Essentials of Human Anatomy & Physiology

Seventh Edition

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Chapter 11

The Cardiovascular System

Slides 11.1 – 11.19

Lecture Slides in PowerPoint by Jerry L. Cook

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

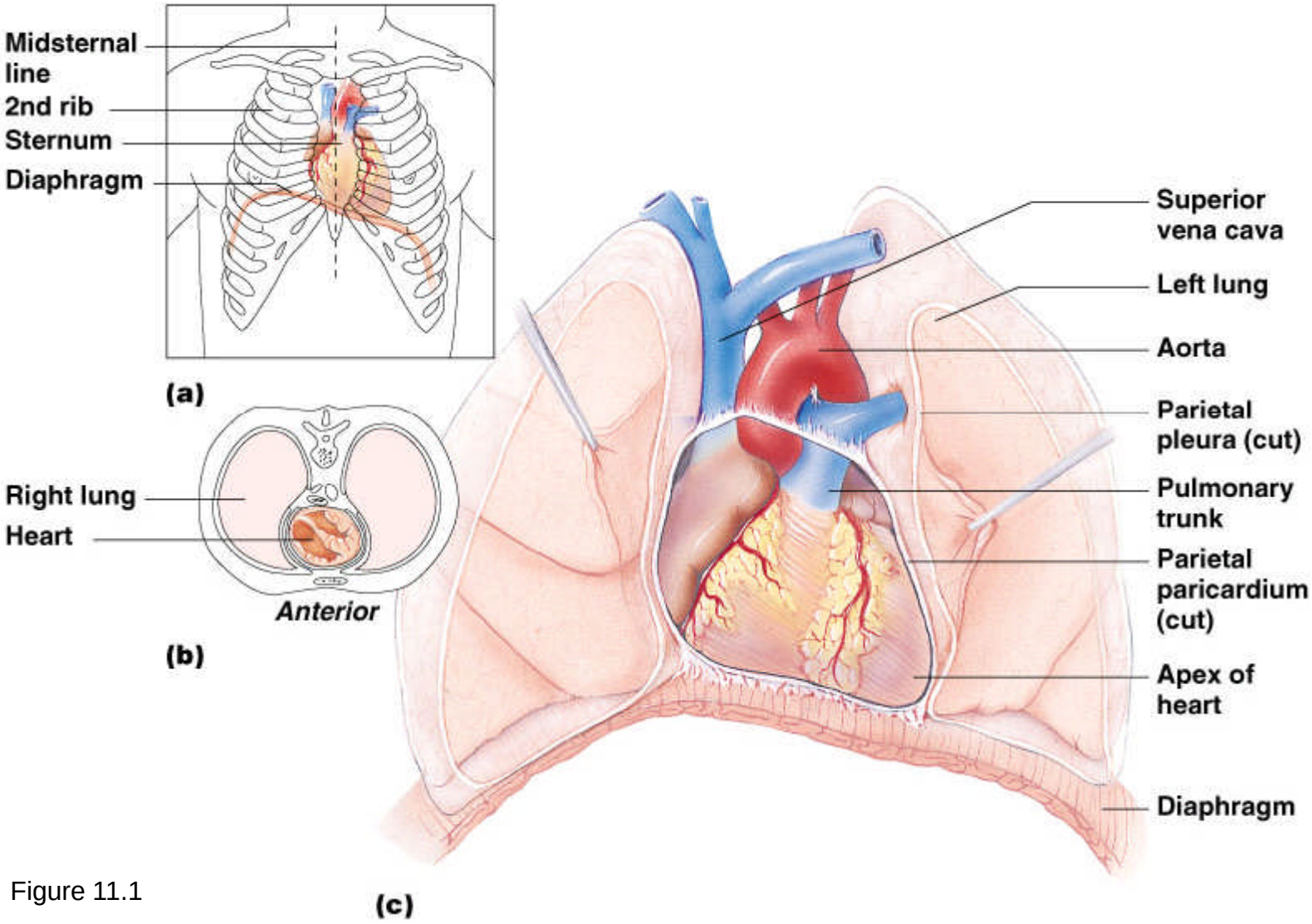

Figure 11.1

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: Heart Wall

- Three 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

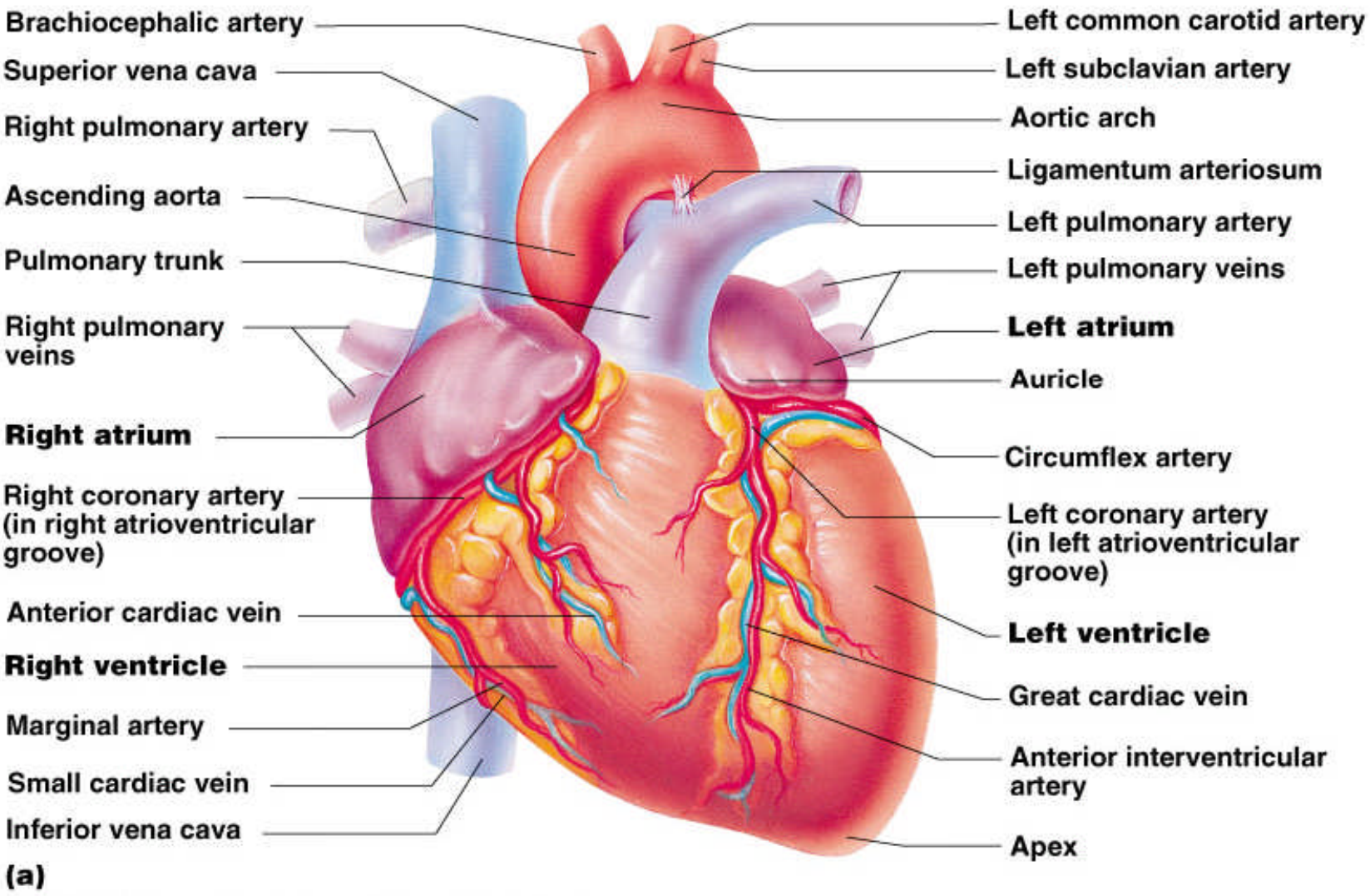

