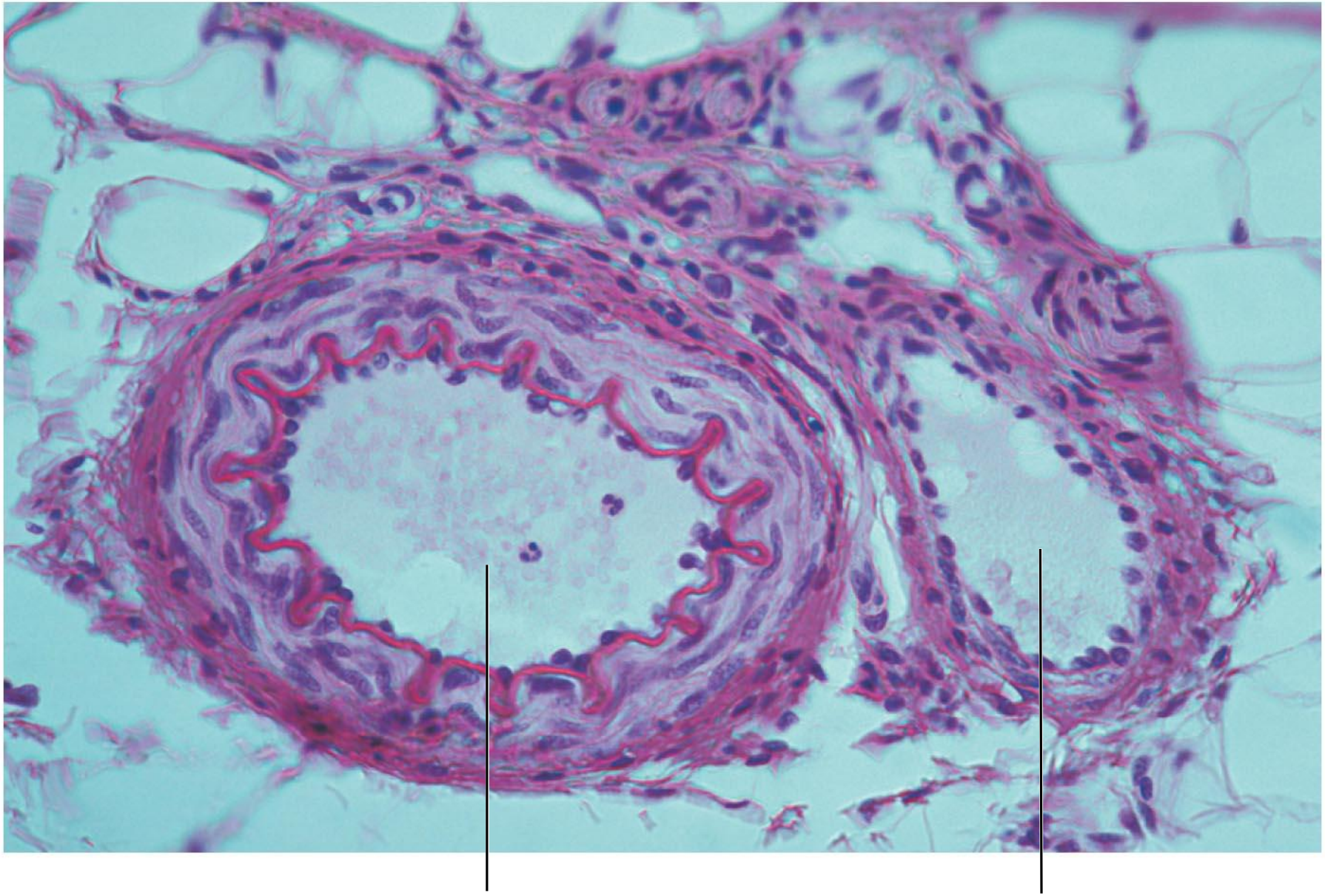
# Blood Vessels: The Vascular System

- 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




(a)



Figure 11.10a

# Blood Vessels: Microscopic Anatomy

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

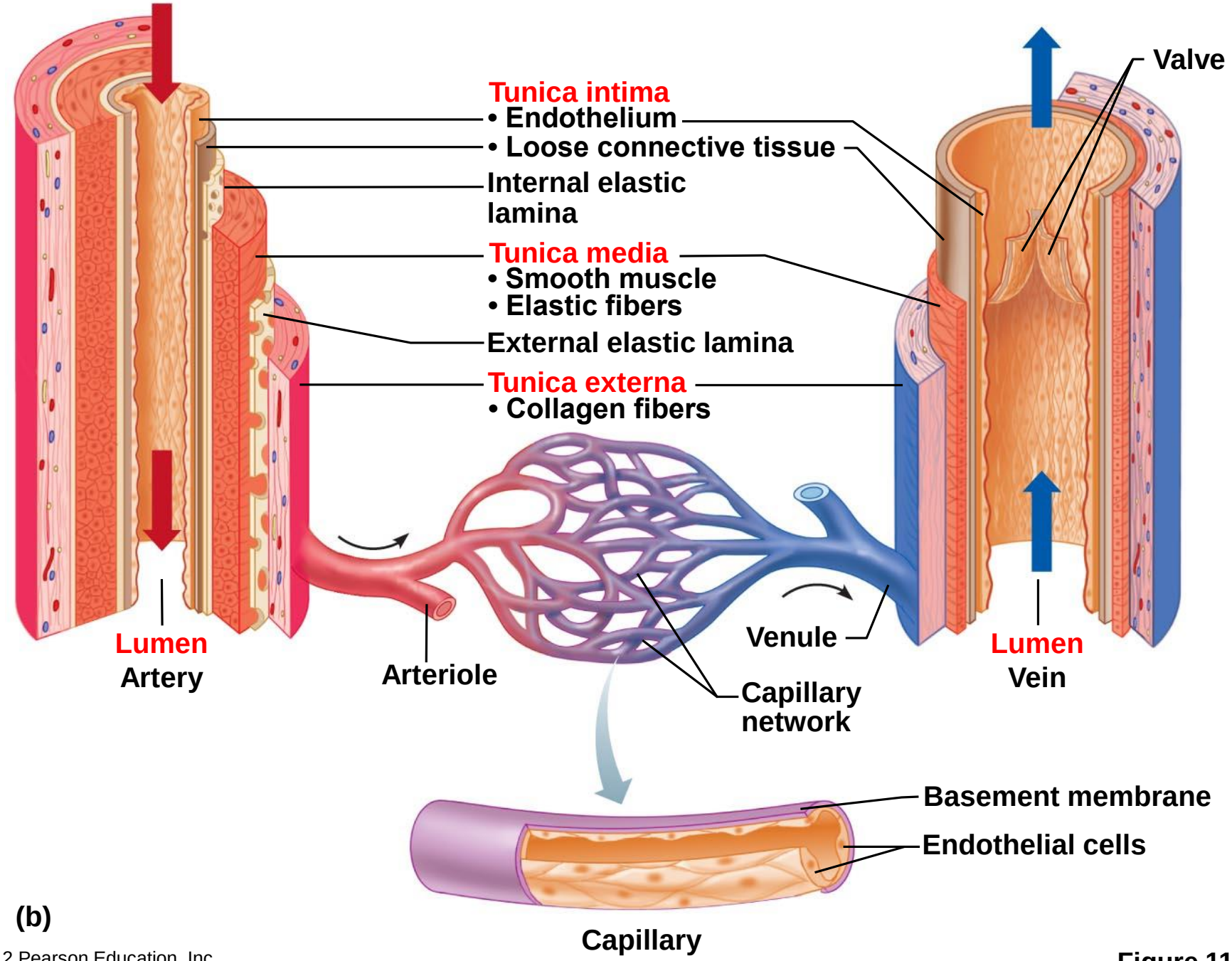





Figure 11.10b

# Structural Differences Among Blood Vessels

- Arteries have a thicker tunica media than veins
- Capillaries are only one cell layer (tunica intima) to allow for exchanges between blood and tissue
- Veins have a thinner tunica media than arteries
  - Veins also have valves to prevent backflow of blood
  - Lumen of veins are larger than arteries

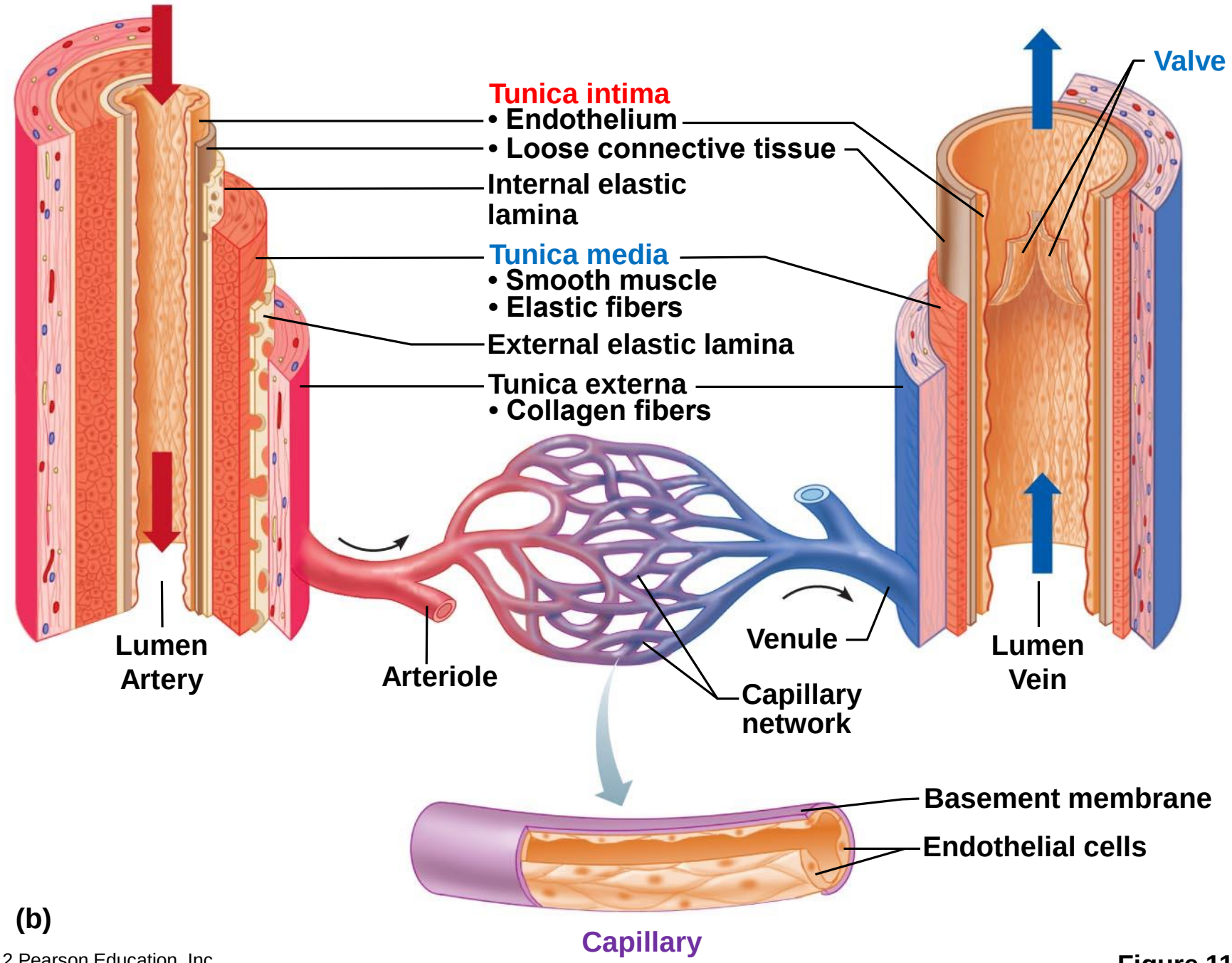





Figure 11.10b

# Venous Aids for the Return of Blood to the Heart

- Veins:
  - Have a thinner tunica media
  - Operate under low pressure
  - Have a larger lumen than arteries

- To assist in the movement of blood back to the heart:
  - Larger veins have valves to prevent backflow
  - Skeletal muscle “milks” blood in veins (and lymph, for that matter) toward the heart

