

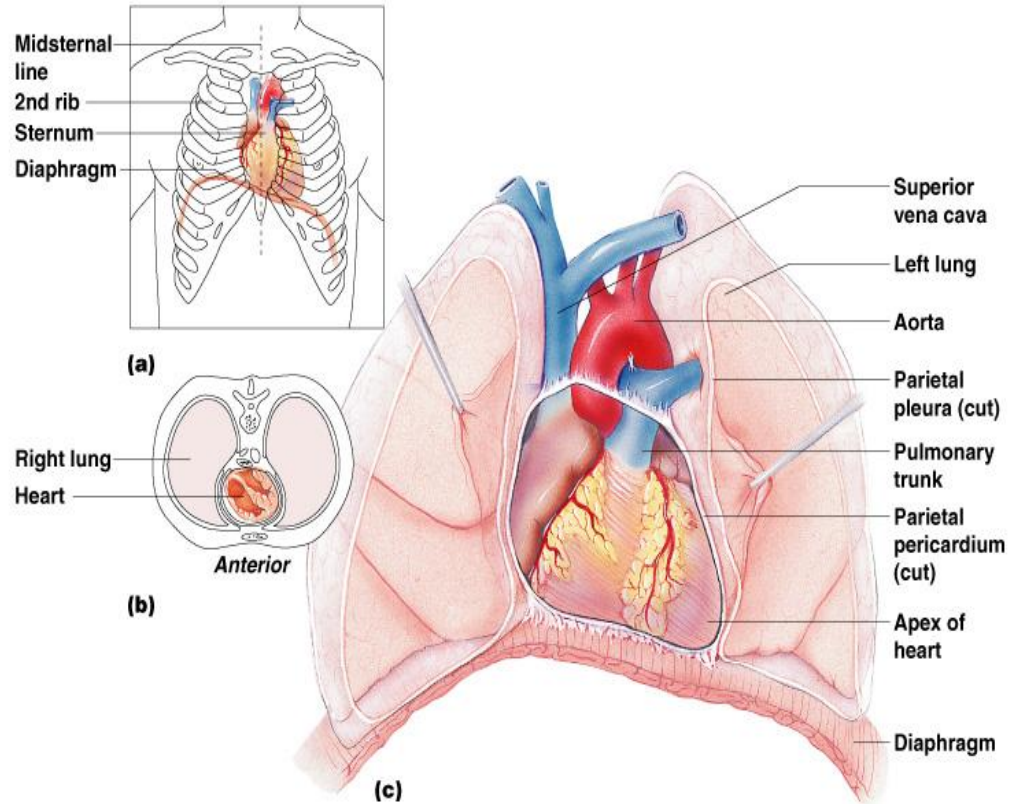
# The Cardiovascular System

# 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
  - Pointed apex directed toward left hip
- About the size of your fist



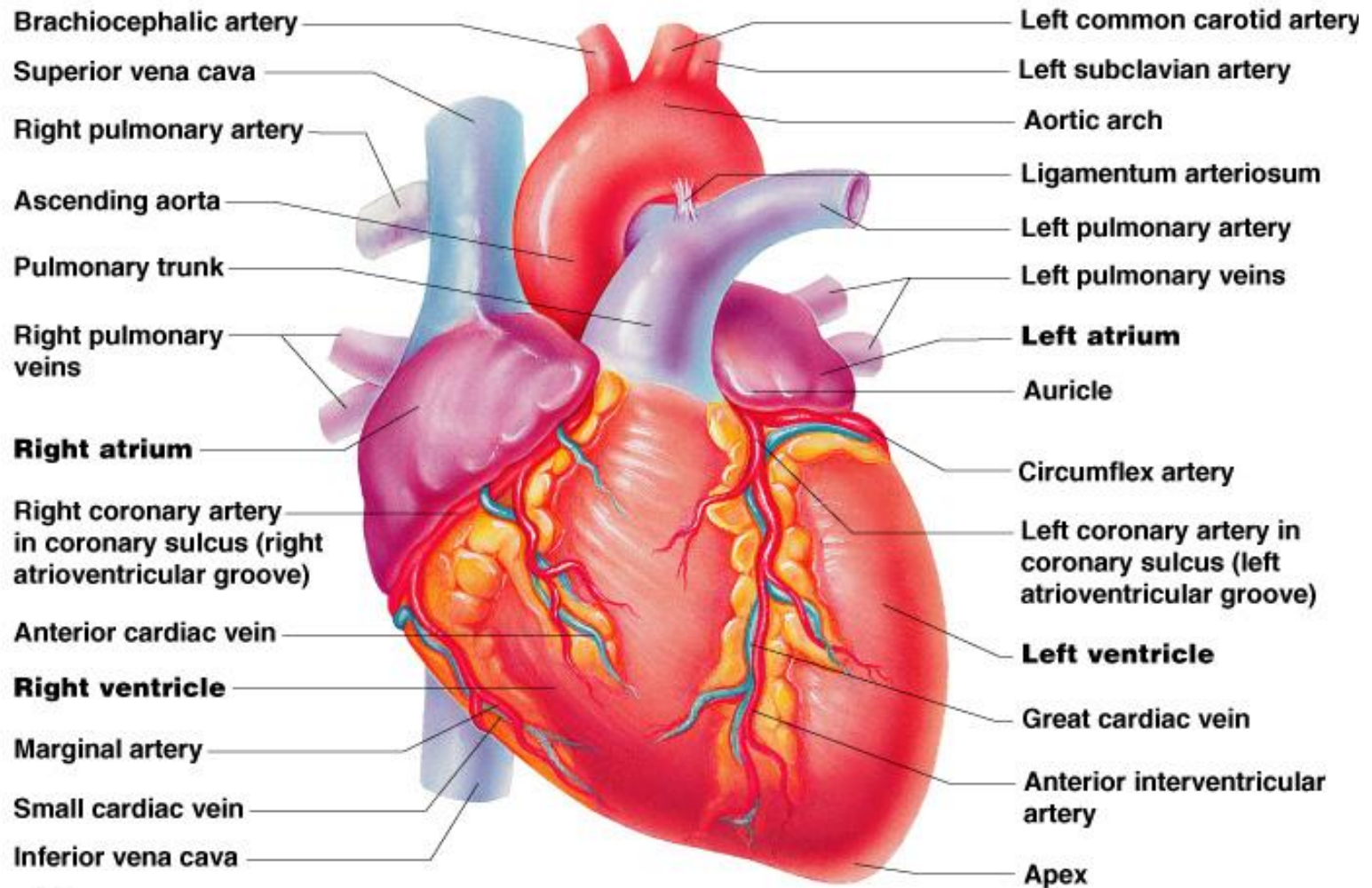
# The Heart: Coverings

- Pericardium – a double serous membrane
  - Visceral pericardium - Next to heart
  - Parietal pericardium - Outside layer
- Serous fluid fills the space between the layers of pericardium

# The Heart Wall: 3 layers

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

# External Heart Anatomy



(a)

