PowerPoint® Lecture Slide Presentation
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The Cardiovascular System

11 PART A

The Cardiovascular System

- A closed system of the heart and blood vessels
  - The heart pumps blood
  - Blood vessels allow blood to circulate to all parts of the body
- The function of the cardiovascular system is to deliver oxygen and nutrients and to remove carbon dioxide and other waste products

The Heart

- Location
  - Thorax between the lungs in the mediastinum
- Orientation
  - Pointed apex directed toward left hip
  - Base points toward right shoulder
- About the size of your fist

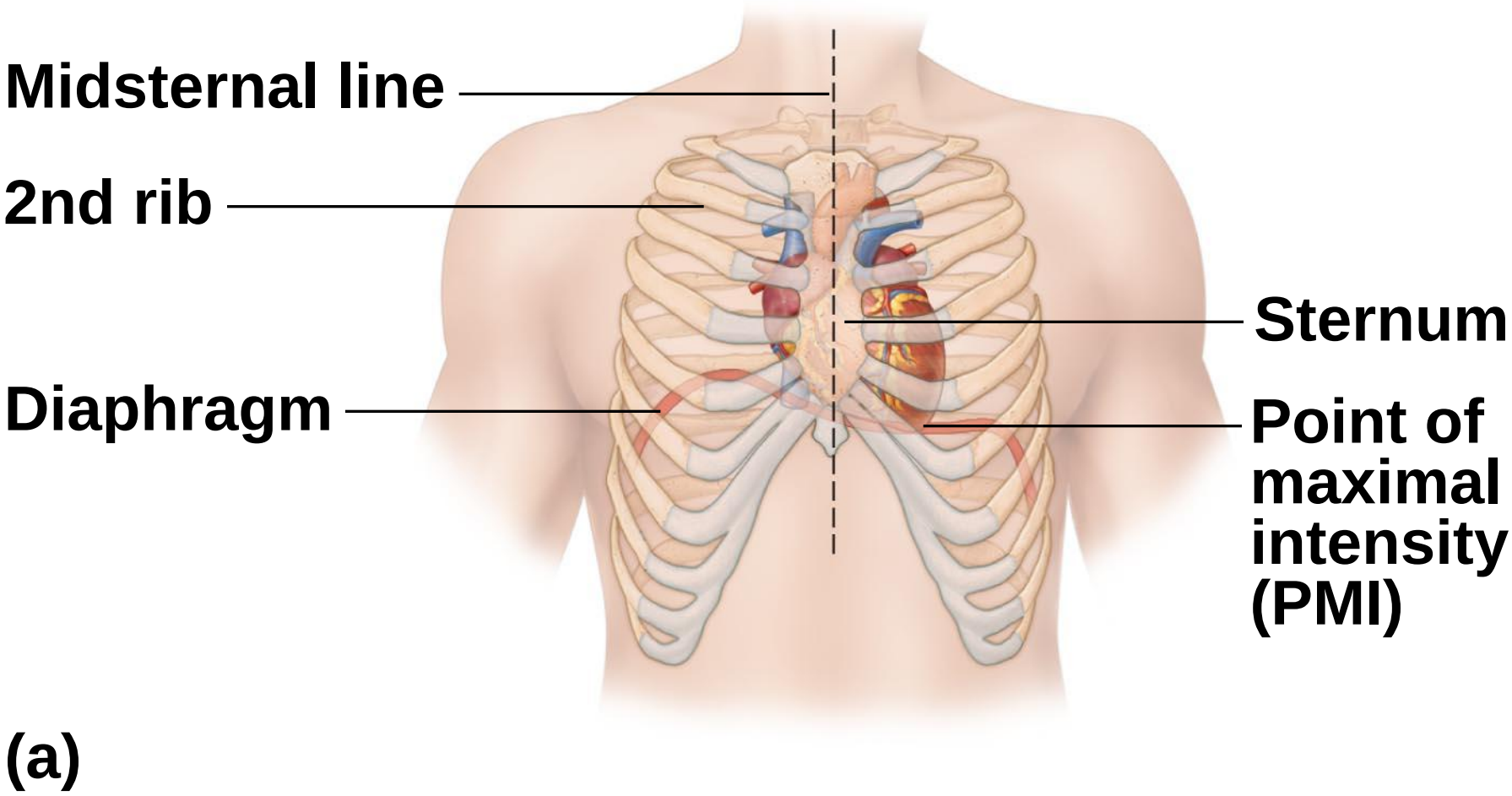


Figure 11.1a

The Heart

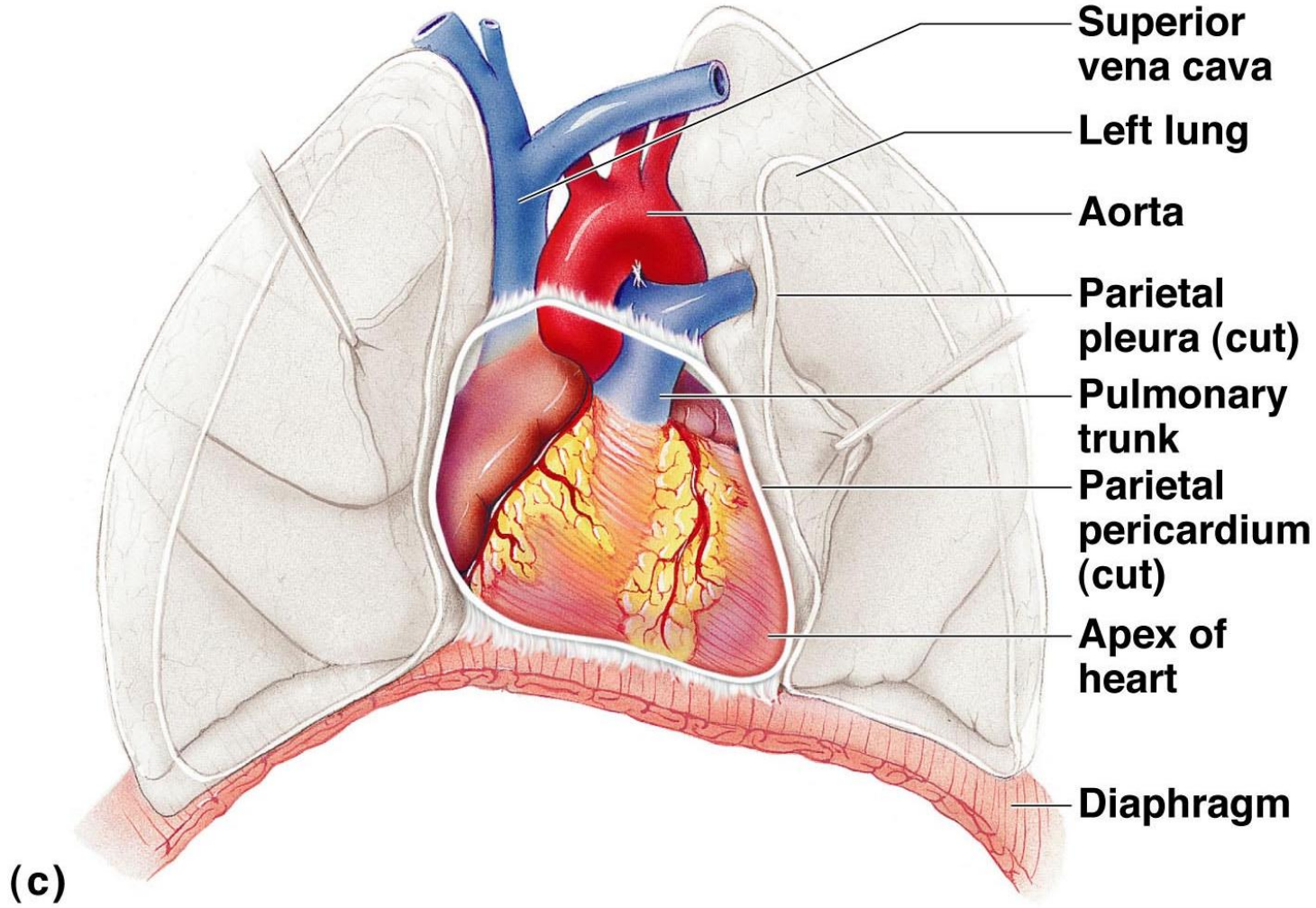


Figure 11.1c

The Heart: Coverings

- Pericardium—a double-walled sac
  - Serous membrane composed of two layers
    - Visceral pericardium
      - On top of heart; also known as the epicardium
    - Parietal pericardium
      - Outside layer that lines the inner surface of the fibrous pericardium
  - Serous fluid (pericardial fluid) fills the space between the layers of pericardium

The Heart: Heart Wall

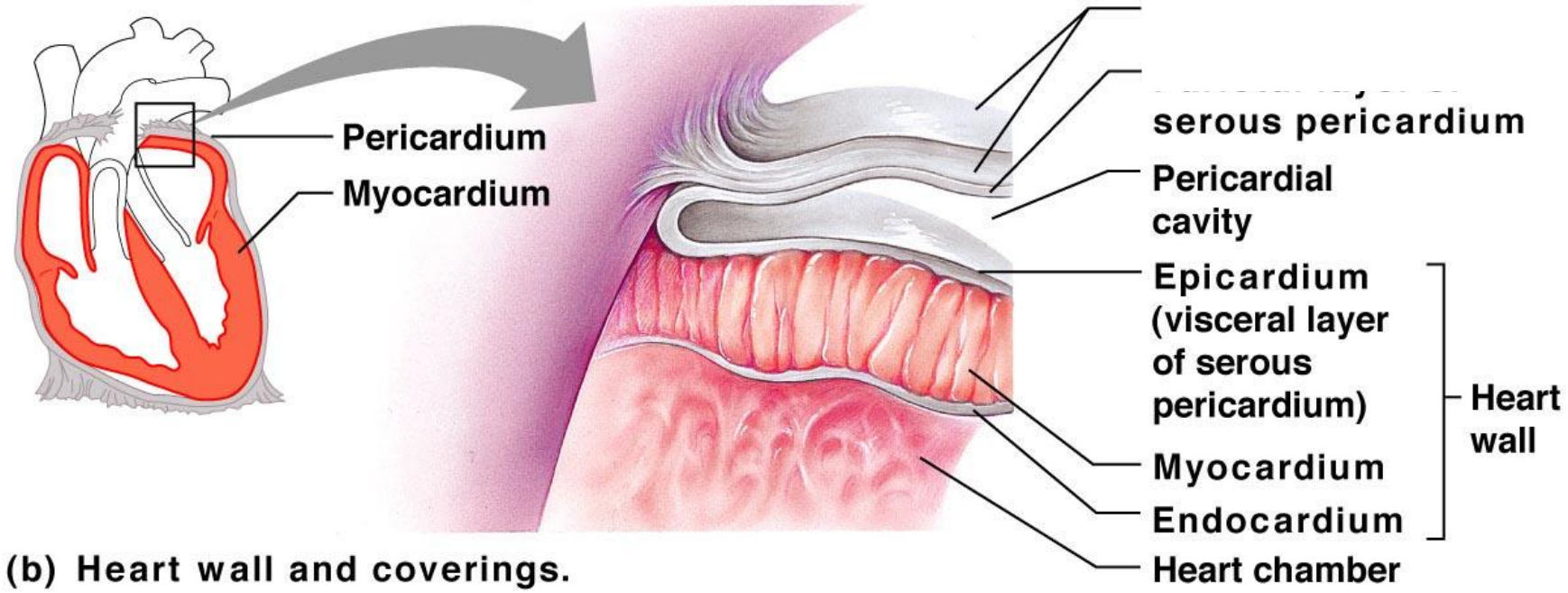


Figure 11.2b

The Heart: Heart Wall

- Three layers
  - Epicardium
    - Outside layer
    - This layer is the visceral pericardium
    - Connective tissue layer
  - Myocardium
    - Middle layer
    - Mostly cardiac muscle
  - Endocardium
    - Inner layer
    - Endothelium

The Heart: Heart Wall

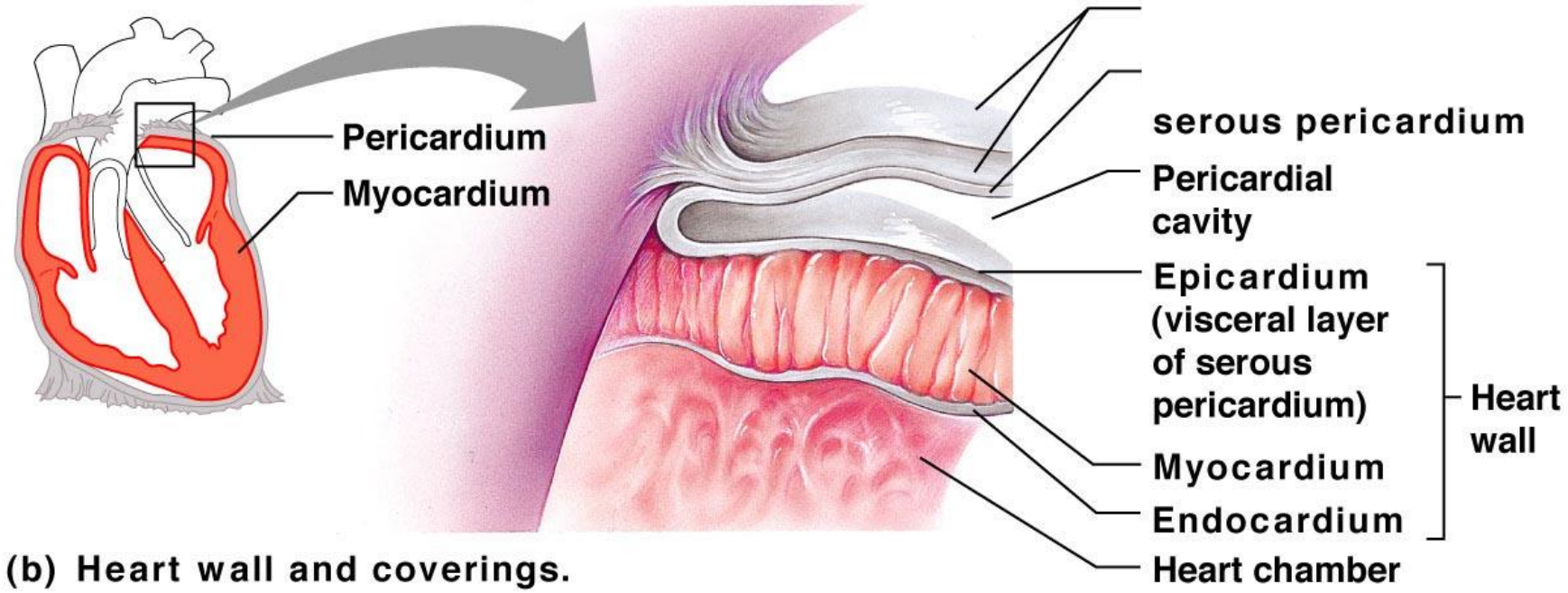
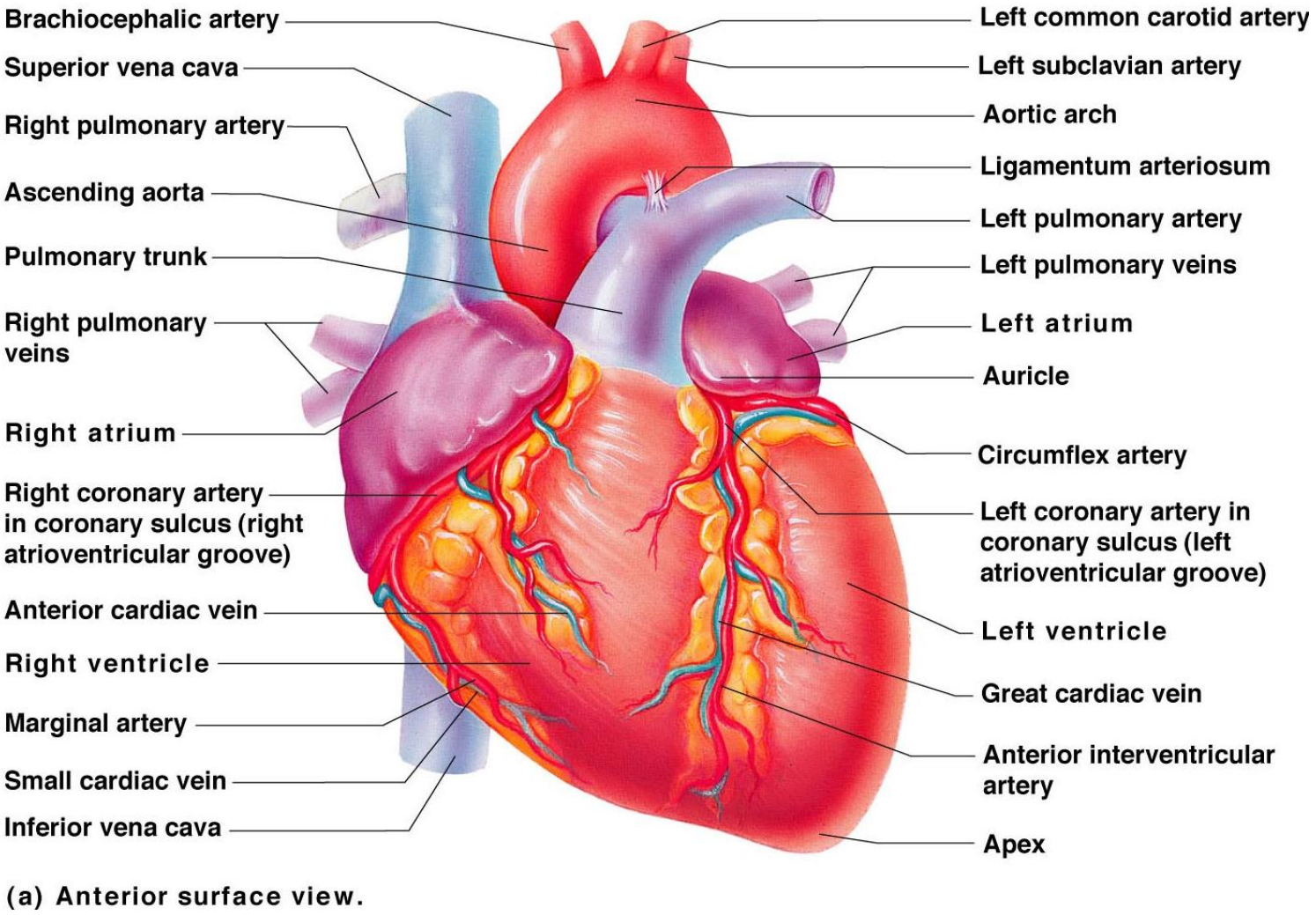


