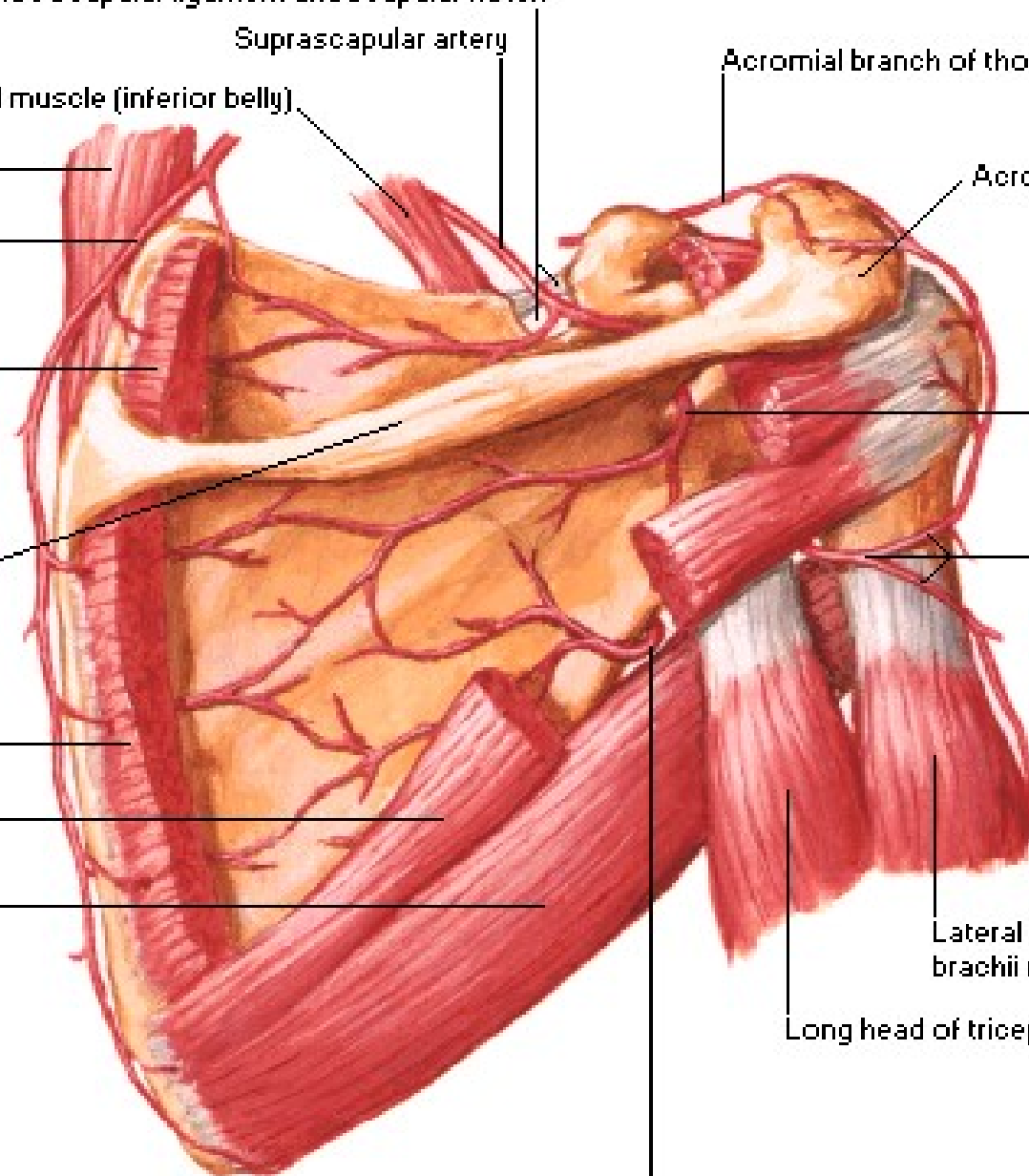
Teres minor muscle (cut)

Teres major muscle

Lateral head of triceps
brachii muscle

Long head of triceps brachii muscle

Circumflex scapular artery
(in triangular space)



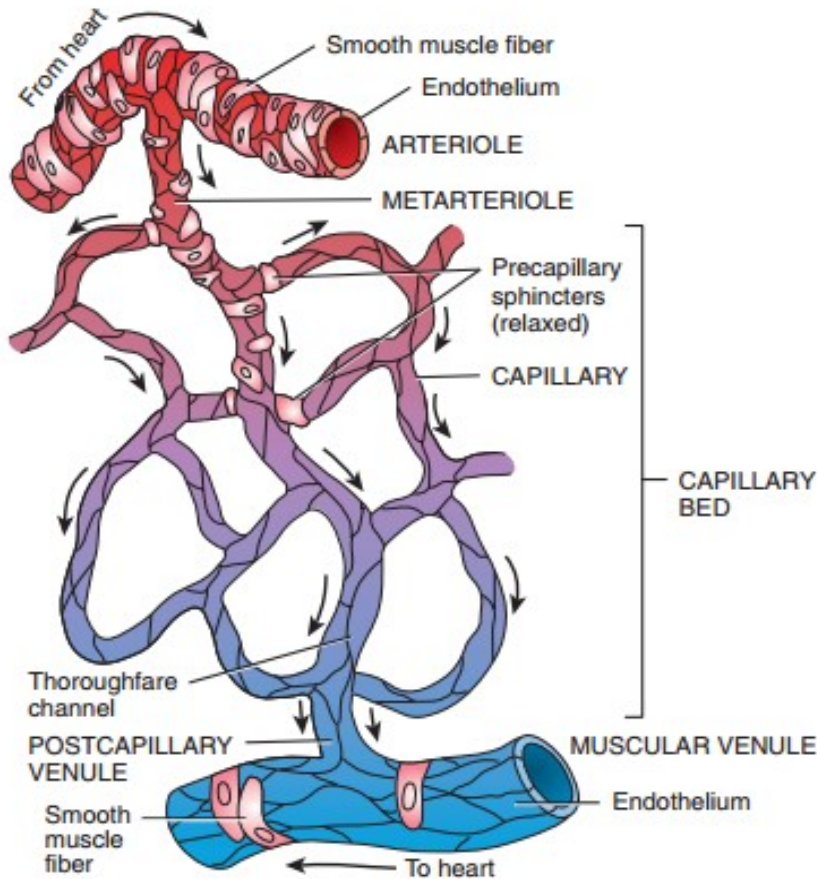
Capillaries

- The smallest of blood vessels
- have diameters of 5–10 μm
- It connect the arterial outflow to the venous return.
- The primary function of capillary is exchange of substances between the **blood** and **interstitial fluid**.
- Because of this, these thin-walled vessels are referred to as **exchange vessels**.

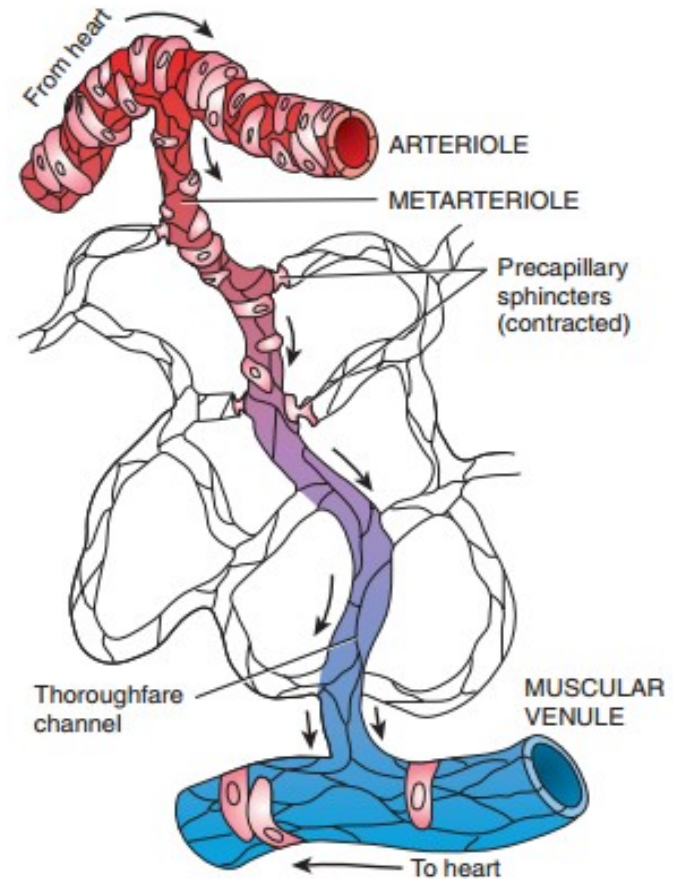
Capillaries

Figure 21.3 Arteriole, capillaries, and venule. Precapillary sphincters regulate the flow of blood through capillary beds.