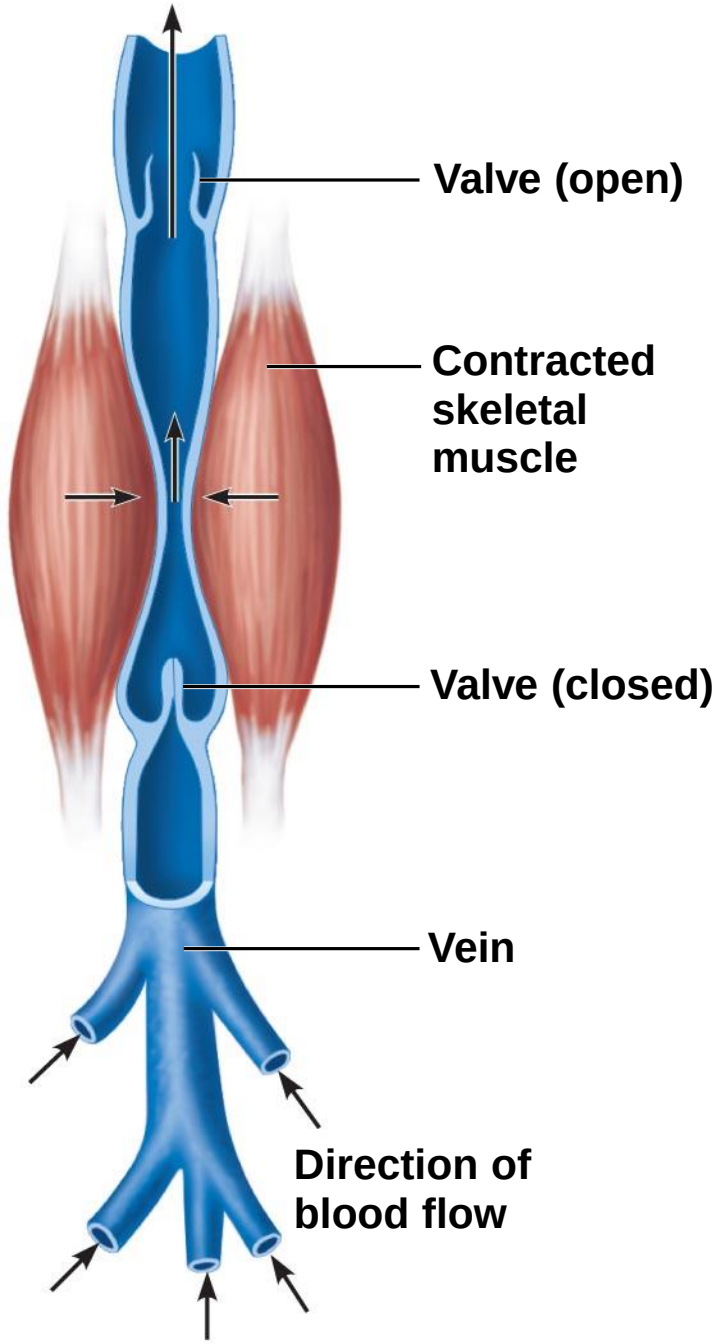




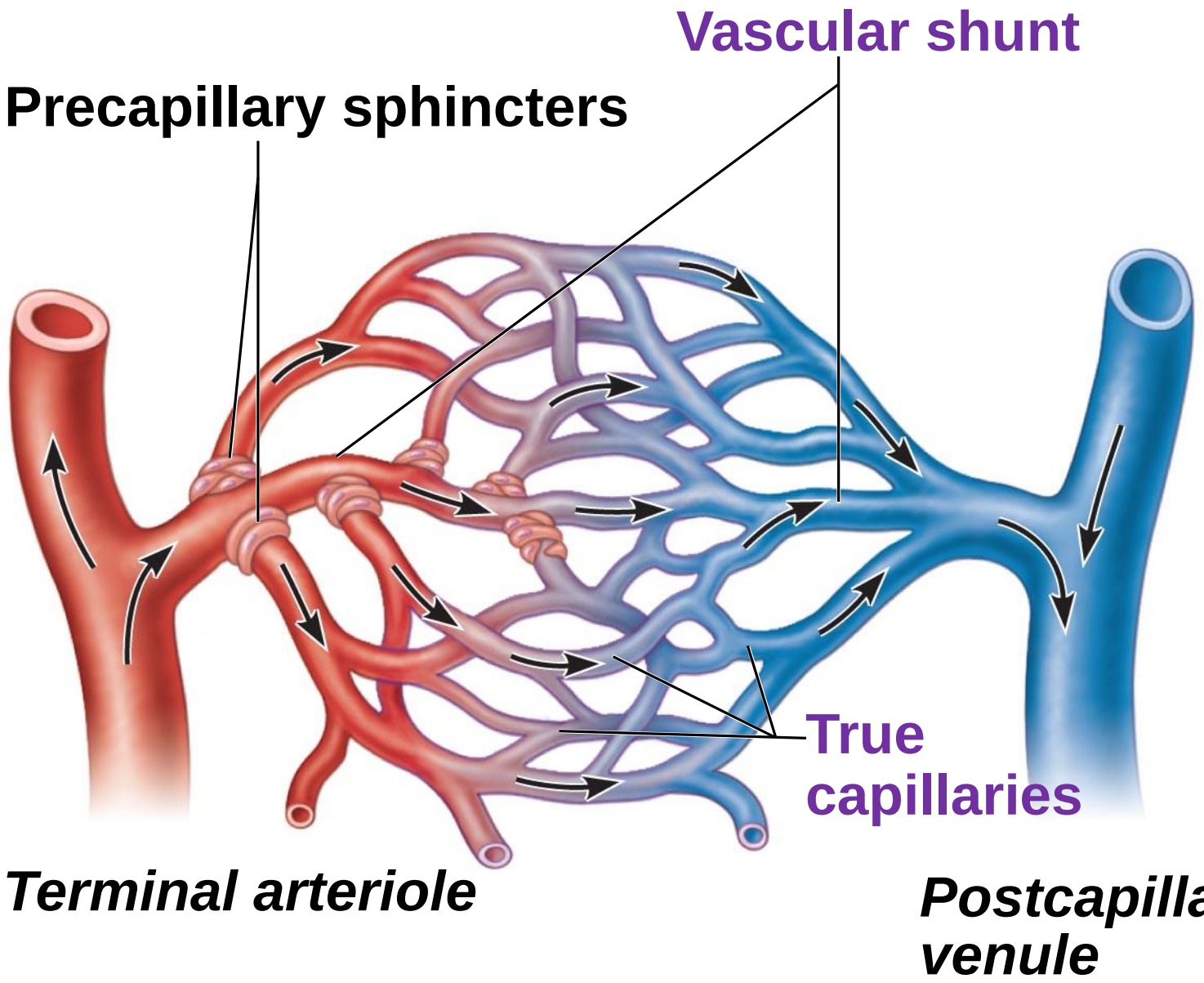

Figure 11.11

# Movement of Blood Through Vessels

- Most arterial blood is pumped by the heart
- Veins use the “milking” action of muscles to help move blood

# Capillary Beds

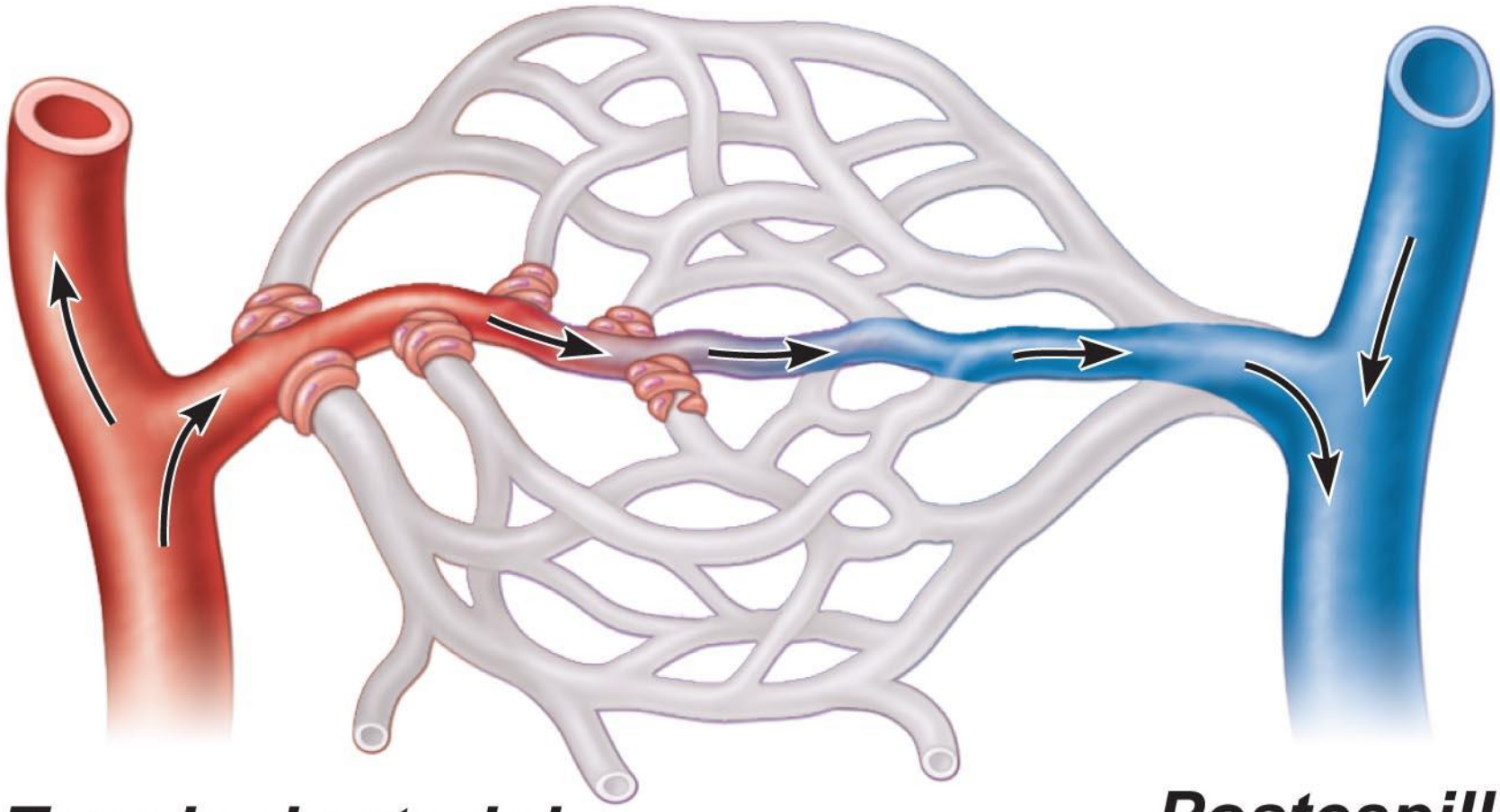
- Capillary beds consist of two types of vessels
  - Vascular shunt — vessel directly connecting an arteriole to a venule
  - True capillaries — exchange vessels
    - Oxygen and nutrients cross to cells
    - Carbon dioxide and metabolic waste products cross into blood




(a) Sphincters open; blood flows through true capillaries.



Figure 11.12a

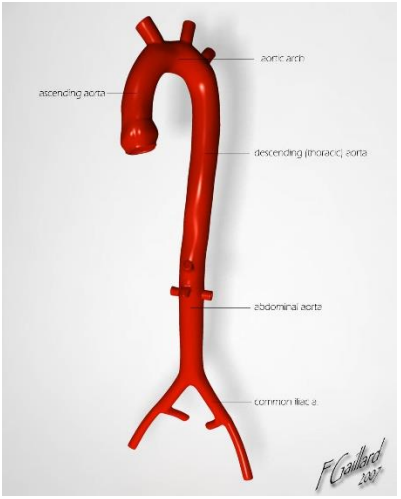



(b) Sphincters closed; blood flows through vascular shunt.



**Figure 11.12b**

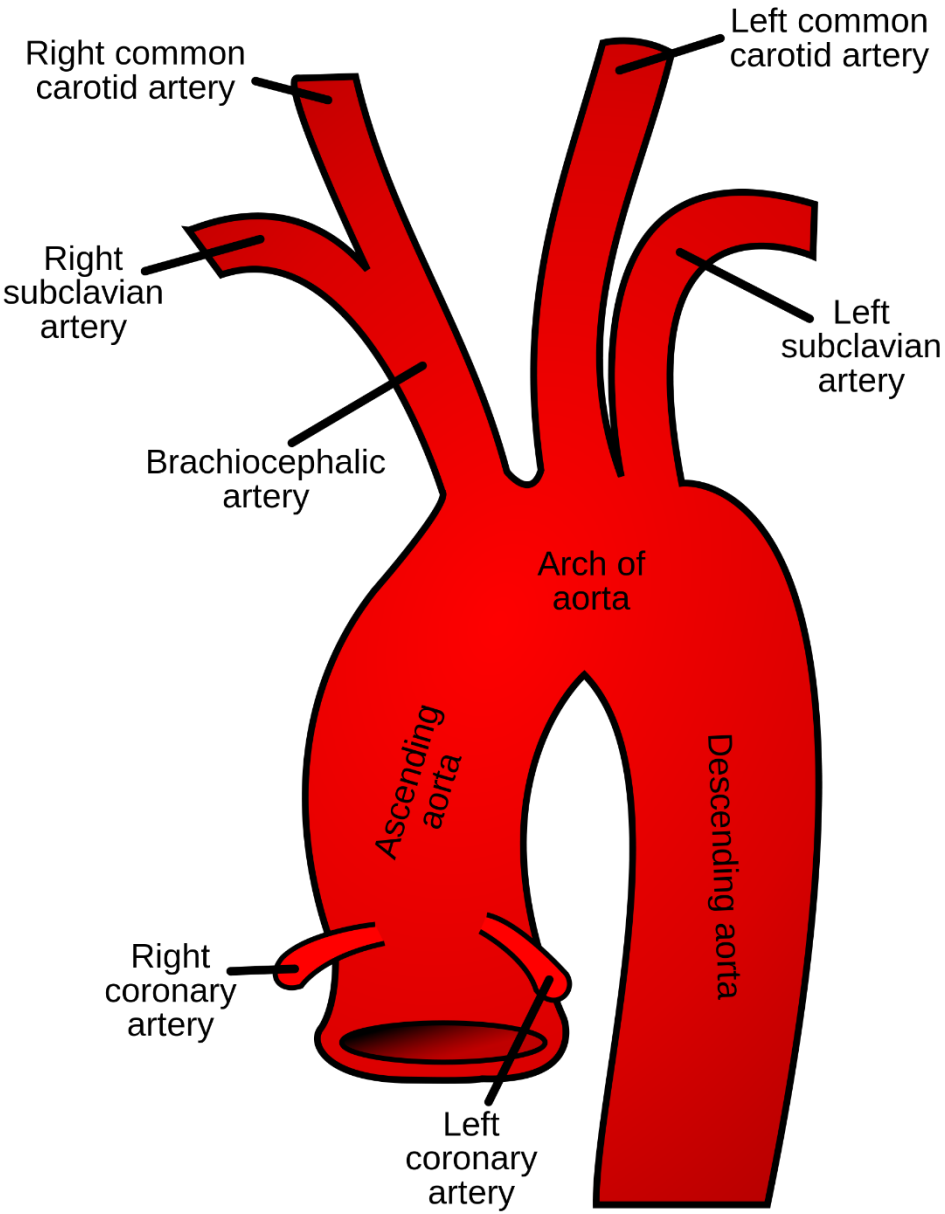
# Major Arteries of System Circulation




- 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

# Major Arteries of System Circulation

- Arterial branches of the ascending aorta
  - Right and left coronary arteries serve the heart