Figure 11.2b

The Heart



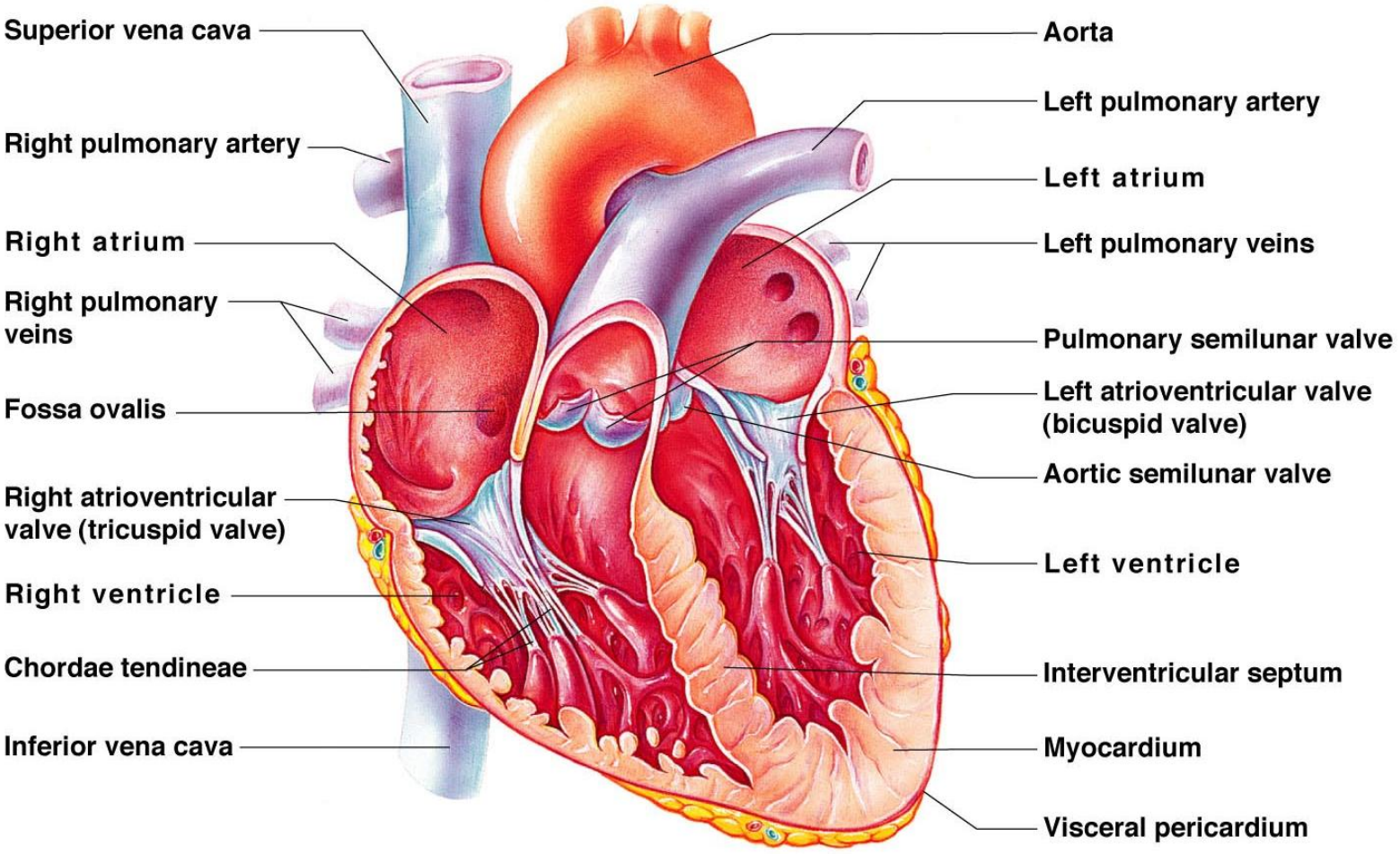
(a) Anterior surface view.

Figure 11.2a

The Heart: Sides & Chambers

- Right and left side act as separate pumps
- Four chambers
  - Atria
    - Receiving chambers
      - Right atrium
      - Left atrium
  - Ventricles
    - Discharging chambers
      - Right ventricle
      - Left ventricle

The Heart: Chambers



(c) Frontal section showing interior chambers and valves.

Figure 11.2c

Differences in Right and Left Ventricles

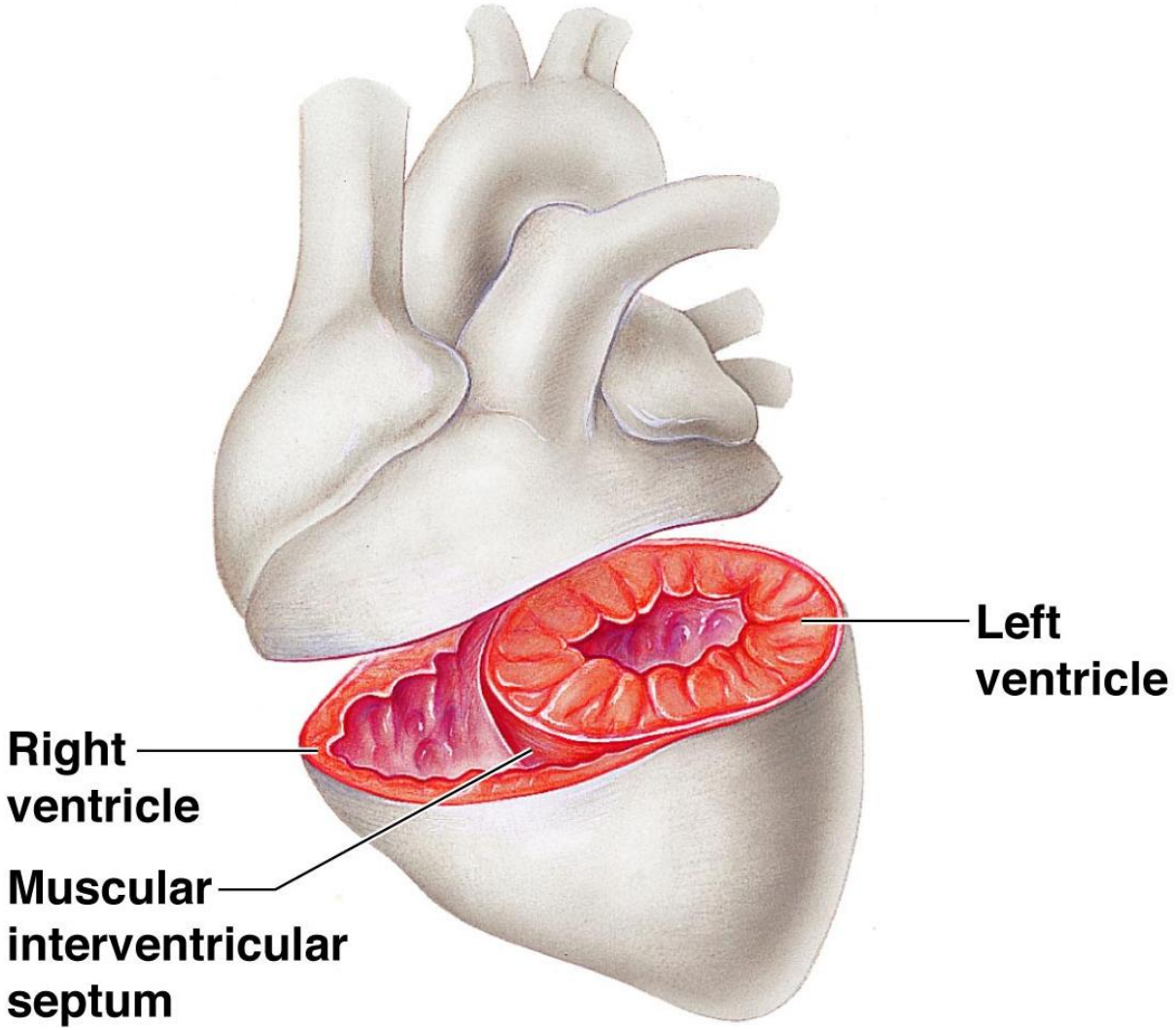
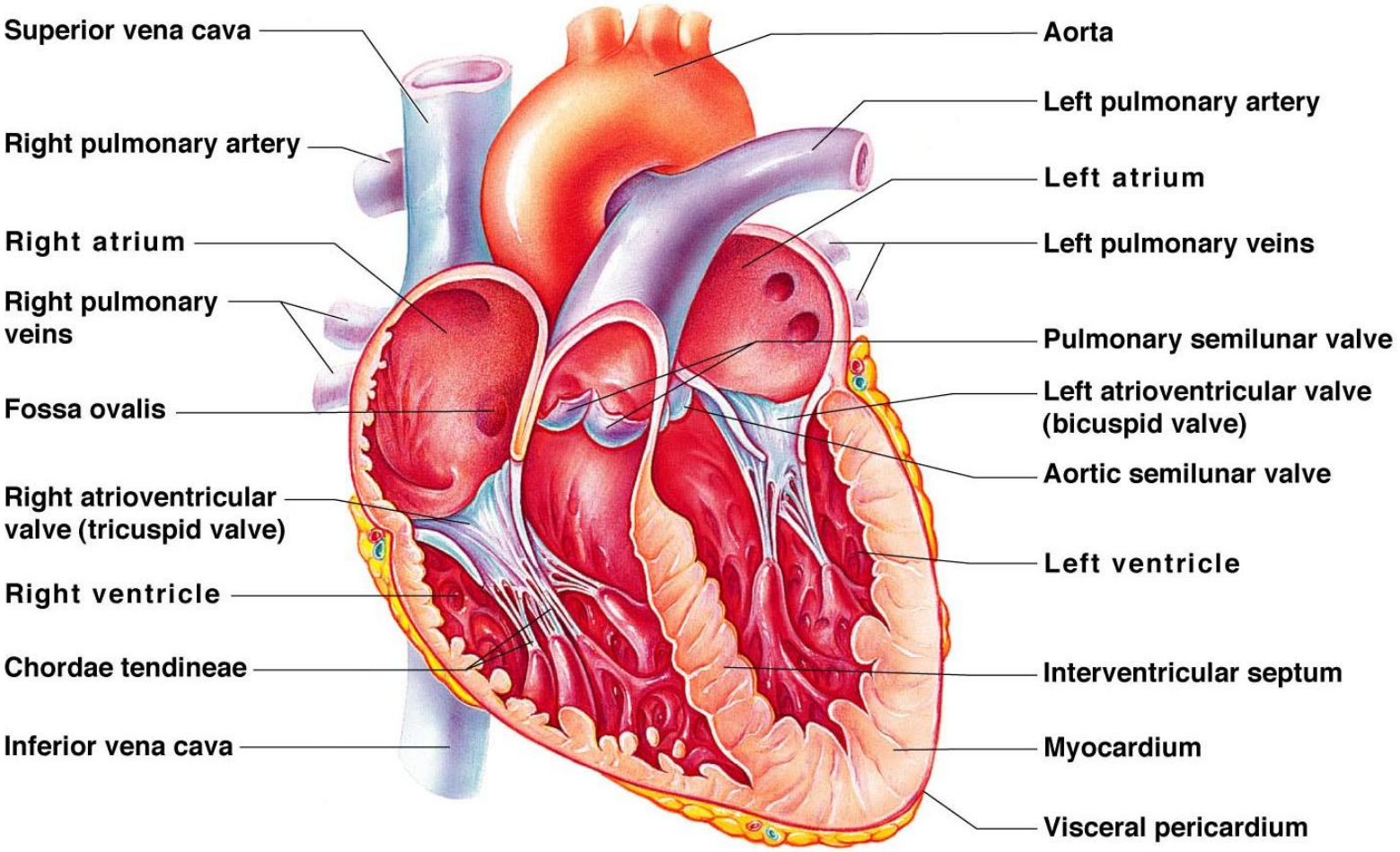


Figure 11.4

The Heart: Valves

- Allow blood to flow in only one direction to prevent backflow
- Four valves
  - 2 Atrioventricular (AV) valves—between atria and ventricles
    - Bicuspid (mitral) valve (left side of heart)
    - Tricuspid valve (right side of heart)
  - 2 Semilunar valves—between ventricles and arteries
    - Pulmonary semilunar valve
    - Aortic semilunar valve

The Heart: Valves



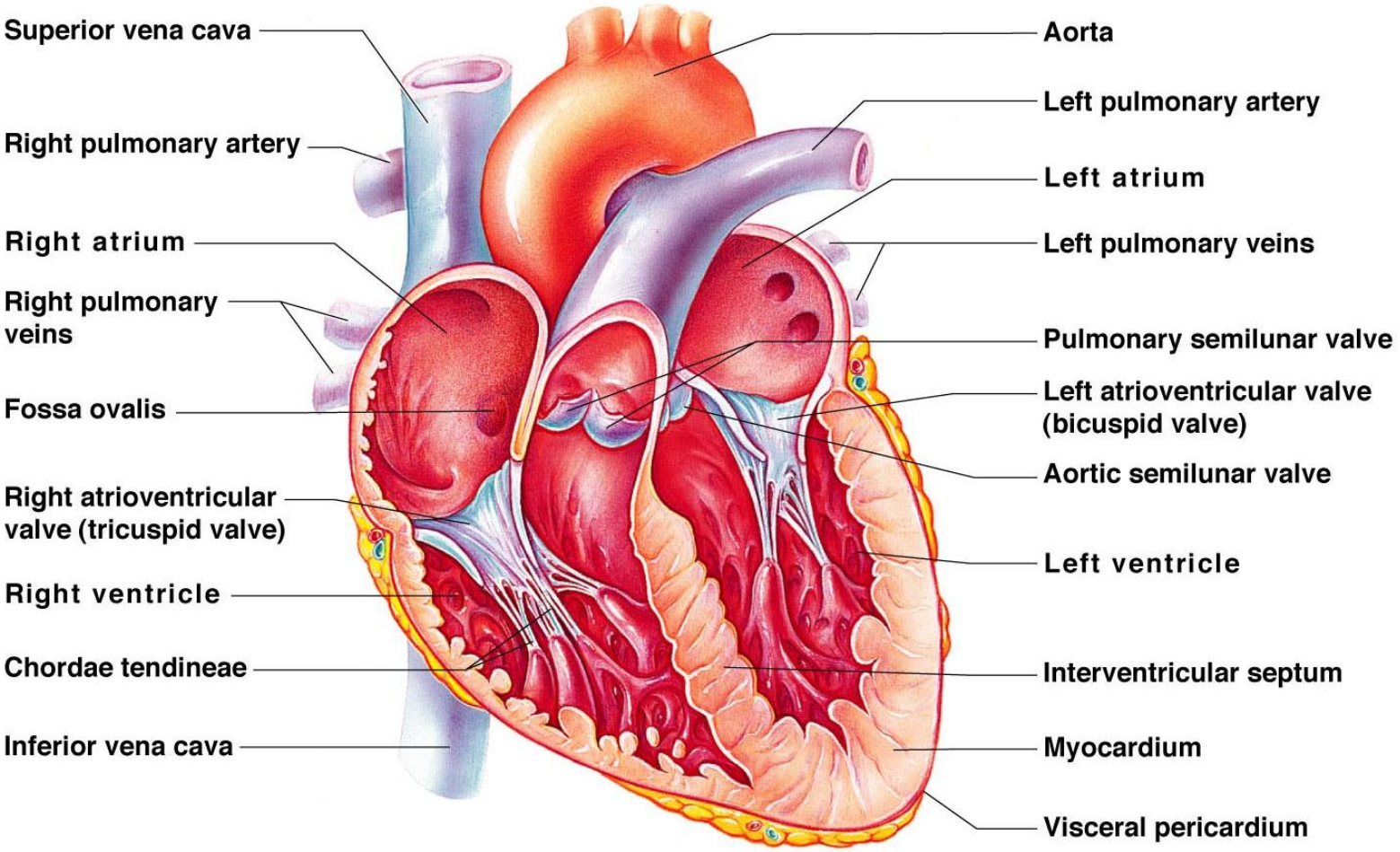
(c) Frontal section showing interior chambers and valves.

Figure 11.2c

The Heart: Valves

- AV valves
  - Anchored in place by chordae tendineae ("heart strings")
  - *Open* during heart relaxation and *closed* during ventricular contraction
- Semilunar valves
  - *Closed* during heart relaxation but *open* during ventricular contraction
- Notice these valves operate opposite of one another to force a one-way path of blood through the heart

The Heart: Valves

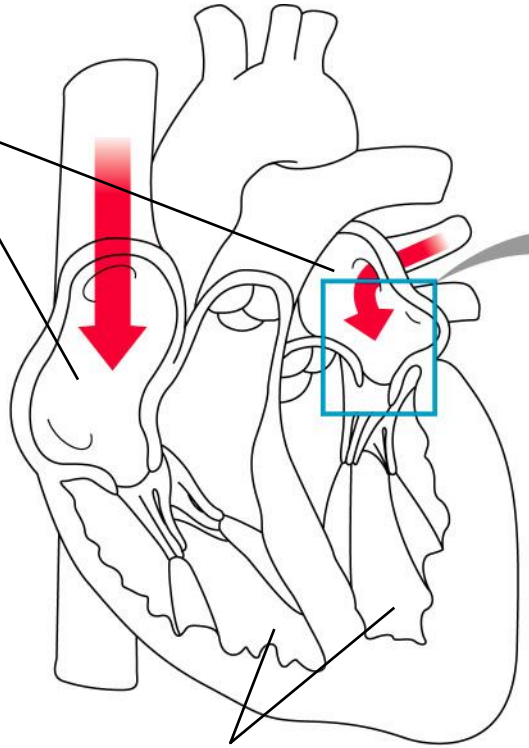


(c) Frontal section showing interior chambers and valves.