Figure 11.2a

# The Heart: 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

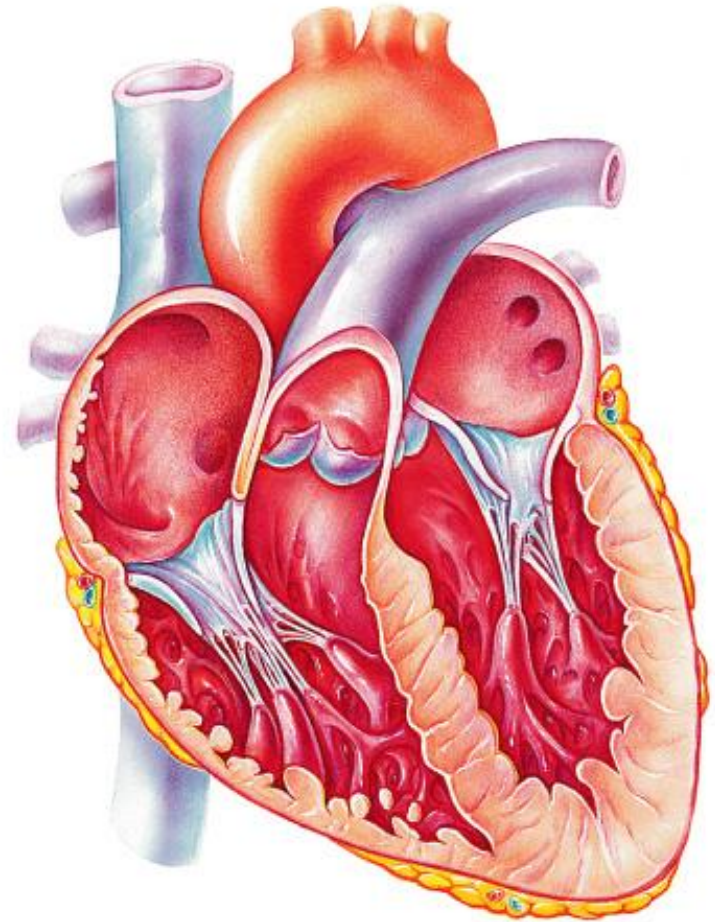


Figure 11.2c

# Blood Circulation

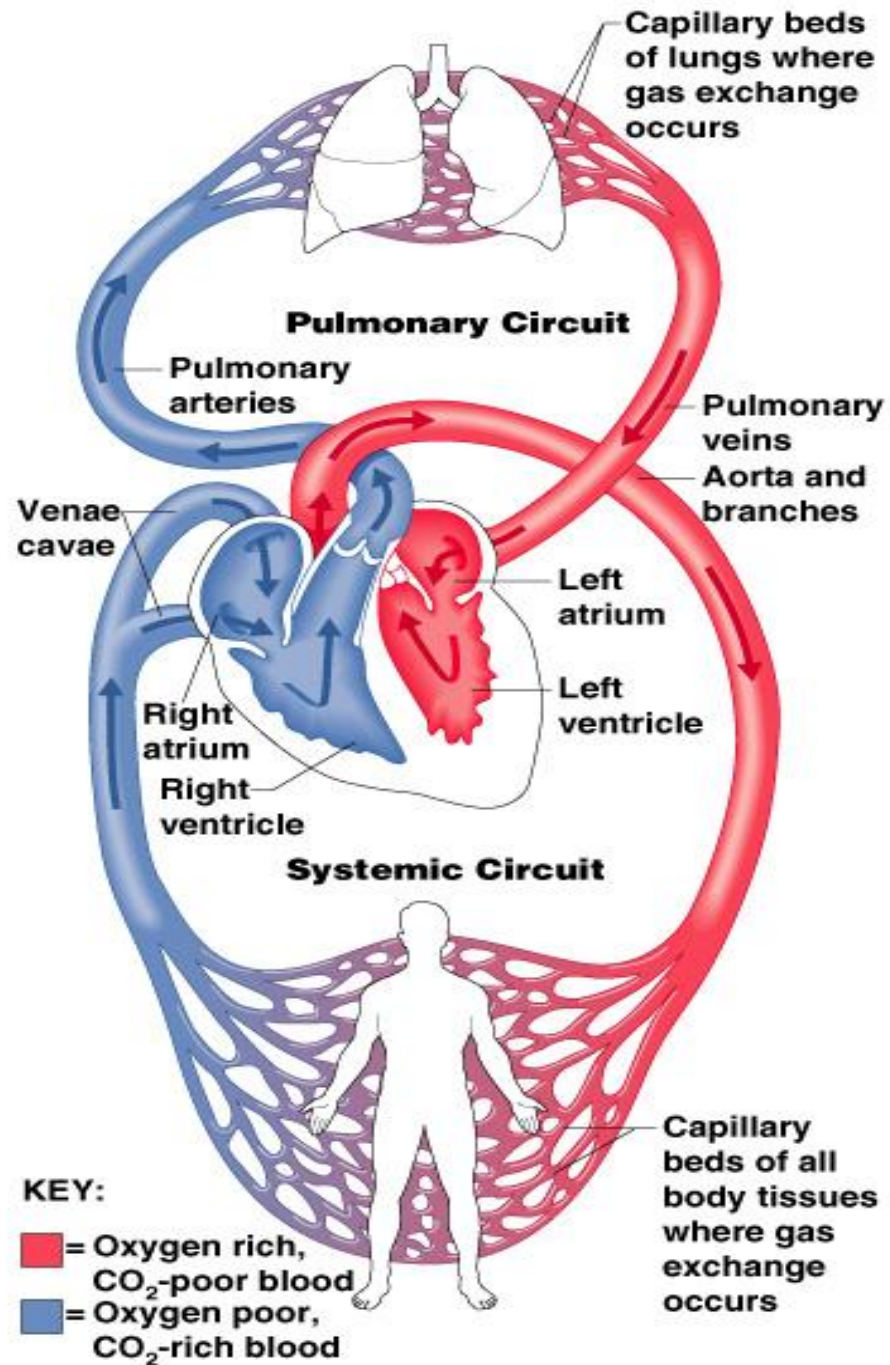


Figure 11.3



# The Heart: Valves

- Allow blood to flow in only one direction
- Four valves
  - Atrioventricular valves – between atria and ventricles
    - Bicuspid valve (left)
    - Tricuspid valve (right)
  - Semilunar valves between ventricle and artery
    - Pulmonary semilunar valve
    - Aortic semilunar valve

# The Heart: Valves

- Valves open as blood is pumped through
- Held in place by chordae tendineae (“heart strings”)
- Close to prevent backflow

# Operation of Heart Valves

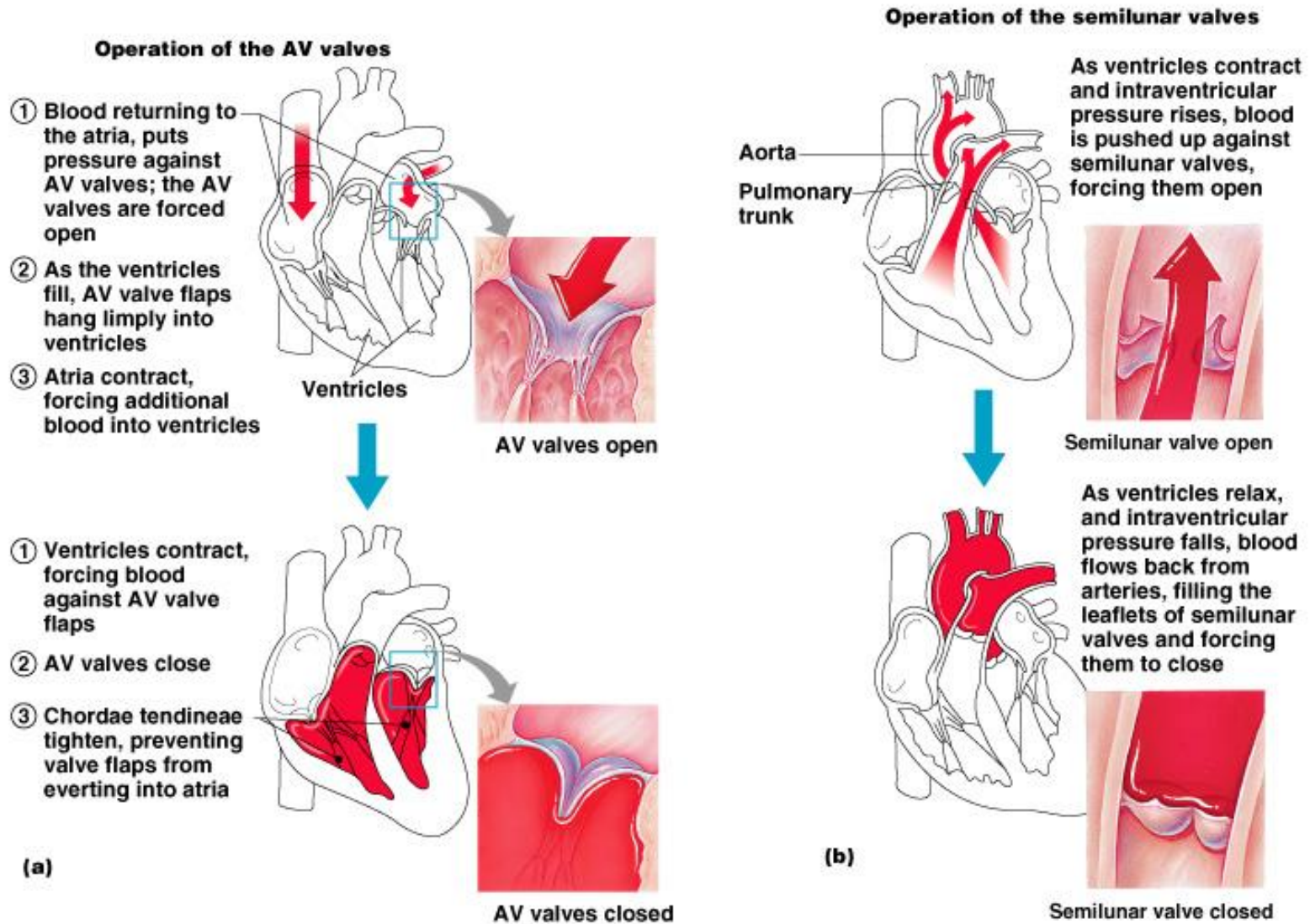


Figure 11.4

# The Heart: Associated Great Vessels

- Aorta - leaves left ventricle
- Pulmonary arteries - leave right ventricle
- Vena cava - enters right atrium
- Pulmonary veins (four) - enter left atrium

# Coronary Circulation

- Blood in the heart chambers does not nourish the myocardium
- The heart has its own nourishing circulatory system
  - Coronary arteries
  - Cardiac veins
  - Blood empties into the right atrium via the coronary sinus