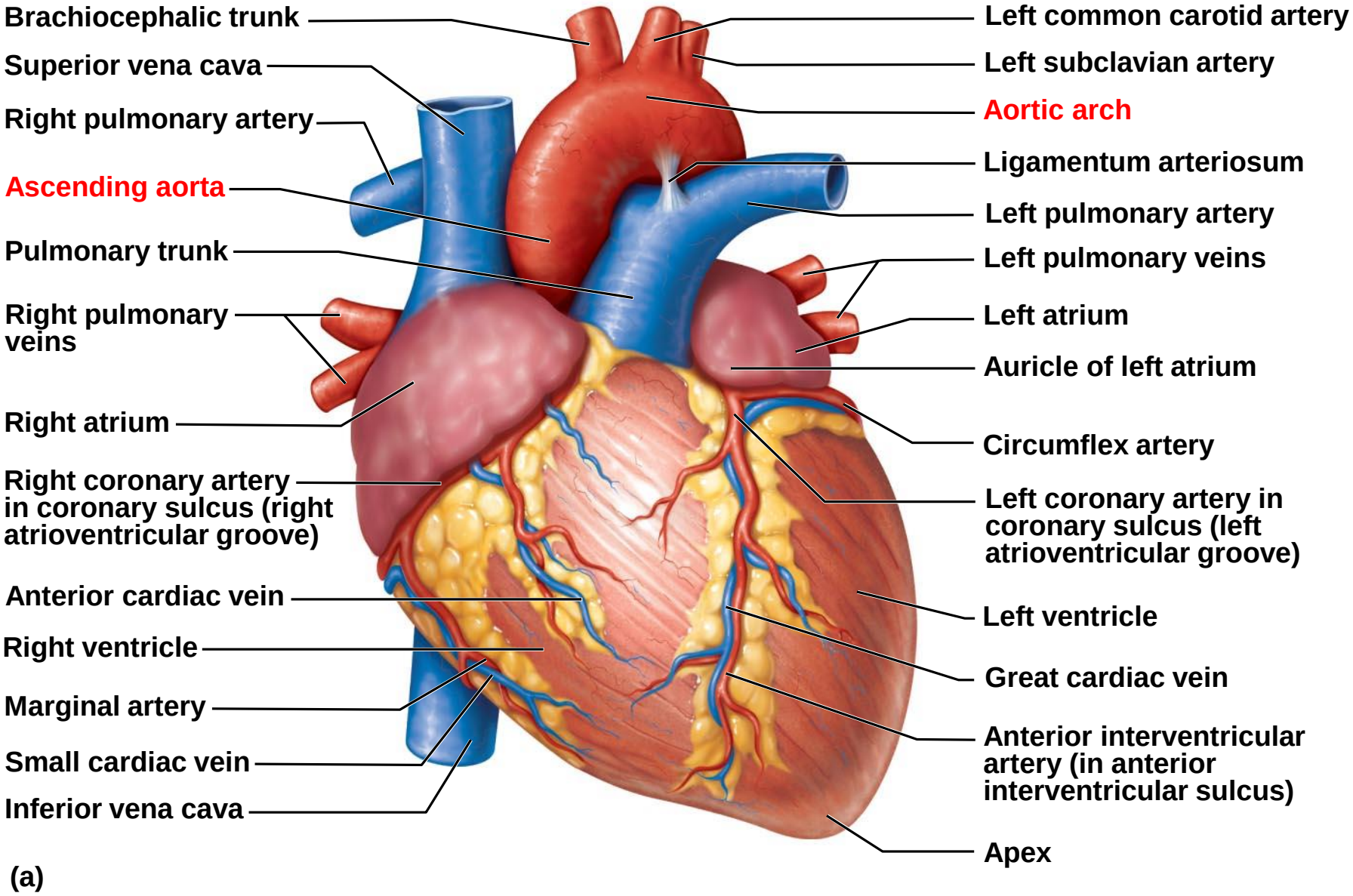
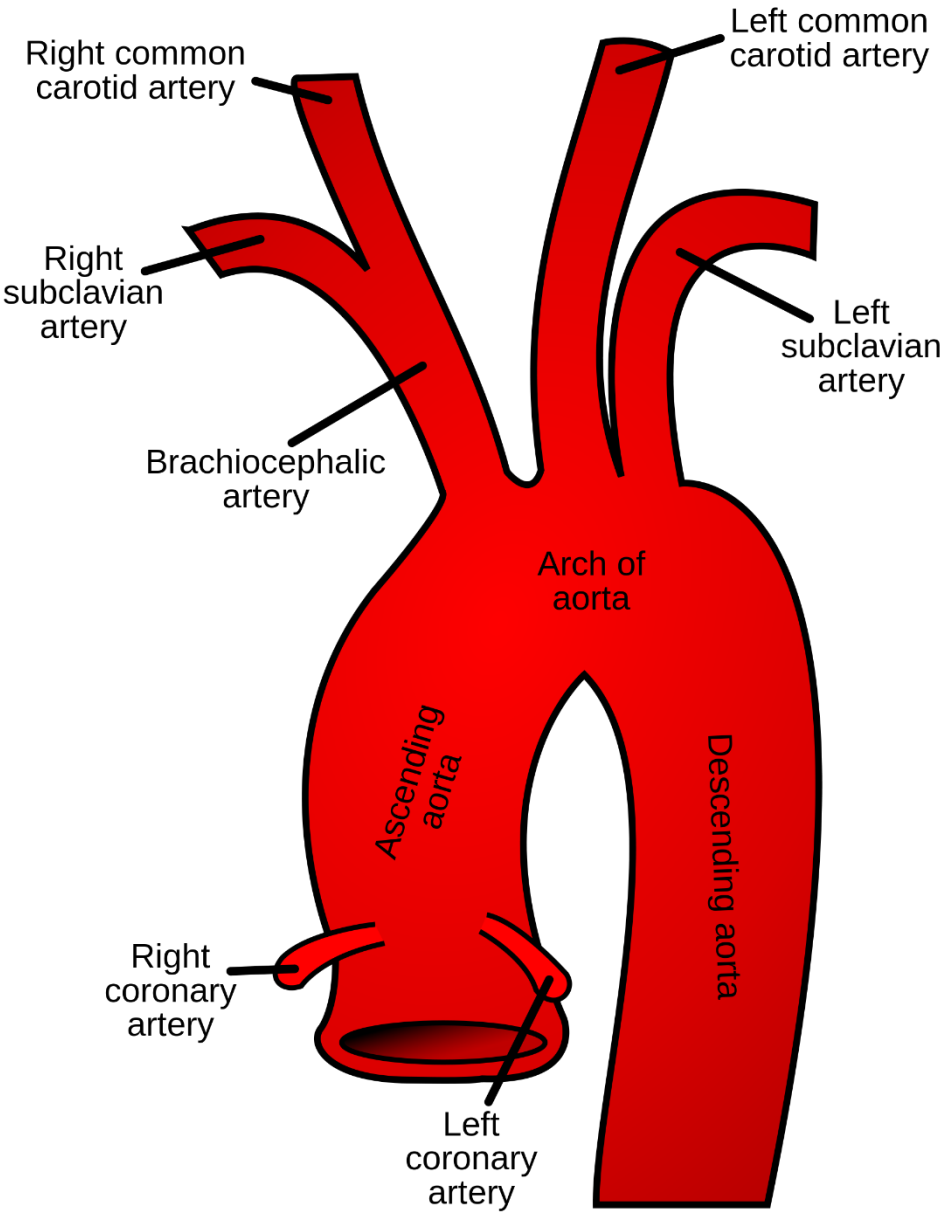




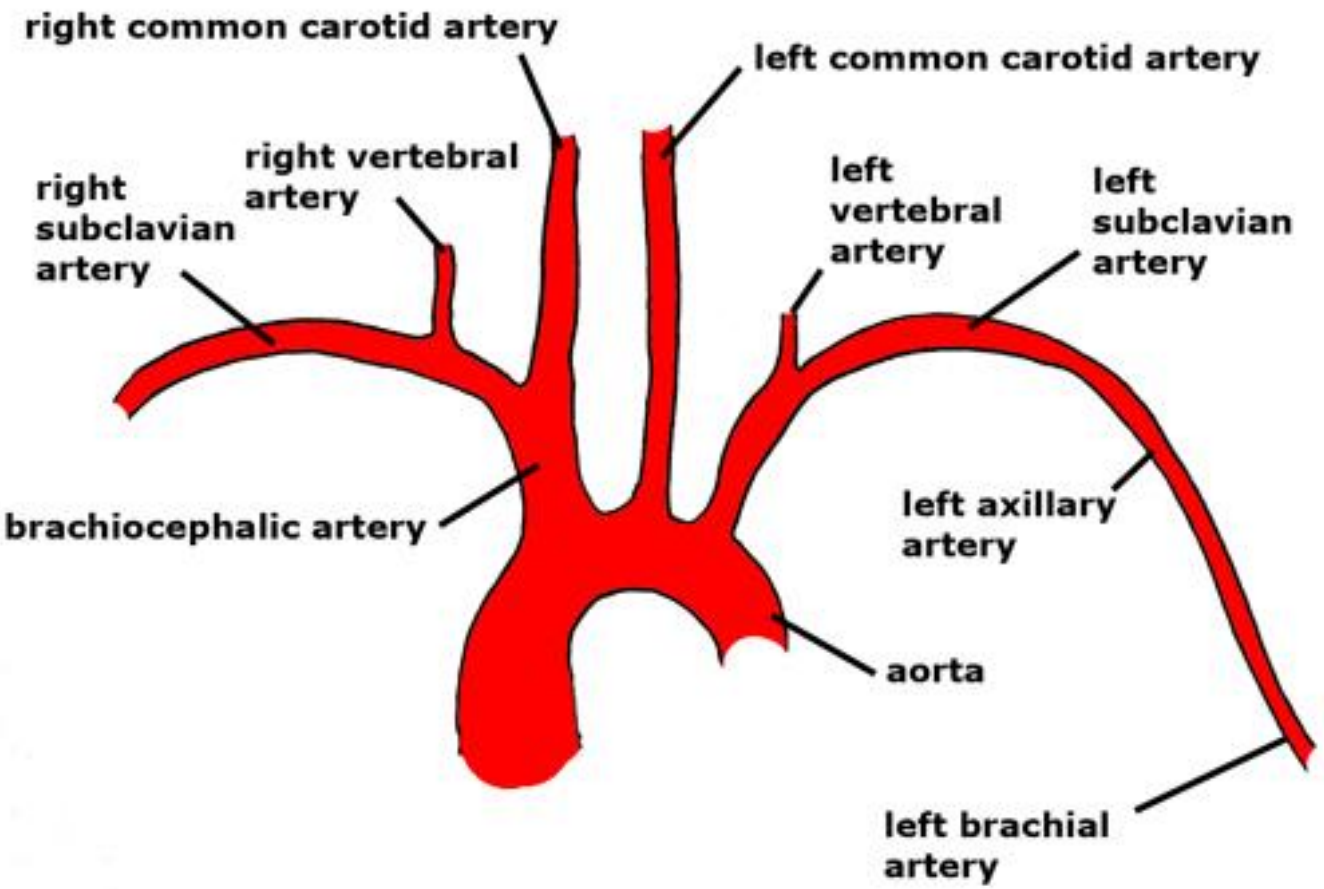

Figure 11.3a

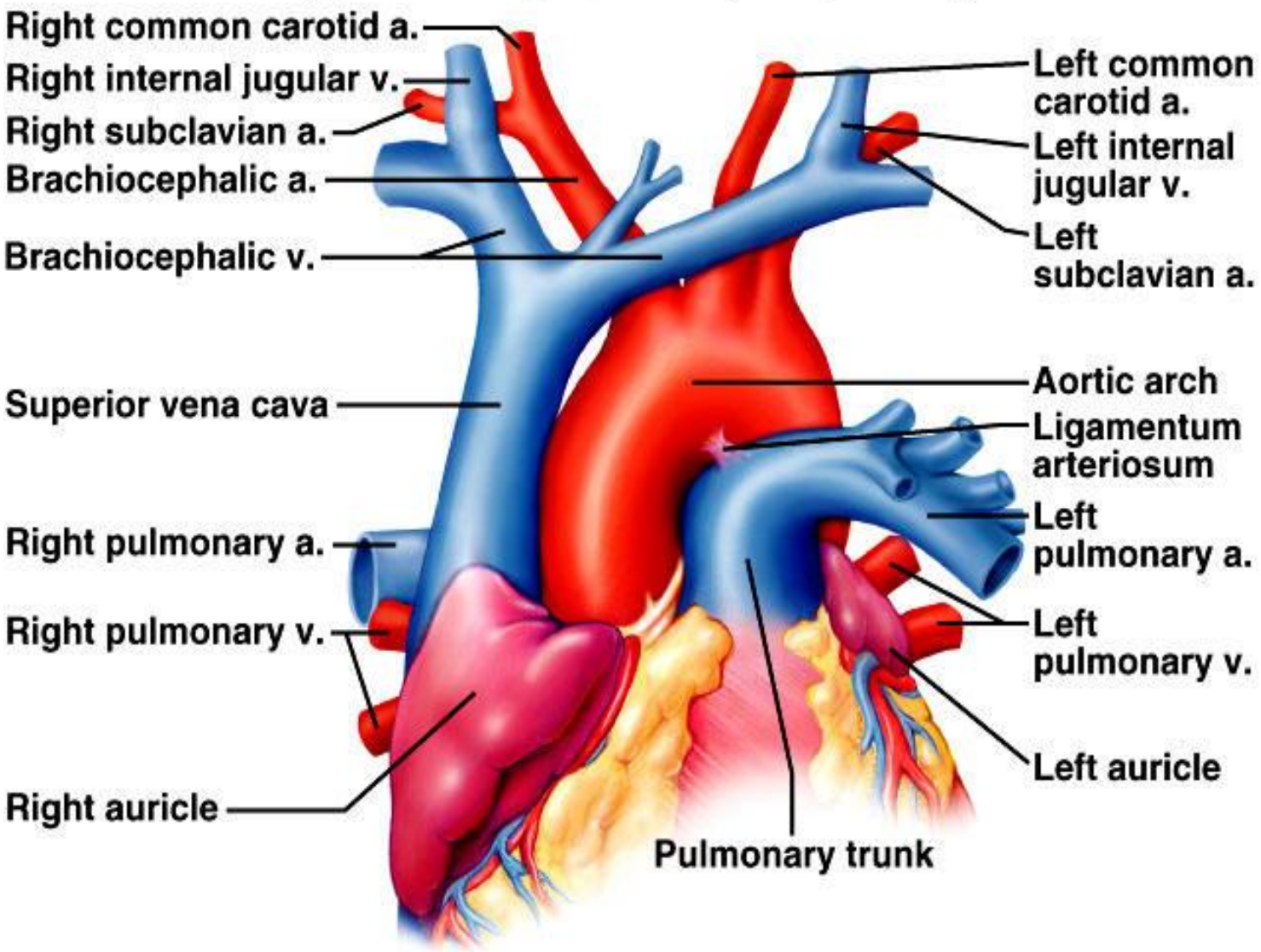
# Major Arteries of Systemic Circulation