Figure 11.2a

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

Blood Circulation

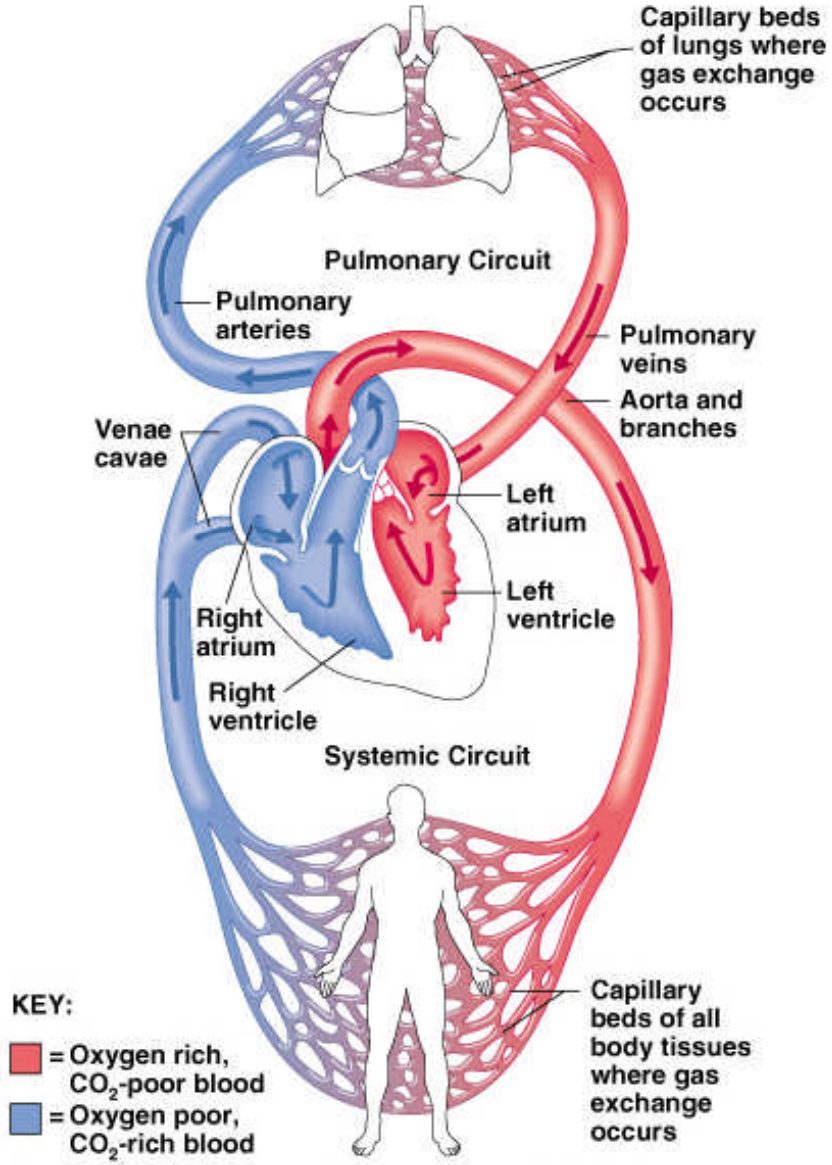

Figure 11.3

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

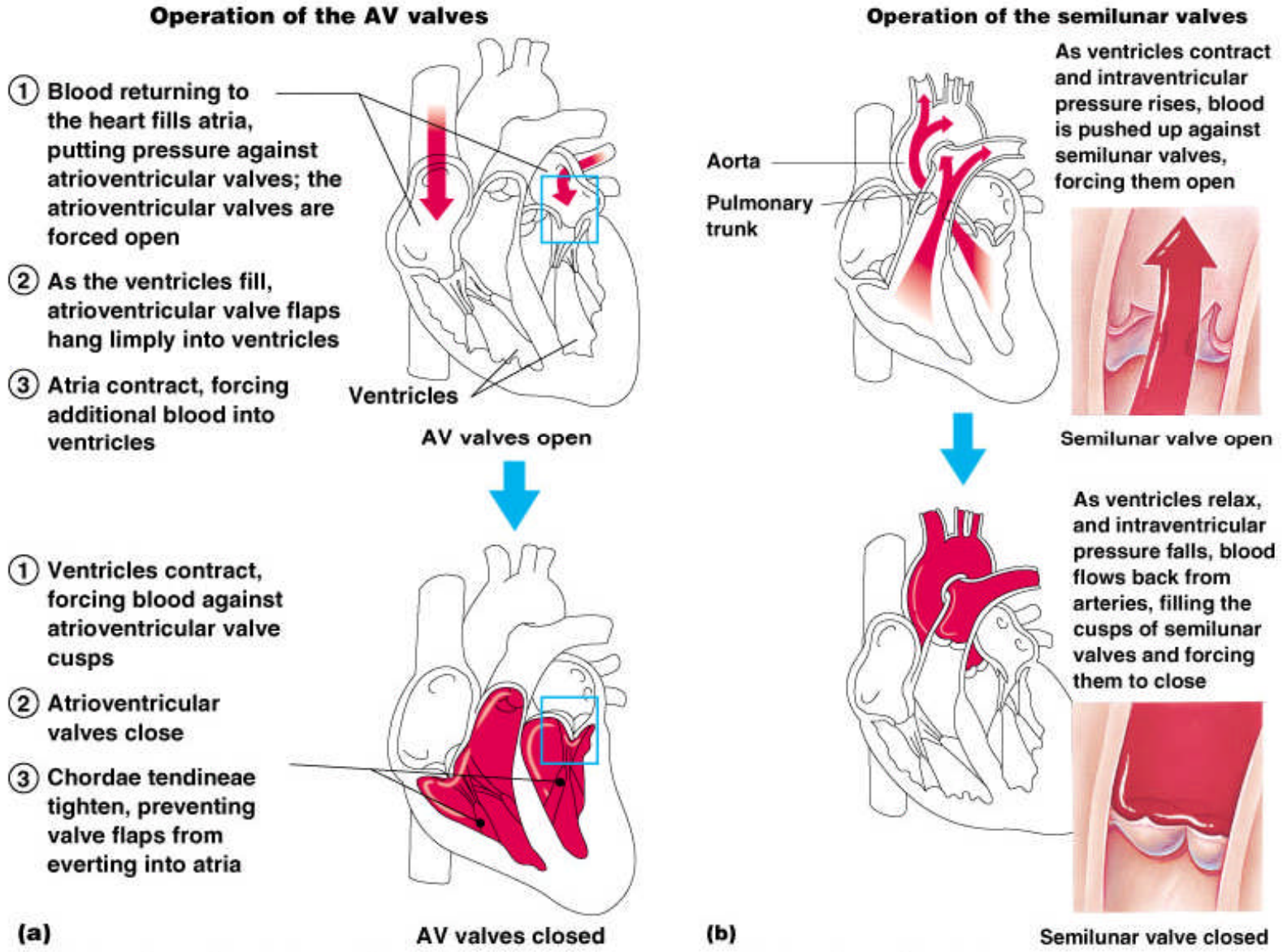

Figure 11.4

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

The Heart: Conduction System

- Special tissue sets the pace
  - Sinoatrial node
    - Pacemaker
  - Atrioventricular node
  - Atrioventricular bundle
  - Bundle branches
  - Purkinje fibers