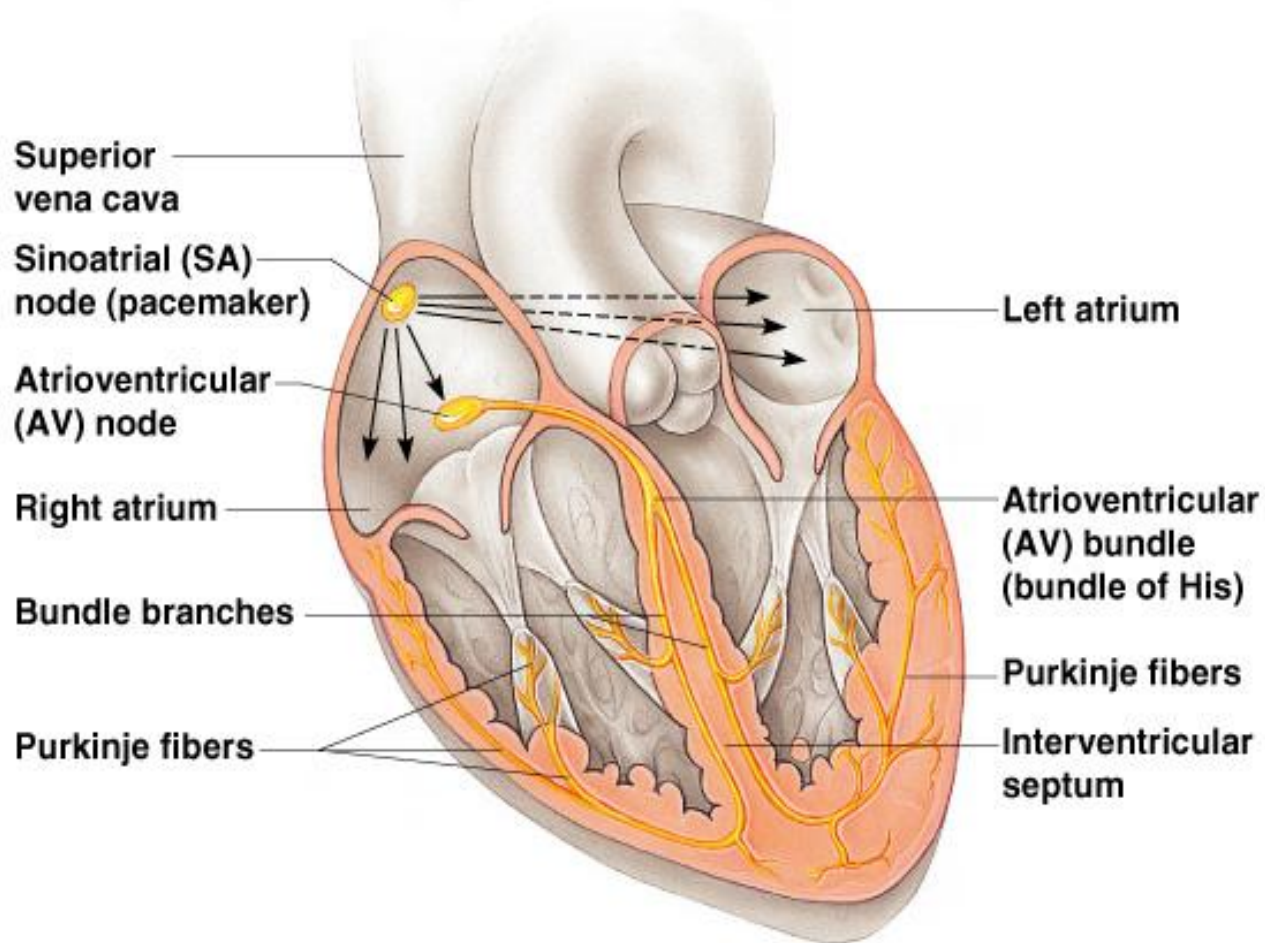
# The Heart: Conduction System

- Intrinsic conduction system (nodal system)
  - Heart muscle cells contract, without nerve impulses, in a regular, continuous way
- Special tissue sets the pace
  - Sinoatrial node (SA) - Pacemaker
  - Atrioventricular node (AV)
  - Atrioventricular bundle
  - Bundle branches
  - Purkinje fibers

# The Heart's Cardiac Cycle

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

# Heart Contractions



- **Contraction is initiated by the sinoatrial node**
- **Sequential stimulation occurs at other autorhythmic cells**



# Filling of Heart Chambers – the Cardiac Cycle

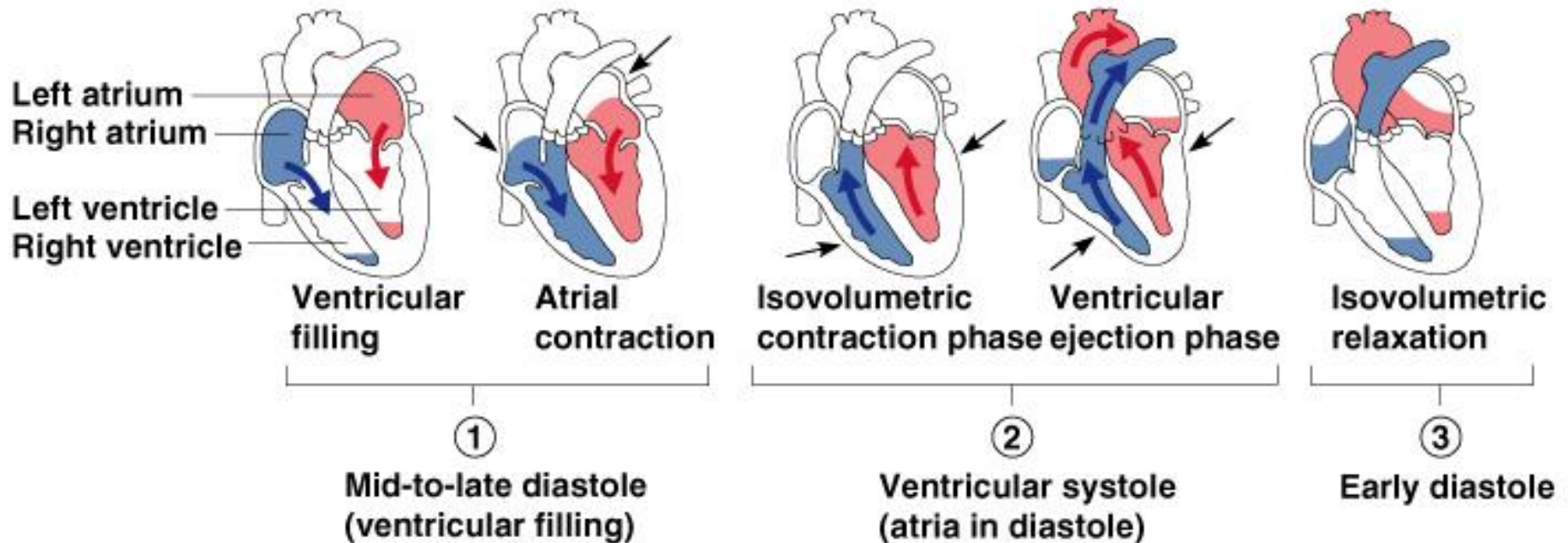


Figure 11.6

# The Heart: Cardiac Cycle

- Cardiac cycle – events of one complete heart beat
  - Mid-to-late diastole – blood flows into ventricles
  - Ventricular systole – blood pressure builds before ventricle contracts, pushing out blood
  - Early diastole – atria finish re-filling, ventricular pressure is low

# The Heart: Cardiac Output

- Cardiac output (CO)
  - Amount of blood pumped by each side of the heart in one minute
  - $CO = (\text{heart rate [HR]}) \times (\text{stroke volume [SV]})$
- Stroke volume
  - Volume of blood pumped by each ventricle in one contraction