- Arterial branches of the aortic arch (BCS)
  - Brachiocephalic trunk splits into the
    - Right common carotid artery
    - Right subclavian artery
  - Left common carotid artery splits into the
    - Left internal and external carotid arteries
  - Left subclavian artery branches into the
    - Vertebral artery – branch from subclavian
    - In the axilla, the subclavian artery becomes the axillary artery → brachial artery → radial and ulnar arteries



# Major arteries superior to the heart





# 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 most of the small intestine and first half 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
  - Inferior mesenteric artery serves the second half of the large intestine
  - 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 → popliteal artery → anterior and posterior tibial arteries

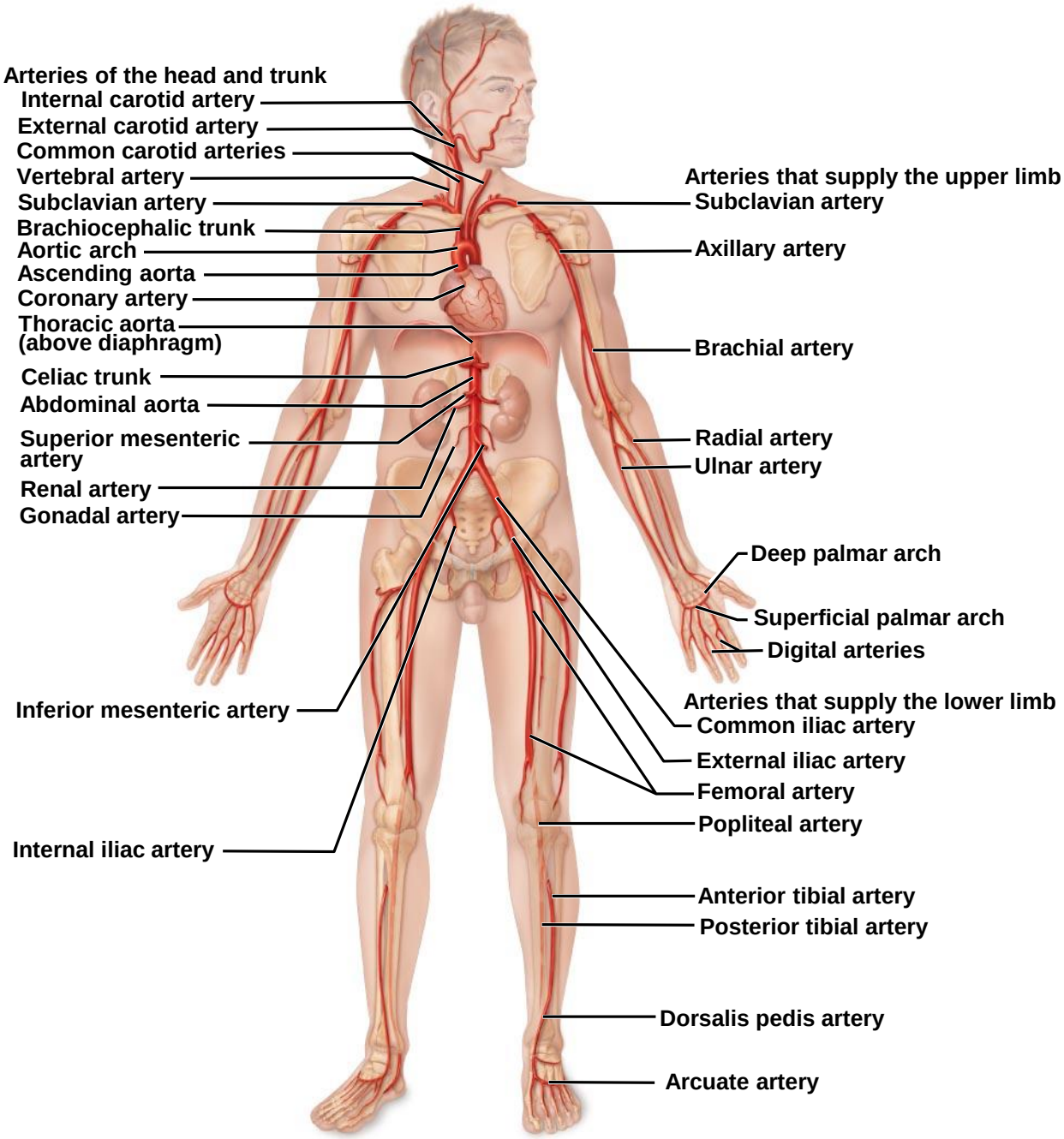
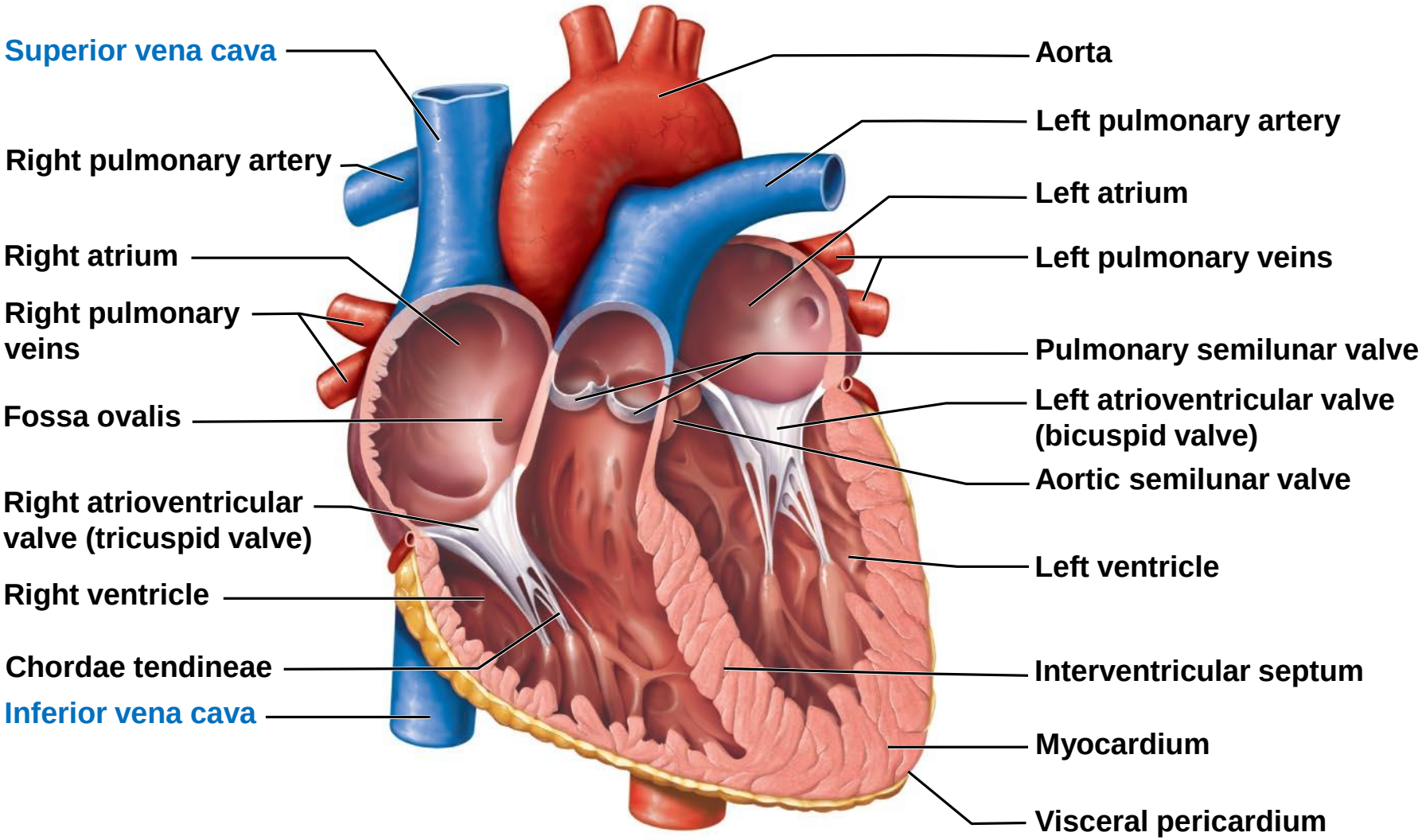





**Figure 11.13**

# Major Veins of Systemic Circulation

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




**(b) Frontal section showing interior chambers and valves.**



**Figure 11.3b**

# Major Veins of Systemic Circulation

- Veins draining into the **superior** vena cava
  - Radial and ulnar veins → brachial vein → axillary vein
  - These veins drain the arms:
    - Cephalic vein drains the lateral aspect of the arm and empties into the axillary vein
    - Basilic vein drains the medial aspect of the arm and empties into the brachial vein
    - Basilic and cephalic veins are jointed at the median cubital vein (elbow area)

# Major Veins of Systemic Circulation

- Veins draining into the **superior** vena cava
  - Subclavian vein receives
    - Venous blood from the arm via the axillary vein
    - Venous blood from skin and muscles via external jugular vein
  - Vertebral vein drains the posterior part of the head
  - Internal jugular vein drains the dural sinuses of the brain

# Major Veins of Systemic Circulation

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

# Major Veins of Systemic Circulation

- Veins draining into the **inferior** vena cava
  - Anterior and posterior tibial veins and fibial veins drain the legs
  - Posterior tibial vein → popliteal vein → femoral vein → external iliac vein
  - Great saphenous veins (longest veins of the body) 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 gonadal vein drains the right ovary in females and right testicle in males
  - Left gonadal vein empties into the left renal vein
  - Left and right renal veins drain the kidneys
  - Hepatic portal vein drains the digestive organs and travels through the liver before it enters systemic circulation