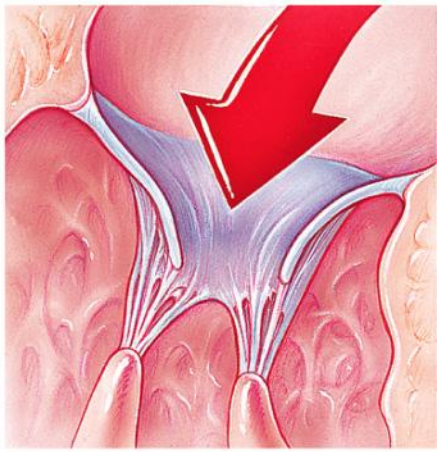
Figure 11.2c

Operation of the AV valves

① Blood returning to the atria, puts pressure against AV valves; the AV valves are forced open



Ventricles



AV valves open

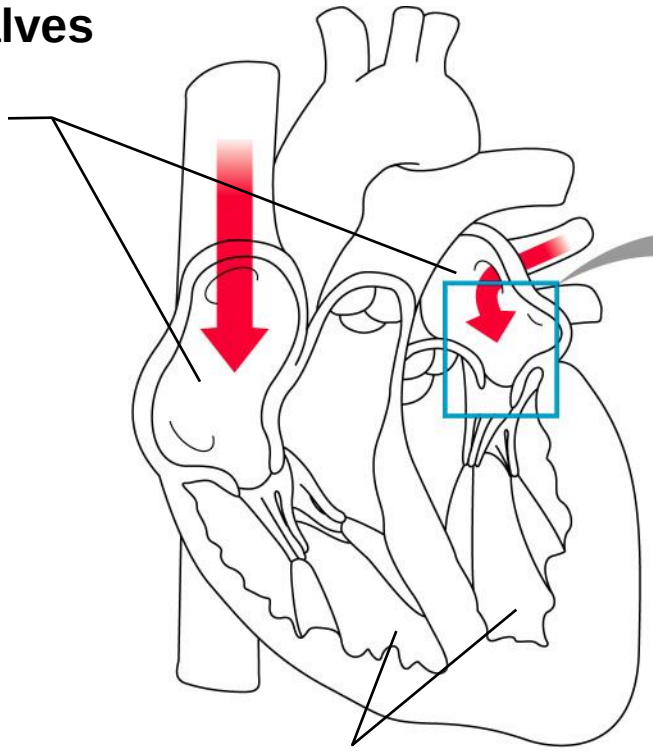
(a)

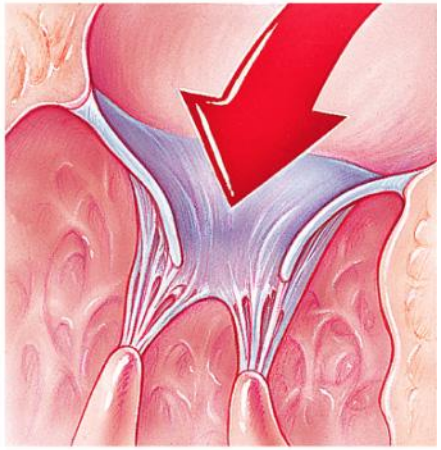
Figure 11.5a, step 1

Operation of the AV valves

① Blood returning to the atria, puts pressure against AV valves; the AV valves are forced open

② As the ventricles fill, AV valve flaps hang limply into ventricles





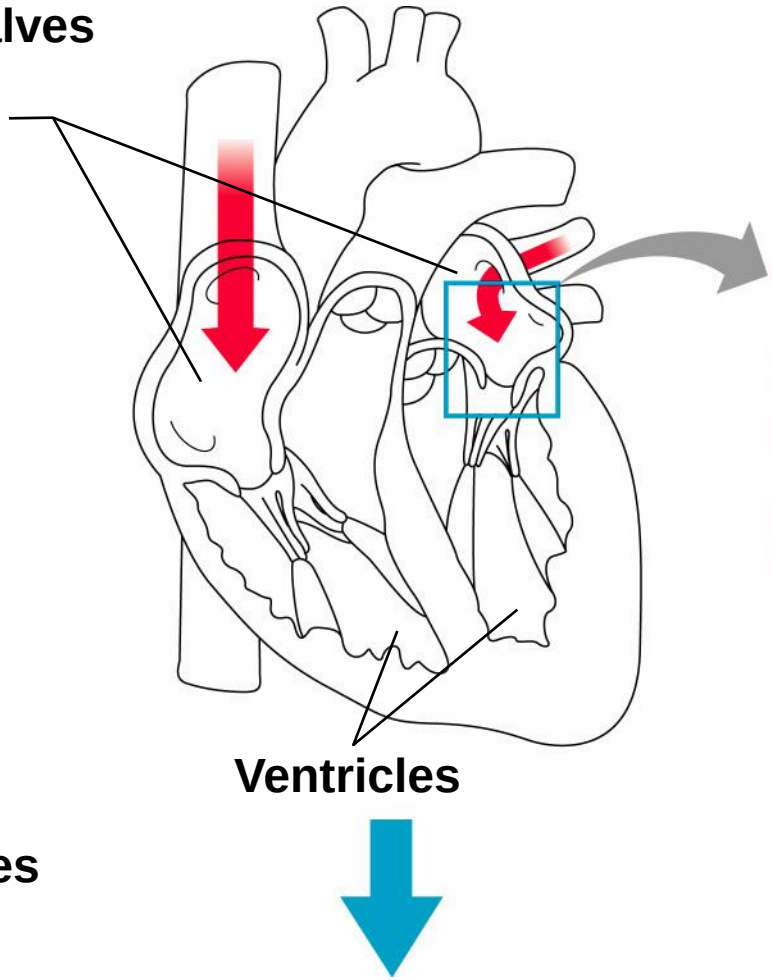
AV valves open

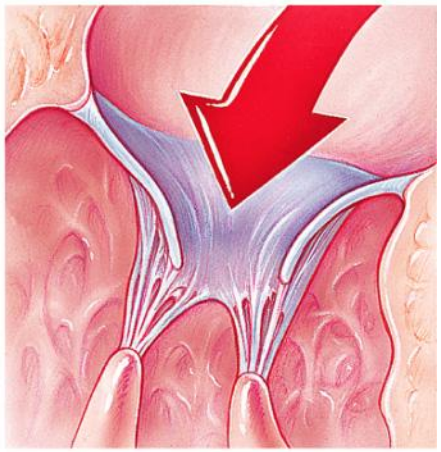
(a)

Figure 11.5a, step 2

Operation of the AV valves

1. Blood returning to the atria, puts pressure against AV valves; the AV valves are forced open
2. As the ventricles fill, AV valve flaps hang limply into ventricles
3. Atria contract, forcing additional blood into ventricles



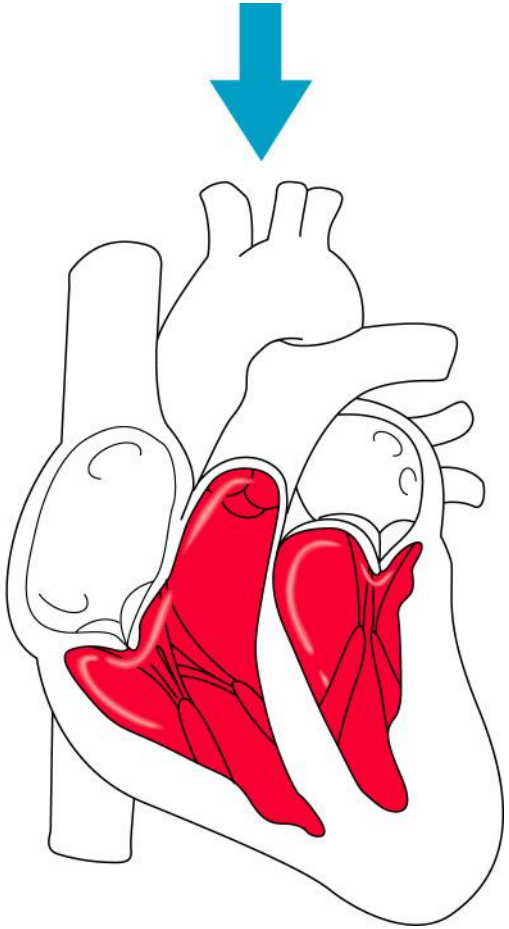


AV valves open

(a)

Figure 11.5a, step 3

① **Ventricles contract, forcing blood against AV valve flaps**

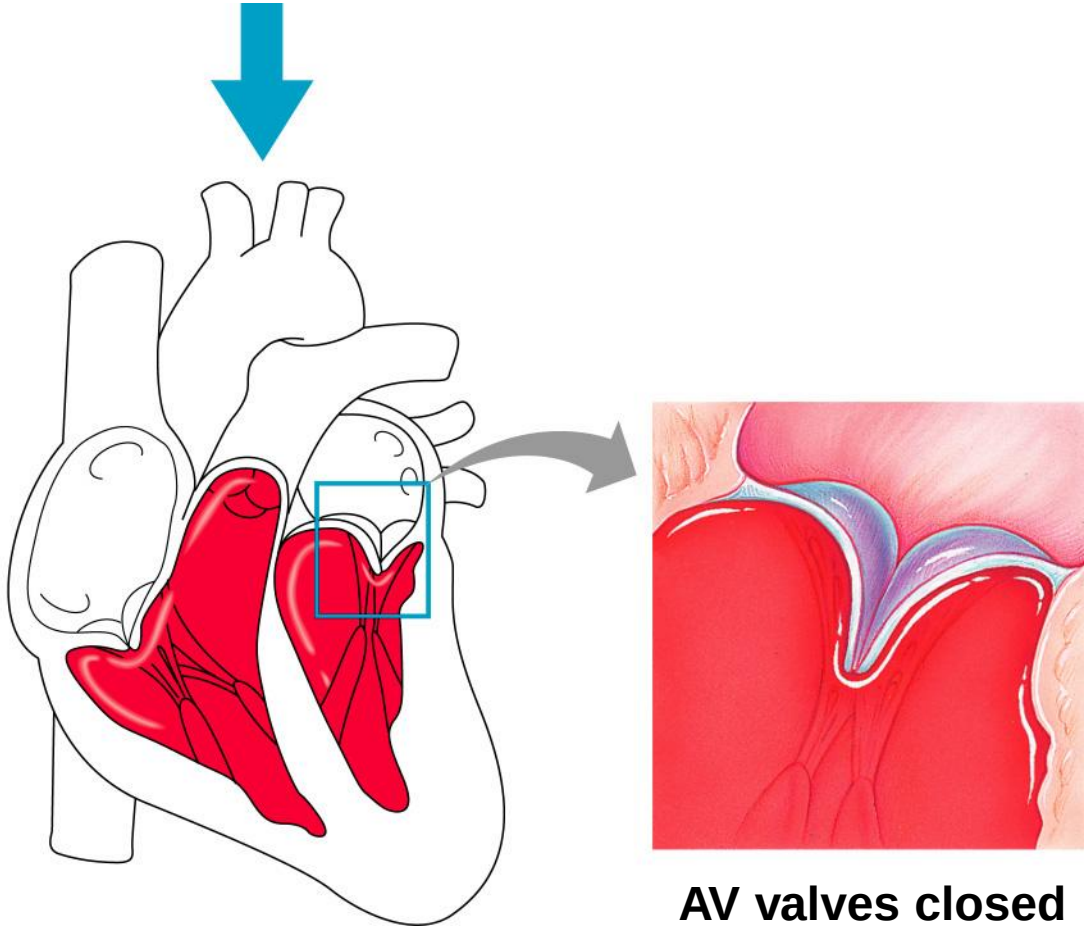


(a)

Figure 11.5a, step 4

① Ventricles contract, forcing blood against AV valve flaps

② AV valves close



AV valves closed

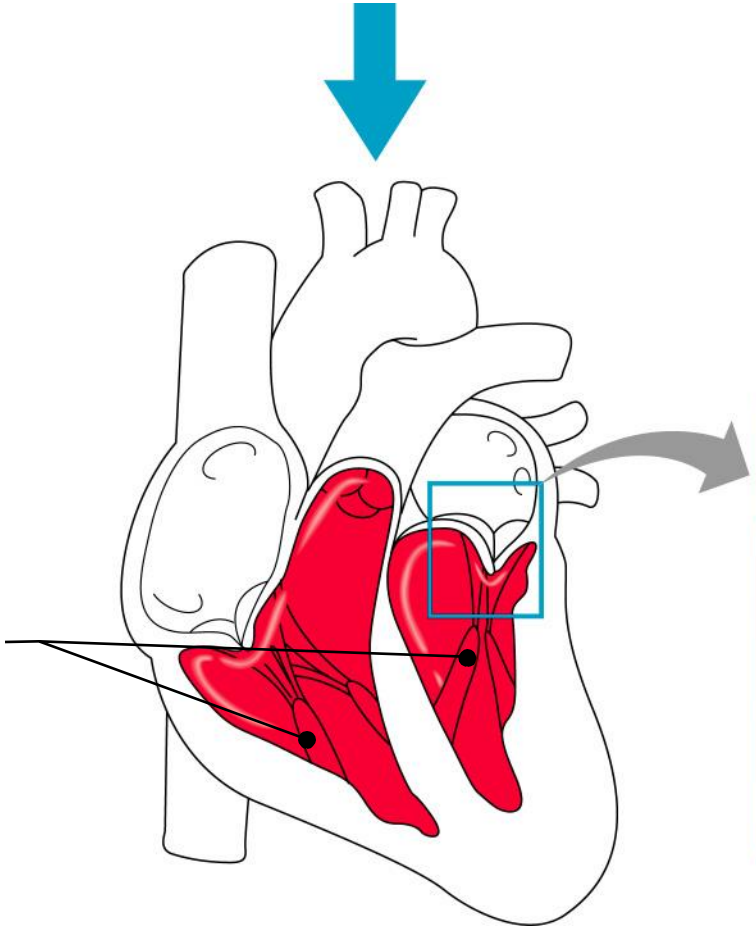
(a)

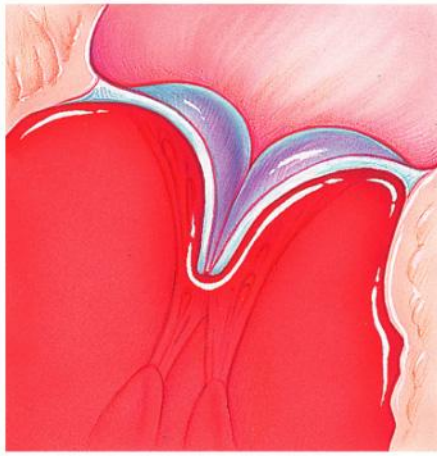
Figure 11.5a, step 5

① Ventricles contract, forcing blood against AV valve flaps

② AV valves close

③ Chordae tendineae tighten, preventing valve flaps from everting into atria





AV valves closed

(a)

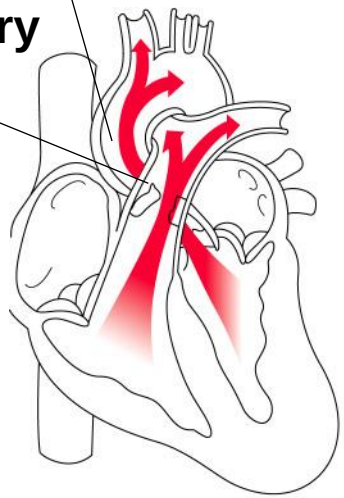
Figure 11.5a, step 6

Operation of the semilunar valves

As ventricles contract and intraventricular pressure rises, blood is pushed up against semilunar valves, forcing them open

Aorta

Pulmonary trunk



Semilunar valve open

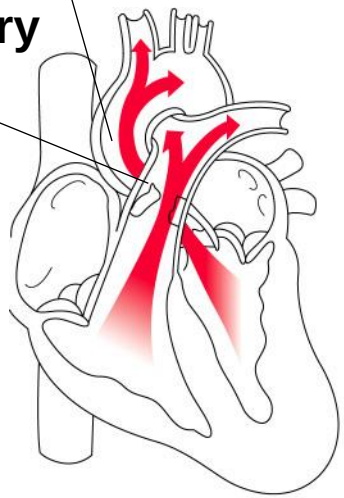
(b)

Figure 11.5b, step 1

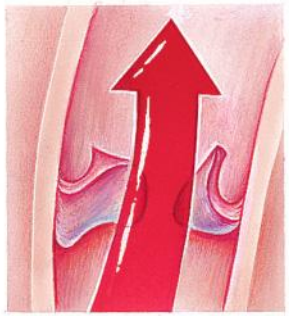
Operation of the semilunar valves

Aorta

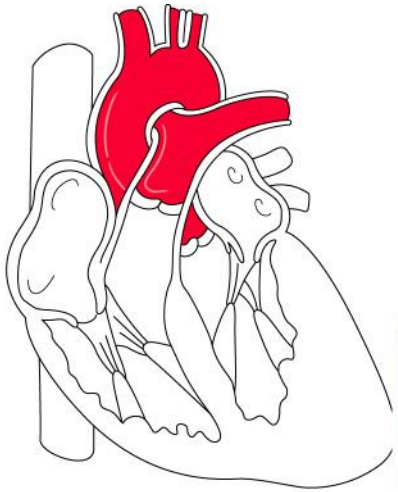
Pulmonary trunk



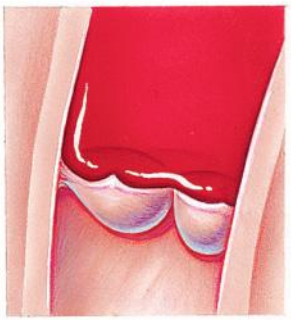
As ventricles contract and intraventricular pressure rises, blood is pushed up against semilunar valves, forcing them open



Semilunar valve open



As ventricles relax, and intraventricular pressure falls, blood flows back from arteries, filling the leaflets of semilunar valves and forcing them to close



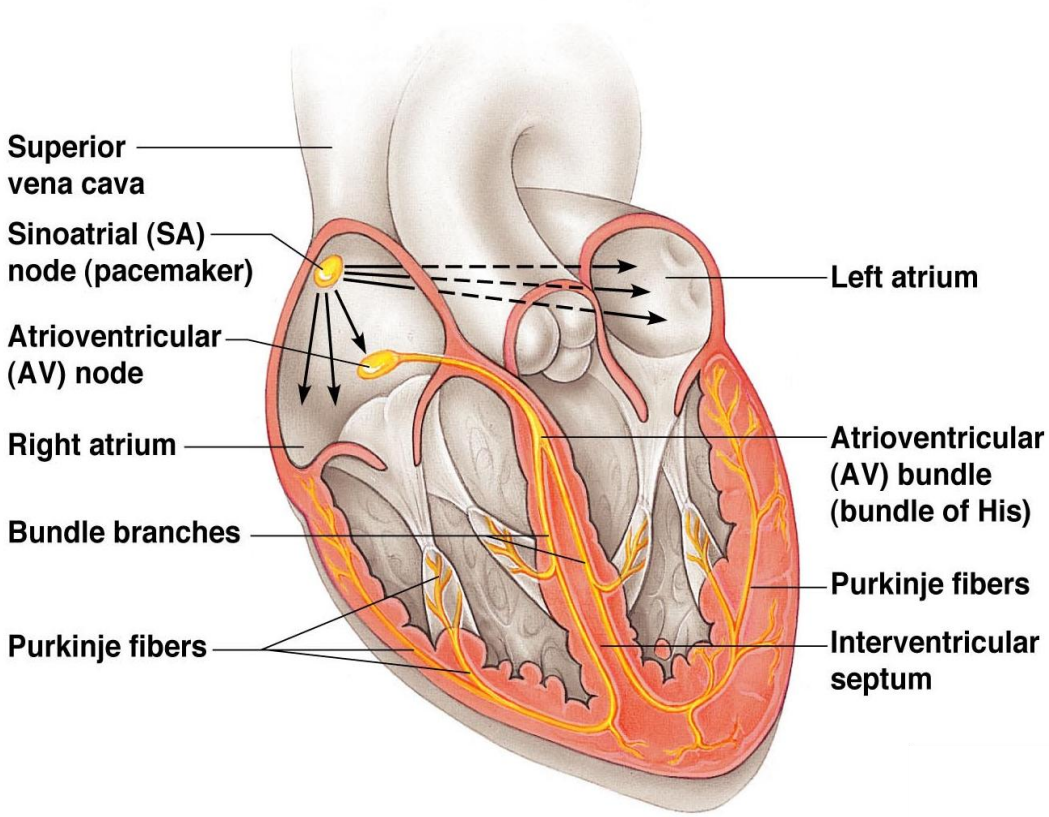
Semilunar valve closed

(b)