 In capillaries, nutrients, gases, and wastes are exchanged between the blood and interstitial fluid.



(a) Sphincters relaxed: blood flowing through capillaries



(b) Sphincters contracted: blood flowing through thoroughfare channel

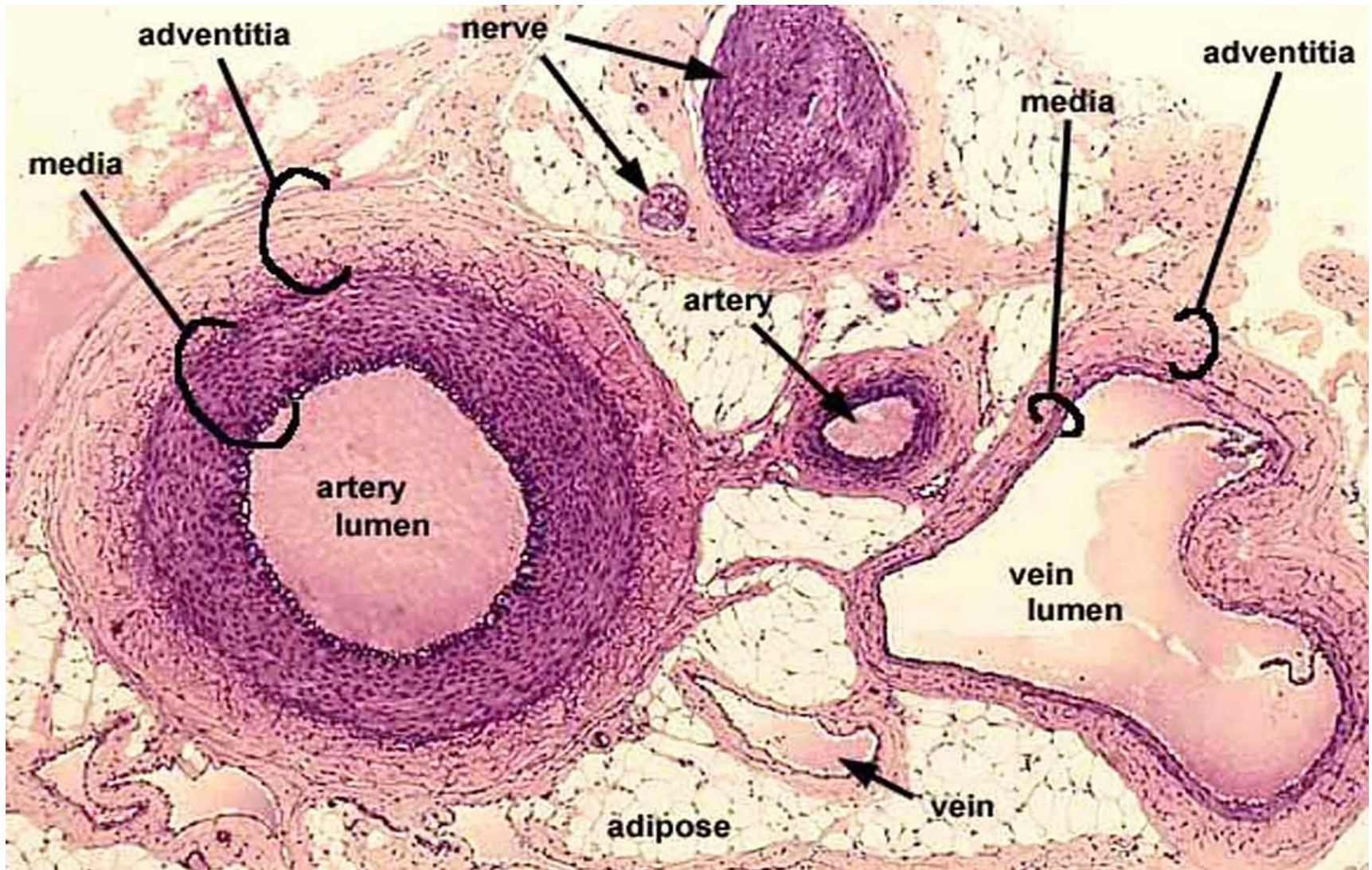
Venules

- **Venules** (little vein)
- Venules drain the capillary blood and begin the return flow of blood back toward the heart.
- Venules that initially receive blood from capillaries are called **postcapillary venules**.

VEINS

- **VEINS** - return blood to the heart by the actions of the smooth muscles and the specialized **valves** ➡ *prevent retrograde flow of blood.*
- Veins have thinner walls and larger, more regular lumen than the corresponding arteries.
- These valves:
 - ↳ are especially abundant in the veins of the **lower limbs.**
 - ↳ direct venous blood towards the heart.

Note the thickness of the wall and the relative amount of muscle tissue (media).



CIRCULATORY ROUTES

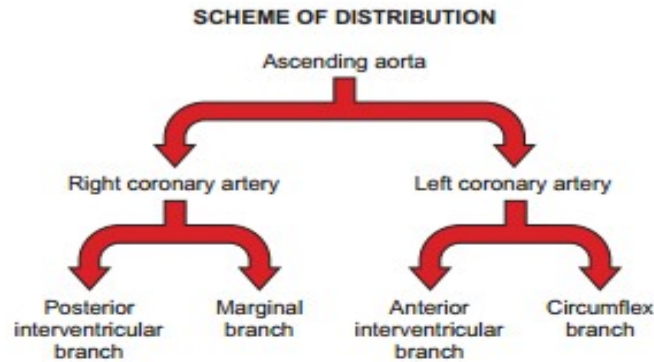
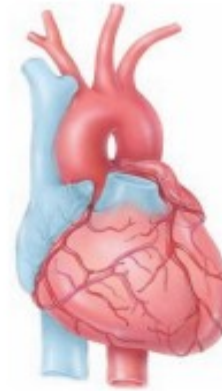
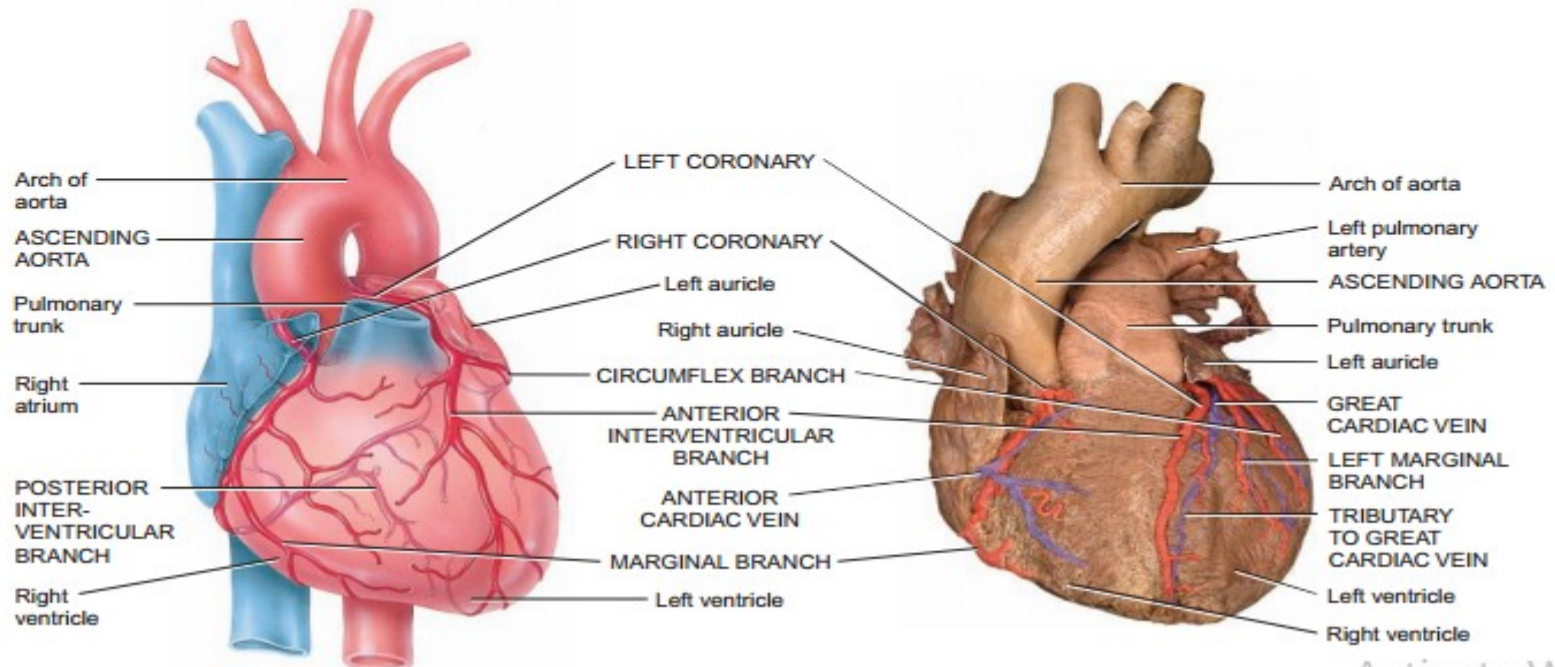
- Arteries, arterioles, capillaries, venules, and veins are organized into **circulatory routes** that deliver blood throughout the body.