Heart Contractions

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

Heart Contractions

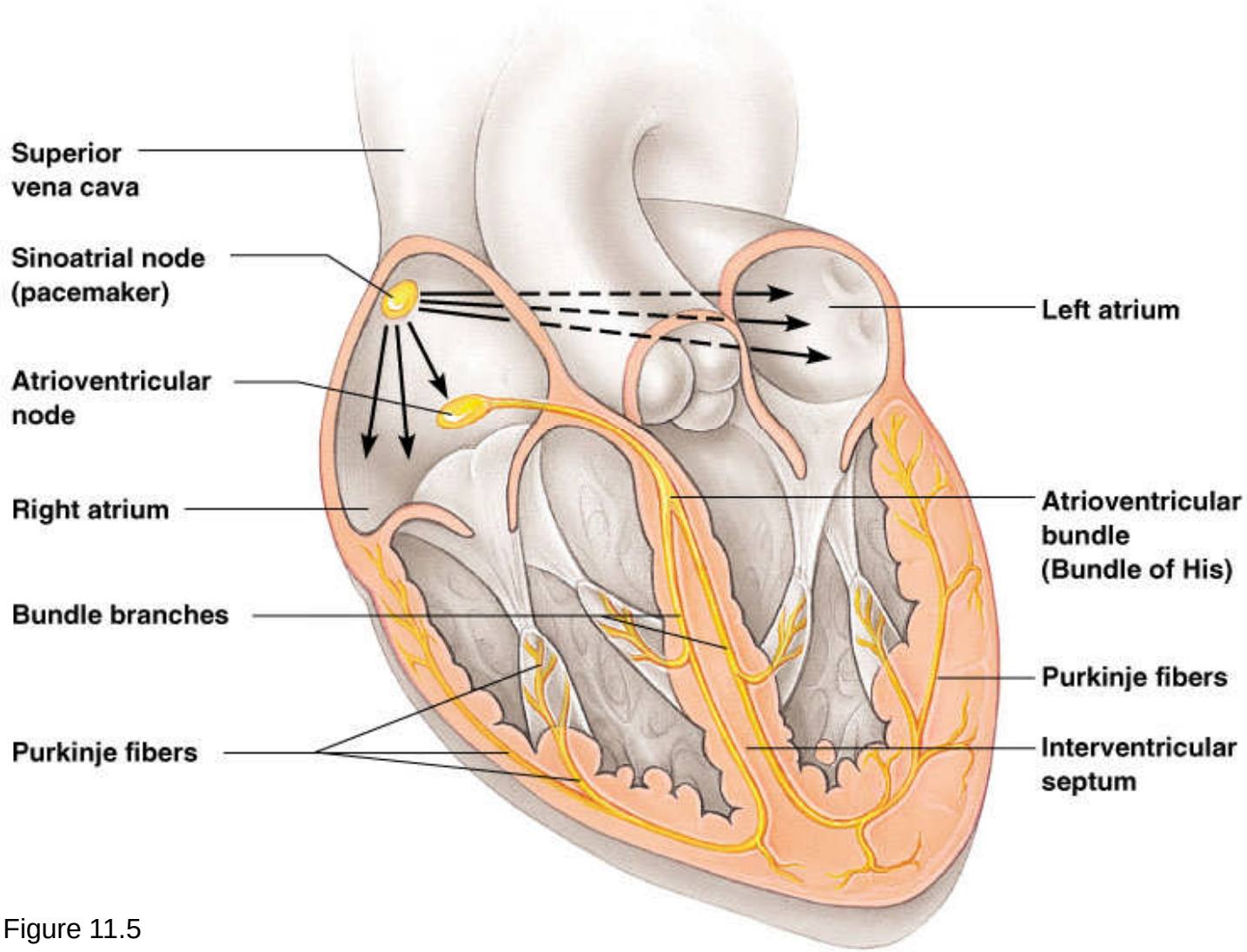

Figure 11.5

Filling of Heart Chambers – the Cardiac Cycle

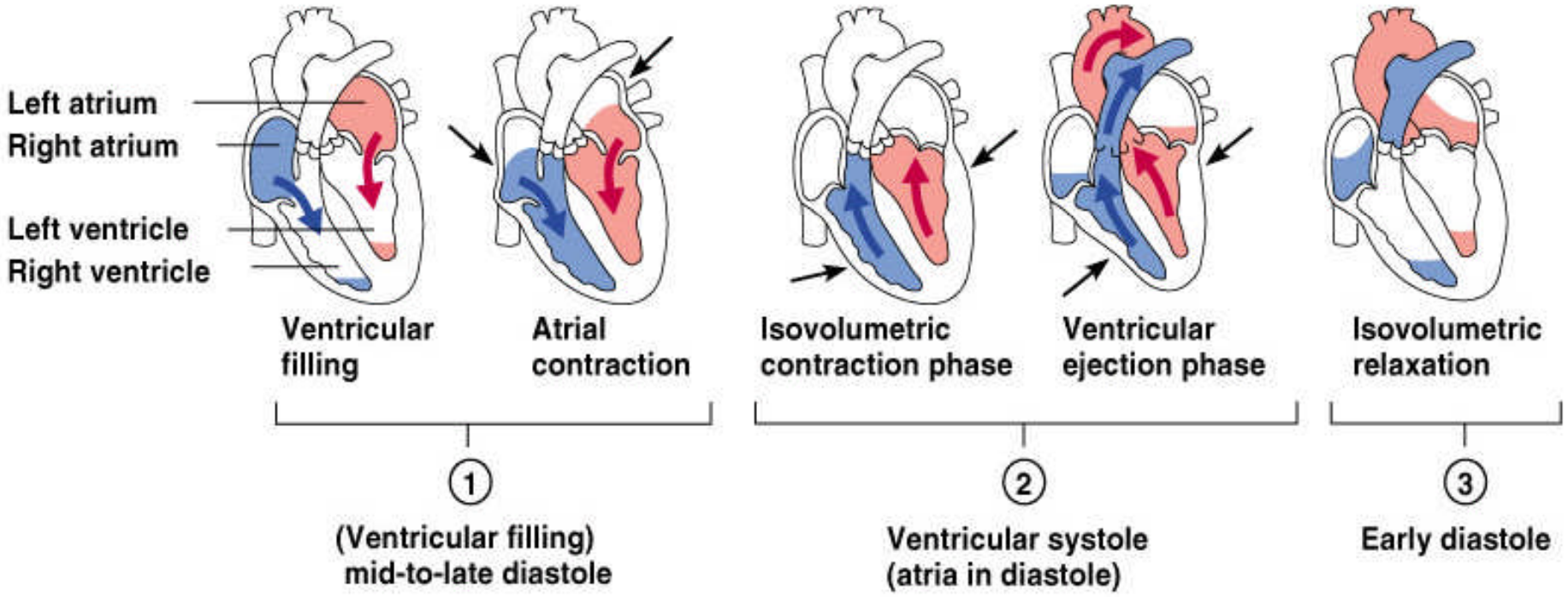

Figure 11.6

The Heart: Cardiac Cycle

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

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 = (heart rate [HR]) x (stroke volume [SV])
- Stroke volume
  - Volume of blood pumped by each ventricle in one contraction