# Cardiac Output Regulation

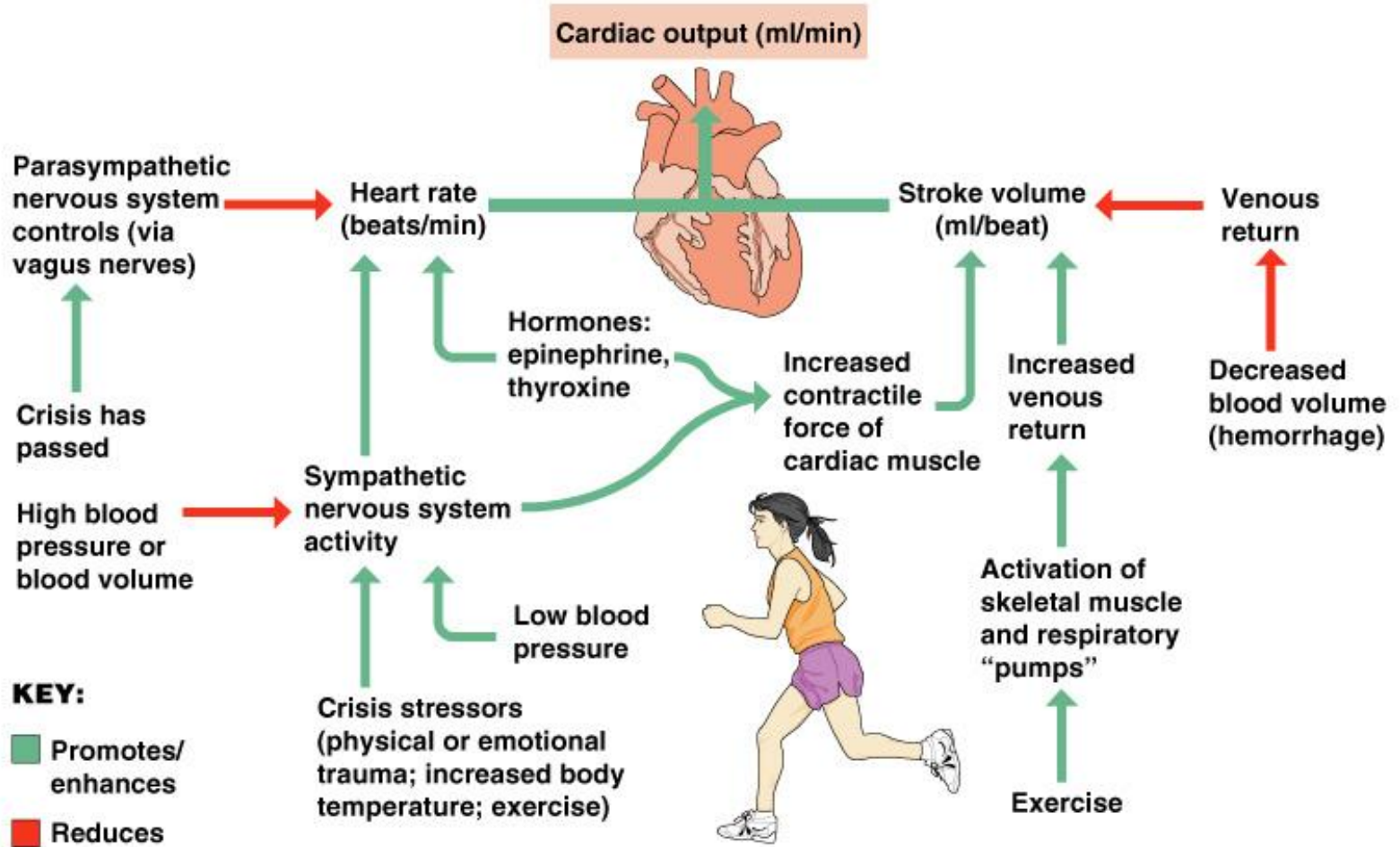


Figure 11.7

# Regulation of Heart Rate

- Stroke volume usually remains relatively constant
  - Starling's law of the heart – the more that the cardiac muscle is stretched, the stronger the contraction
- Changing heart rate is the most common way to change cardiac output

# Regulation of Heart Rate

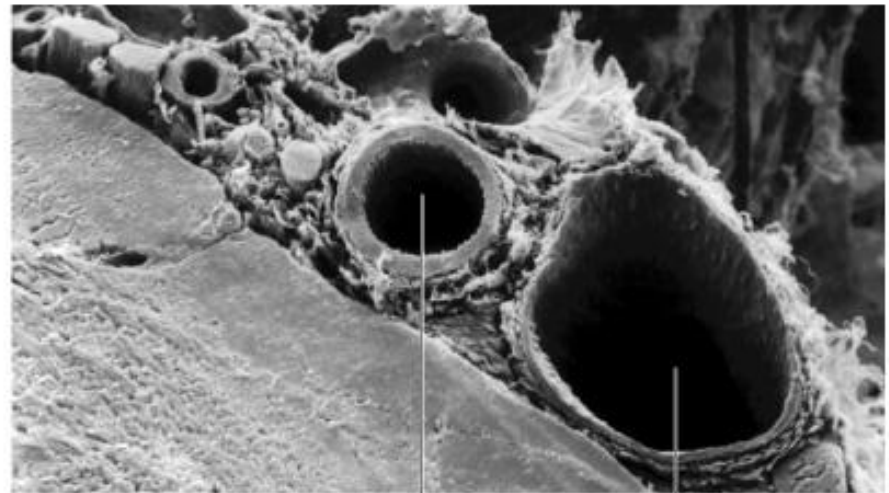
- Increased heart rate
  - Sympathetic nervous system
    - Activated in a Crisis
    - Low blood pressure
  - Hormones
    - Epinephrine
    - Thyroxine
  - Exercise
  - Decreased blood volume

# Regulation of Heart Rate

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

# Blood Vessels: The Vascular System

- Taking blood to the tissues and back
  - Arteries
  - Arterioles
  - Capillaries
  - Venules
  - Veins



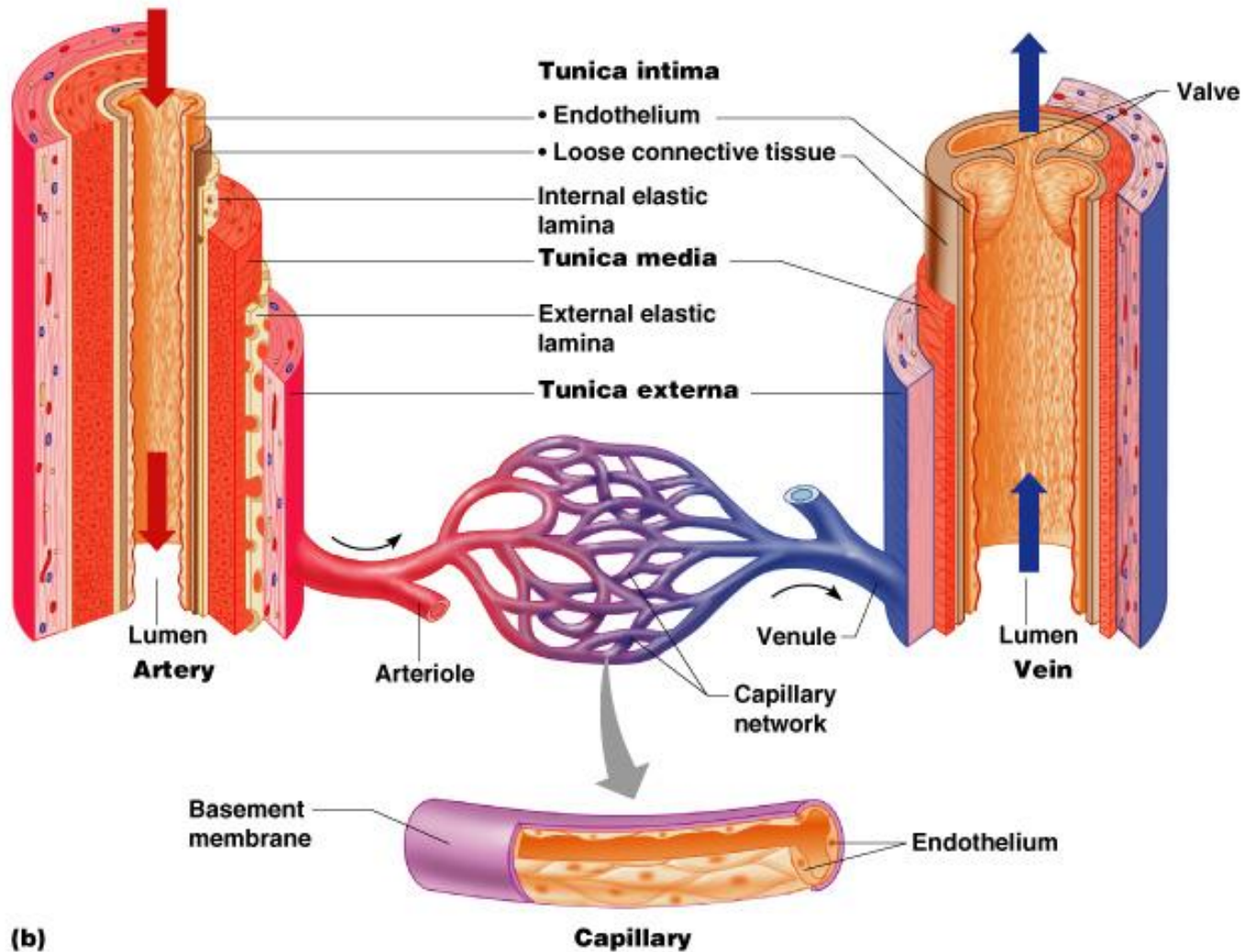
(a)

Artery

Vein



# The Vascular System



(b)

Figure 11.8b

# Blood Vessels: Anatomy

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

# Differences Between Blood Vessel Types

- Walls of arteries are the thickest
- Lumens of veins are larger
- 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

# Movement of Blood Through Vessels

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

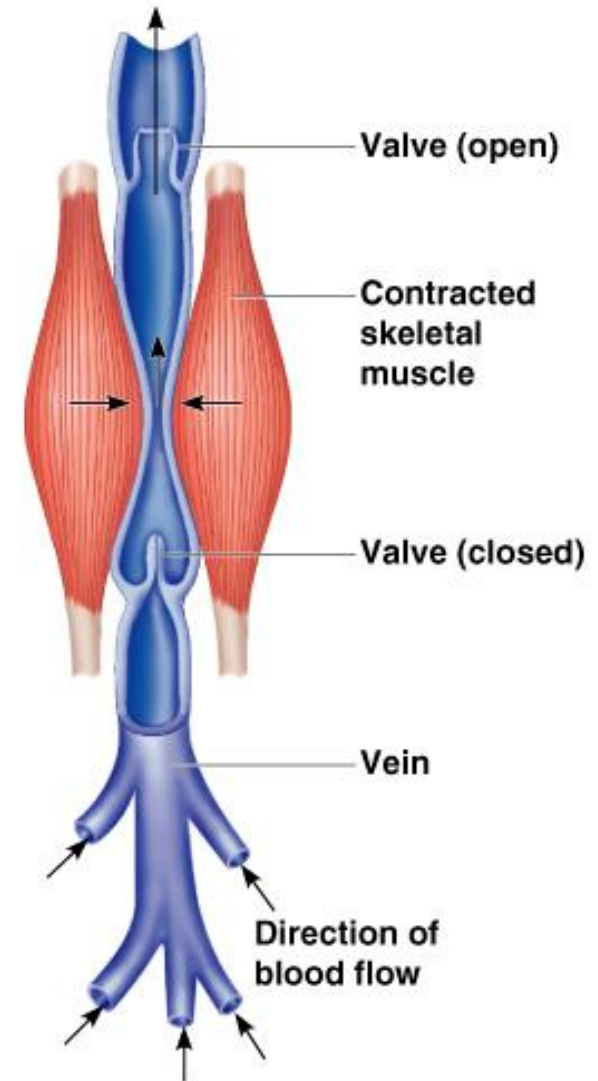


Figure 11.9

# Capillary Beds

- Capillary beds consist of two types of vessels
  - Vascular shunt – directly connects an arteriole to a venule