1. The Systemic Circulation:

- Carries oxygen and nutrients to body tissues and removes carbon dioxide and other wastes and heat from the tissues.
- All systemic arteries branch from the **aorta**.
- Deoxygenated blood returns to the heart through the systemic veins.
- All the veins of the systemic circulation drain into the **superior venacava & inferior venacava**, or **coronary sinus**, which in turn empty into the right atrium.

DIVISION AND BRANCHES	REGIONS SUPPLIED
ASCENDING AORTA <ul style="list-style-type: none"> • Right and left coronary arteries 	<ul style="list-style-type: none"> • Heart
ARCH OF AORTA <ul style="list-style-type: none"> ▪ Brachiocephalic trunk <ul style="list-style-type: none"> • Right common carotid artery • Right subclavian artery ▪ Left common carotid artery ▪ Left subclavian artery 	<ul style="list-style-type: none"> • Right side of head and neck • Right upper limb and CNS • Left side of head and neck • Left upper limb and CNS
THORACIC AORTA <ul style="list-style-type: none"> • Pericardial arteries • Bronchial arteries • Esophageal arteries • Mediastinal arteries • Posterior intercostal arteries • Subcostal arteries • Superior phrenic arteries 	<ul style="list-style-type: none"> • Pericardium • Bronchi of lungs • Esophagus • Structures in mediastinum • Intercostal and chest muscles • Same as posterior intercostals • Superior and posterior surfaces of diaphragm
ABDOMINAL AORTA <ul style="list-style-type: none"> ➤ Inferior phrenic arteries ➤ Celiac trunk <ul style="list-style-type: none"> • Common hepatic artery • Left gastric artery • Splenic artery ➤ Superior mesenteric artery <ul style="list-style-type: none"> • Suprarenal arteries • Renal arteries. • Gonadal arteries (Ovarian/testicular arteries) ➤ Inferior mesenteric artery ➤ Common iliac arteries <ul style="list-style-type: none"> • External iliac arteries • Internal iliac arteries 	<ul style="list-style-type: none"> • Inferior surface of diaphragm • Liver, stomach, duodenum, and pancreas. • Stomach and esophagus • Spleen, pancreas, and stomach • Small intestine, cecum, ascending and transverse colons, and pancreas • Adrenal (suprarenal) glands • Kidneys • Ovaries/Testes • Transverse, descending, and sigmoid colons; rectum • Lower limbs • Uterus (female), prostate (male), muscles of buttocks, and urinary bladder

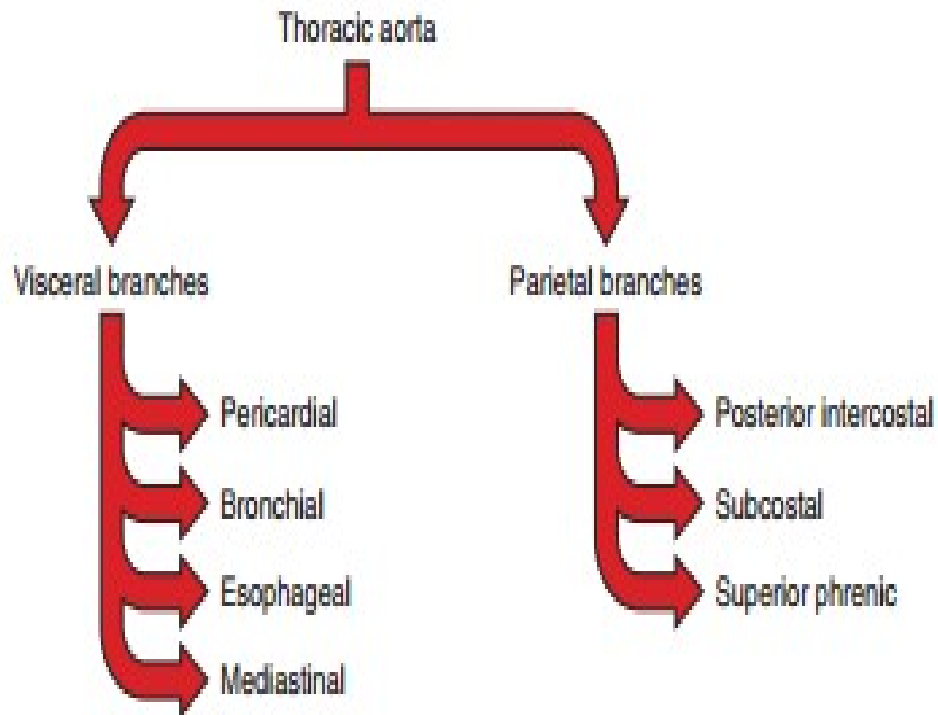
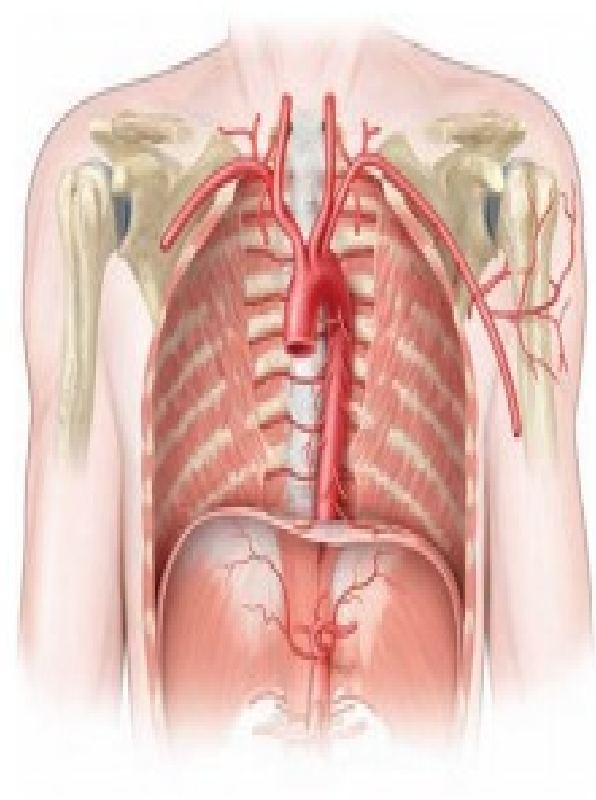
Ascending aorta