# Major Veins of Systemic Circulation

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

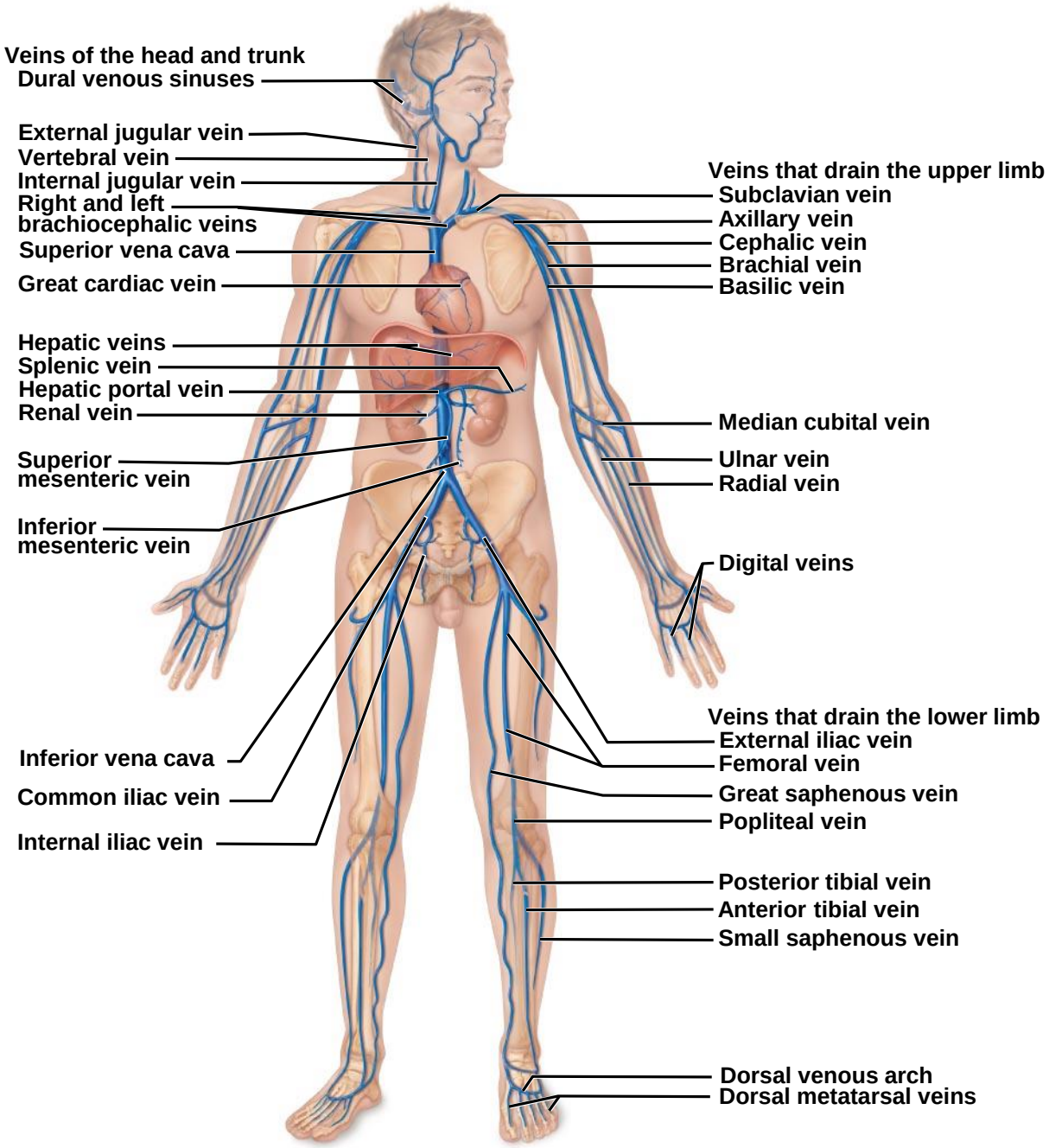





**Figure 11.14**

# 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 serves 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

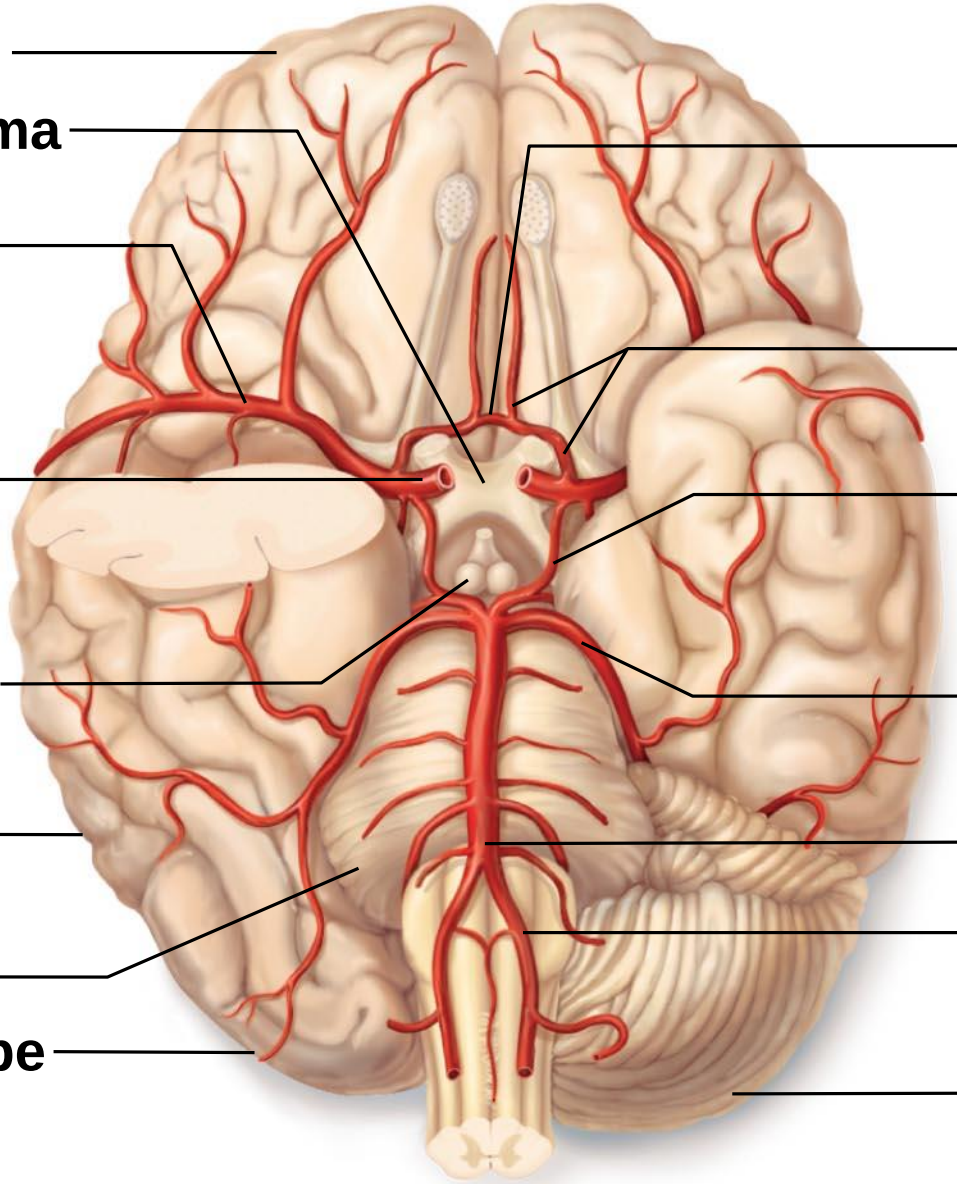
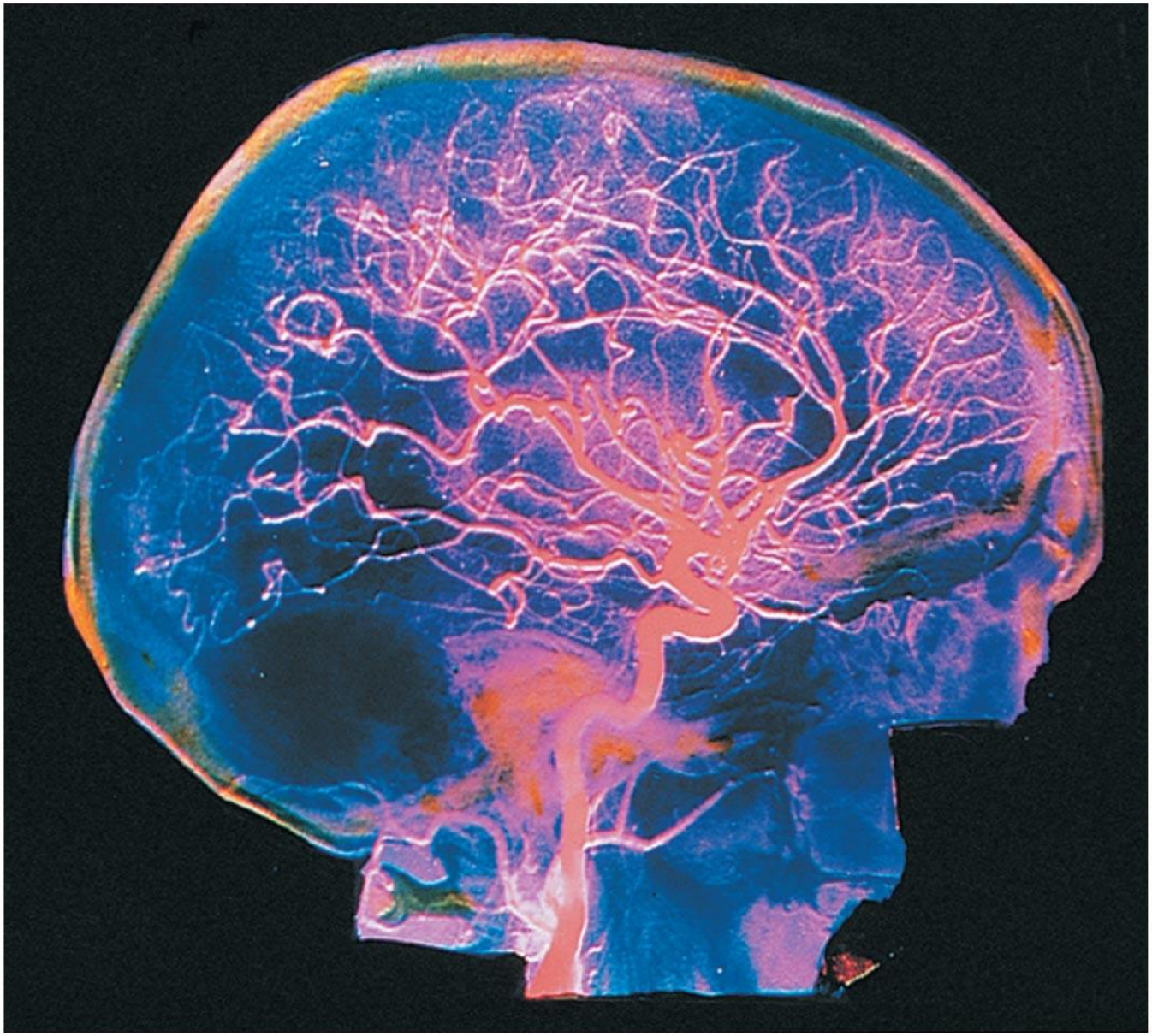





Figure 11.15a



(b)



**Figure 11.15b**

# Fetal Circulation

- Fetus receives exchanges of gases, nutrients, and wastes through the placenta

- Umbilical cord contains three vessels
  - Umbilical vein — carries blood rich in nutrients and oxygen to the fetus
  - Umbilical arteries (2) — carry carbon dioxide and debris-laden blood from fetus to placenta

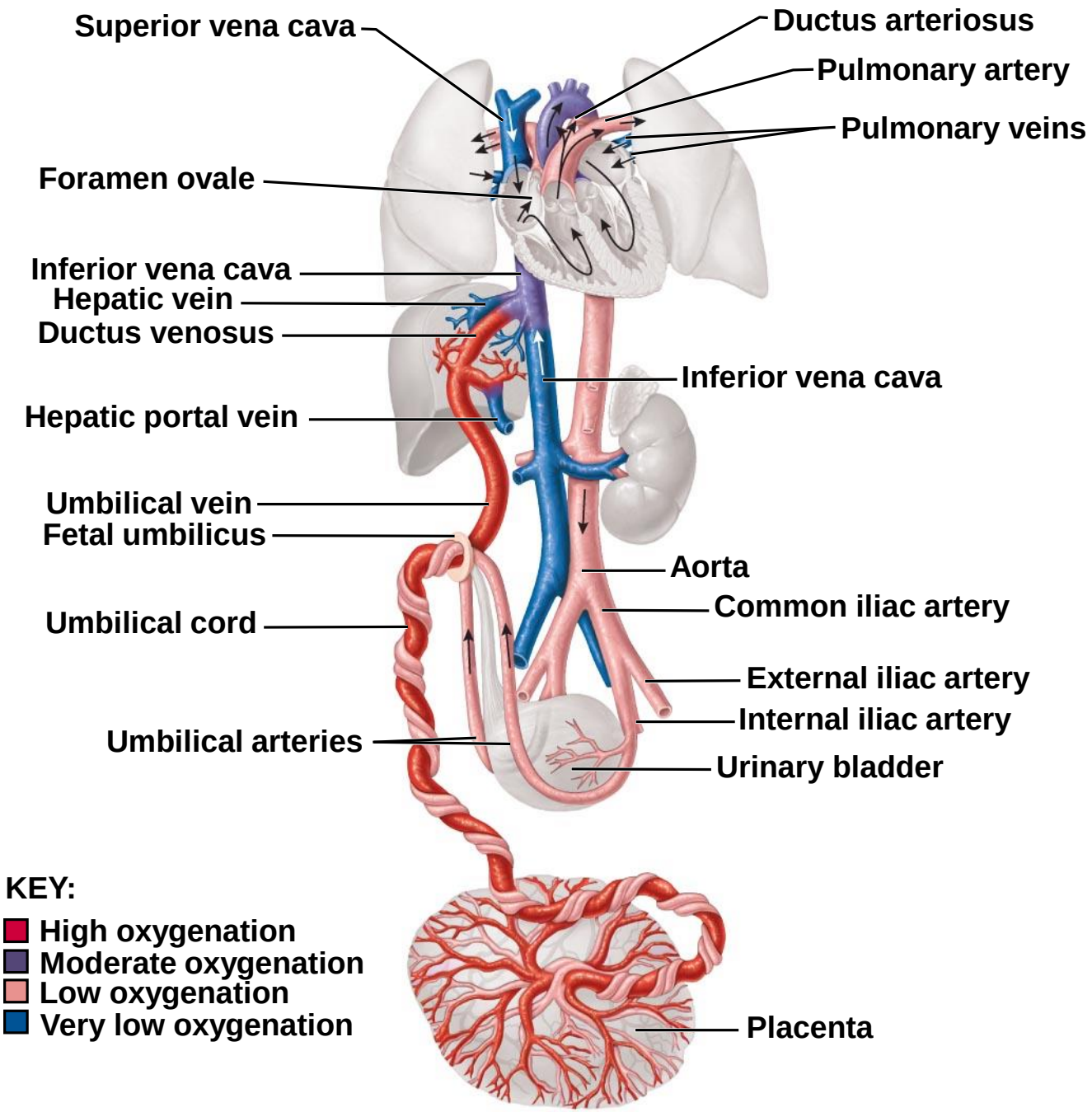





Figure 11.16

# Fetal Circulation

- Blood flow bypasses the liver through the ductus venosus and enters the inferior vena cava → right atrium of heart

- Blood flow **bypasses** the lungs
  - Blood entering right atrium is shunted directly into the left atrium through the foramen ovale
  - Ductus arteriosus connects the aorta and pulmonary trunk (becomes ligamentum arteriosum at birth)