Cardiac Output Regulation

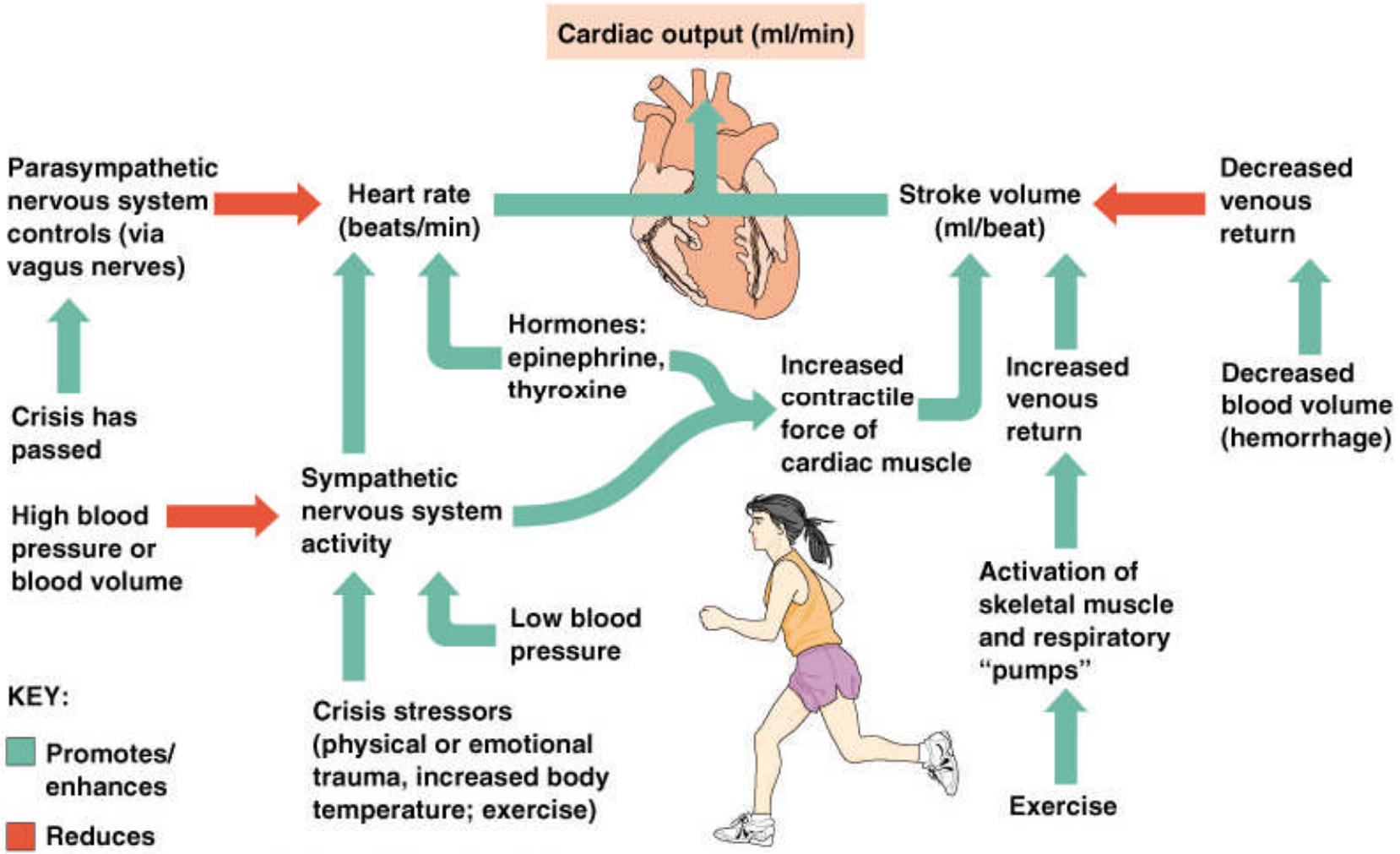

Figure 11.7

The Heart: 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

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
  - Dereased venous return