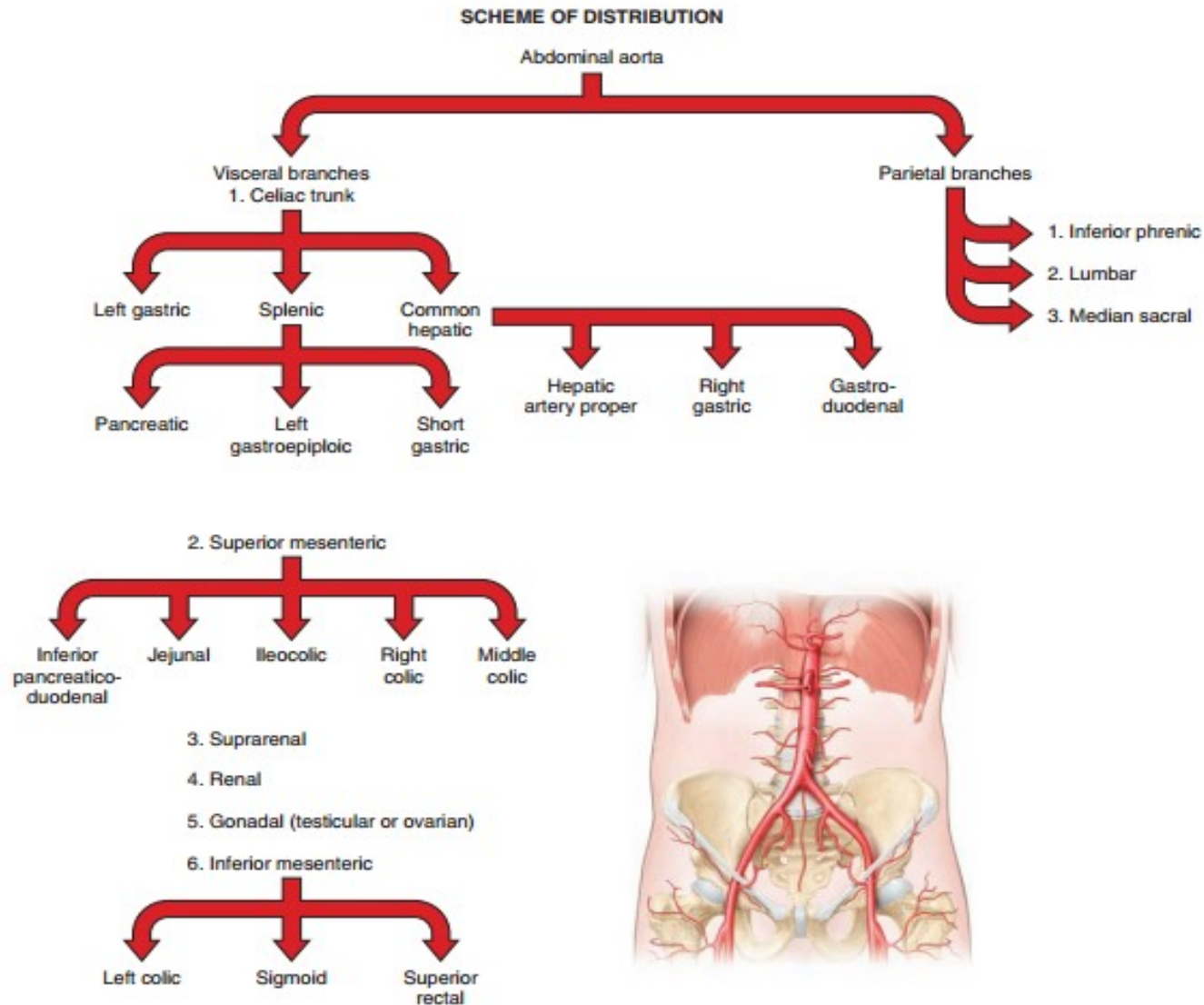
Anterior view of coronary arteries and their major branches