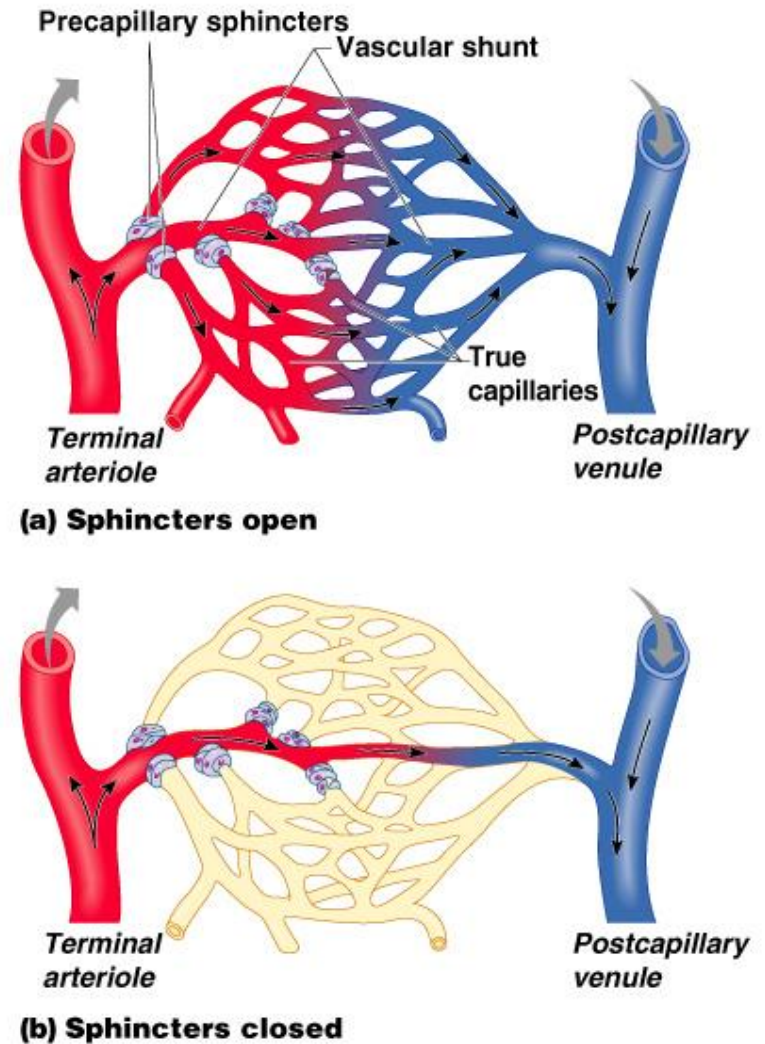


Figure 11.10

# Capillary Beds

- True capillaries – exchange vessels
  - Oxygen and nutrients cross to cells
  - Carbon dioxide and metabolic waste products cross into blood

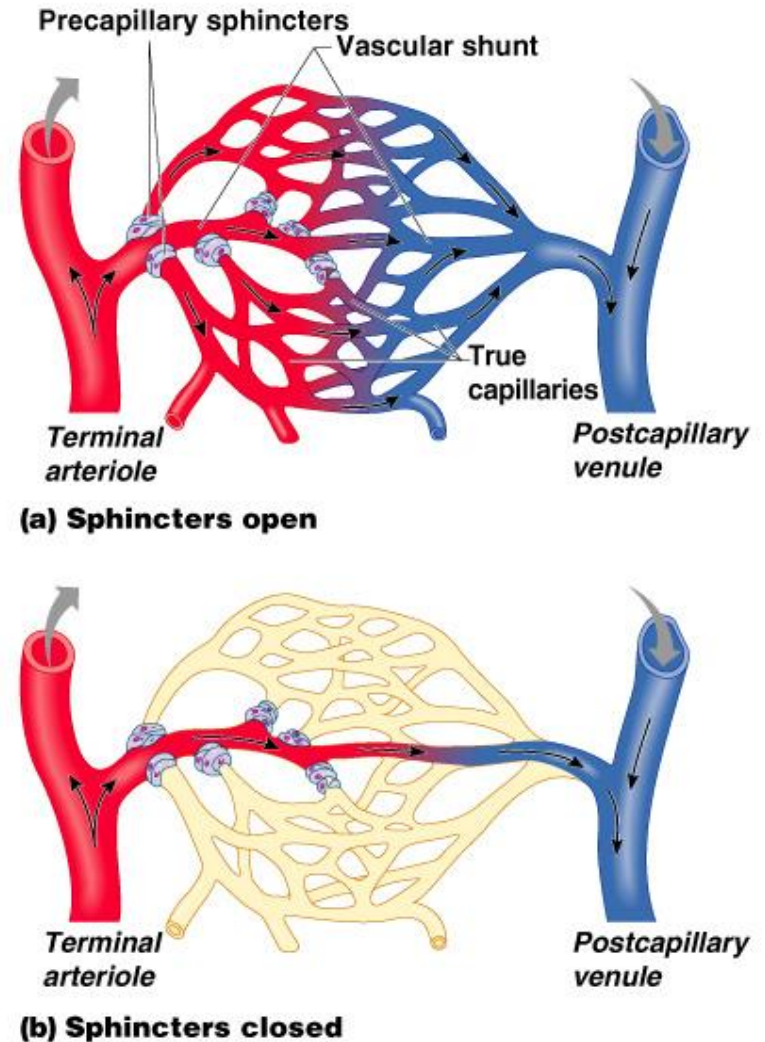
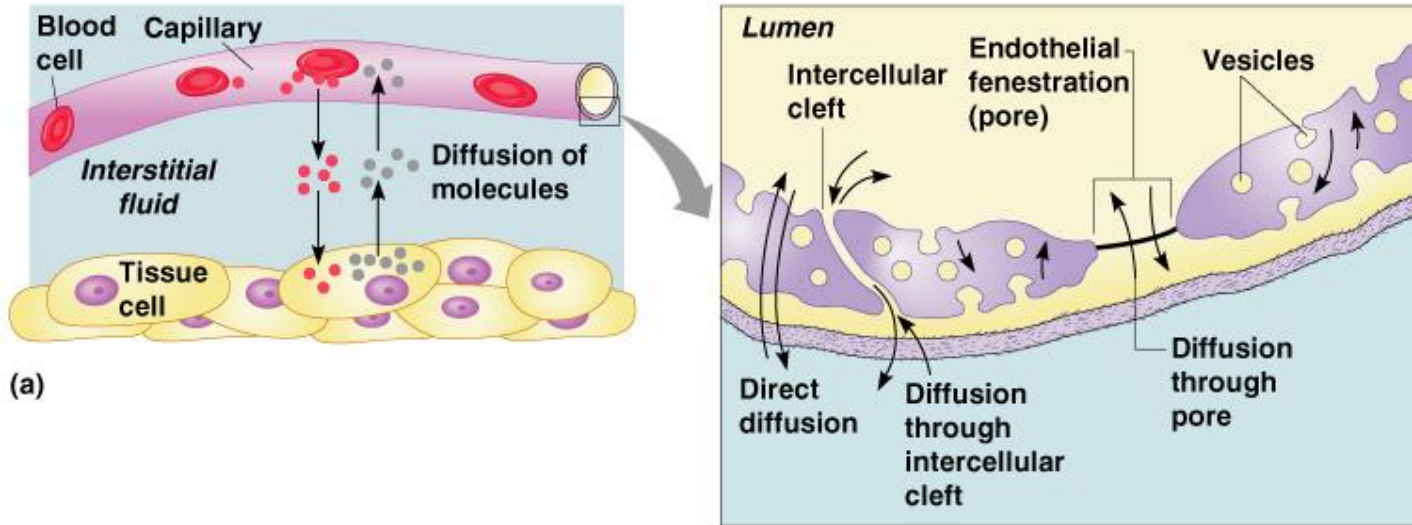
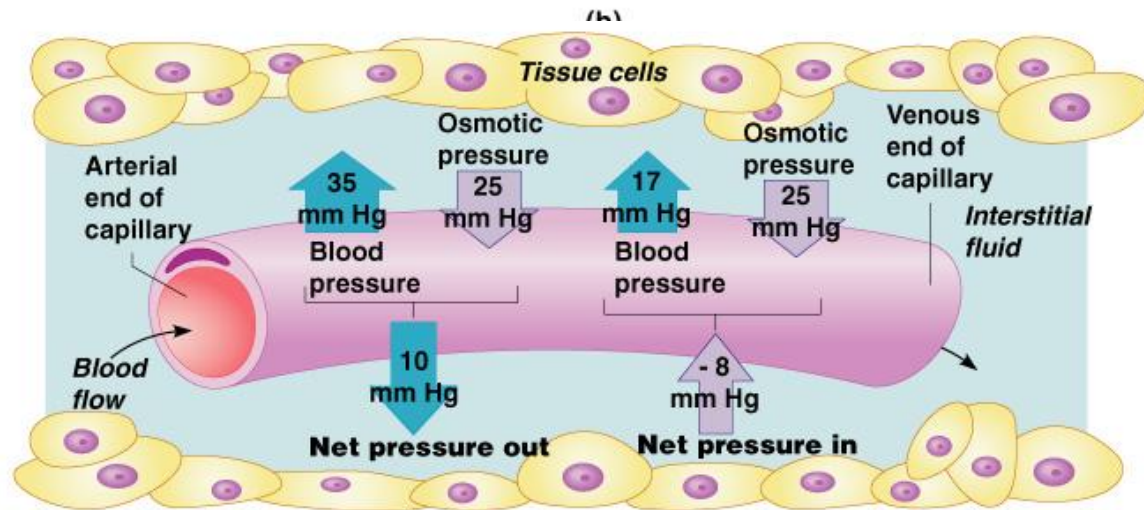