Figure 11.5b, step 2

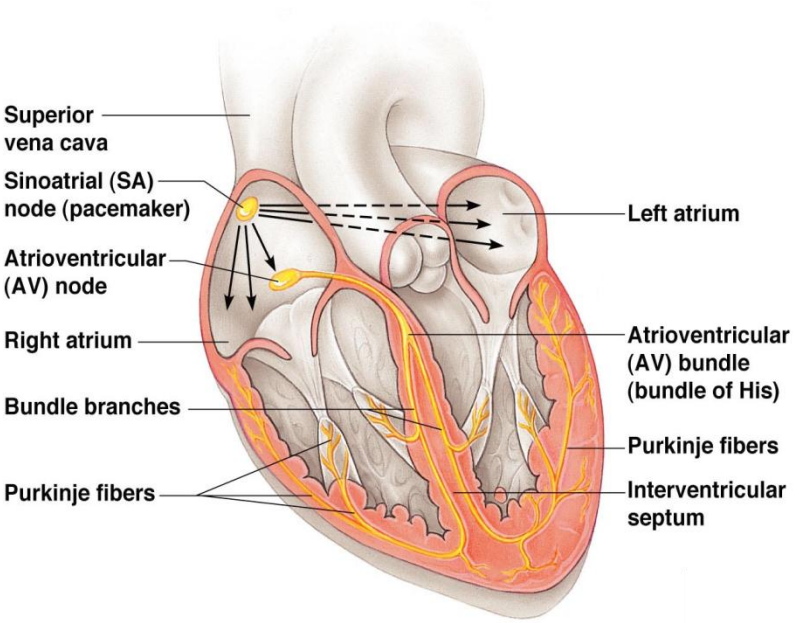
The Heart: Conduction System

- **Intrinsic conduction system (nodal system)**
  - **Heart muscle cells contract, without nerve impulses, in a regular, continuous way**



The Heart: Conduction System

- Special tissue sets the pace
  - Sinoatrial node = SA node (“pacemaker”), is in the right atrium
  - Atrioventricular node = AV node, is at the junction of the atria and ventricles
  - Atrioventricular bundle = AV bundle (bundle of His), is in the interventricular septum
  - Bundle branches are in the interventricular septum
  - Purkinje fibers spread within the ventricle wall muscles
- Force cardiac muscle depolarization in one direction—from atria to ventricles



Heart Contractions

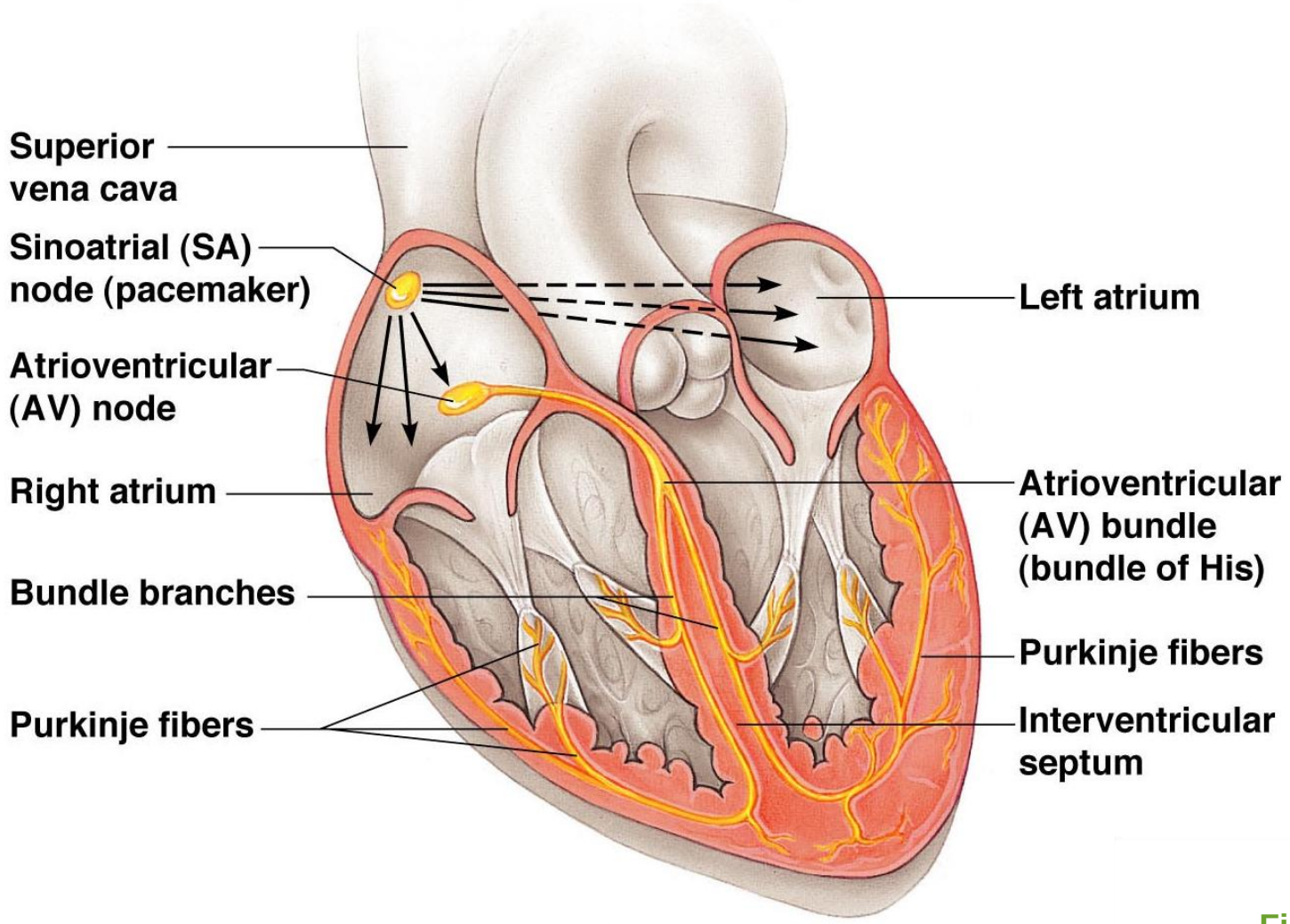
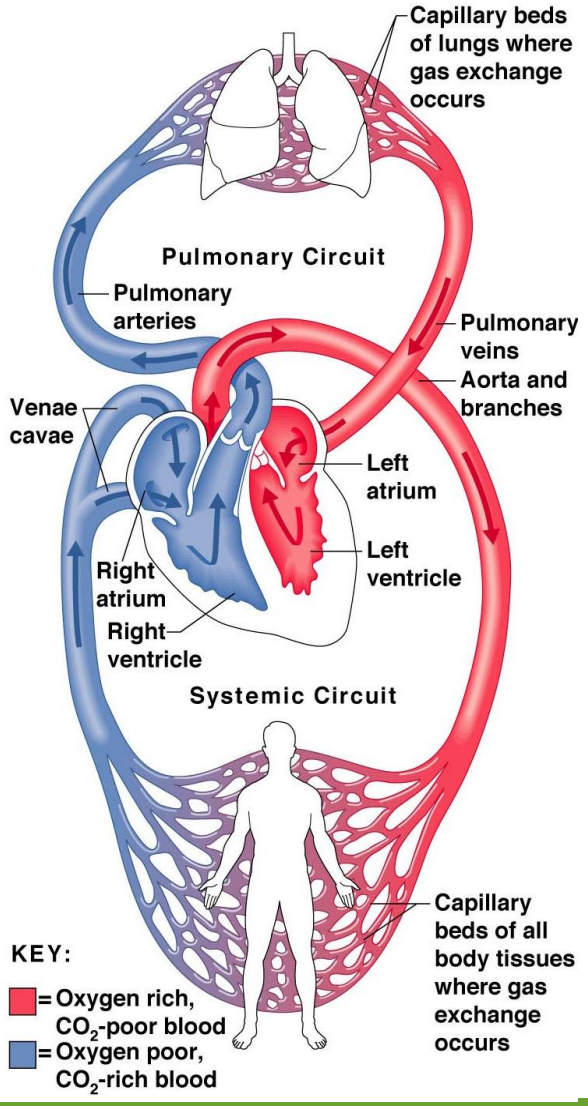


Figure 11.6

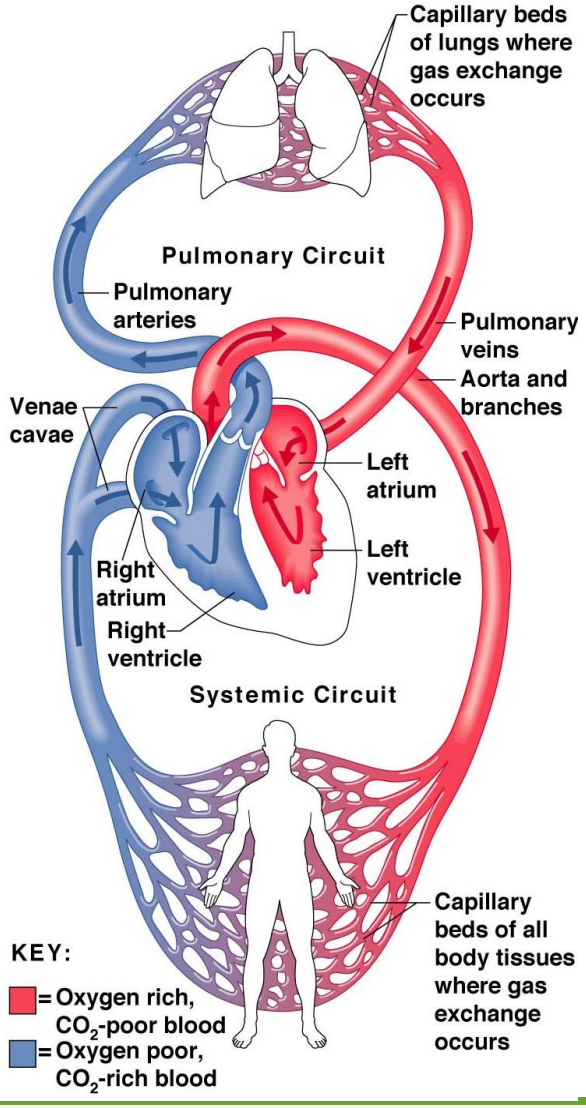
Blood Flow Through the Heart

- Superior and inferior venae cavae return blood to the right atrium
- From right atrium, through the tricuspid valve, blood travels to the right ventricle
- From the right ventricle, blood leaves the heart as it passes through the pulmonary semilunar valve into the pulmonary trunk
- Pulmonary trunk splits into right and left pulmonary arteries that carry blood to the lungs



Blood Flow Through the Heart

- Oxygen is picked up and carbon dioxide is dropped off by blood in the lungs
- Oxygen-rich blood returns to the heart through the four pulmonary veins
- Blood enters the left atrium and travels through the bicuspid valve into the left ventricle
- From the left ventricle, blood leaves the heart via the aortic semilunar valve into aorta



Heart Contractions

- **Homeostatic imbalance**
  - **Heart block—damaged AV node releases them from control of the SA node; result is in a slower heart rate as ventricles contract at their own rate**
  - **Ischemia—lack of adequate oxygen supply to heart muscle**
  - **Fibrillation—a rapid, uncoordinated shuddering of the heart muscle**
  - **Tachycardia—rapid heart rate over 100 beats per minute**
  - **Bradycardia—slow heart rate less than 60 beats per minutes**

Systemic and Pulmonary Circulations

- **Pulmonary circulation**
  - **Blood flows from the right side of the heart to the lungs and back to the left side of the heart**
- **Systemic circulation**
  - **Blood flows from the left side of the heart through the body tissues and back to the right side of the heart**

Systemic and Pulmonary Circulations

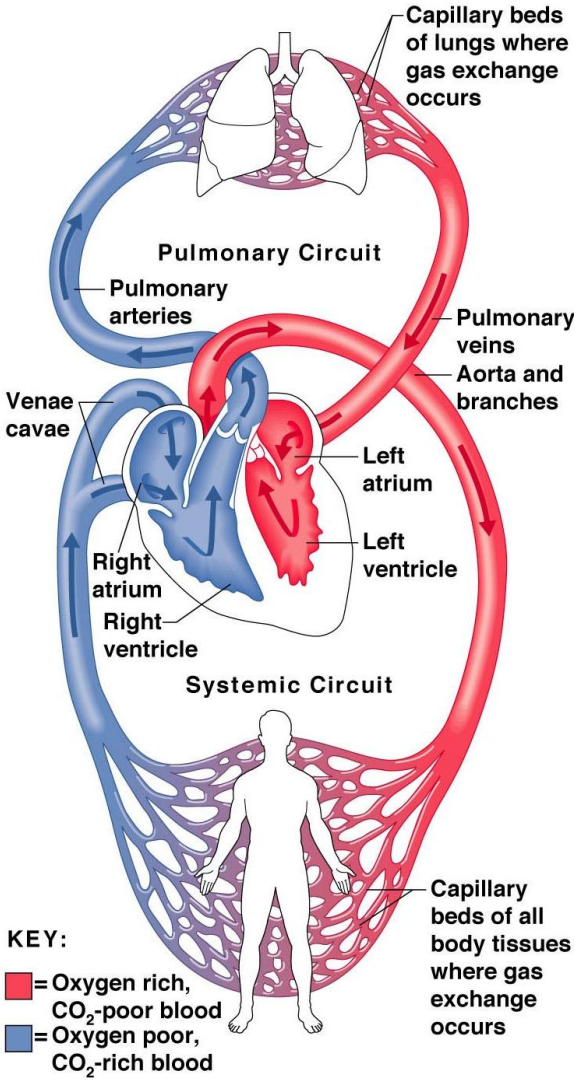


Figure 11.3

The Heart: Associated Great Vessels

- Arteries – take blood away from heart
  - Aorta
    - Leaves left ventricle
  - Pulmonary trunk/artery
    - Leaves right ventricle

The Heart: Associated Great Vessels

- Veins – return blood to heart
  - Superior and inferior venae cavae
    - Enter right atrium
  - Pulmonary veins (four)
    - Enter left atrium