Thoracic Aorta

SCHEME OF DISTRIBUTION



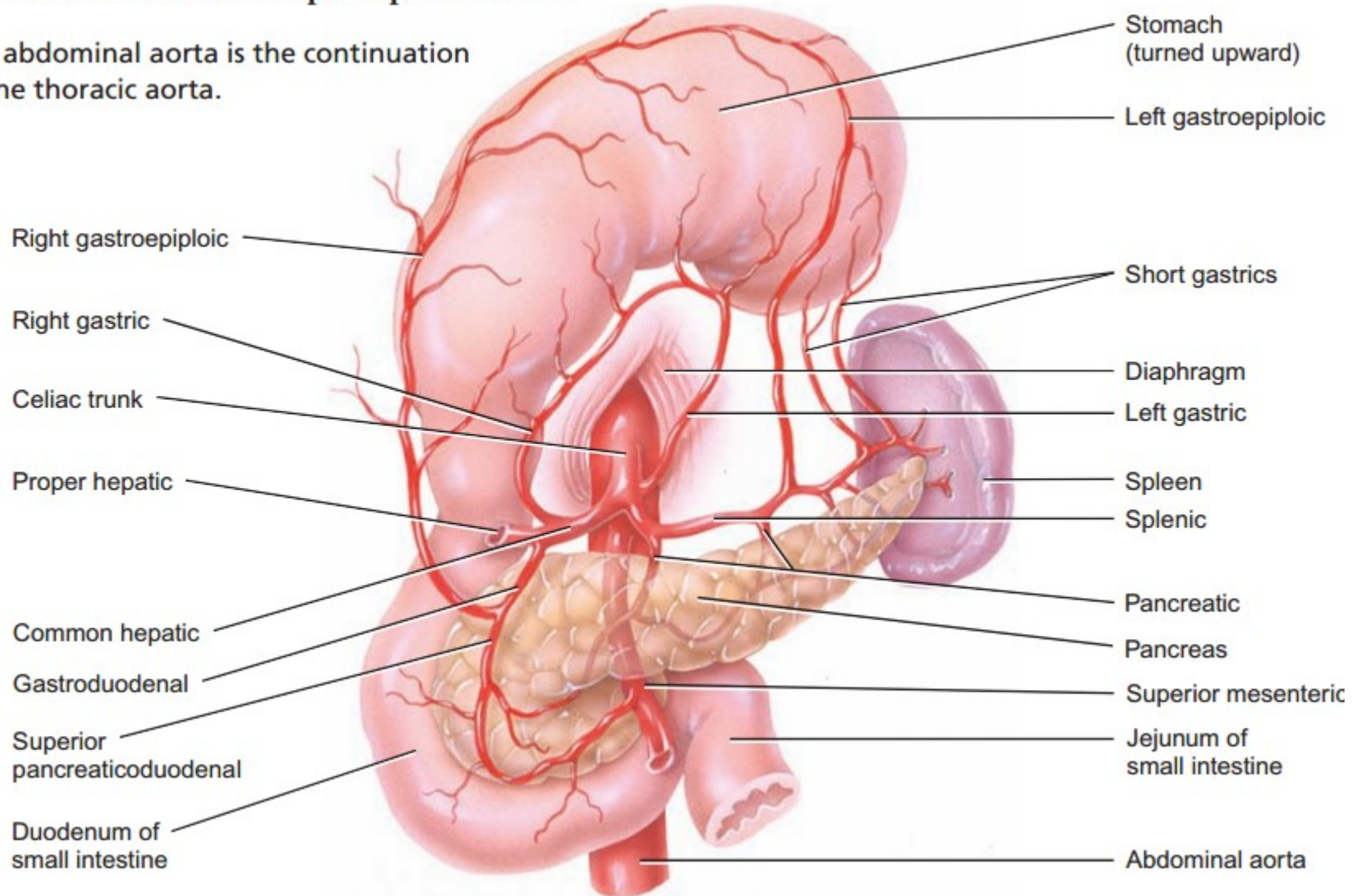
Abdominal Aorta



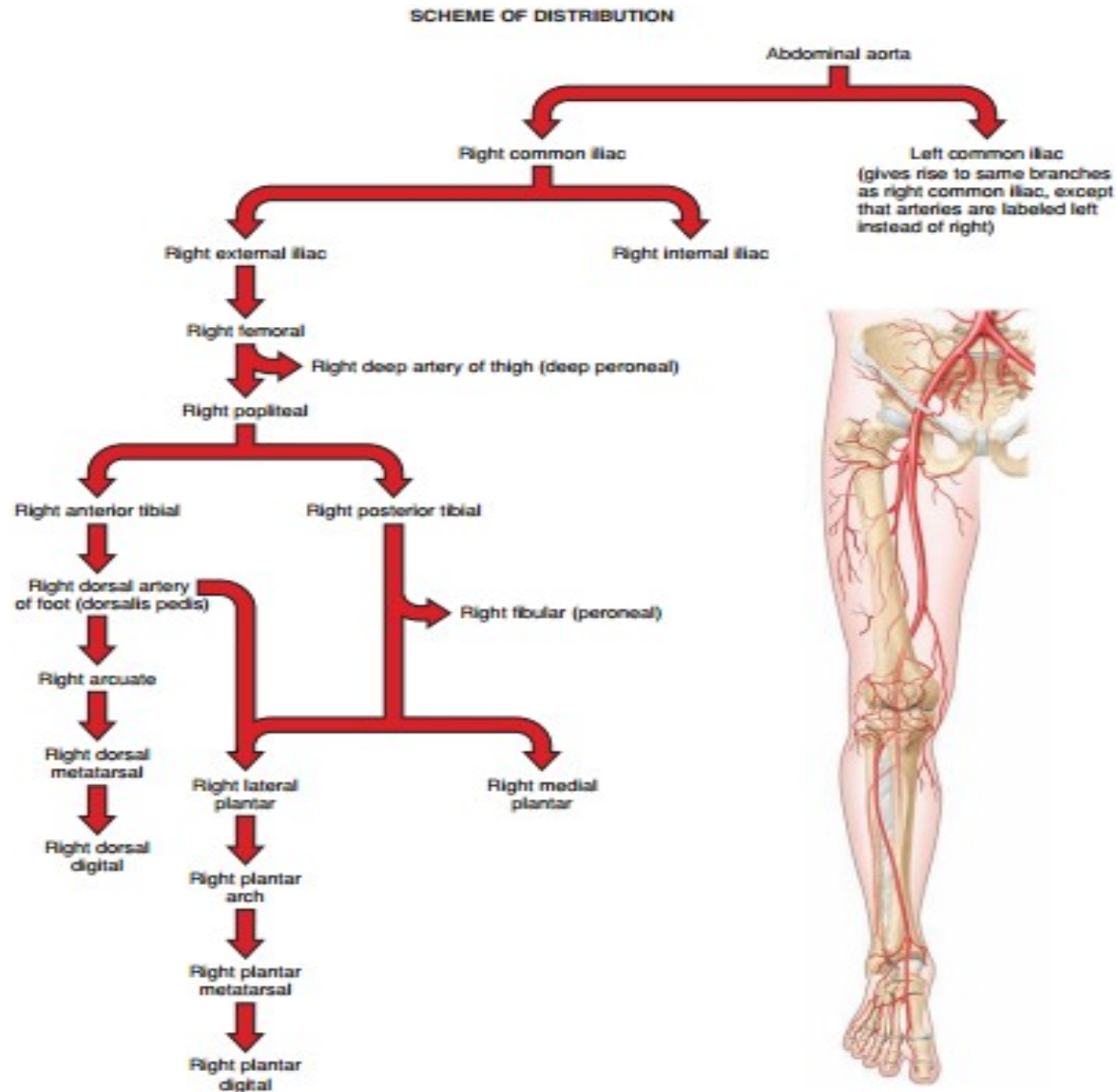
Celiac trunk

4.8 Abdominal aorta and principal branches.