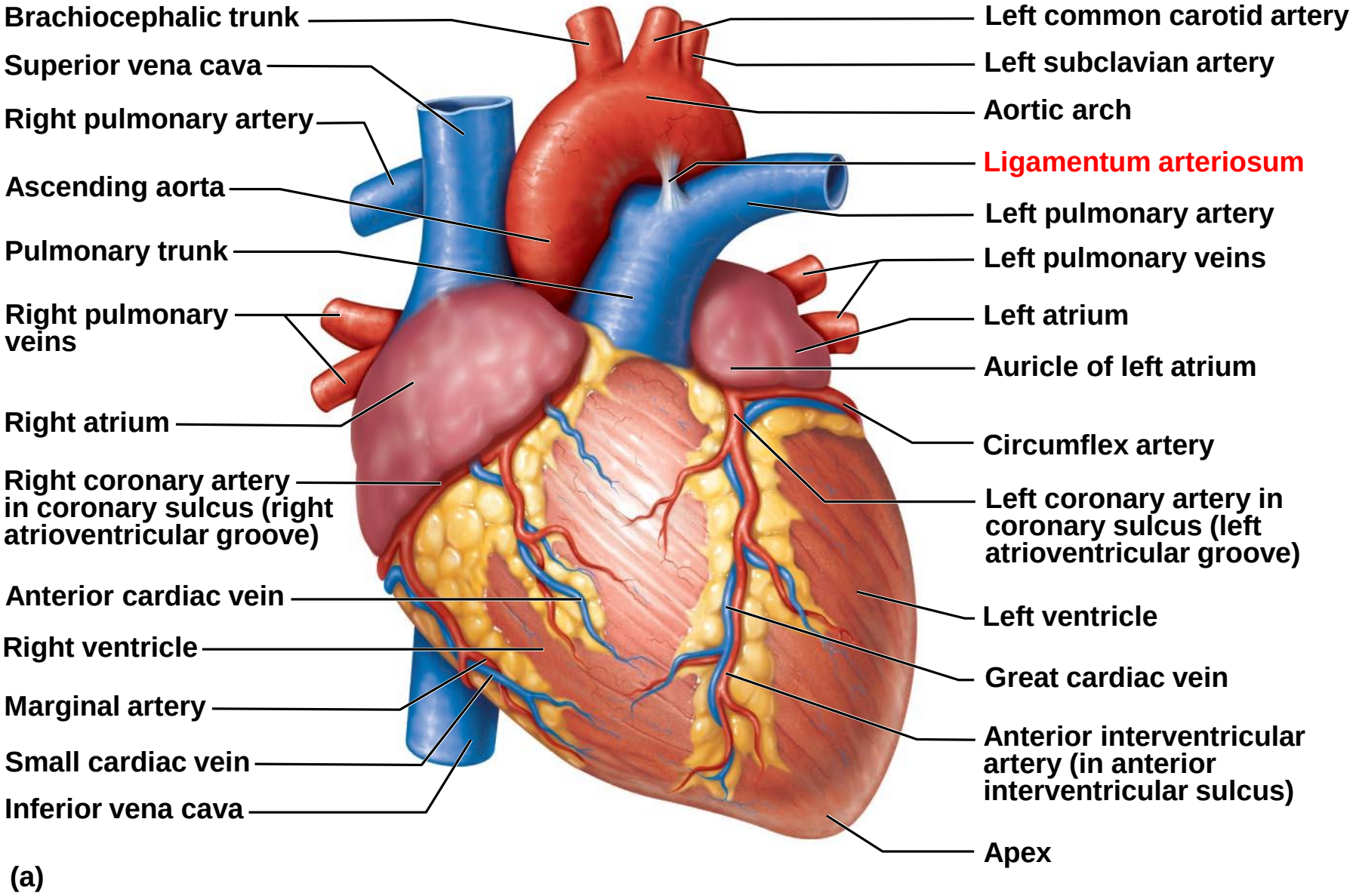
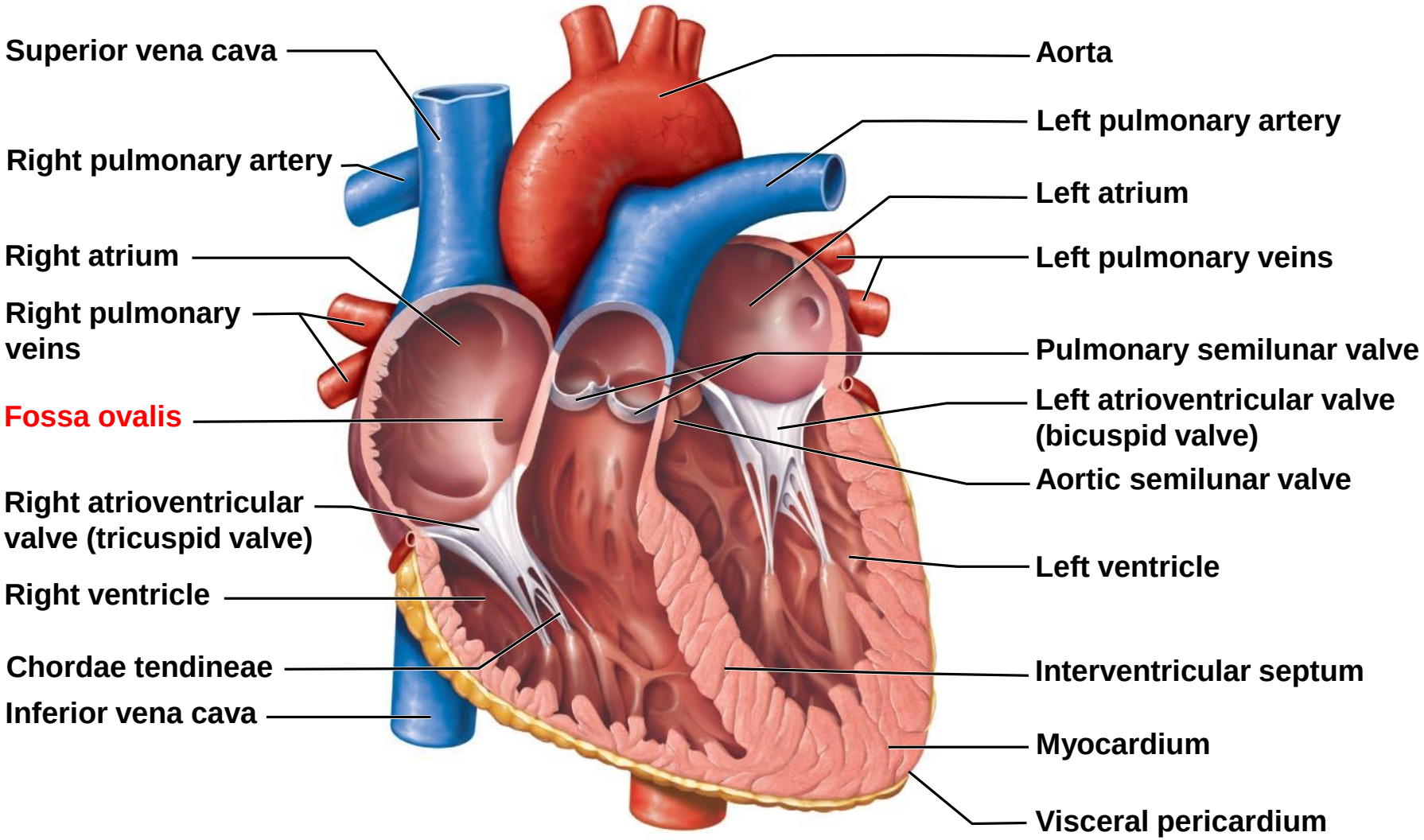





Figure 11.3a




**(b) Frontal section showing interior chambers and valves.**



**Figure 11.3b**

# Hepatic Portal Circulation

- Veins of hepatic portal circulation drain
  - Digestive organs
  - Spleen
  - Pancreas

- Hepatic portal vein carries this blood to the liver
  - Liver helps maintain proper glucose, fat, and protein concentrations in blood