Blood Vessels: The Vascular System

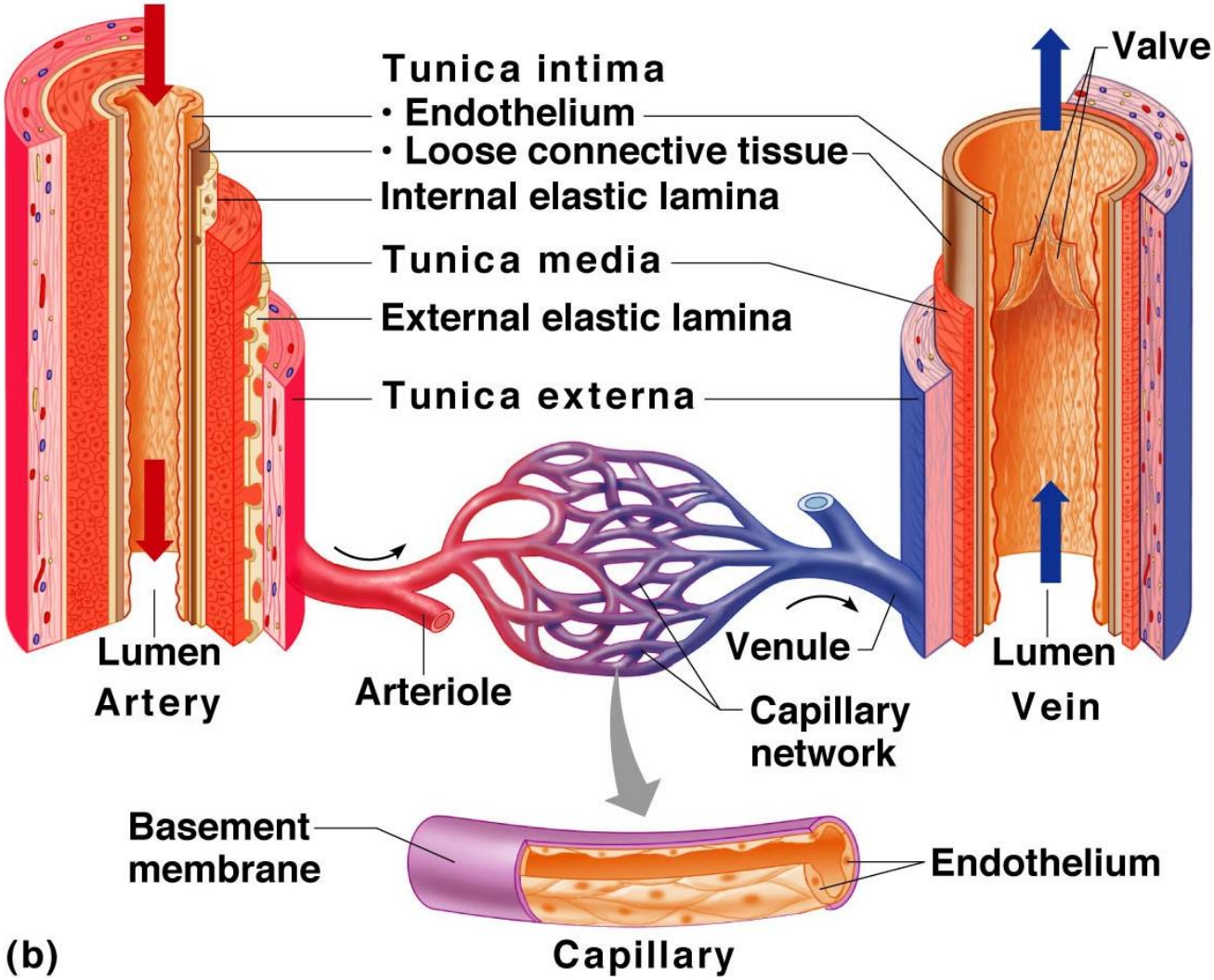
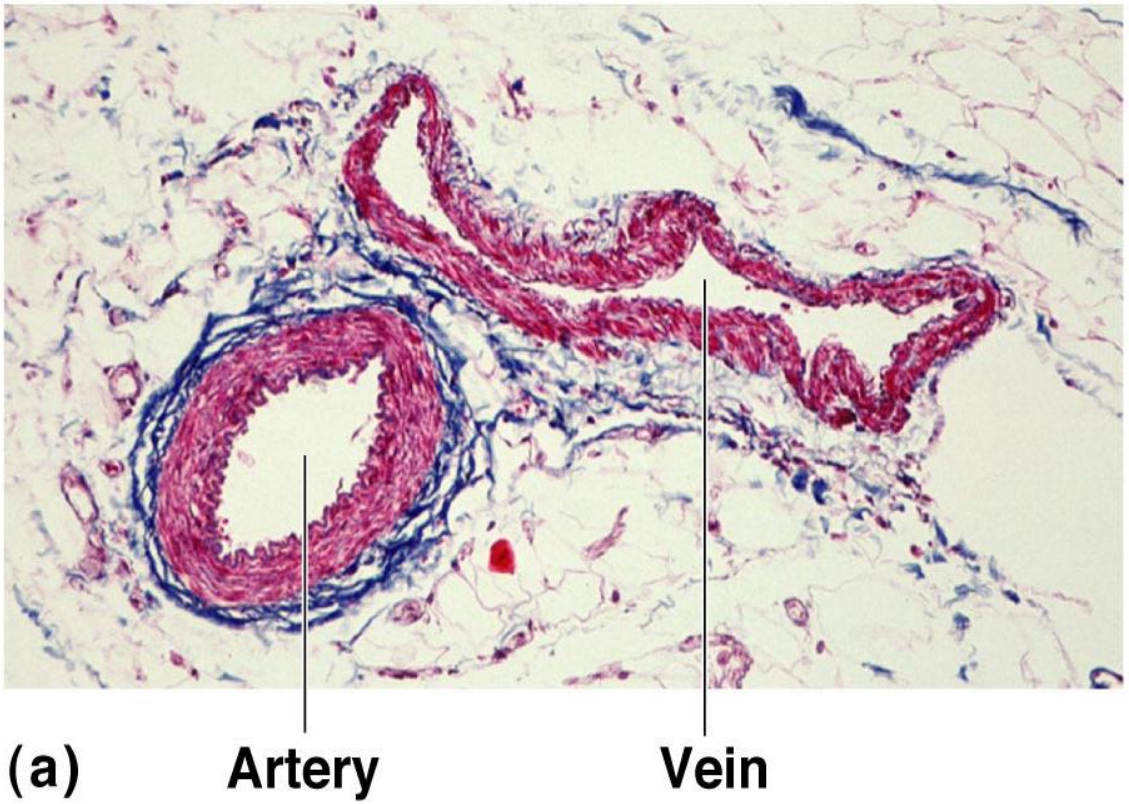


Figure 11.9b

Differences Between Blood Vessels

- Walls of arteries are the thickest
- Lumens of veins are larger
- Larger veins have valves to prevent backflow
- Skeletal muscle “milks” blood in veins toward the heart
- Walls of capillaries are only one cell layer thick to allow for exchanges between blood and tissue



Blood Vessels: The Vascular System

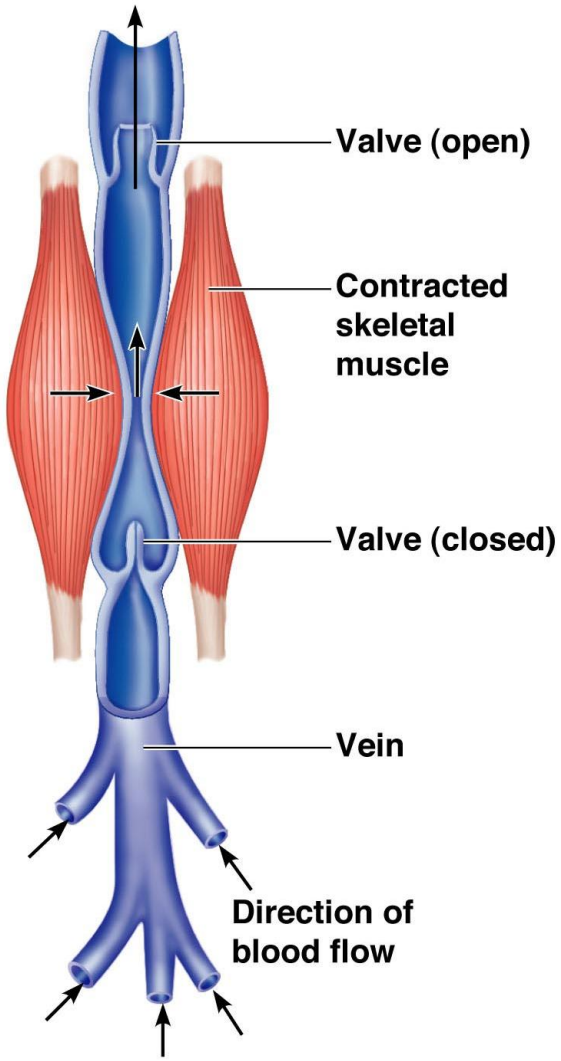


Figure 11.10

Capillary Beds

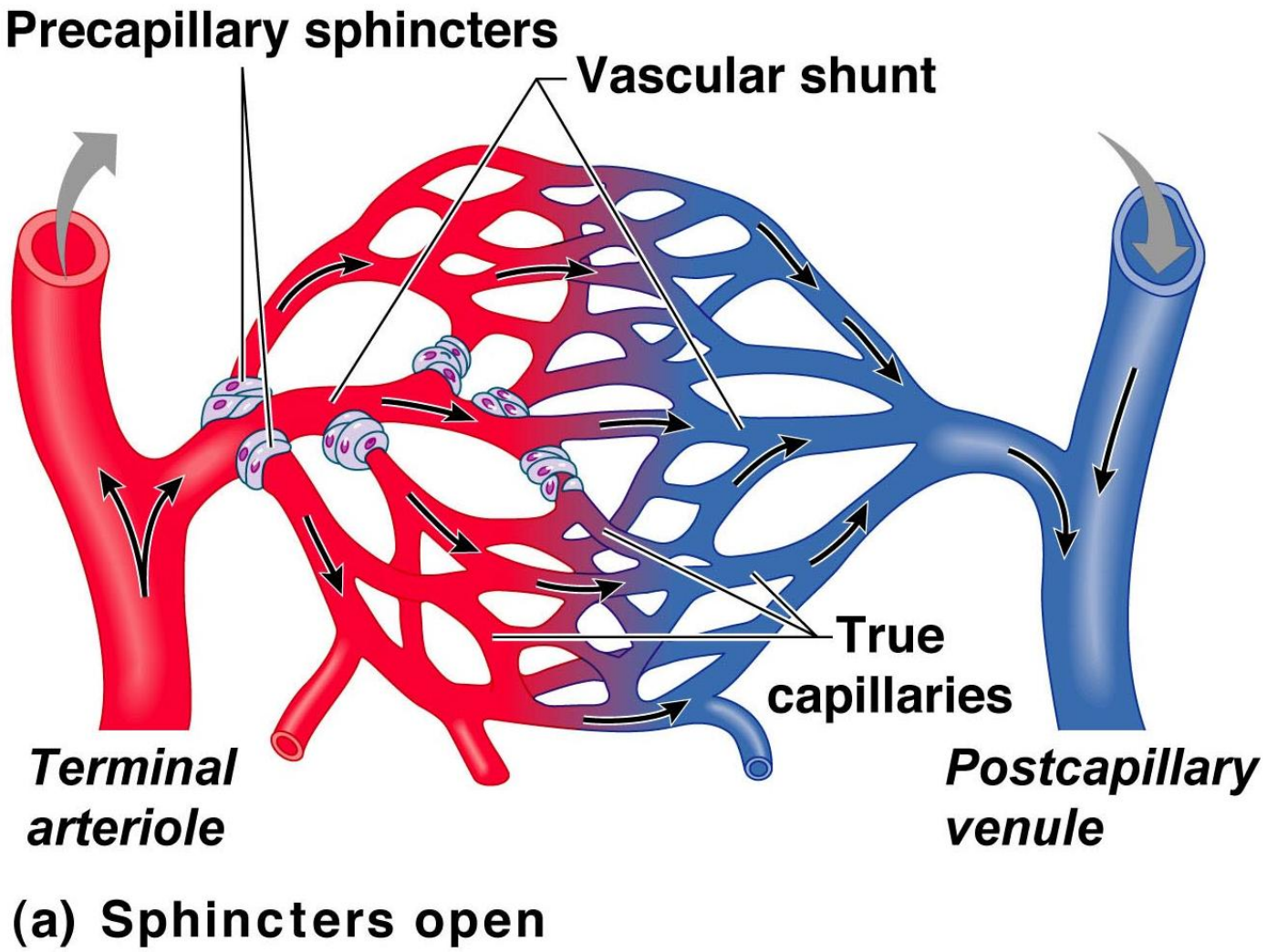
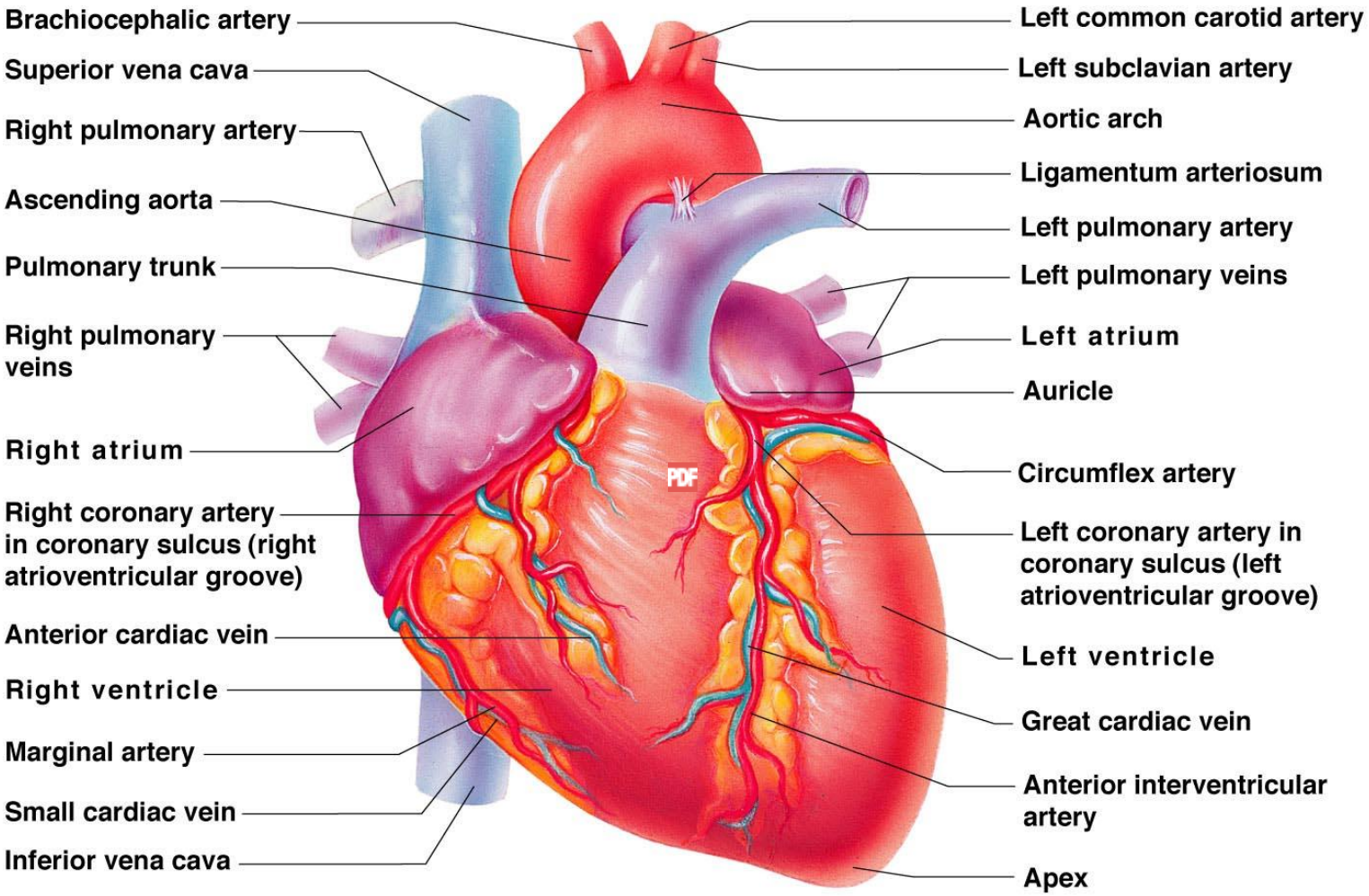


Figure 11.11a

Major Arteries of System Circulation

- Aorta
  - Largest artery in the body
  - Leaves from the left ventricle of the heart
  - Regions
    - Ascending aorta—leaves the left ventricle
    - Aortic arch—arches to the left
    - Thoracic aorta—travels downward through the thorax
    - Abdominal aorta—passes through the diaphragm into the abdominopelvic cavity

The Heart



(a) Anterior surface view.