Blood Vessels: The Vascular System

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

The Vascular System

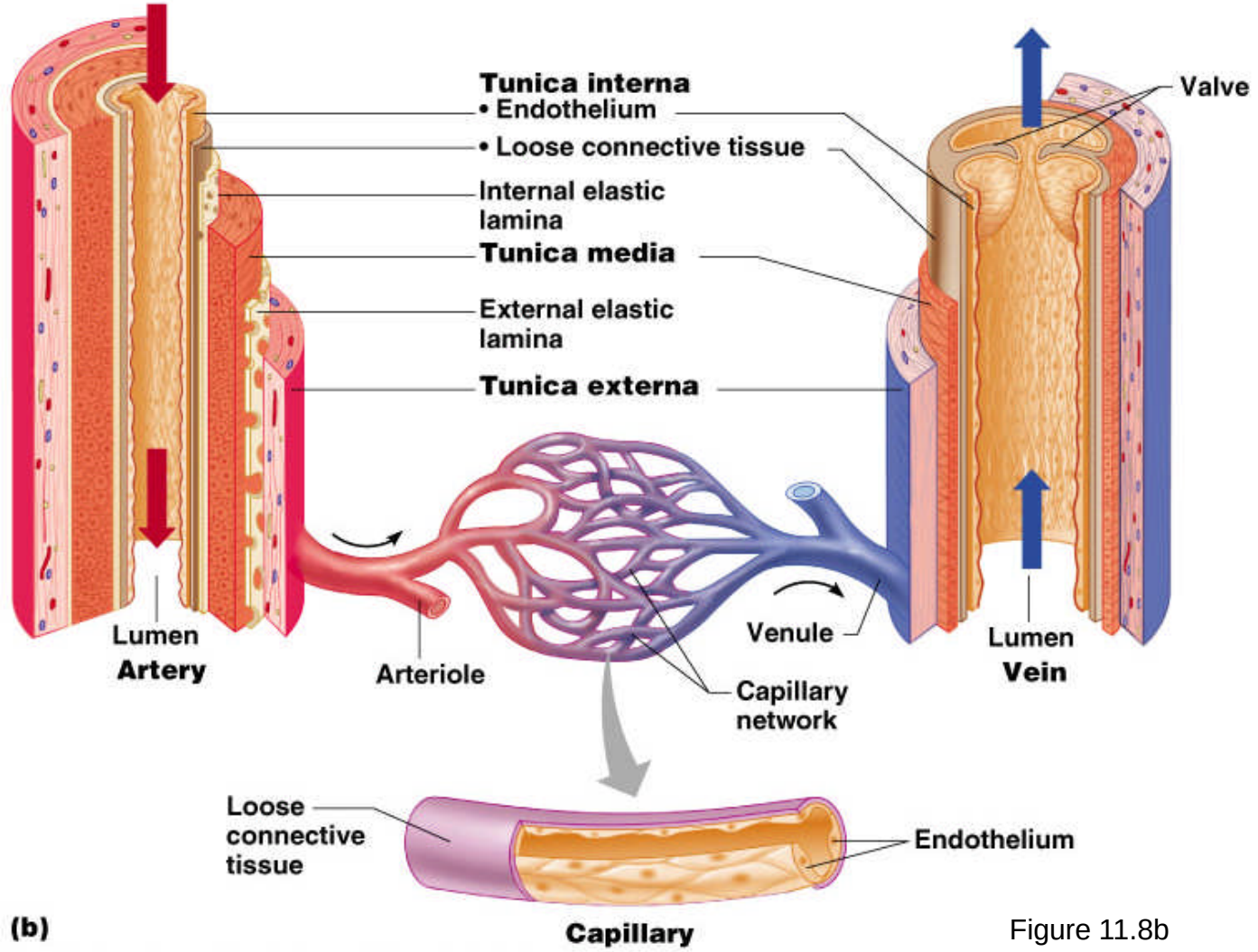

Figure 11.8b

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