The abdominal aorta is the continuation of the thoracic aorta.



Common iliac



Arteries of the pelvis and right free lower limb

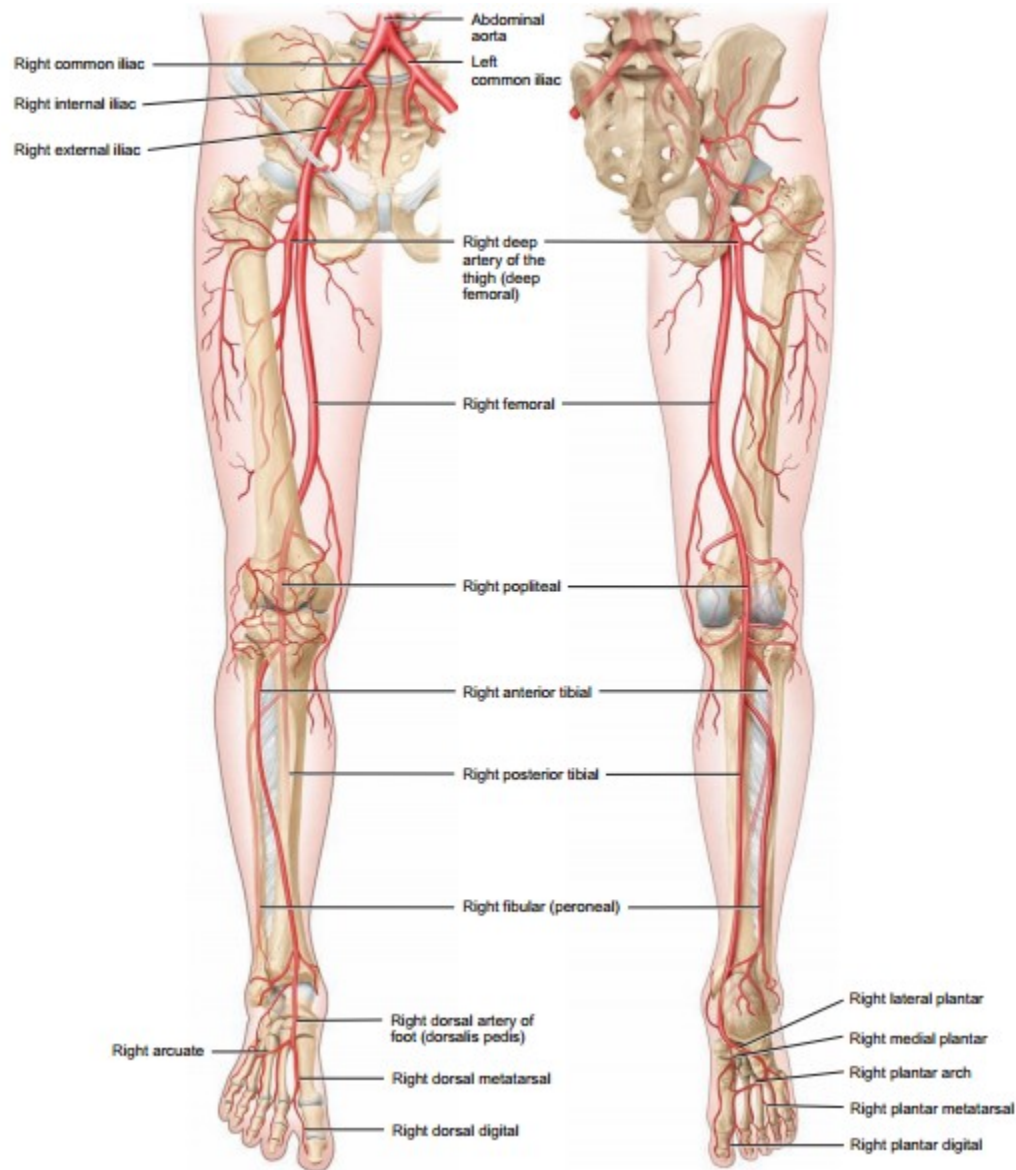
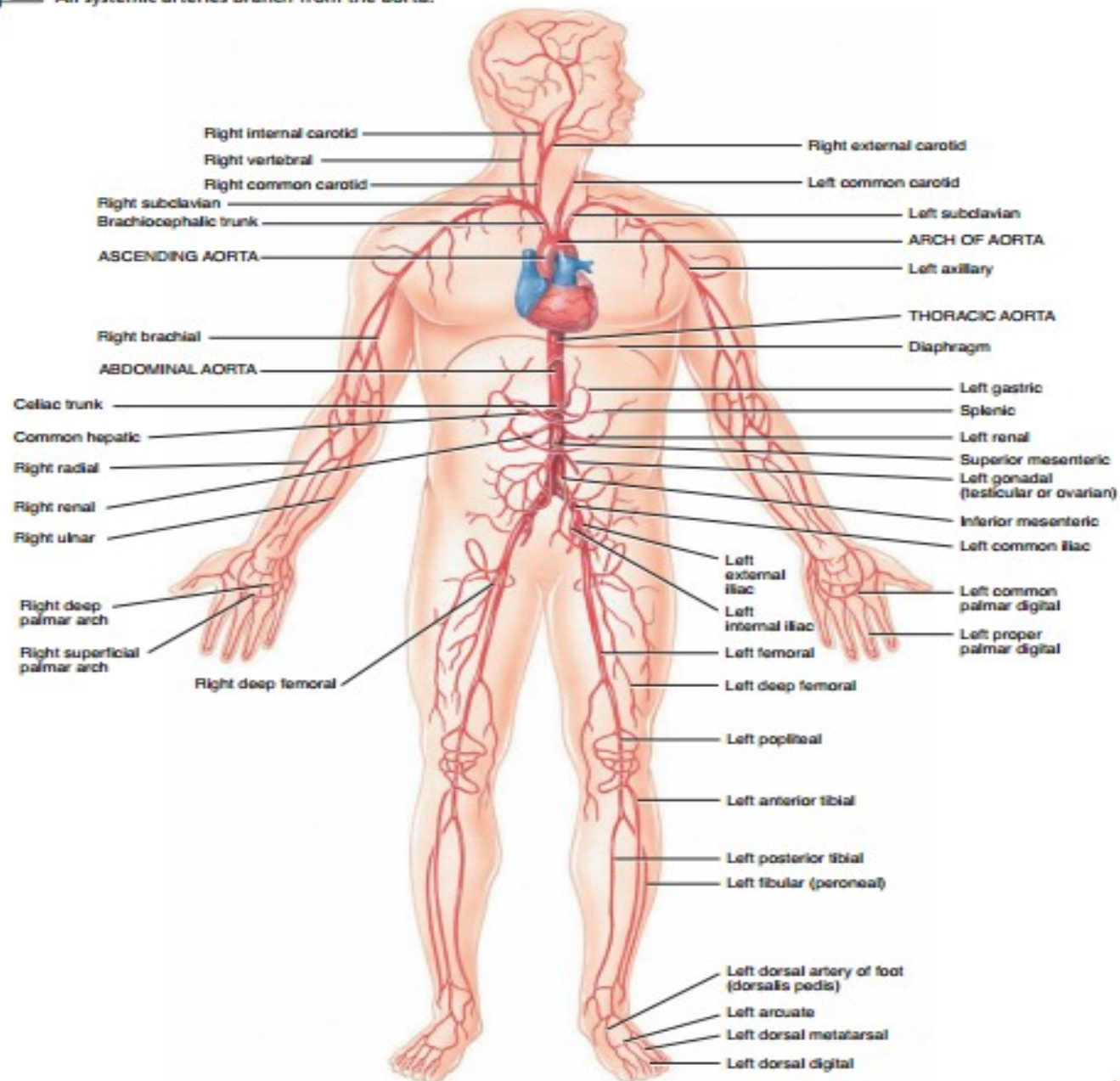