# Hepatic Portal Circulation

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

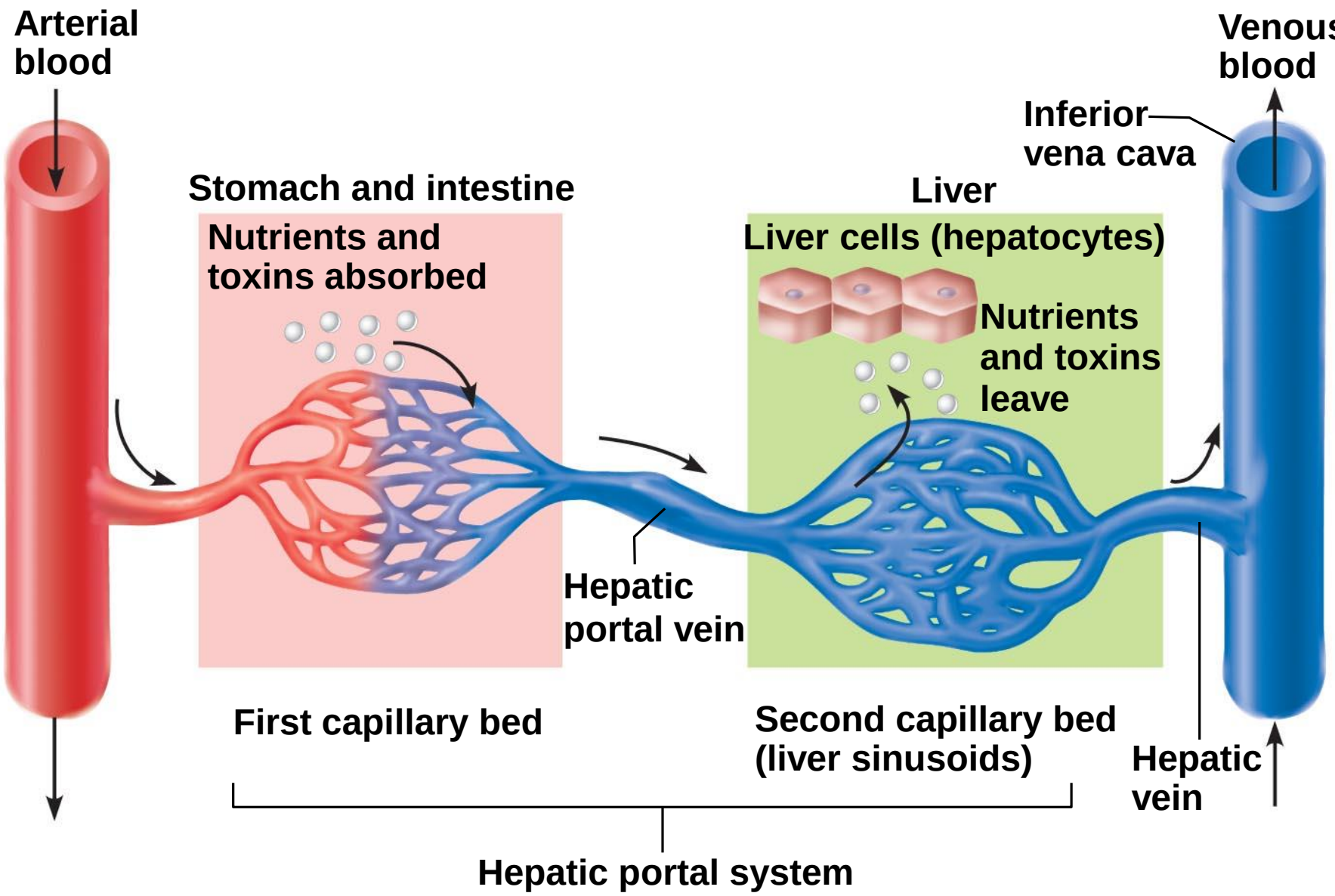





Figure 11.17

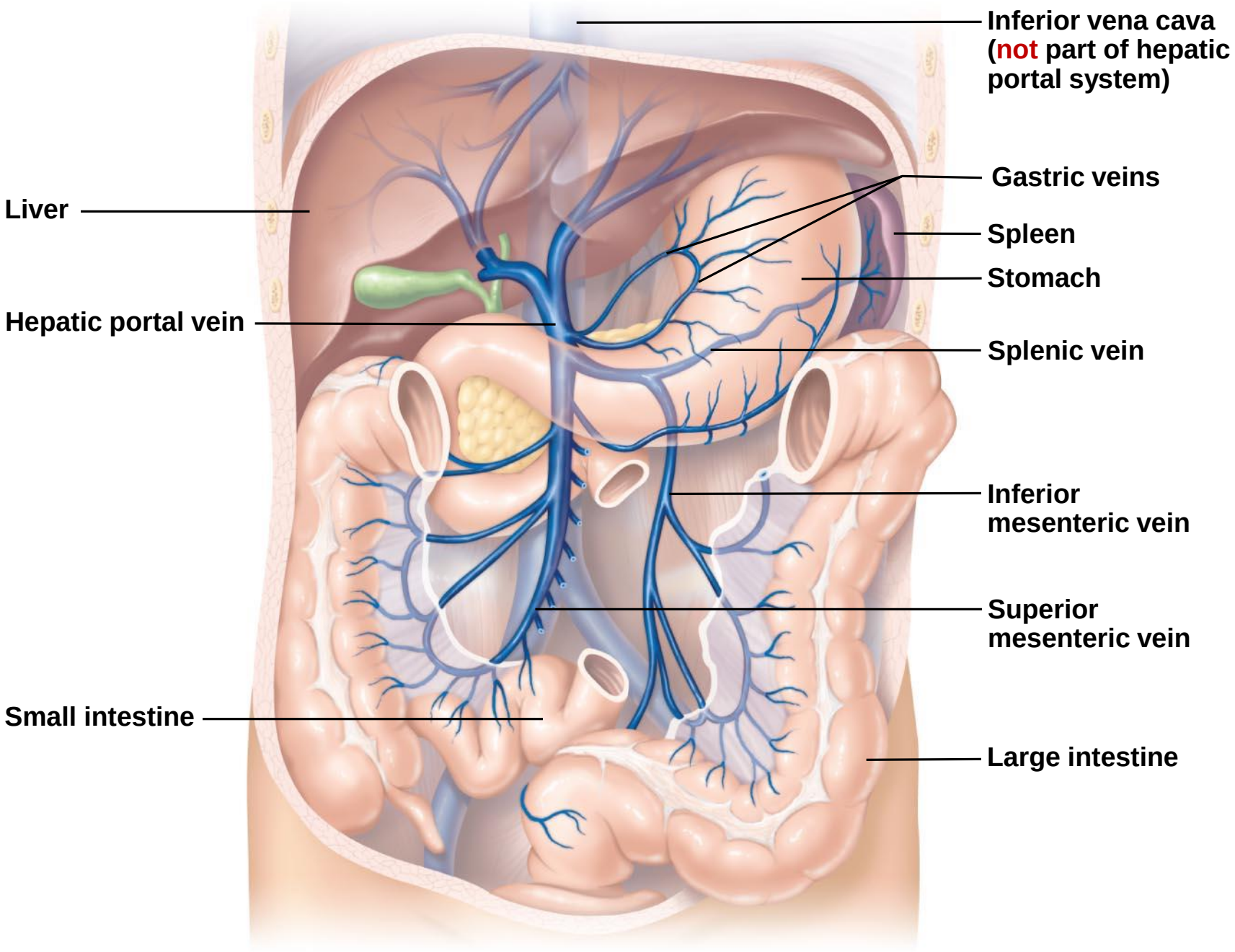





Figure 11.18

# Pulse

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

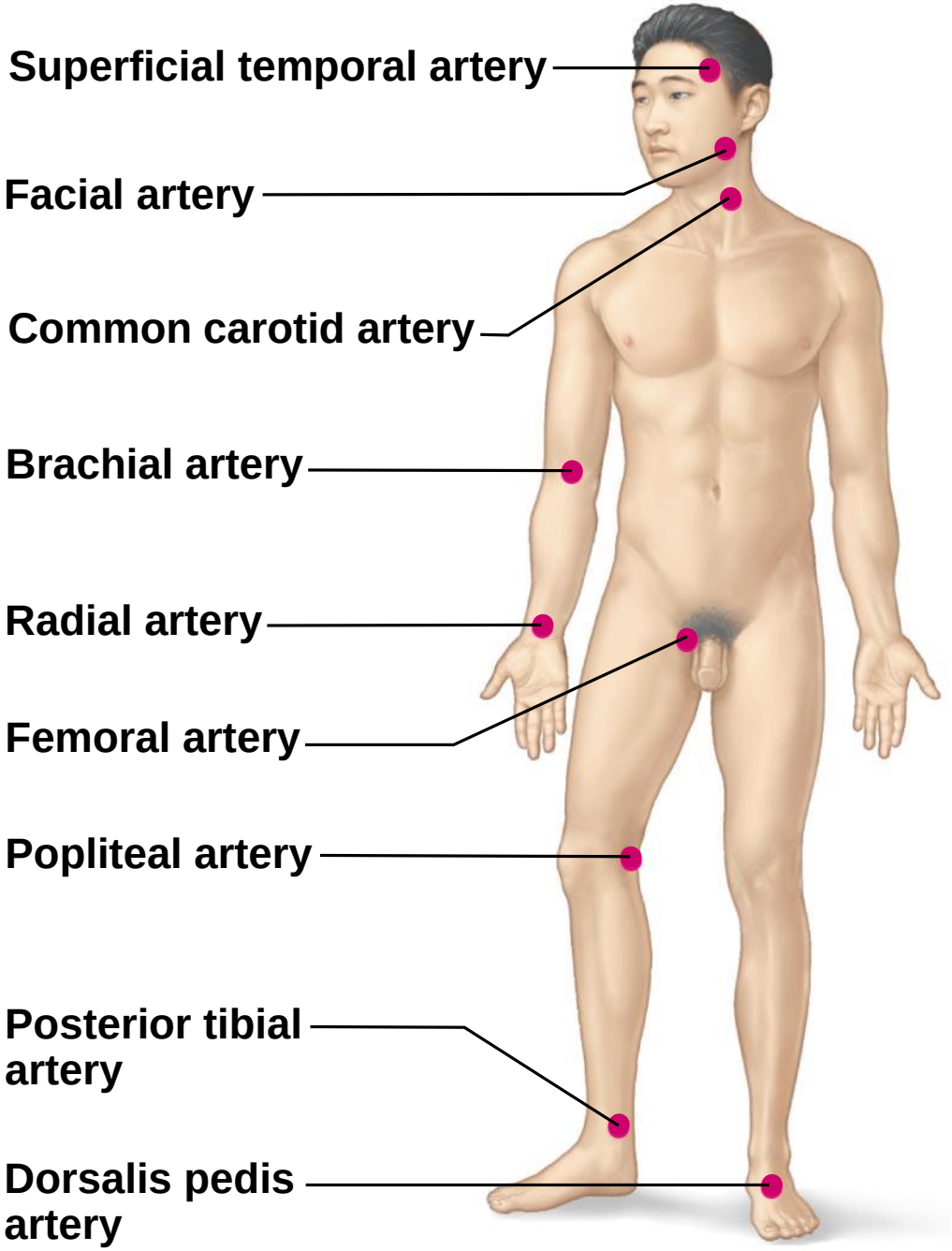





Figure 11.19

# 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

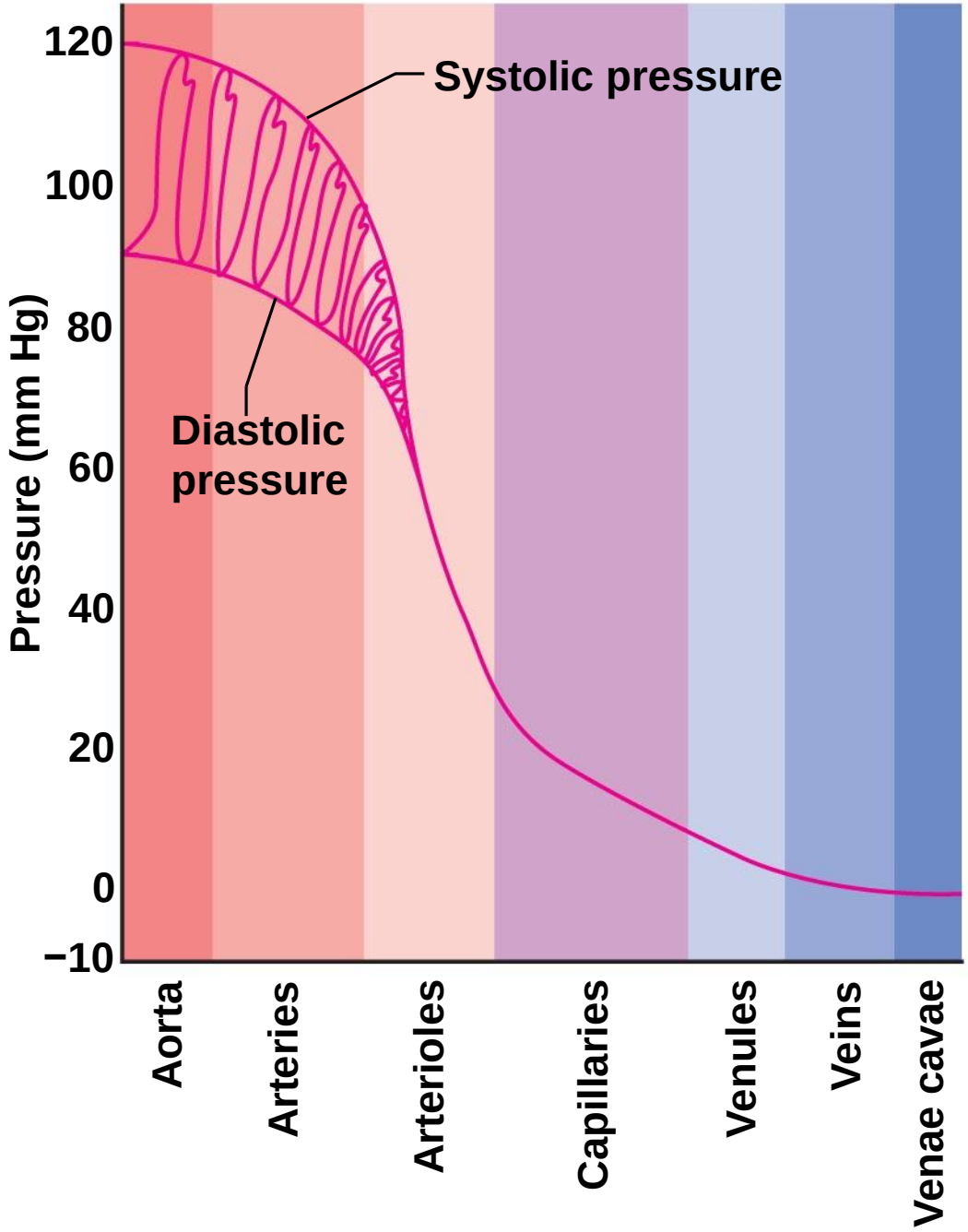
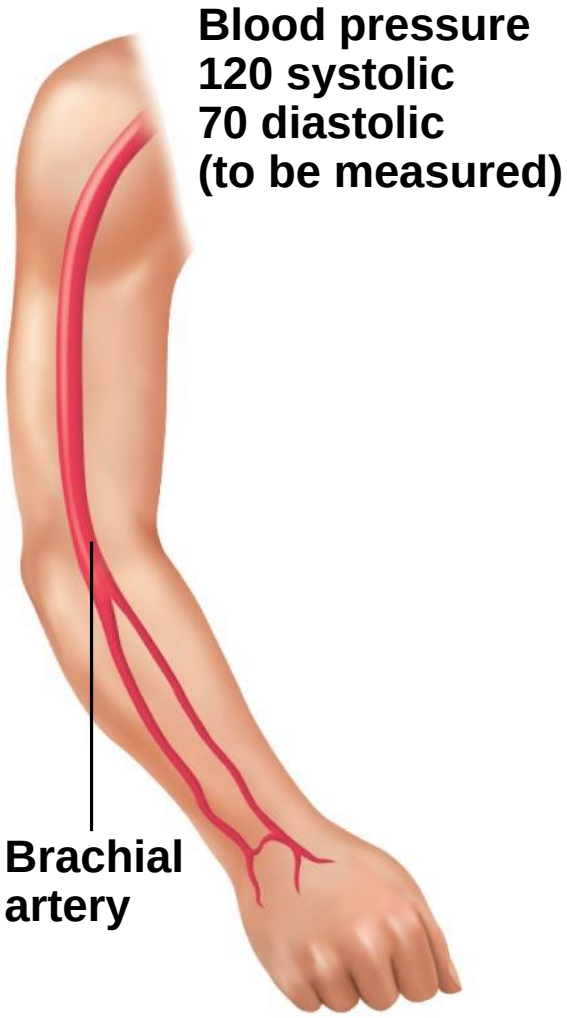





Figure 11.20

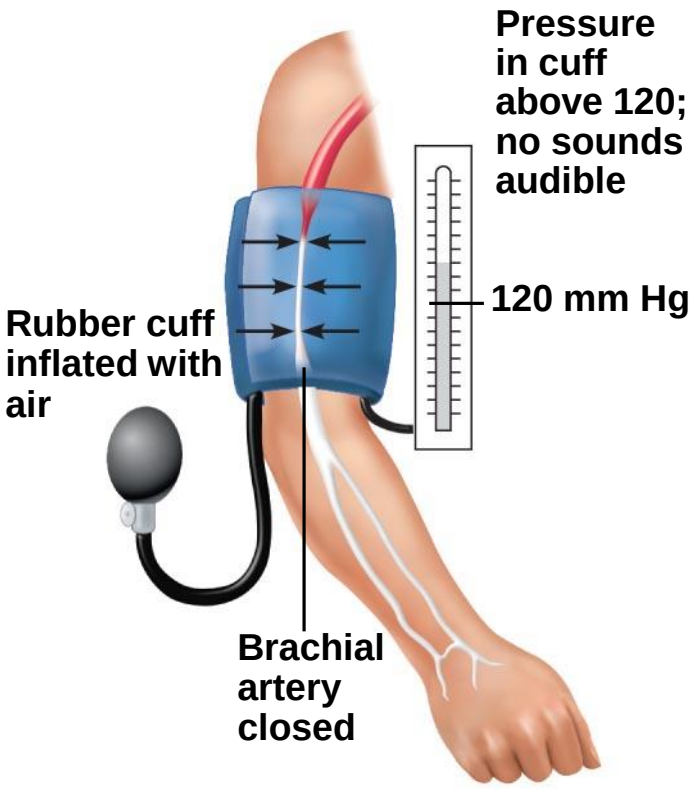
- https://www.youtube.com/watch?v=qWti317qb_w




(a) The course of the brachial artery of the arm. Assume a blood pressure of 120/70 in a young, healthy person.



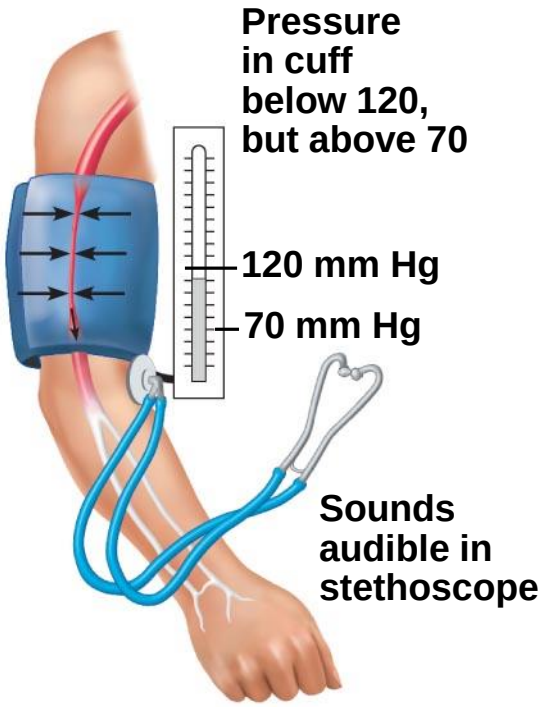
Figure 11.21a




(b) The blood pressure cuff is wrapped snugly around the arm just above the elbow and inflated until the cuff pressure exceeds the systolic blood pressure. At this point, blood flow into the arm is stopped, and a brachial pulse cannot be felt or heard.