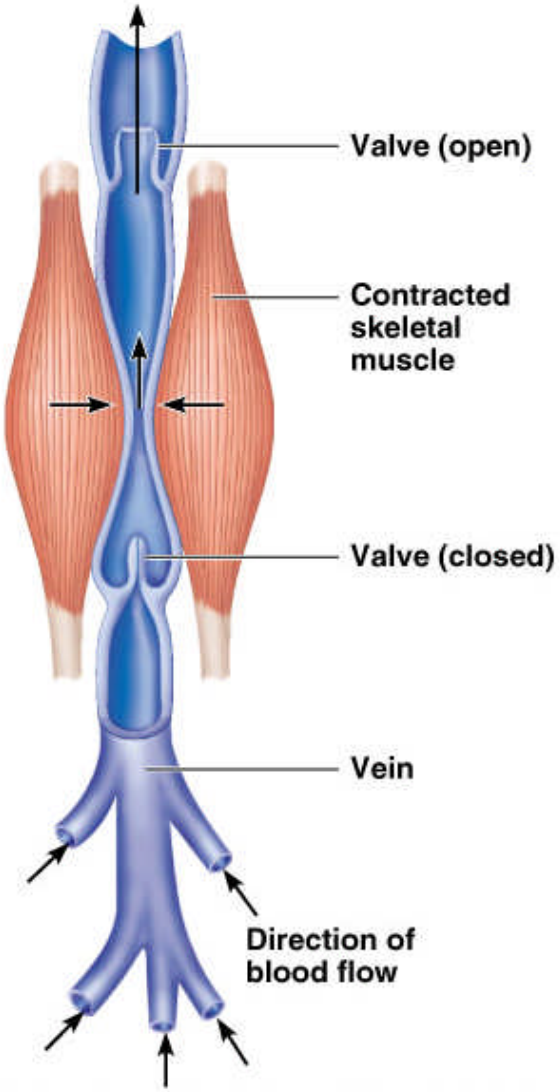

Figure 11.9

Capillary Beds

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

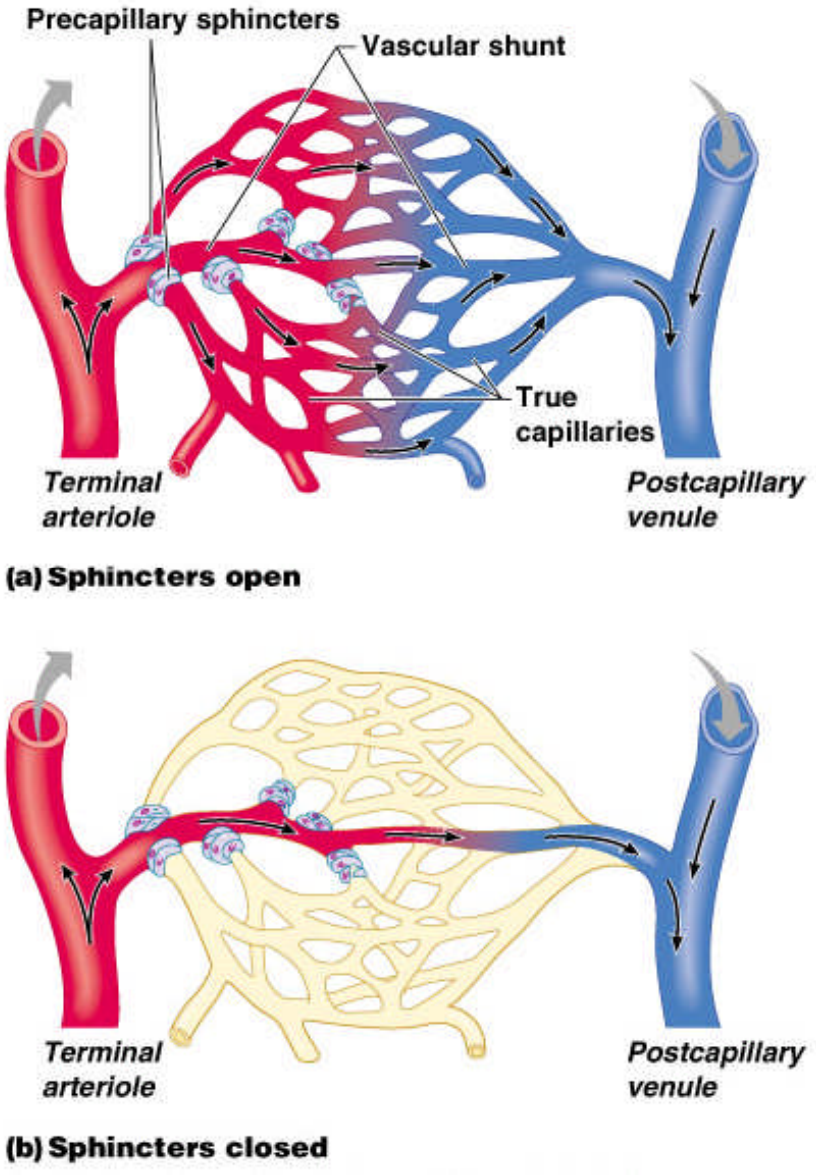

Figure 11.10

Capillary Beds

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