Figure 21.18 Aorta and its principal branches.

 All systemic arteries branch from the aorta.

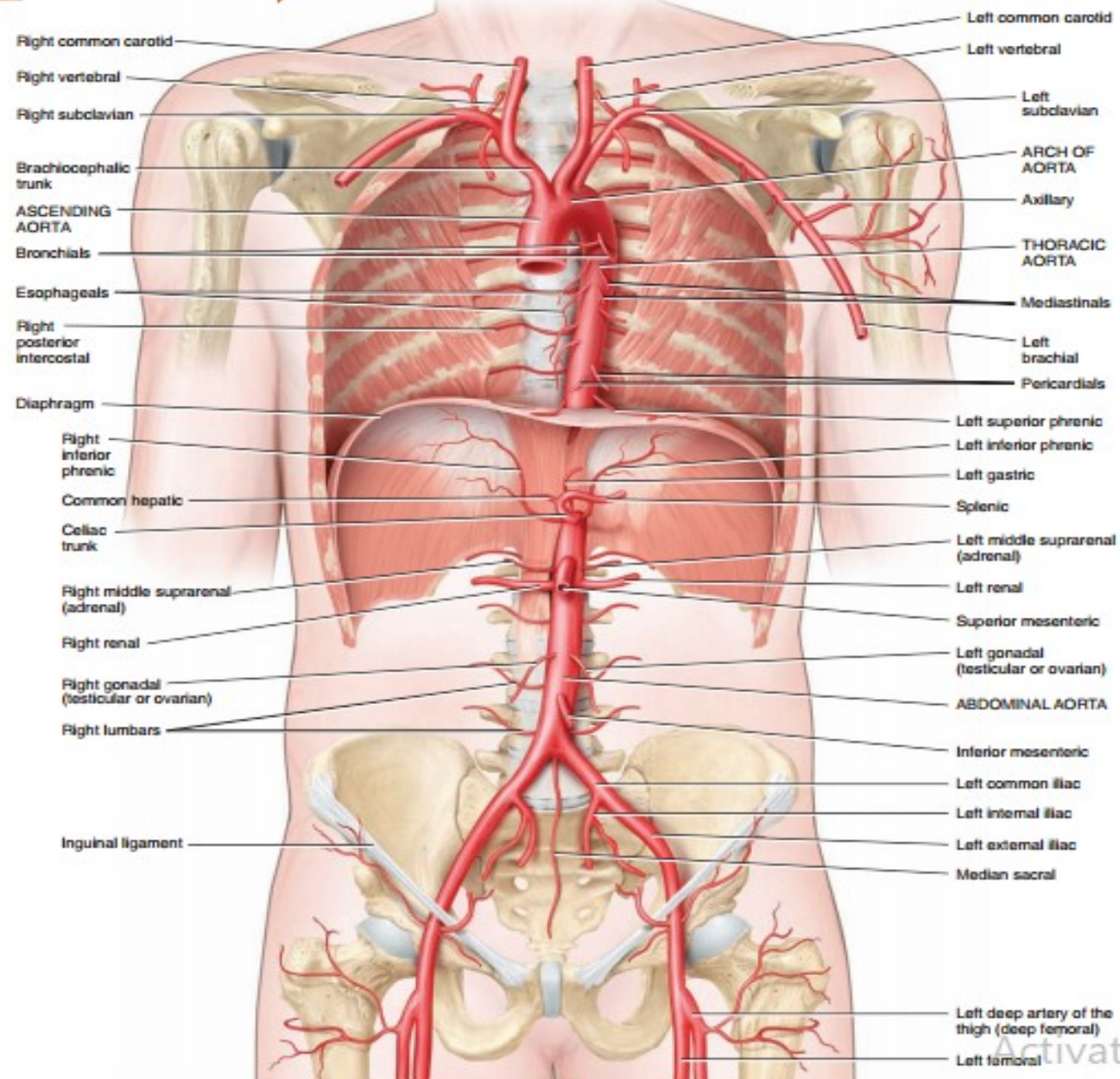


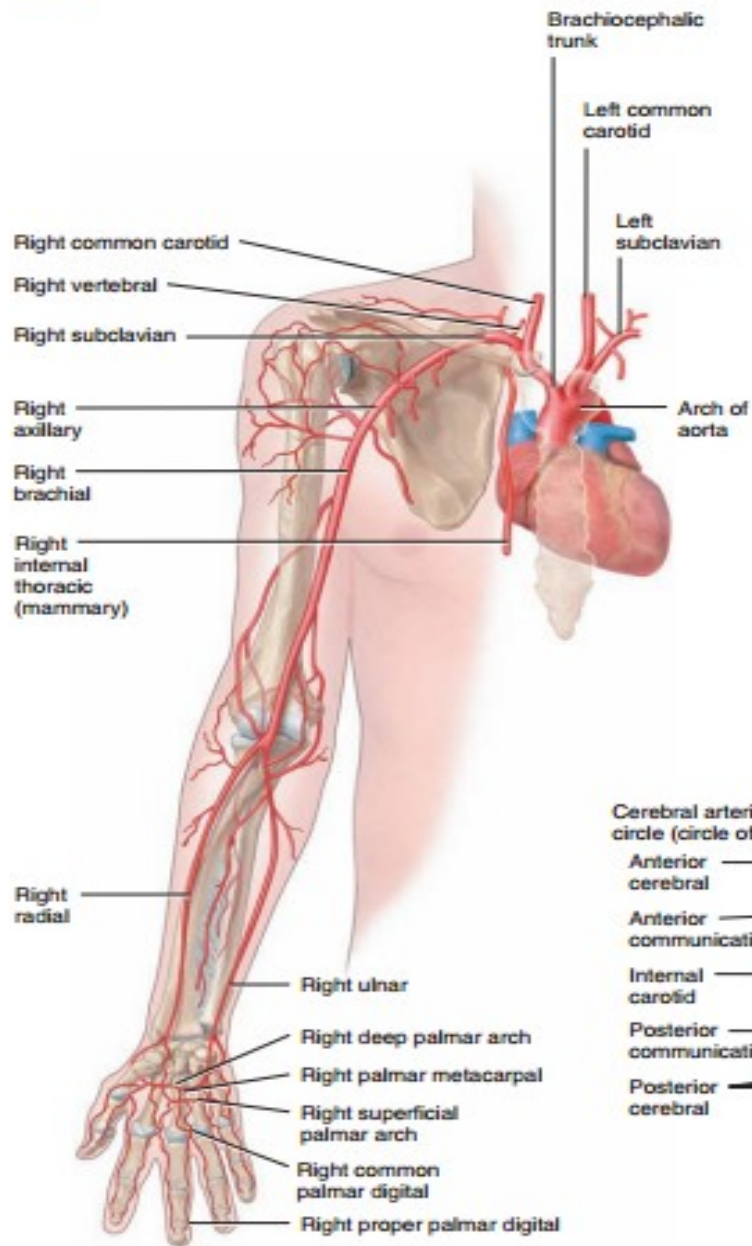
(a) Overall anterior view of the principal branches of aorta