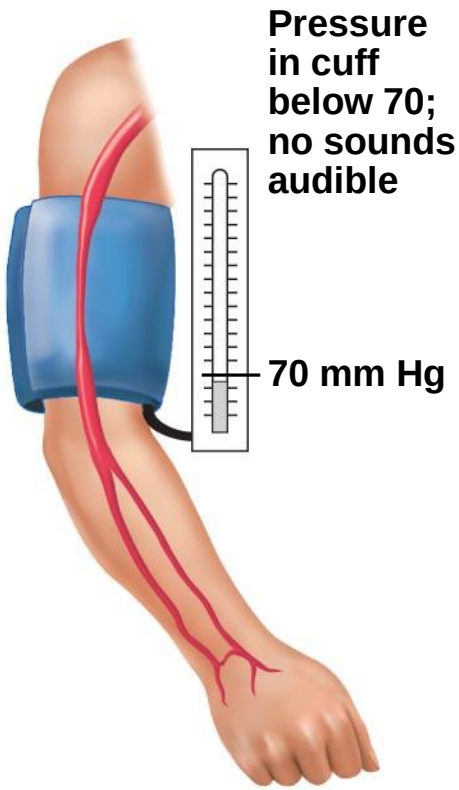
Figure 11.21b




(c) The pressure in the cuff is gradually reduced while the examiner listens (auscultates) for sounds in the brachial artery with a stethoscope. The pressure read as the first soft tapping sounds are heard (the first point at which a small amount of blood is spurting through the constricted artery) is recorded as the systolic pressure.



Figure 11.21c




(d) As the pressure is reduced still further, the sounds become louder and more distinct; when the artery is no longer constricted and blood flows freely, the sounds can no longer be heard. The pressure at which the sounds disappear is recorded as the diastolic pressure.



Figure 11.20d

# 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—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

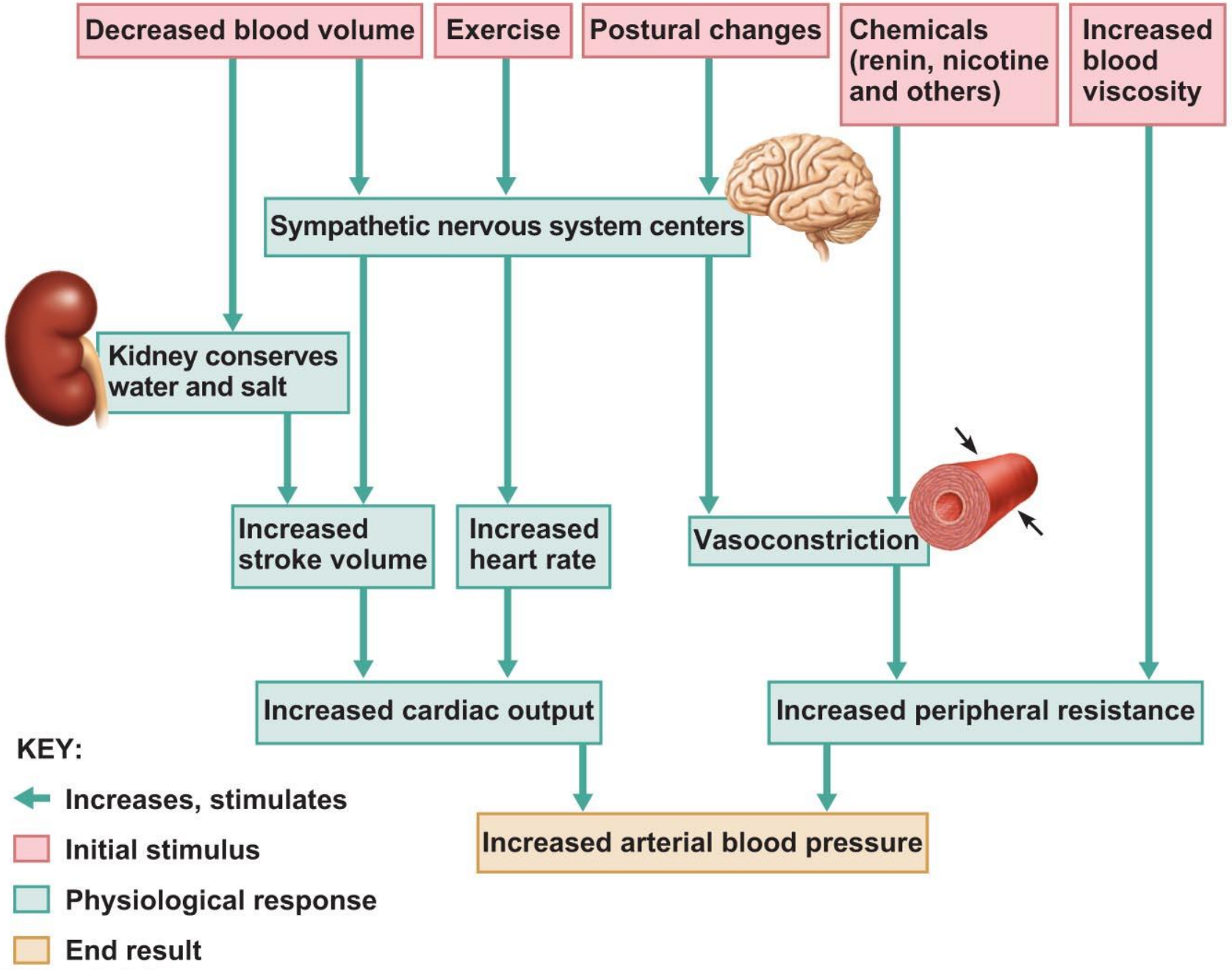





**Figure 11.22**

# Variations in Blood Pressure

- Normal human range is variable
  - Normal
    - 140 to 110 mm Hg systolic
    - 80 to 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

# Capillary Exchange

- Substances exchanged due to concentration gradients
  - Oxygen and nutrients leave the blood
  - Carbon dioxide and other wastes leave the cells

# Capillary Exchange: Mechanisms

- Direct diffusion across plasma membranes
- Endocytosis or exocytosis
- Some capillaries have gaps (intercellular clefts)
  - Plasma membrane not joined by tight junctions
- Fenestrations (pores) of some capillaries

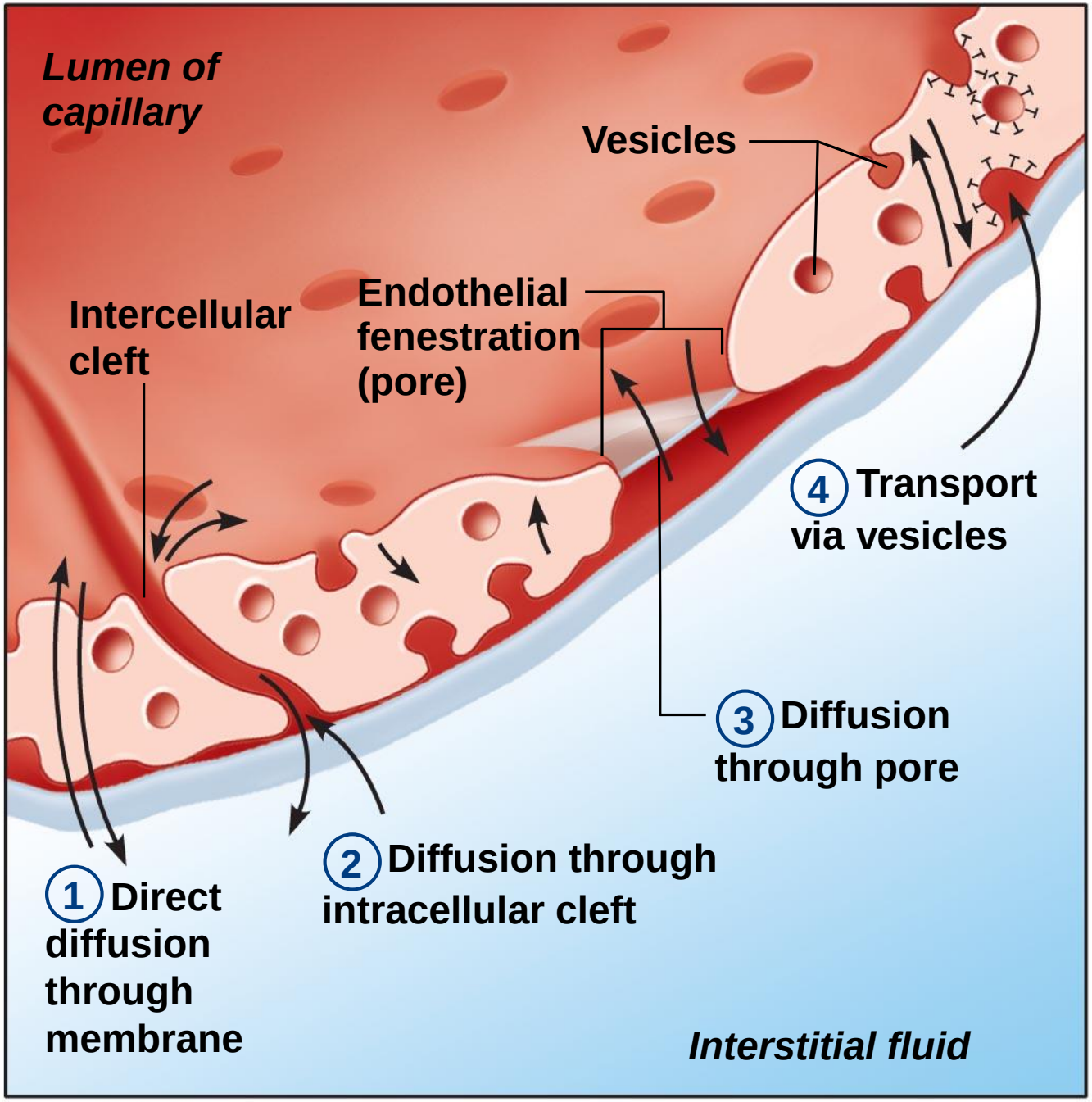





Figure 11.23

# Fluid Movements at Capillary Beds

- Blood pressure forces fluid and solutes out of capillaries
- Osmotic pressure draws fluid into capillaries

  - ! Blood pressure is higher than osmotic pressure at the arterial end of the capillary bed

  - ! Blood pressure is lower than osmotic pressure at the venous end of the capillary bed

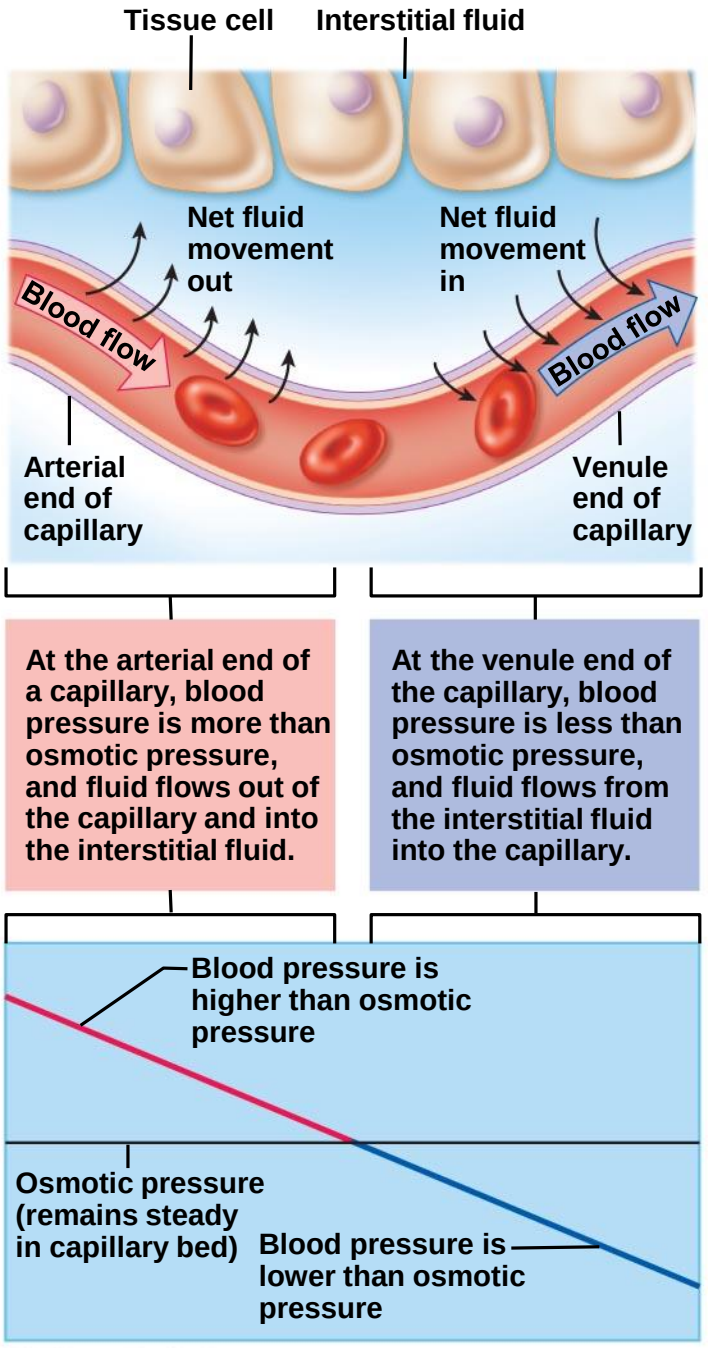





**Figure 11.24**

# Developmental Aspects of the Cardiovascular System

- A simple “tube heart” develops in the embryo and pumps by the fourth week
- The heart becomes a four-chambered organ by the end of seven weeks
- Few structural changes occur after the seventh week

# 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