Figure 11.10

# Diffusion at Capillary Beds



(a)



(b)

Figure 11.20

# Major Arteries of Systemic

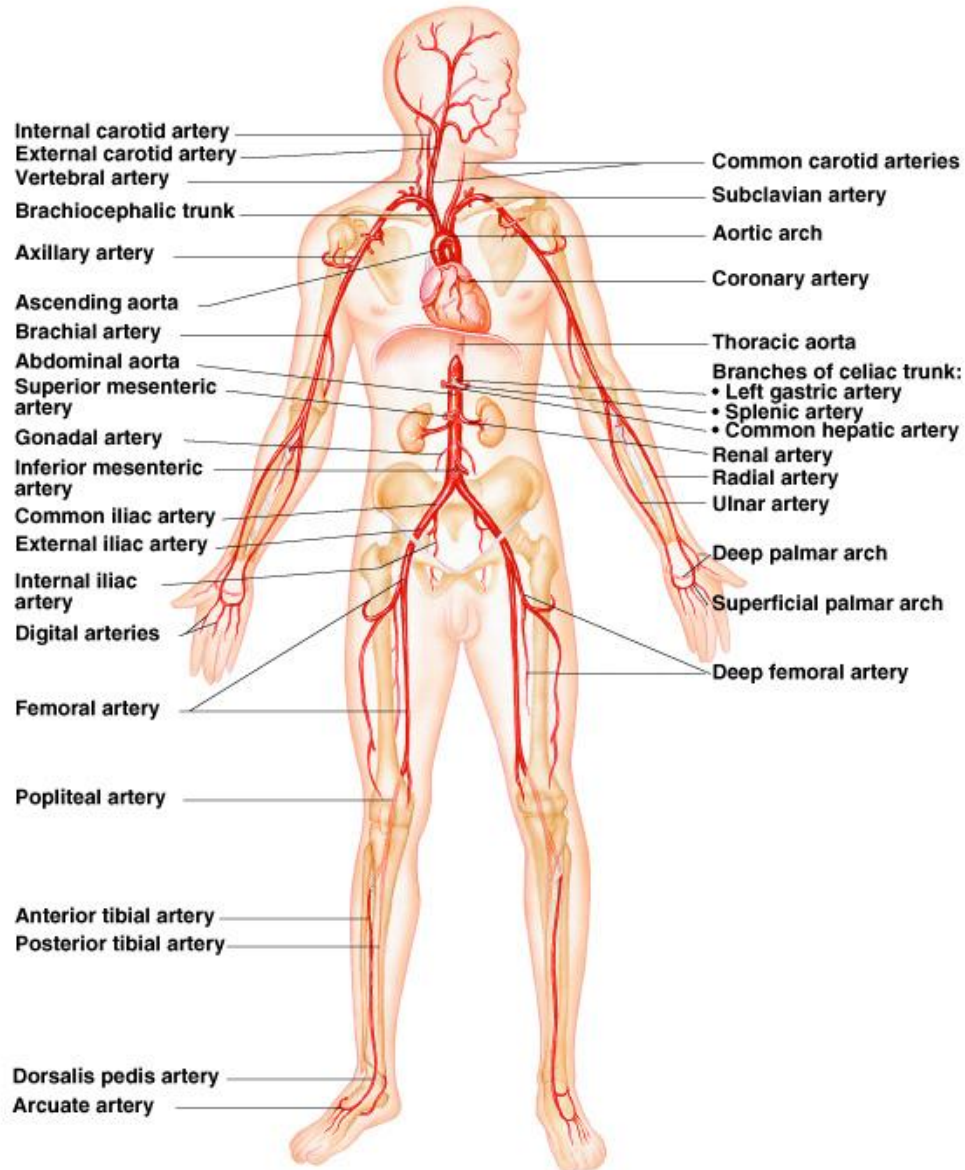


Figure 11.11



# Major Veins of Systemic

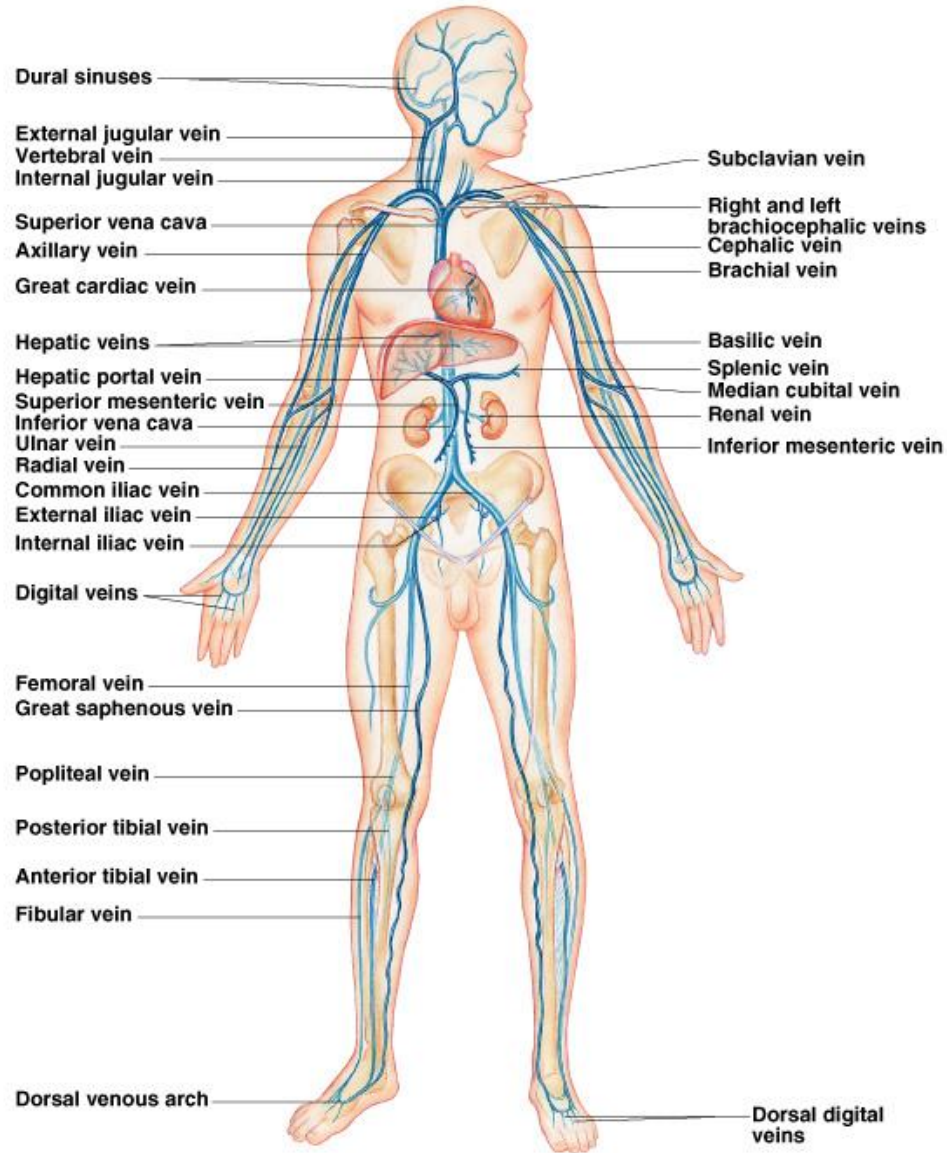