EXHIBIT 21.A CONTINUES

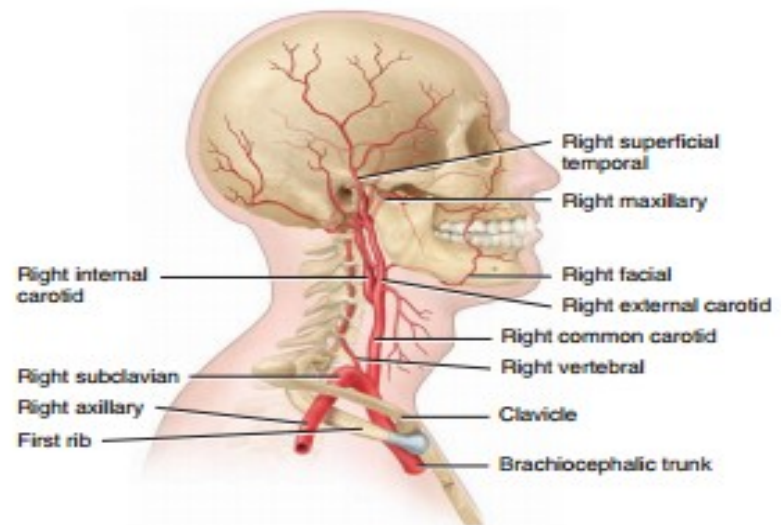


FIGURE 21.18 CONTINUED

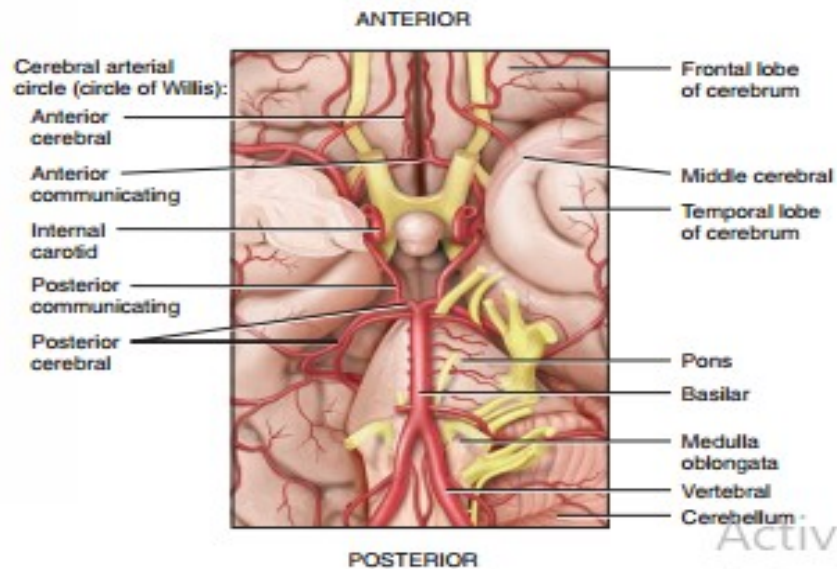




(a) Anterior view of branches of brachiocephalic trunk in upper limb

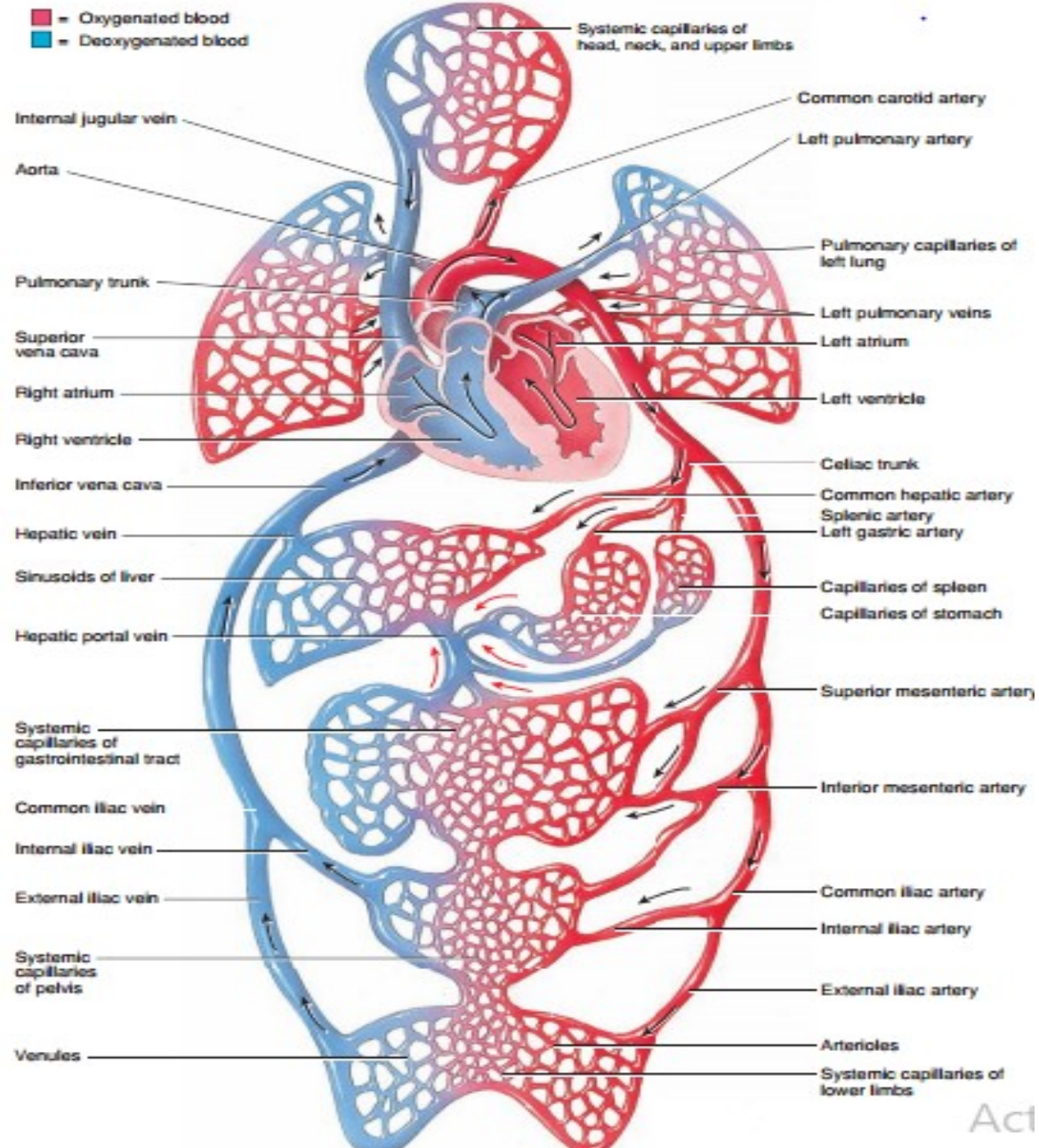


(b) Right lateral view of branches of brachiocephalic trunk in neck and head



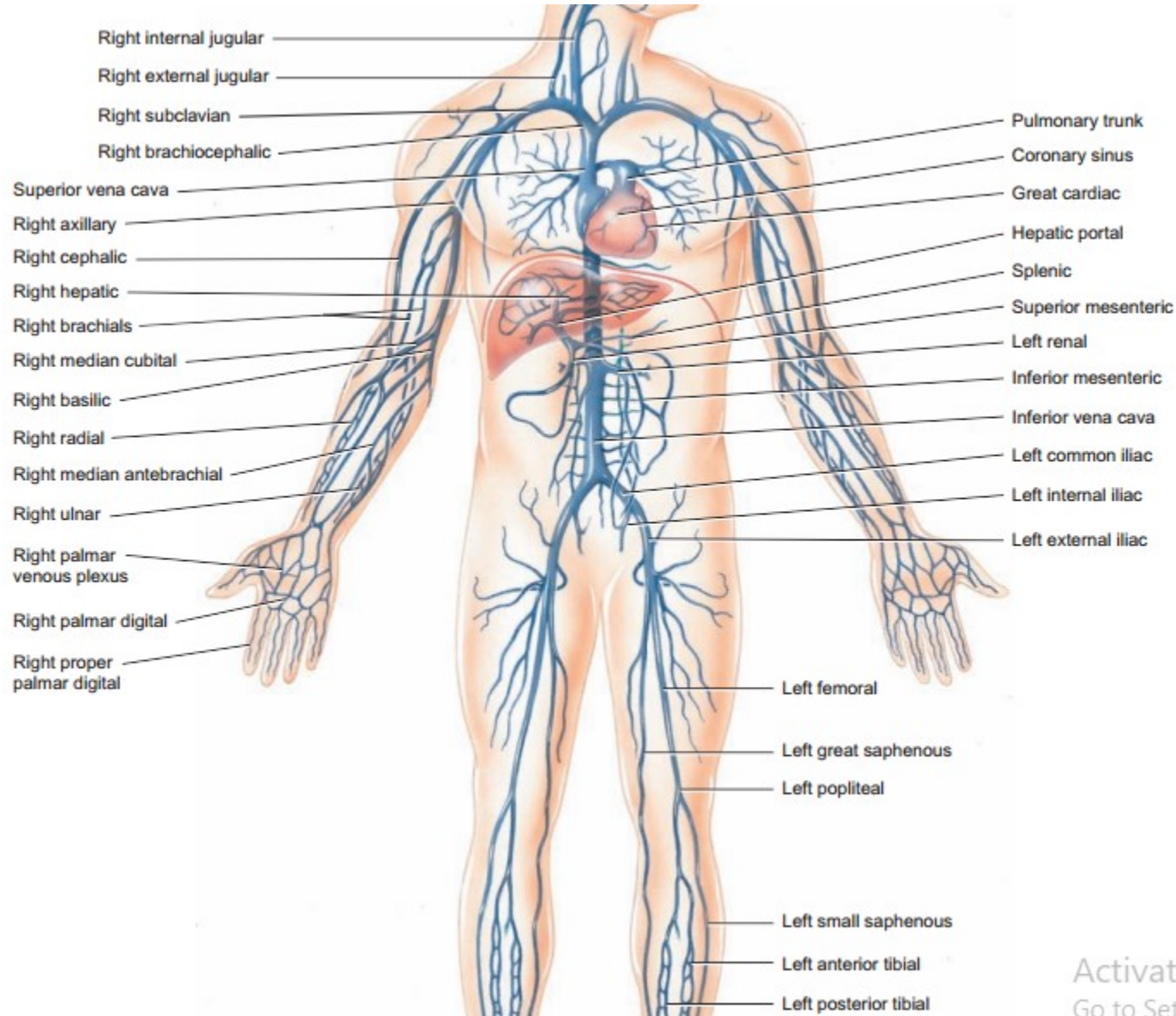


Blood vessels are organized into various routes that deliver blood to tissues of the body.



Act

Venous Drainage

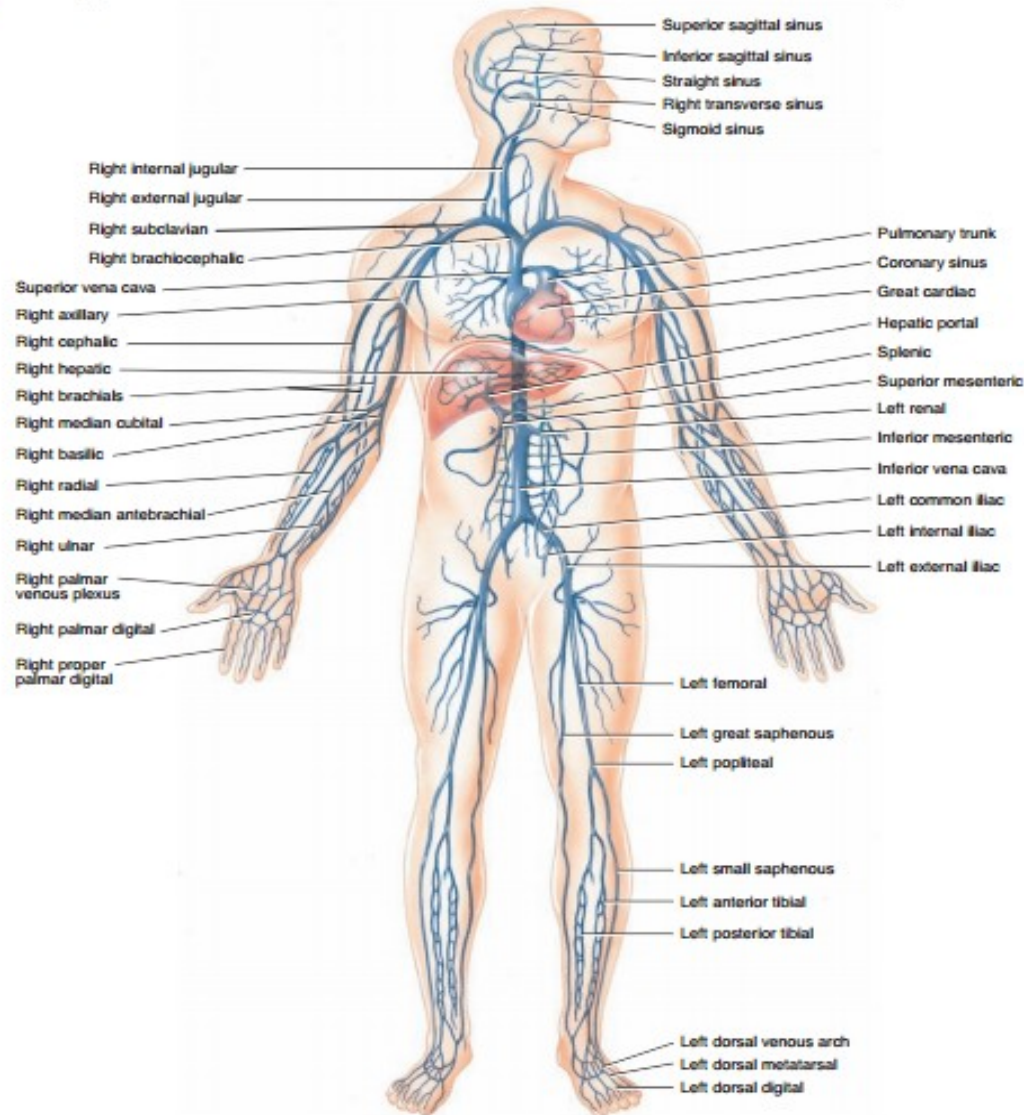


Activate
Go to Sett

Venous Drainage

Figure 21.23 Principal veins.

 Deoxygenated blood returns to the heart via the superior vena cava, inferior vena cava, and coronary sinus.



Overall anterior view of principal veins
CVS for Pharmacy

Thank you!!!