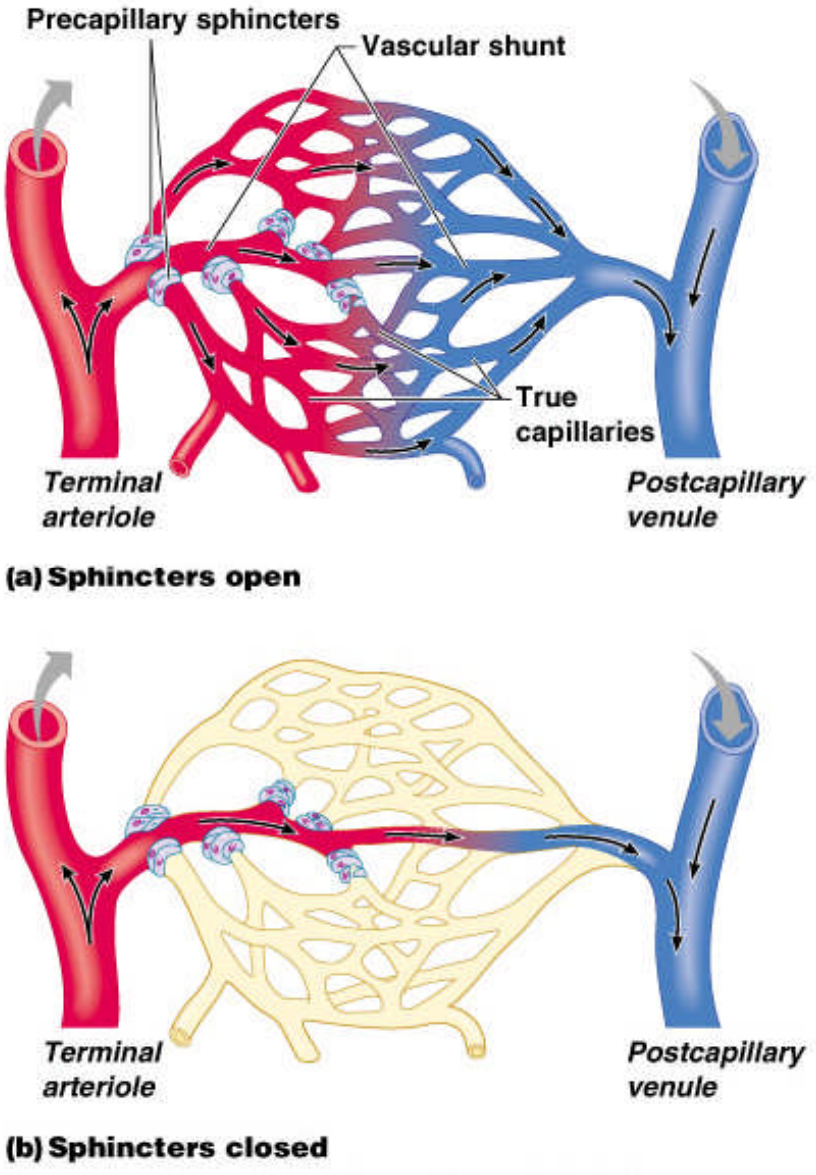

Figure 11.10

Diffusion at Capillary Beds

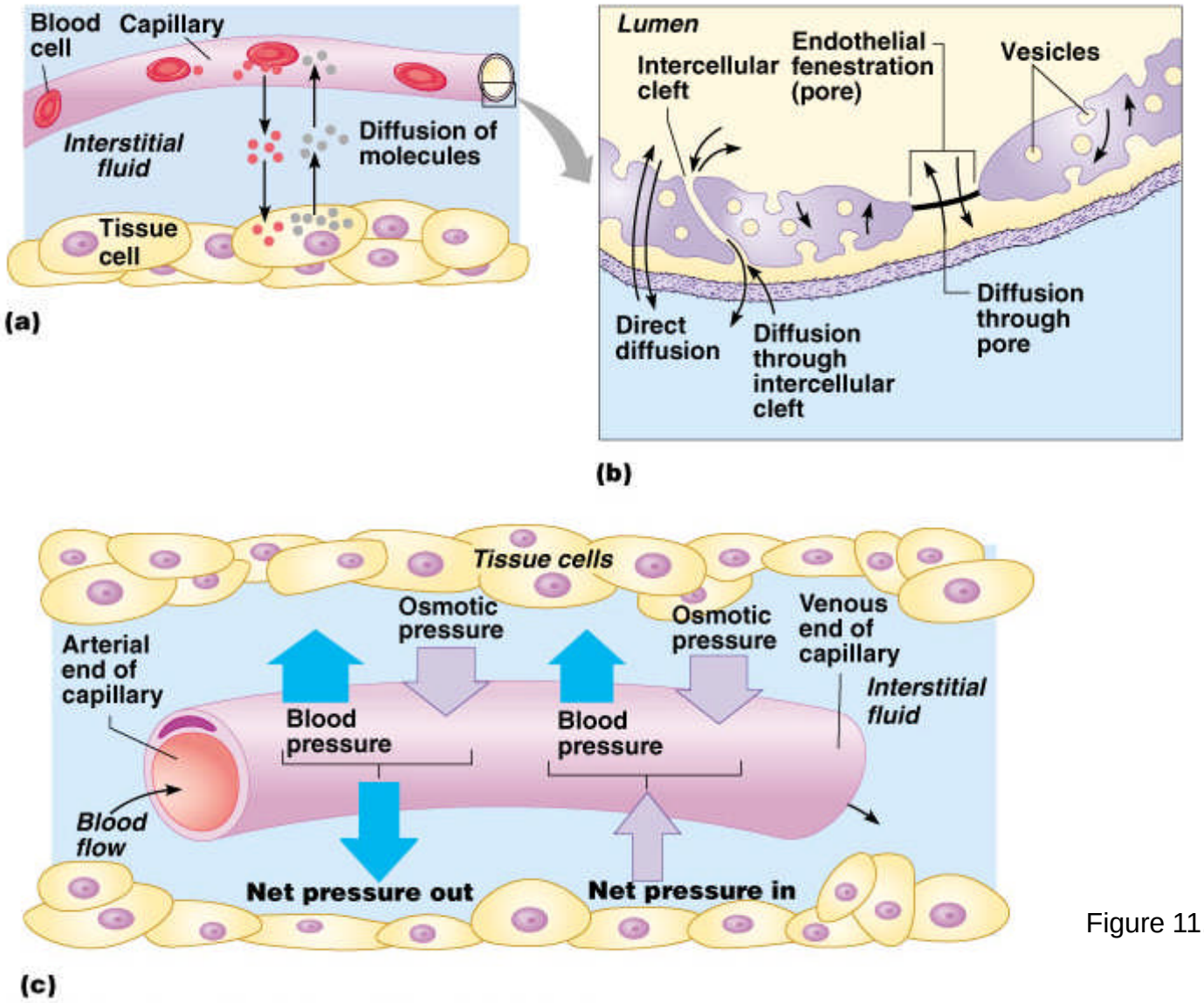

Figure 11.20

Major Arteries of Systemic Circulation

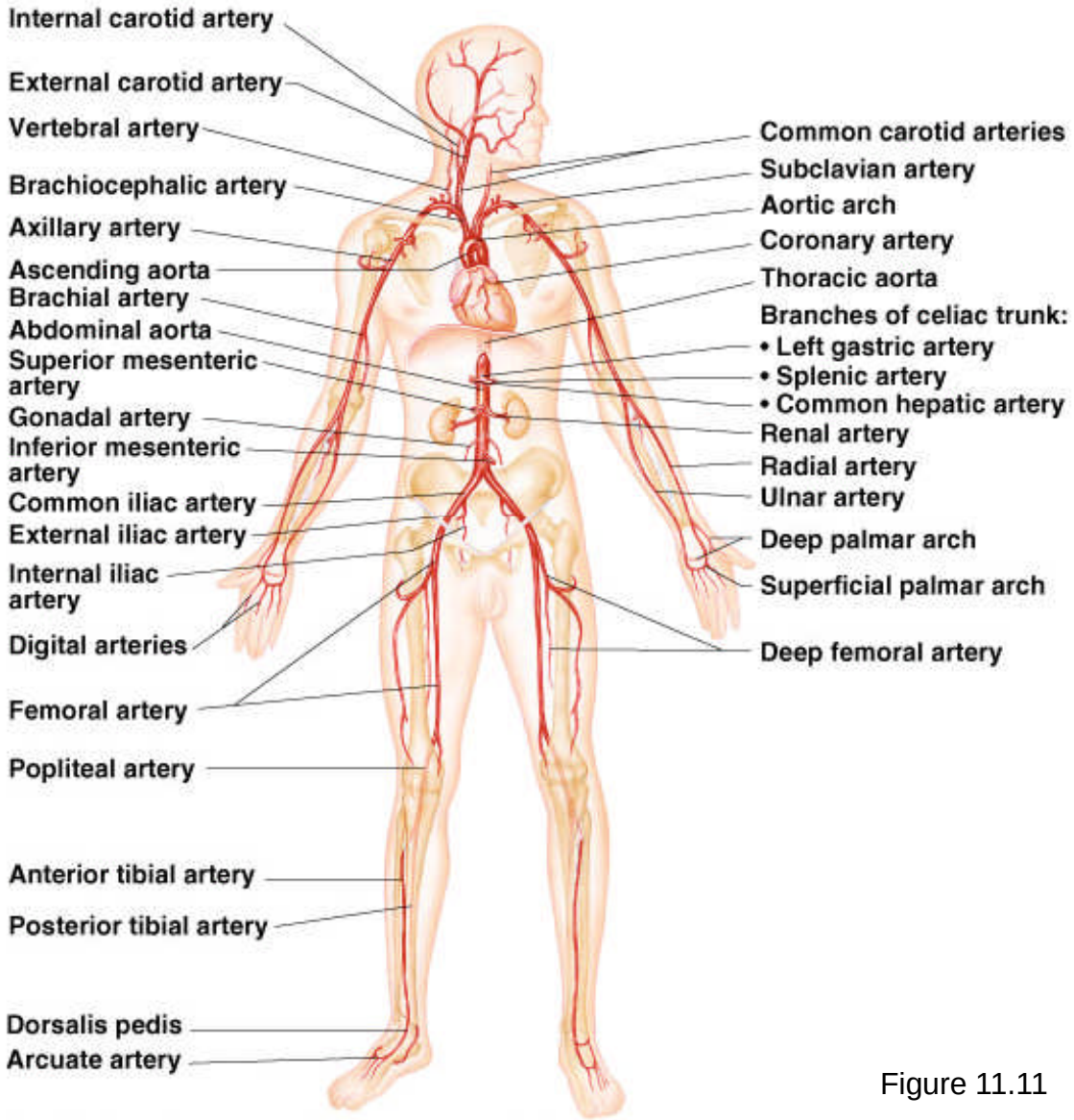