Figure 11.12

# Arterial Supply of the Brain

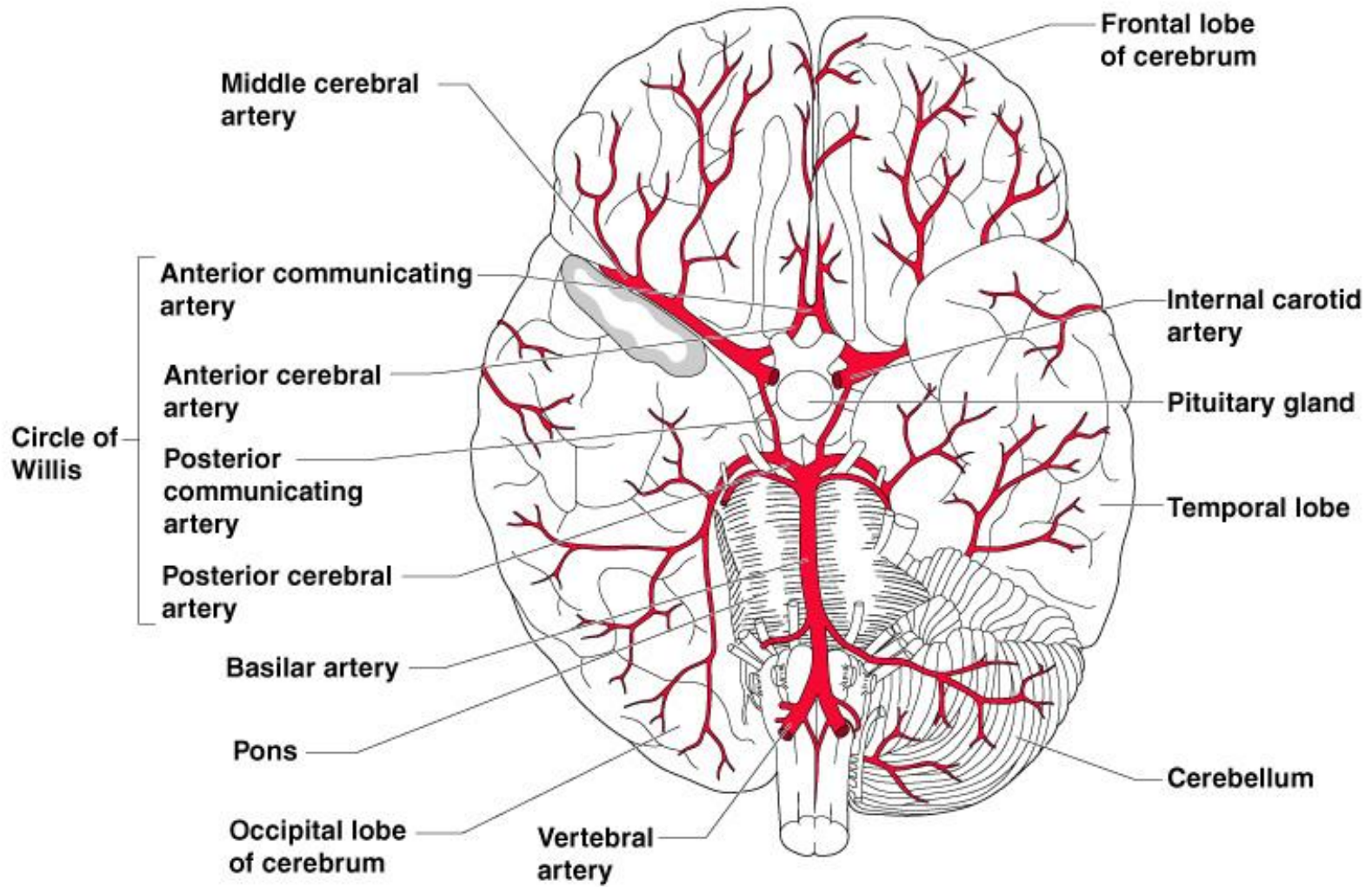


Figure 11.13

# Hepatic Portal Circulation

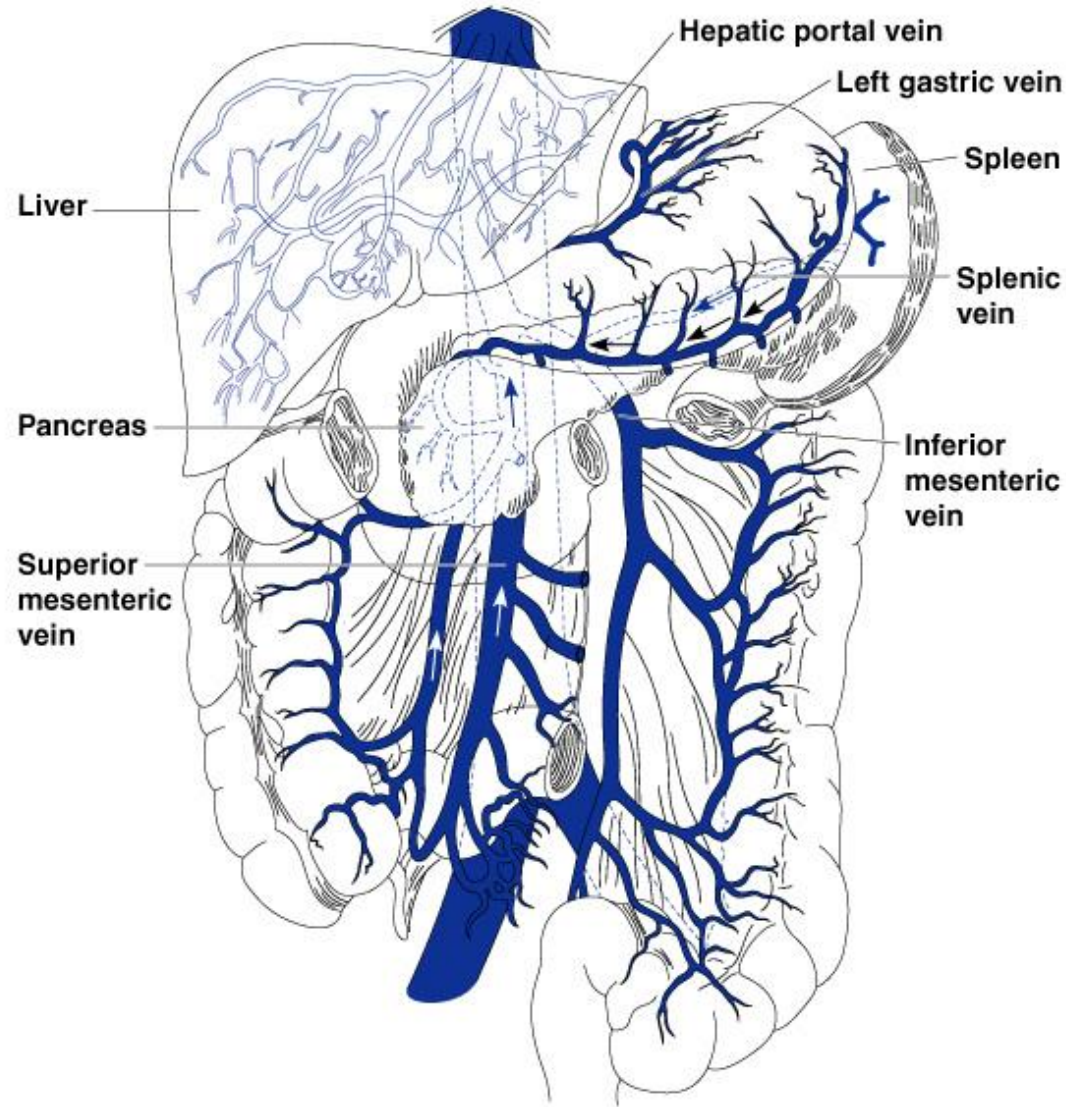
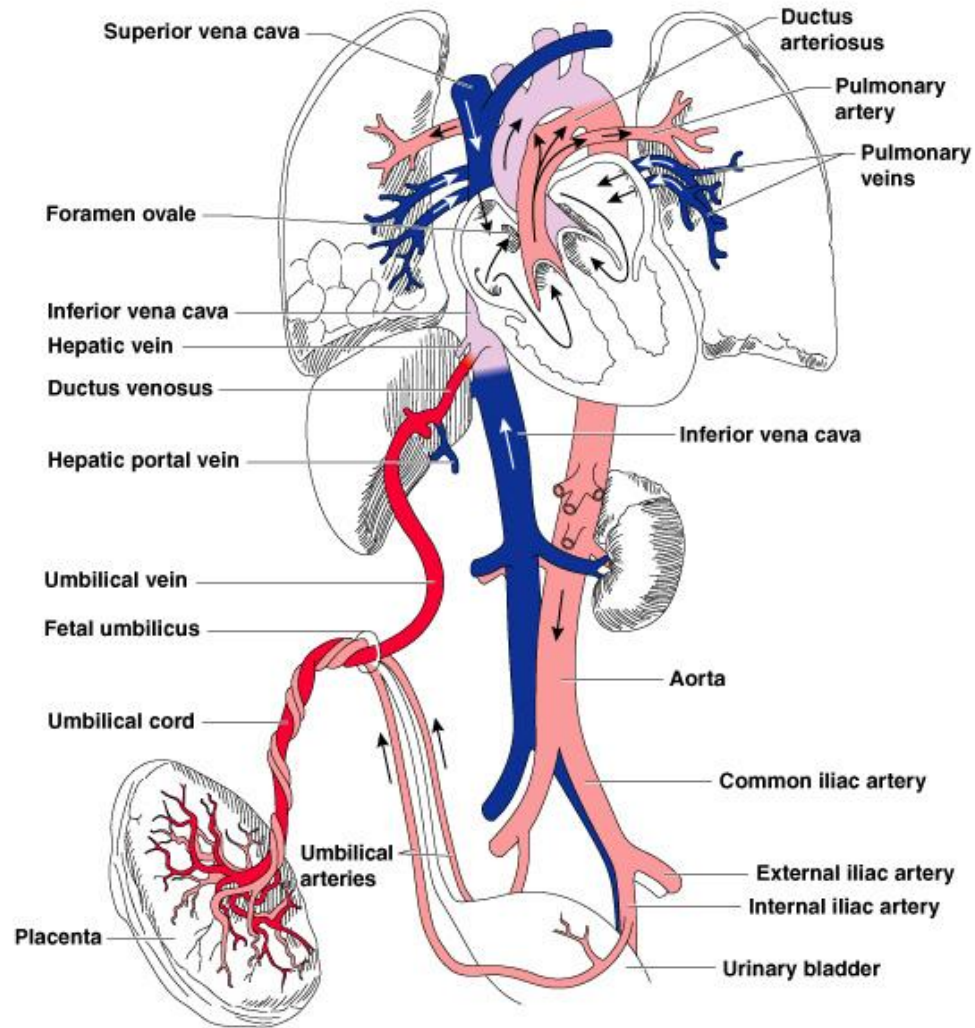