Figure 11.2a

Major Arteries of Systemic Circulation

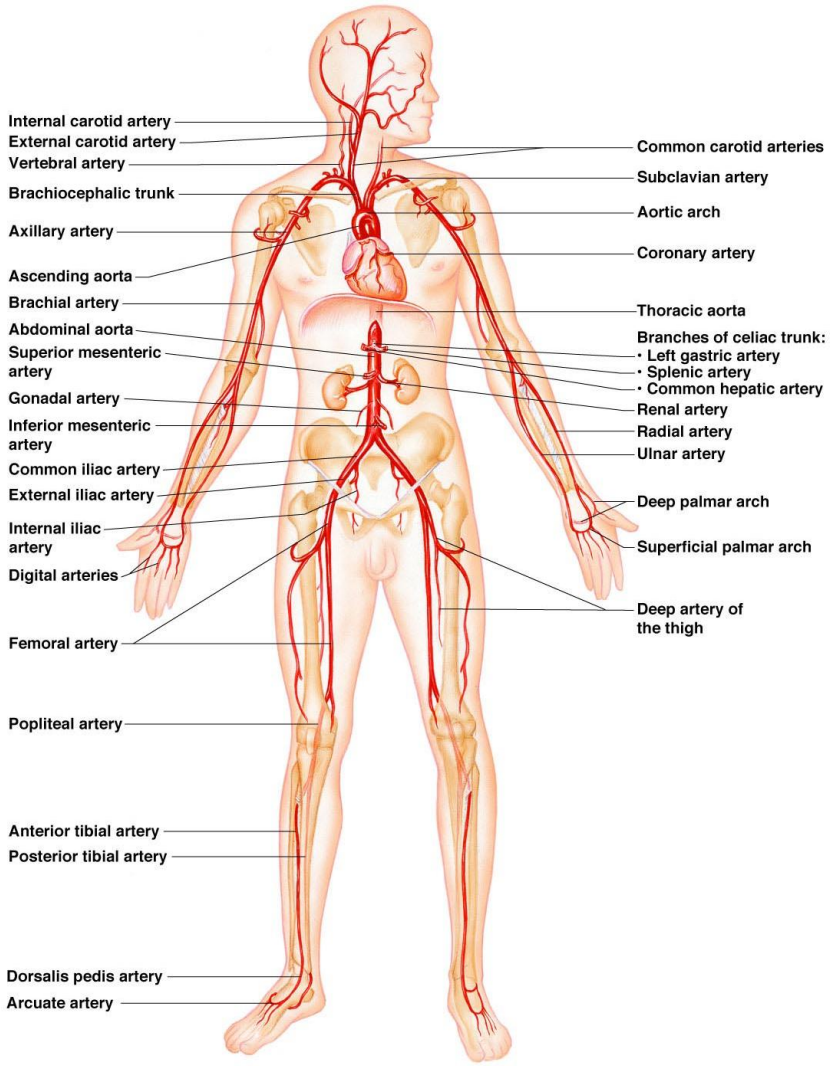


Figure 11.12

Major Veins of Systemic Circulation

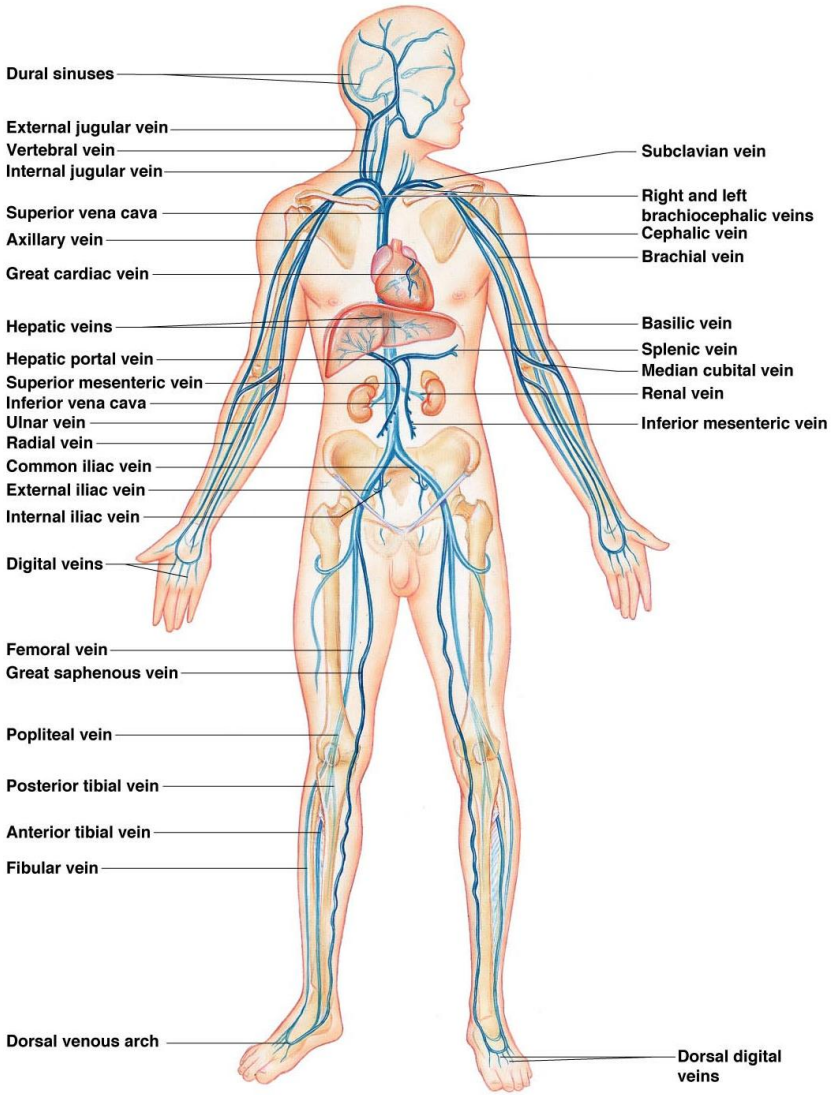
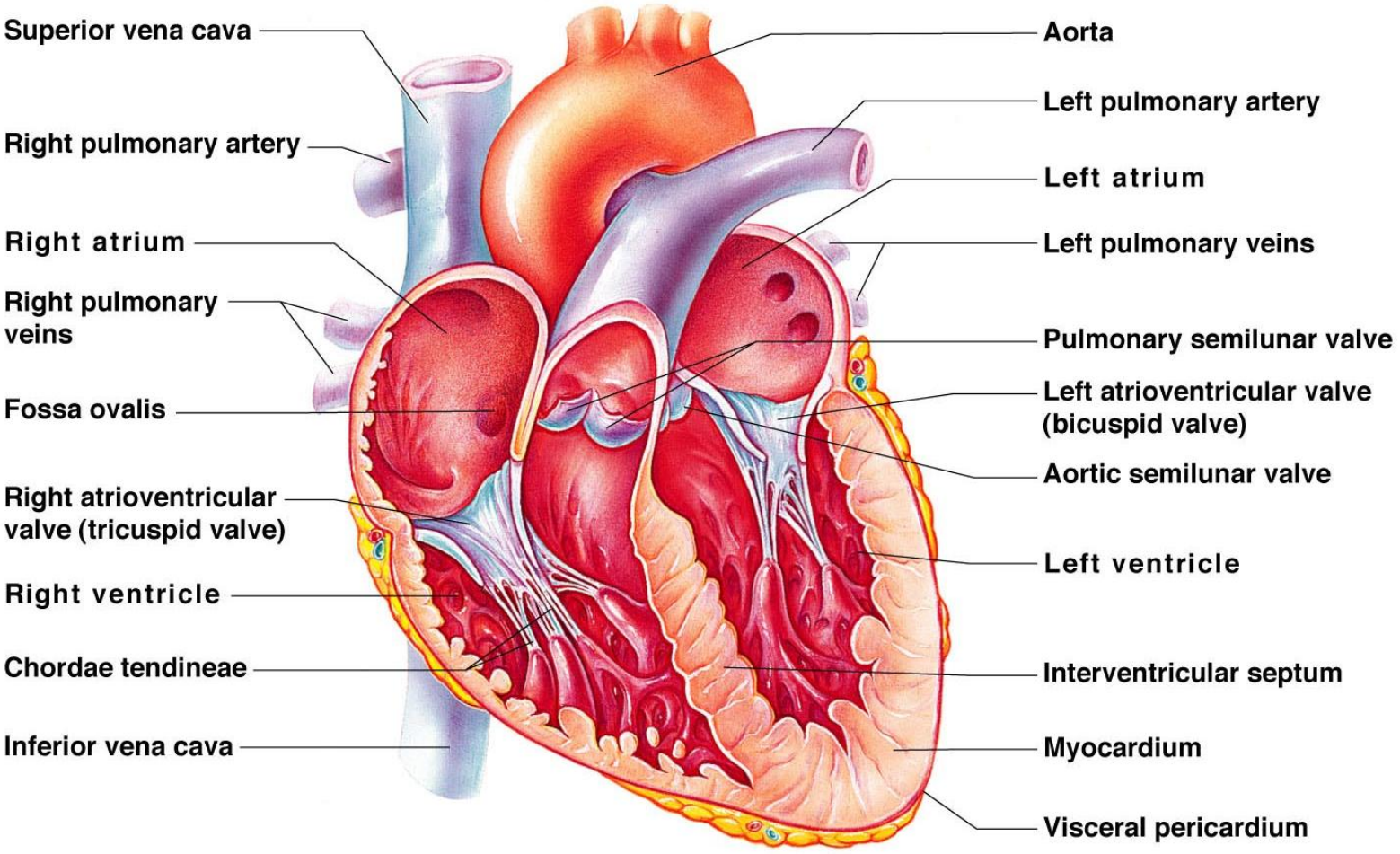


Figure 11.13

The Heart: Associated Great Vessels



(c) Frontal section showing interior chambers and valves.

Figure 11.2c

Coronary Circulation

- Blood in the heart chambers does not nourish the myocardium
- The heart has its own nourishing circulatory system consisting of
  - Coronary arteries—branch from the ascending aorta to supply the heart muscle with oxygenated blood
  - Cardiac veins—drain the myocardium of blood
  - Coronary sinus—a large vein on the posterior of the heart, receives blood from cardiac veins
  - Blood empties into the right atrium via the coronary sinus

Major Arteries of Systemic Circulation

- Arterial branches of the aortia arch (BCS)
  - Brachiocephalic trunk
  - Left Common carotid artery
  - Left subclavian artery

Major Arteries of Systemic Circulation

- Arterial branches of the aortia arch (BCS)
  - **Brachiocephalic trunk** splits into the
    - **Right common carotid** artery
    - **Right subclavian** artery
  - Left Common carotid artery splits into the
    - Internal and external carotid arteries
  - Left subclavian artery branches into the
    - Vertebral artery
    - In the axilla, the subclavian artery becomes the axillary artery → brachial artery → radial and ulnar arteries

Major Arteries of Systemic Circulation

- **Brachiocephalic trunk** splits into the
  - **Right common carotid** artery
  - **Right subclavian** artery
- Common carotid artery splits into the
  - **Internal and external carotid arteries**
- Subclavian artery gives off
  - **Vertebral artery**

Major Arteries of Systemic Circulation

- Subclavian artery, in the axilla → axillary artery, in the arm → brachial artery, in the elbow→ radial and ulnar arteries

Major Arteries of Systemic Circulation

- Arterial branches of the thoracic aorta
  - Intercostal arteries supply the muscles of the thorax wall
  - Other branches of the thoracic aorta supply the
    - Lungs (bronchial arteries)
    - Esophagus (esophageal arteries)
    - Diaphragm (phrenic arteries)

Major Arteries of Systemic Circulation

- Arterial branches of the abdominal aorta
  - Celiac trunk is the first branch of the abdominal aorta. Three branches are
    - Left gastric artery (stomach)
    - Splenic artery (spleen)
    - Common hepatic artery (liver)
  - Superior mesenteric artery supplies the small intestine and 60% of the large intestine
  - Inferior mesenteric artery serves the remainder of the large intestine

Major Arteries of Systemic Circulation

- Arterial branches of the abdominal aorta
  - Left and right renal arteries (kidney)
  - Left and right gonadal arteries
    - Ovarian arteries in females serve the ovaries
    - Testicular arteries in males serve the testes
  - Lumbar arteries serve muscles of the abdomen and trunk

Major Arteries of Systemic Circulation

- Arterial branches of the abdominal aorta
  - Left and right common iliac arteries are the final branches of the aorta
    - Internal iliac arteries serve the pelvic organs
    - External iliac arteries enter the thigh → femoral artery, in the knee→ popliteal artery, in the leg→ anterior and posterior tibial arteries

Major Arteries of Systemic Circulation

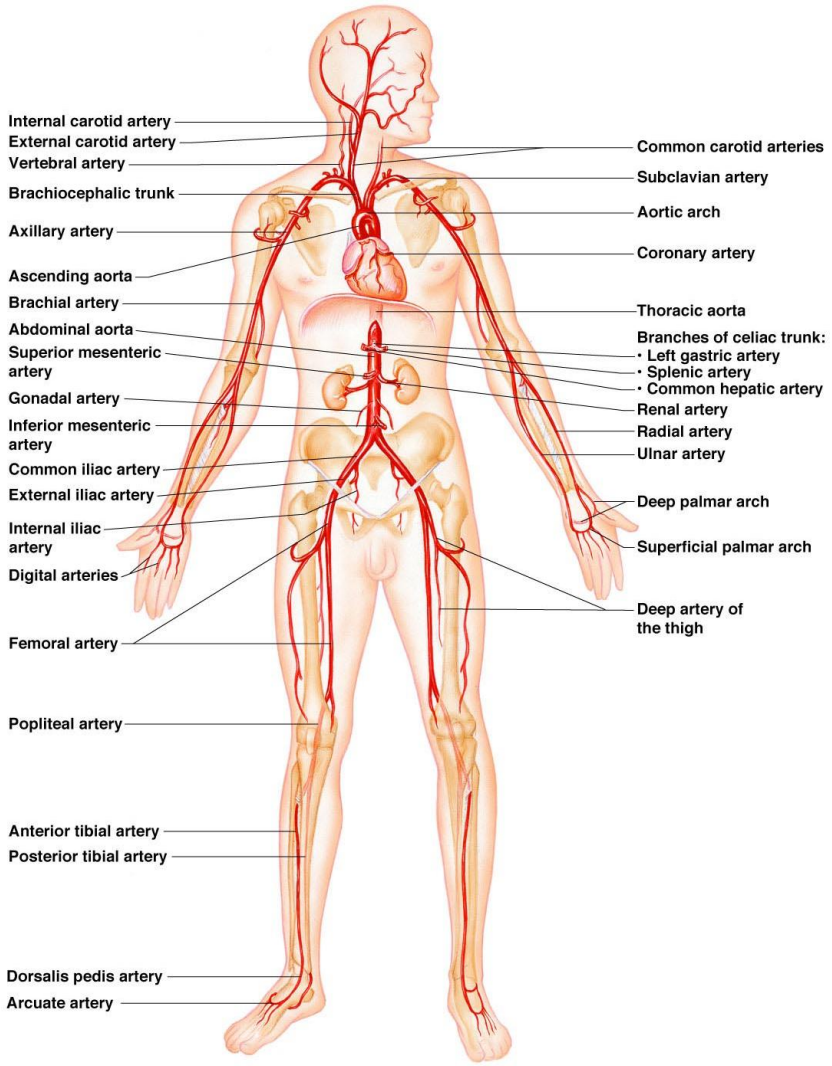


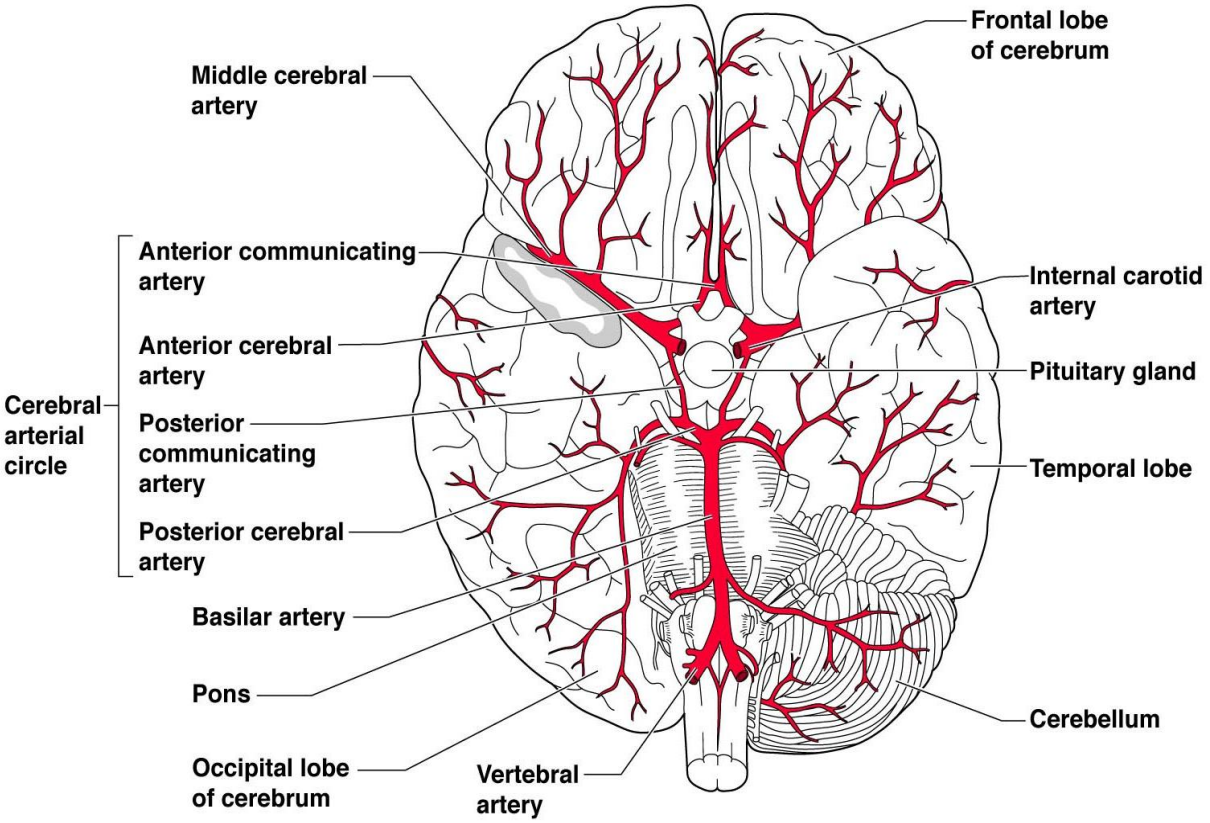
Figure 11.12

Arterial Supply of the Brain

- Internal carotid arteries divide into
  - Anterior and middle cerebral arteries
  - These arteries supply most of the cerebrum
- Vertebral arteries join once within the skull to form the basilar artery
  - Basilar artery branches serve the brain stem and cerebellum
  - Posterior cerebral arteries form from the division of the basilar artery
    - These arteries supply the posterior cerebrum

Circle of Willis

- Anterior and posterior blood supplies are united by small communicating arterial branches
- Result—complete circle of connecting blood vessels called *cerebral arterial circle* or *circle of Willis*



Major Arteries of Systemic Circulation

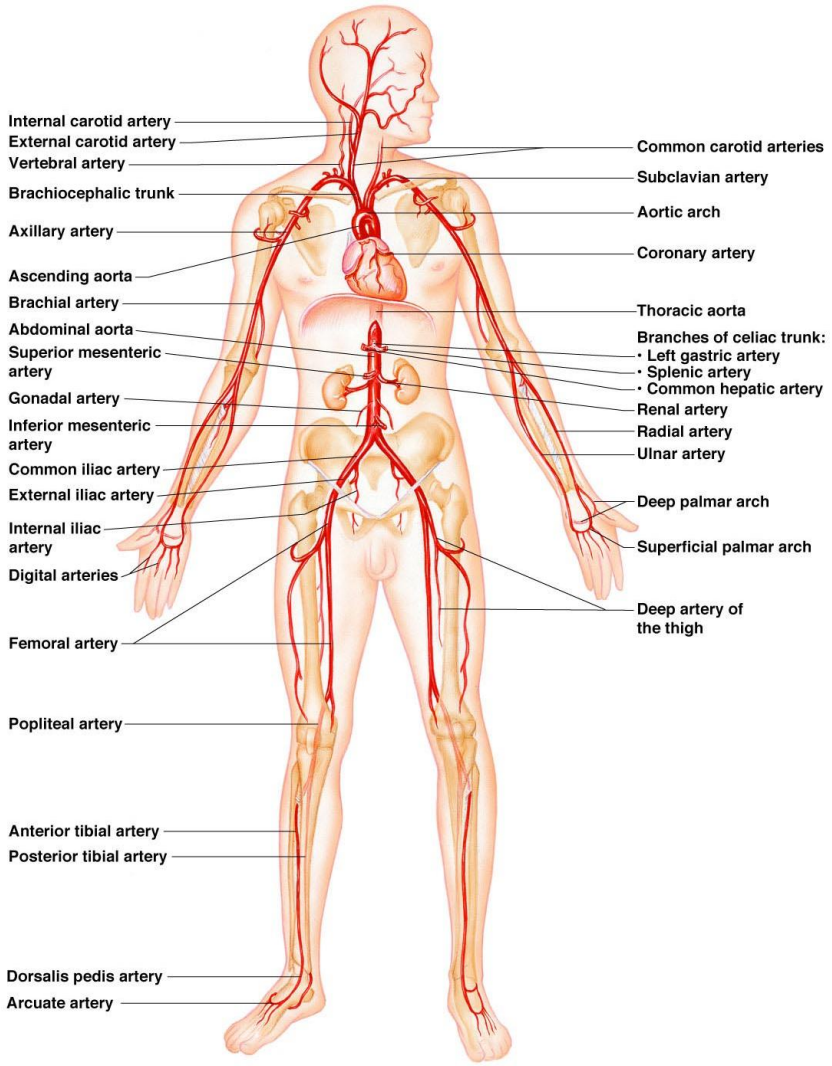


Figure 11.12

Major Veins of Systemic Circulation

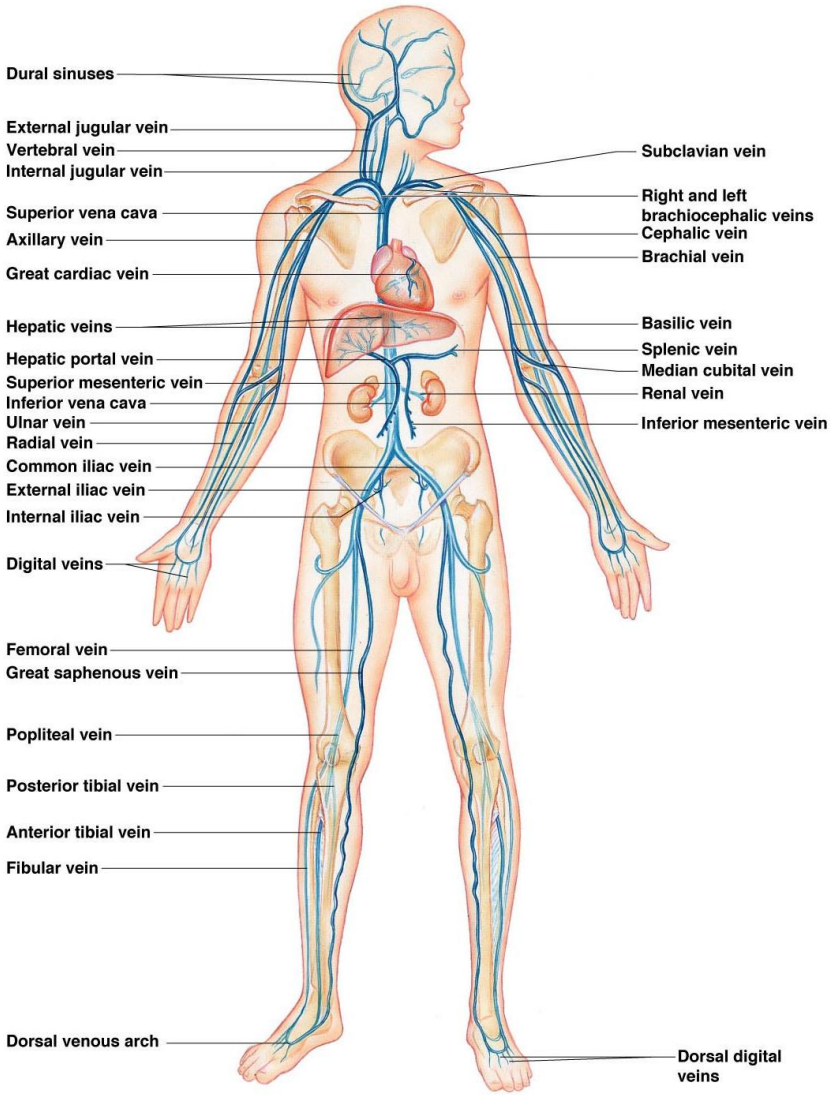
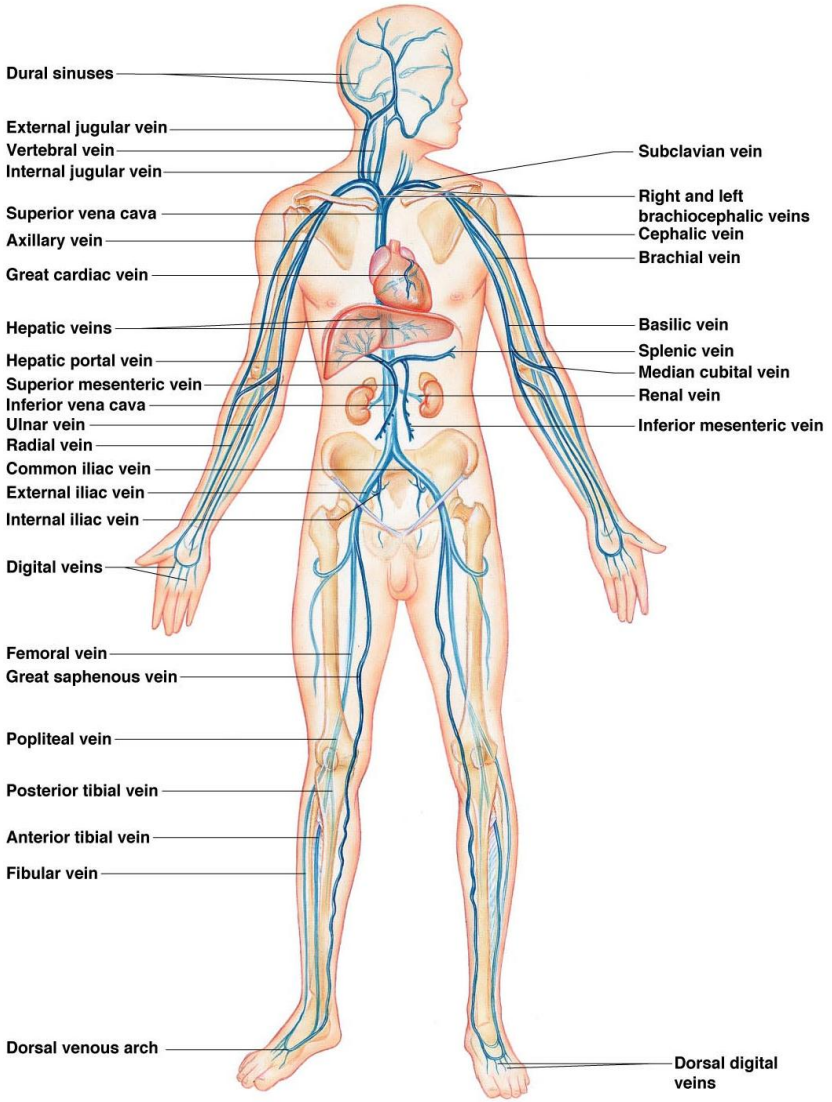


Figure 11.13

Major Veins of Systemic Circulation

- Superior and inferior vena cava enter the right atrium of the heart
  - Superior vena cava drains the head and upper extremity
  - Inferior vena cava drains the lower body



Major Veins of Systemic Circulation

- Radial and ulnar veins → brachial vein → axillary vein
- Superficial, Cephalic vein drains the lateral aspect of the forearm and arm and empties into the axillary vein
- Superficial, Basilic vein drains the medial aspect of the forearm and arm and empties into the brachial vein
- Basilic and cephalic veins are joined at the median cubital vein (elbow area), where blood is often drawn

Major Veins of Systemic Circulation

- Veins draining into the **Brachiocephalic veins**
  - **Subclavian vein** receives
    - Venous blood from the arm via the axillary vein
    - Venous blood from skin and muscles of neck and head via external jugular vein
  - **Internal jugular vein** drains the dural sinuses of the brain and also head structures

Major Veins of Systemic Circulation

- Veins draining into the superior vena cava
  - Left and right **brachiocephalic veins** receive venous blood from the
    - Subclavian veins
    - Internal jugular veins
  - The 2 brachiocephalic veins join to form the **superior vena cava** → right atrium of heart
  - Azygous vein drains the thorax and empties into the superior vena cava

Major Veins of Systemic Circulation

- Veins draining into the inferior vena cava
  - Anterior and posterior tibial veins and fibular veins, drain the legs and foot, form popliteal vein
  - Popliteal vein → femoral vein → external iliac vein
  - Superficial veins: Great saphenous veins (longest veins of the body) & Small saphenous veins receive superficial drainage of the legs
  - Each common iliac vein (left and right) is formed by the union of the internal and external iliac vein on its own side

Major Veins of Systemic Circulation

- Veins draining into the inferior vena cava
  - Right and left common iliac veins form the inferior vena cava
  - Right gonadal vein drains the right ovary in females and right testicle in males, empties into inferior vena cava
  - Left gonadal vein empties into the left renal vein
  - Left and right renal veins drain the kidneys

Major Veins of Systemic Circulation

- Veins draining into the inferior vena cava
  - Left and right hepatic veins drain the liver

Major Veins of Systemic Circulation

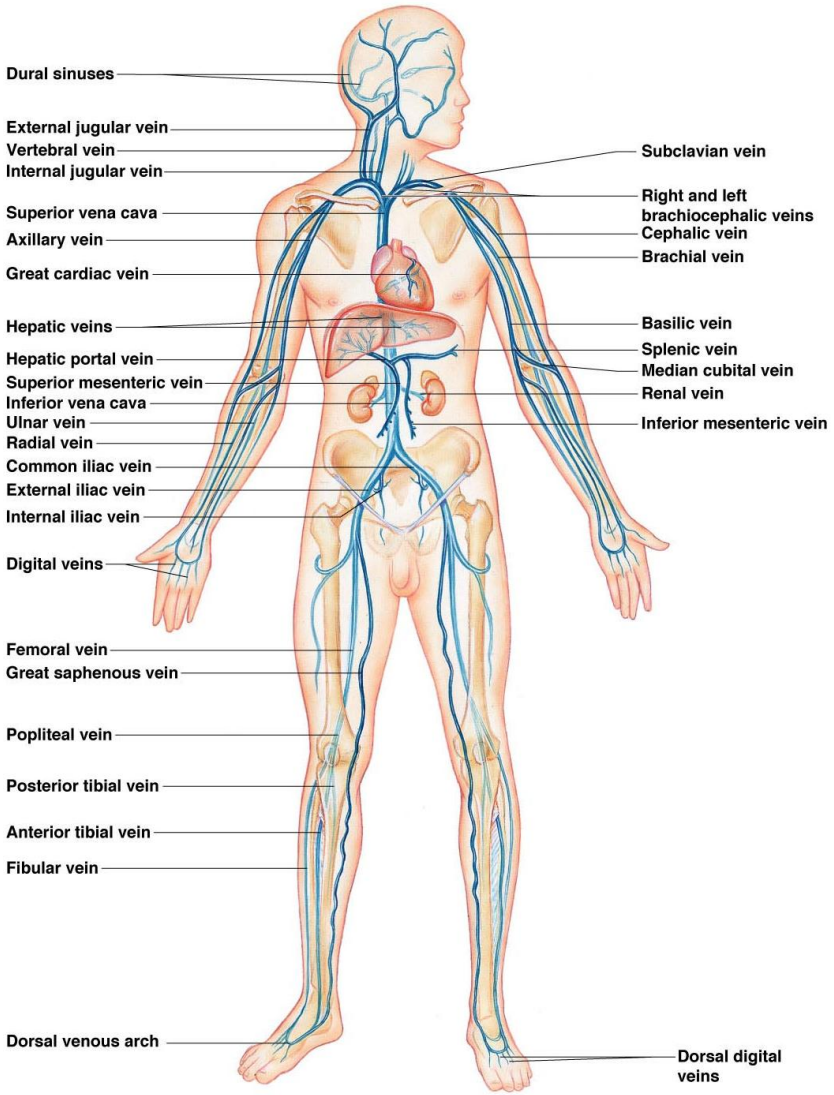


Figure 11.13

Hepatic Portal Circulation

- Veins of hepatic portal circulation drain
  - Digestive organs
  - Spleen
  - Pancreas
- Hepatic portal vein carries this blood to the liver
- Hepatic portal vein drains the digestive organs and travels through the liver before it enters systemic circulation
- Liver helps maintain proper glucose, fat, and protein concentrations in blood

Hepatic Portal Circulation

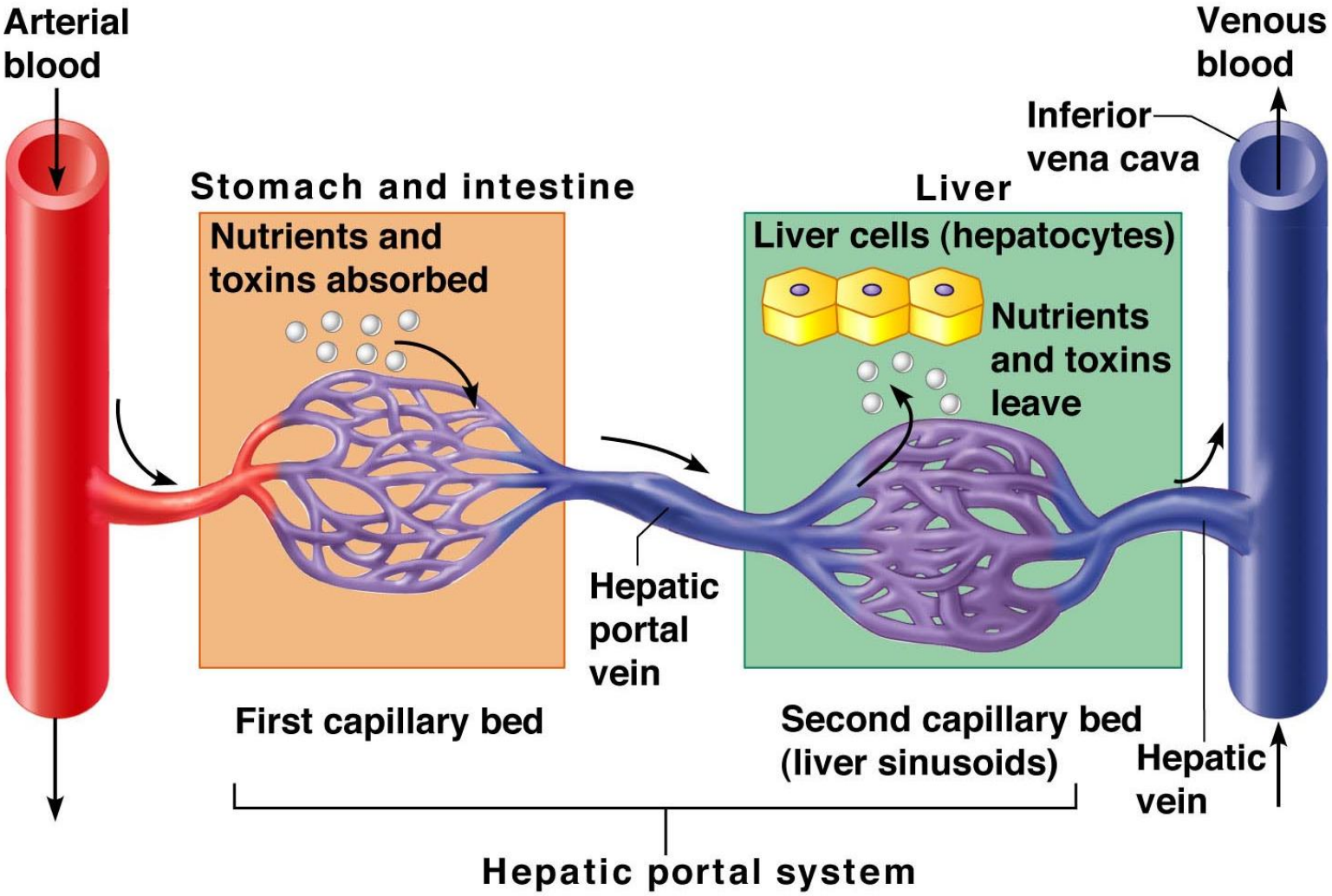
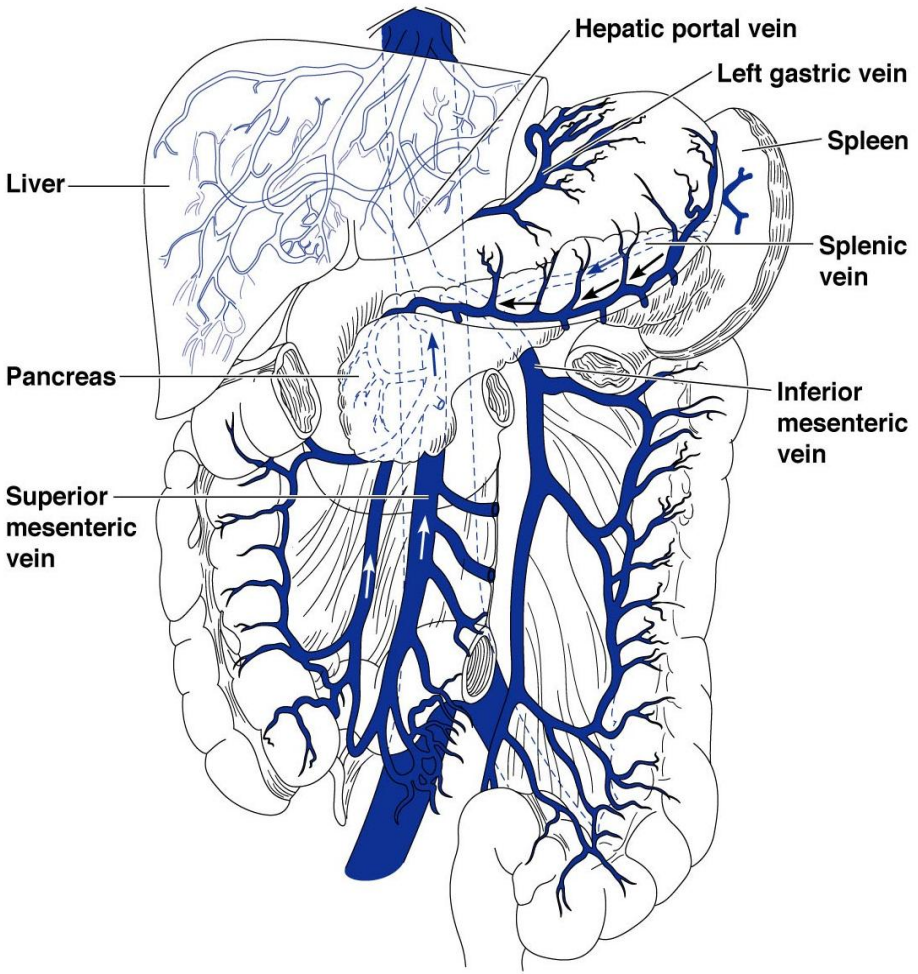


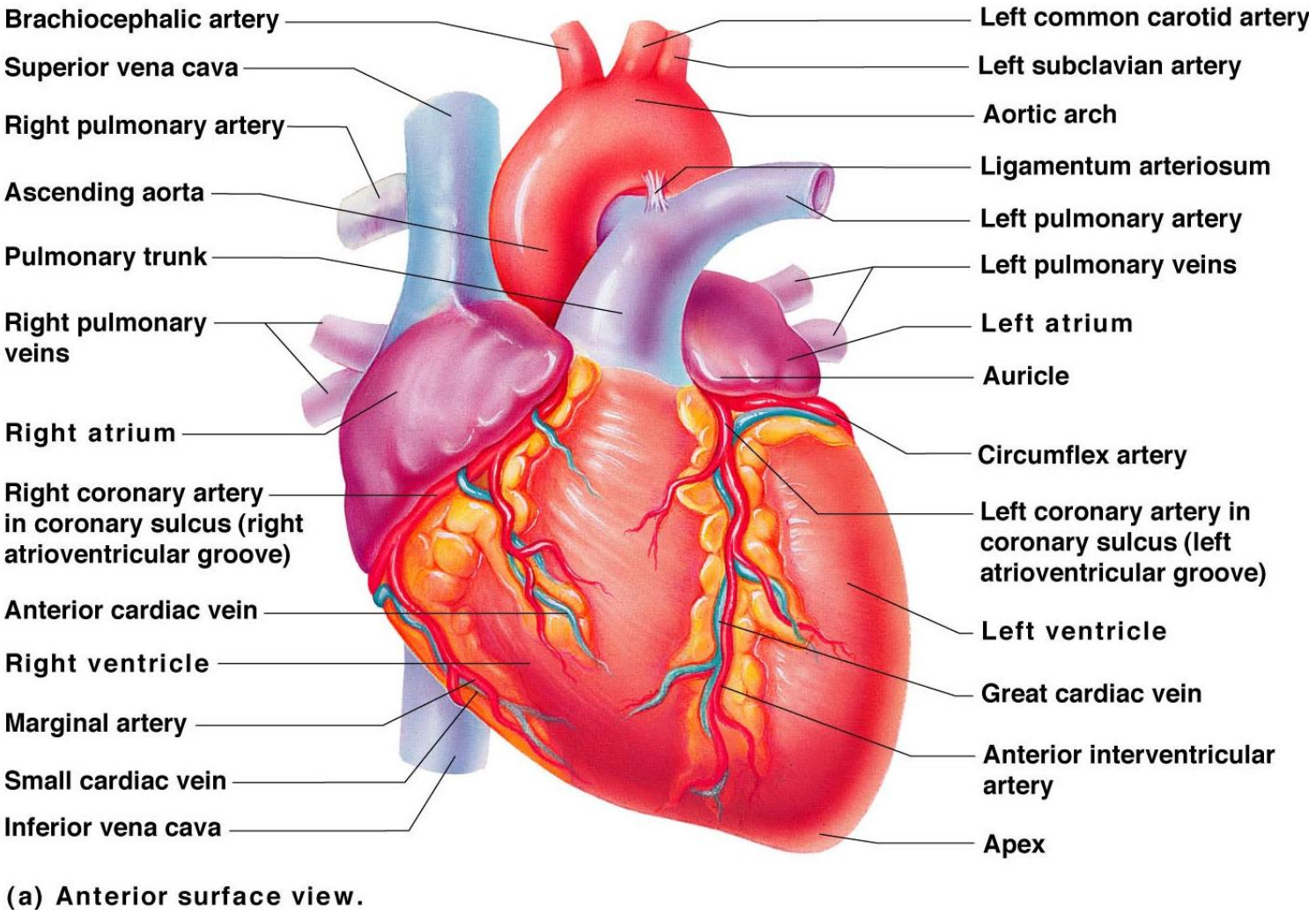
Figure 11.16

Hepatic Portal Circulation

- Major vessels of hepatic portal circulation
  - Inferior and superior mesenteric veins
  - Splenic vein
  - Left gastric vein



The Heart



(a) Anterior surface view.