Figure 11.14

# Circulation to the Fetus



**KEY:**

- High oxygenation
- Moderate oxygenation
- Low oxygenation
- Very low oxygenation

Figure 11.15

# Pulse

- Pulse – pressure wave of blood
- Monitored at “pressure points” where pulse is easily palpated

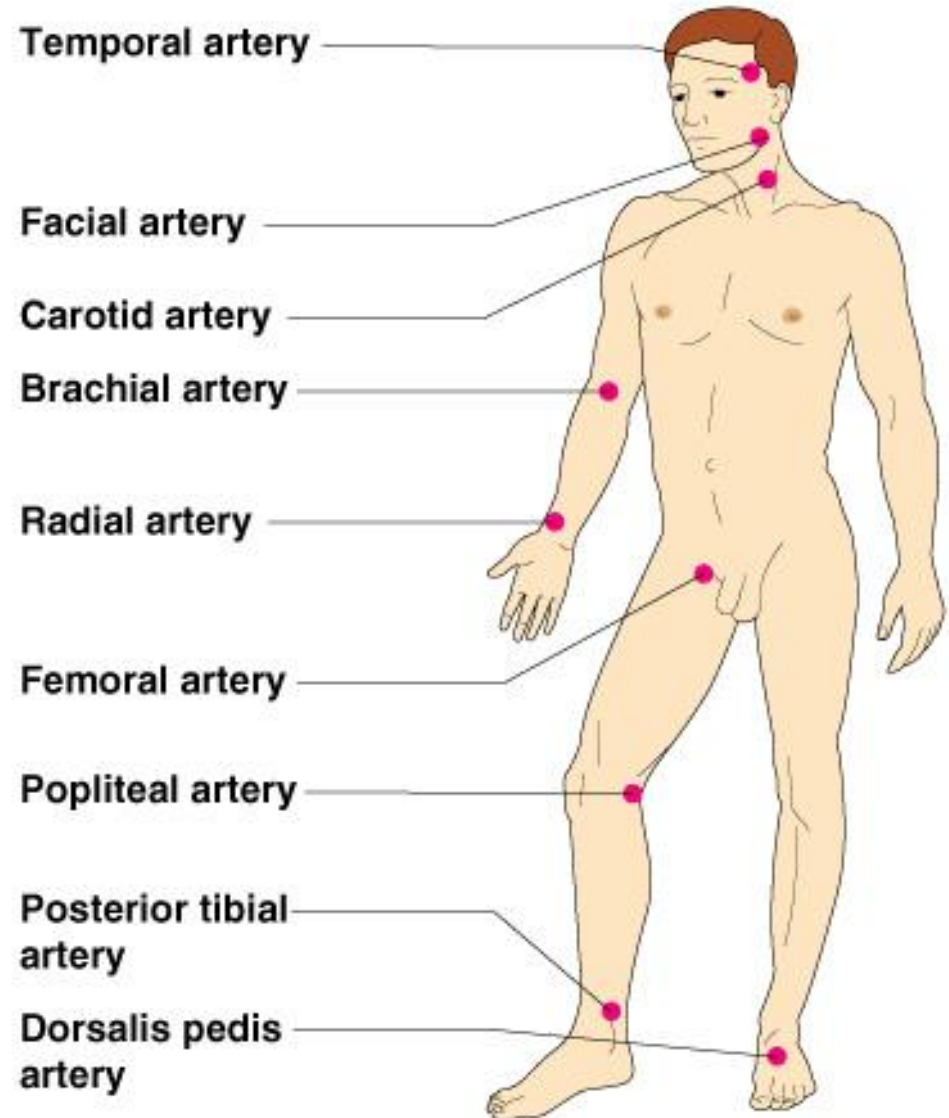


Figure 11.16

# 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
- Pressure in blood vessels decreases as the distance away from the heart increases

# Measuring Arterial Blood Pressure

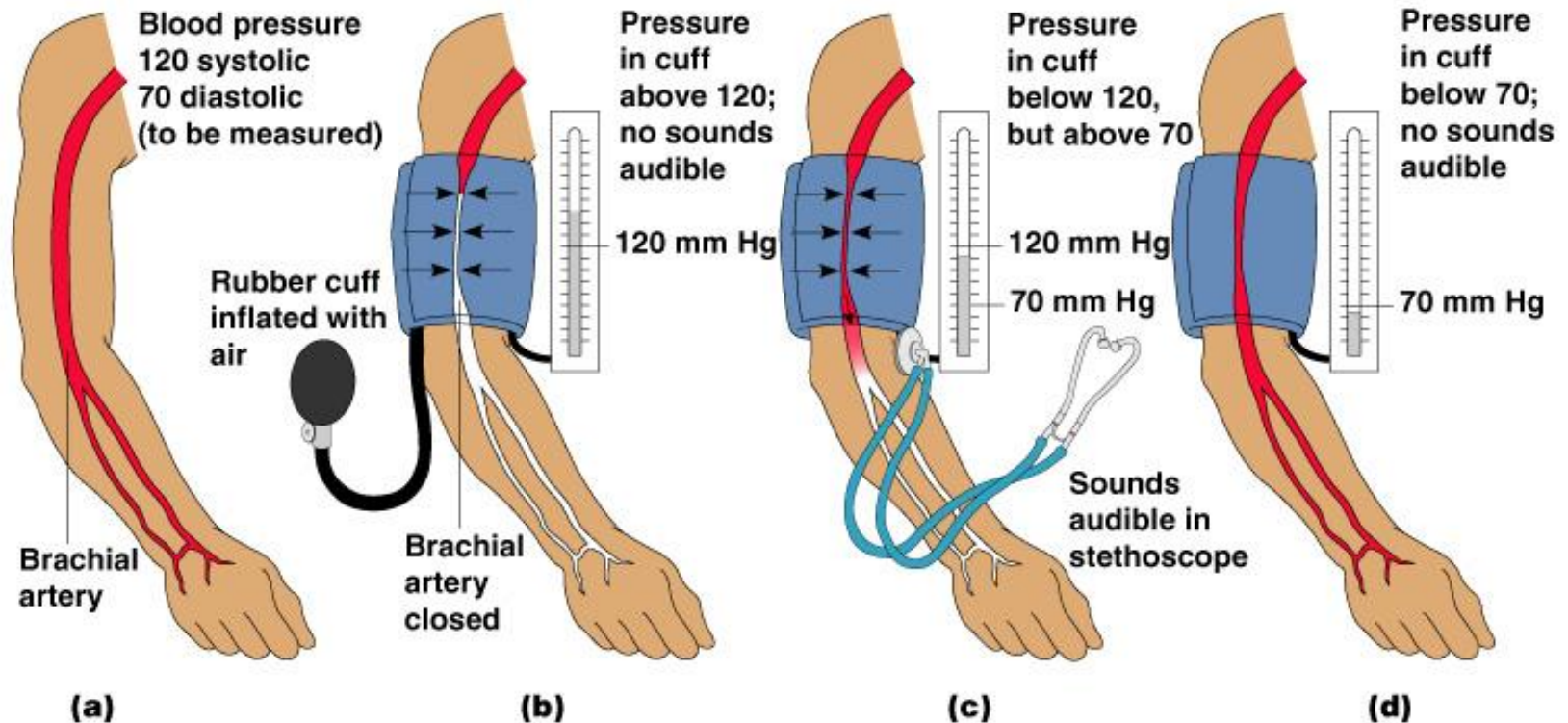


Figure 11.18

# 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 vasodilation effect
  - Cold has a vasoconstricting effect
- Chemicals
  - Various substances can cause increases or decreases
- Diet

# Variations in Blood Pressure

- Human normal 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

# 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 of some capillaries
  - Fenestrations = pores

# 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