Figure 11.2a

The Heart: Cardiac Cycle

- Atria contract simultaneously
- Atria relax, then ventricles contract simultaneously
- Systole = contraction
- Diastole = relaxation

Filling Heart Chambers: Cardiac Cycle

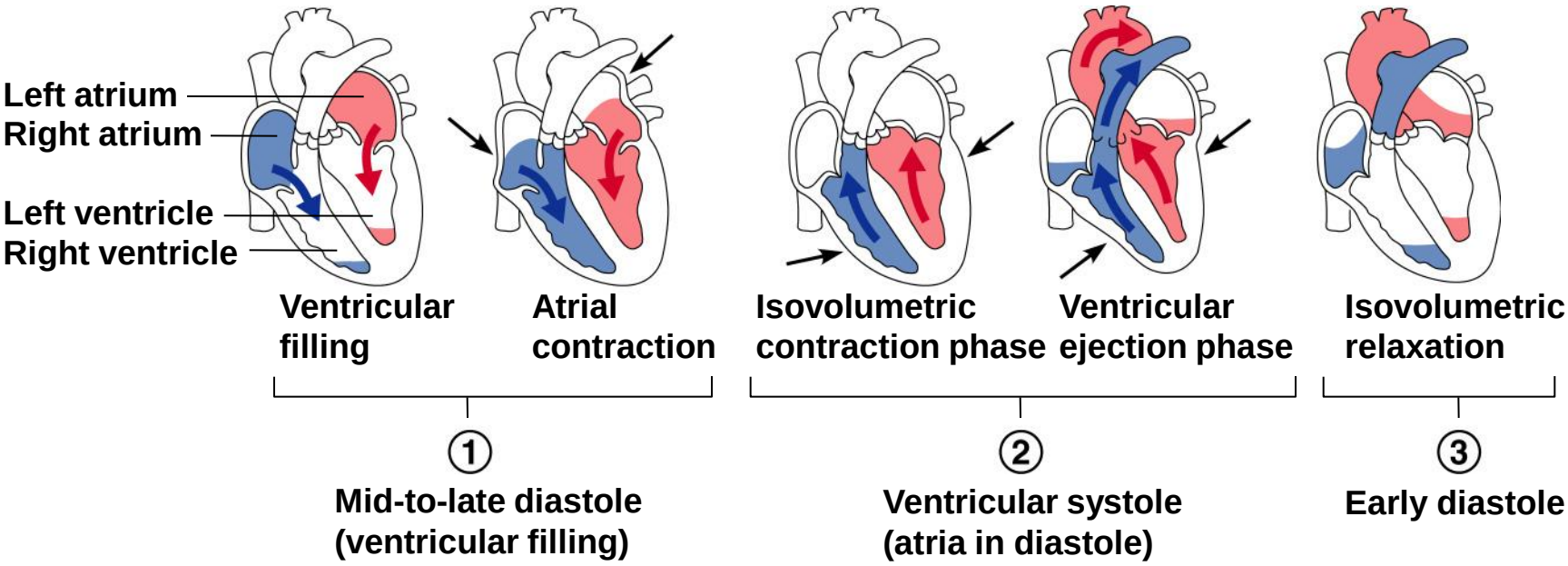


Figure 11.7, step 3

The Heart: Cardiac Output

- Cardiac output (CO)
  - Amount of blood pumped by each side (ventricle) of the heart in one minute
- Stroke volume (SV)
  - Volume of blood pumped by each ventricle in one contraction (each heartbeat)
  - Usually remains relatively constant
  - About 70 mL of blood is pumped out of the left ventricle with each heartbeat
- Heart rate (HR)
  - Typically 75 beats per minute

The Heart: Cardiac Output

- CO = HR × SV
- CO = HR (75 beats/min) × SV (70 mL/beat)
- CO = 5250 mL/min
- Starling's law of the heart—the more the cardiac muscle is stretched, the stronger the contraction

- How can the CO be increased? (hint: 2 ways)

The Heart: Regulation of Heart Rate

- Increased heart rate
  - Sympathetic nervous system
    - Crisis
    - Low blood pressure
  - Hormones
    - Epinephrine
    - Thyroxine
  - Exercise
  - Decreased blood volume

The Heart: Regulation of Heart Rate

- Decreased heart rate
  - Parasympathetic nervous system
  - High blood pressure or blood volume
  - Decreased venous return

Blood Vessels: The Vascular System

- Transport blood to the tissues and back
  - Carry blood away from the heart
    - Arteries
    - Arterioles
  - Exchanges between tissues and blood
    - Capillary beds
  - Return blood toward the heart
    - Venules
    - Veins

Blood Vessels: Microscopic Anatomy

- Three layers (tunics)
  - Tunic intima
    - Endothelium
  - Tunic media
    - Smooth muscle
    - Controlled by sympathetic nervous system
  - Tunic externa
    - Mostly fibrous connective tissue

Pulse

- Pulse
  - Pressure wave of blood
- Monitored at “pressure points” in arteries where pulse is easily palpated
- Pulse averages 70–76 beats per minute at rest

Blood Pressure

- Measurements by health professionals are made on the pressure in large arteries
  - Systolic—pressure at the peak of ventricular contraction
  - Diastolic—pressure when ventricles relax
  - Write systolic pressure first and diastolic last (120/80 mm Hg)
- Pressure in blood vessels decreases as distance from the heart increases

Comparison of Blood Pressures in Different Vessels

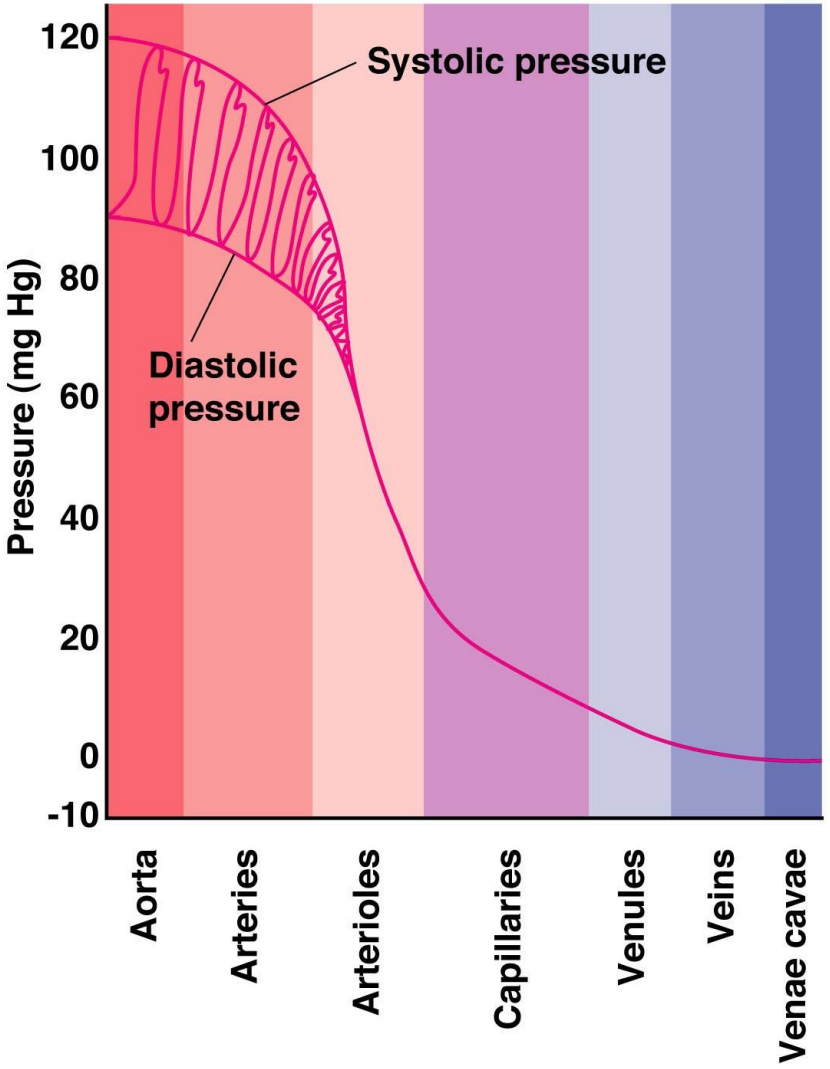


Figure 11.19

Blood Pressure: Effects of Factors

- BP is blood pressure
  - BP is affected by age, weight, time of day, exercise, body position, emotional state
- CO is the amount of blood pumped out of the left ventricle per minute
- PR is peripheral resistance, or the amount of friction blood encounters as it flows through vessels
  - Narrowing of blood vessels and increased blood volume increases PR
- BP = CO × PR

Blood Pressure: Effects of Factors

- Neural factors
  - Autonomic nervous system adjustments (sympathetic division)
- Renal factors
  - Regulation by altering blood volume
  - Renin/angiotension/aldosterone—hormonal control

Blood Pressure: Effects of Factors

- Temperature
  - Heat has a vasodilating effect
  - Cold has a vasoconstricting effect
- Chemicals
  - Various substances can cause increases or decreases
- Diet

Factors Determining Blood Pressure

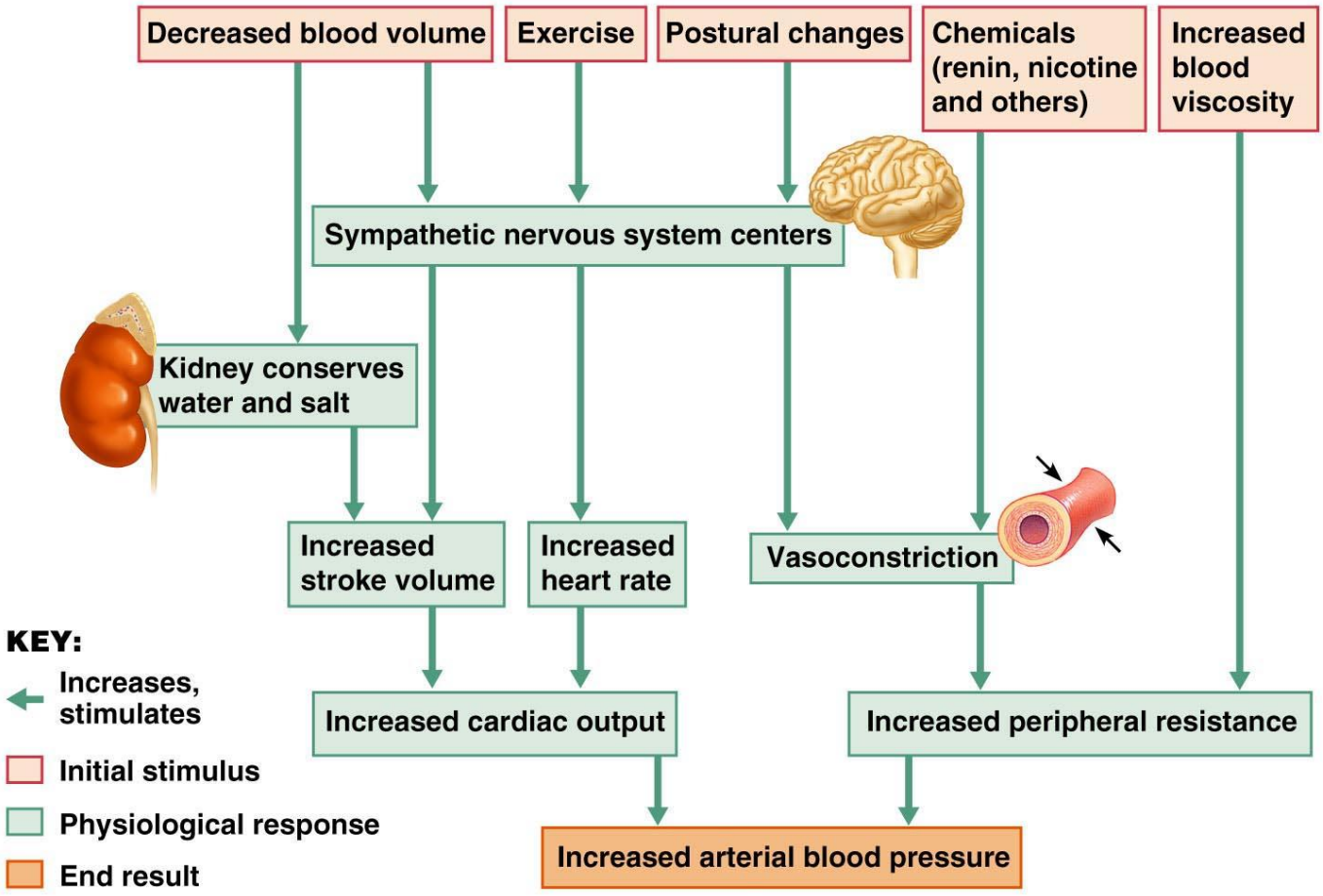


Figure 11.21

Variations in Blood Pressure

- Normal human range is variable
  - Normal
    - 140–110 mm Hg systolic
    - 80–75 mm Hg diastolic
  - Hypotension
    - Low systolic (below 110 mm HG)
    - Often associated with illness
  - Hypertension
    - High systolic (above 140 mm HG)
    - Can be dangerous if it is chronic

Developmental Aspects of the Cardiovascular System

- Aging problems associated with the cardiovascular system include
  - Venous valves weaken
    - Varicose veins
  - Progressive atherosclerosis
    - Loss of elasticity of vessels leads to hypertension
    - Coronary artery disease results from vessels filled with fatty, calcified deposits

Major Veins of Systemic Circulation

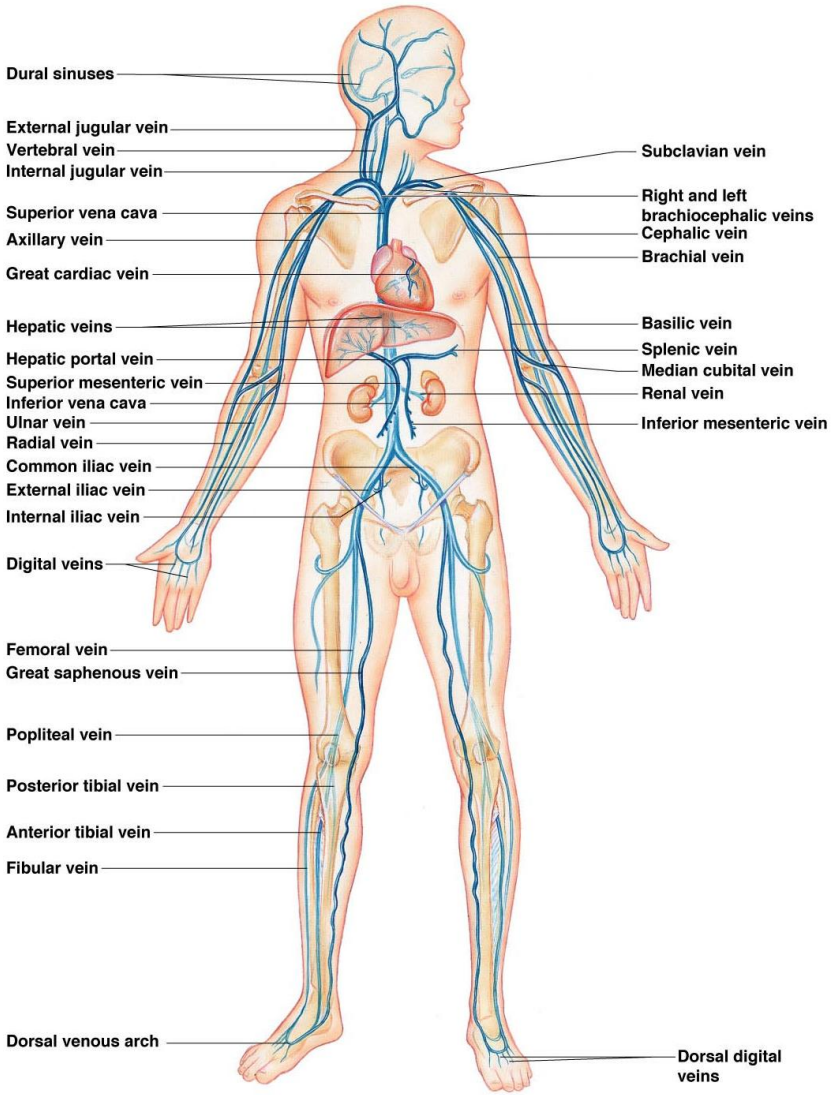


Figure 11.13