Figure 11.11

Major Veins of Systemic Circulation

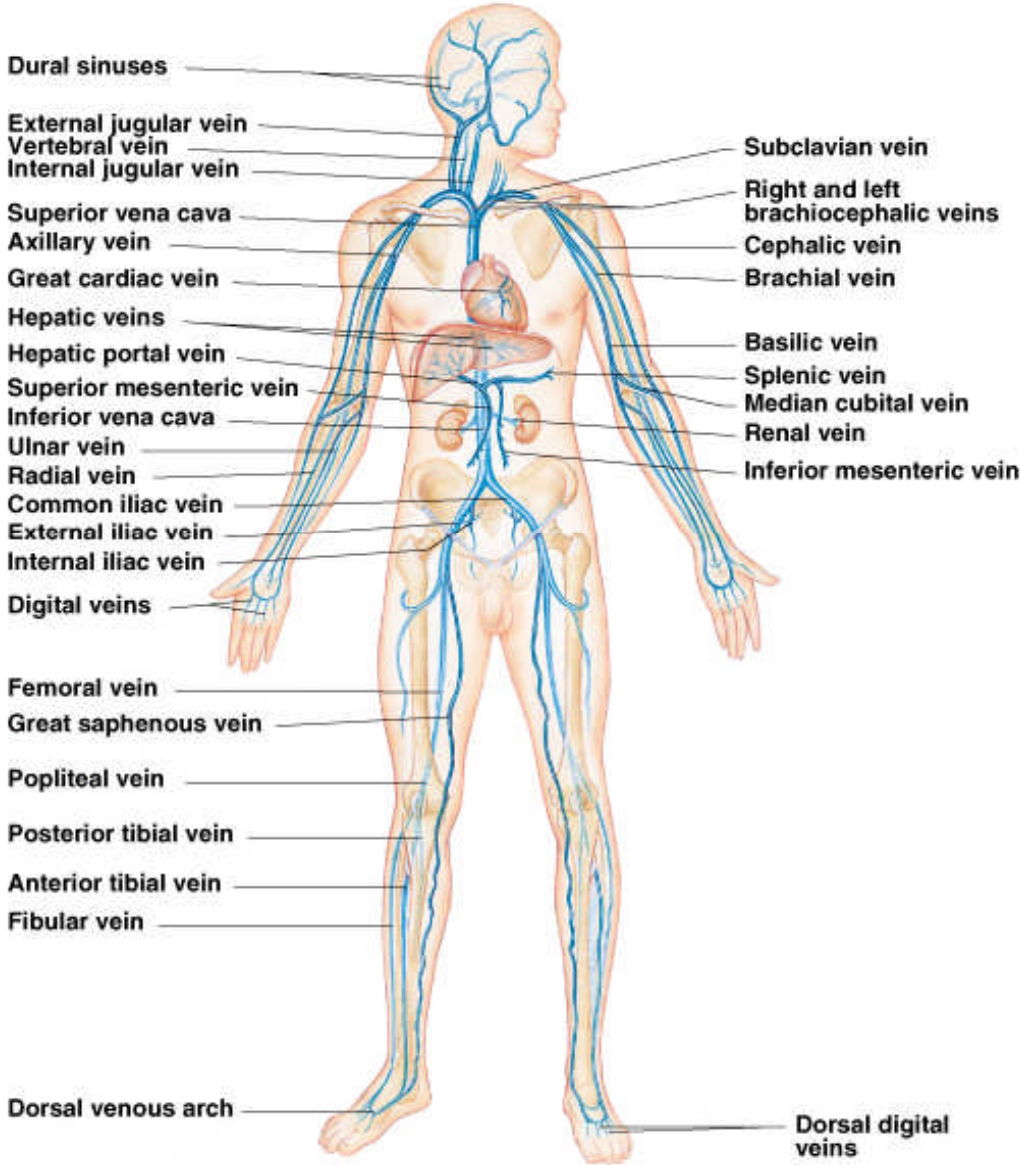

Figure 11.12

Arterial Supply of the Brain

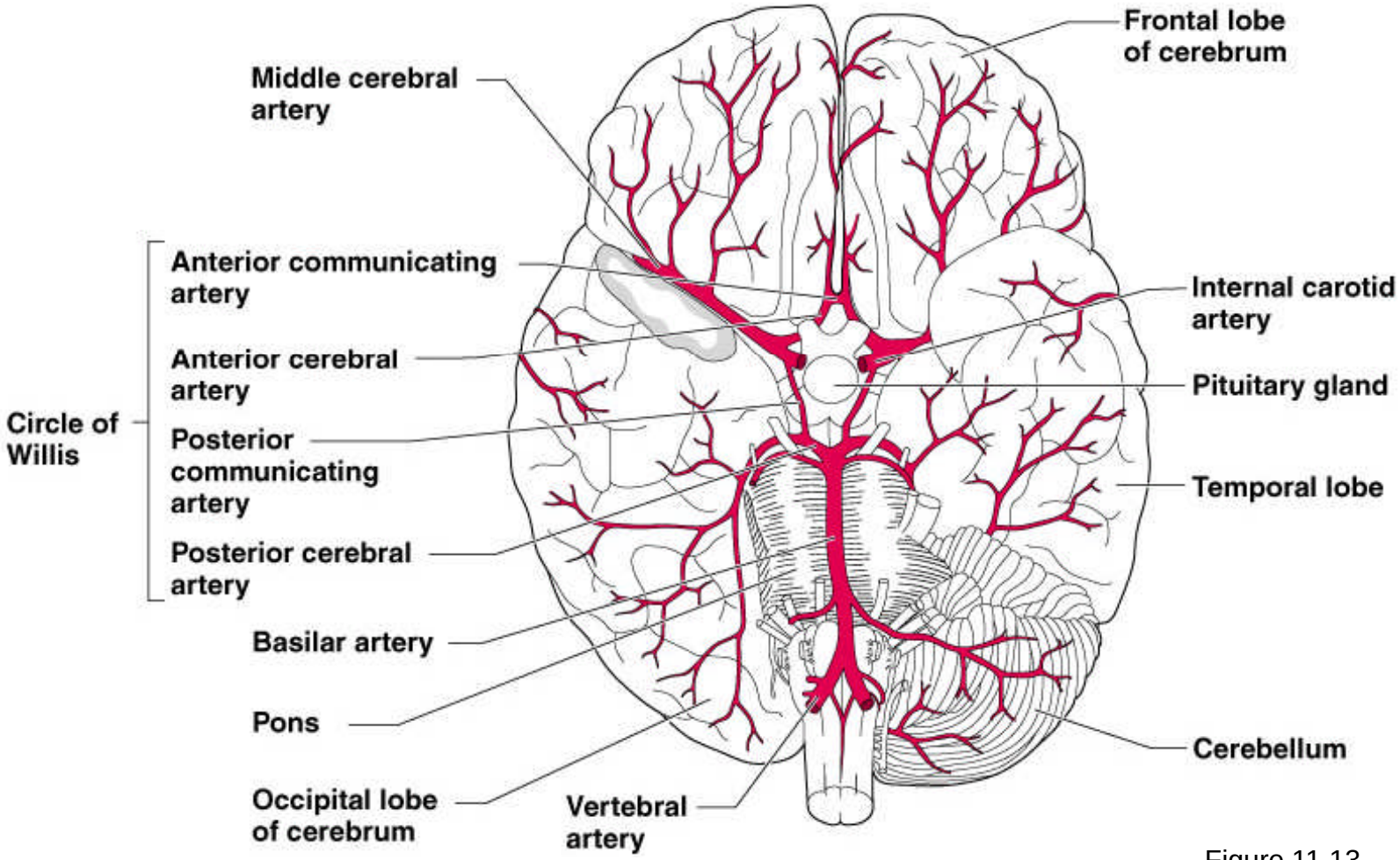

Figure 11.13

Hepatic Portal Circulation

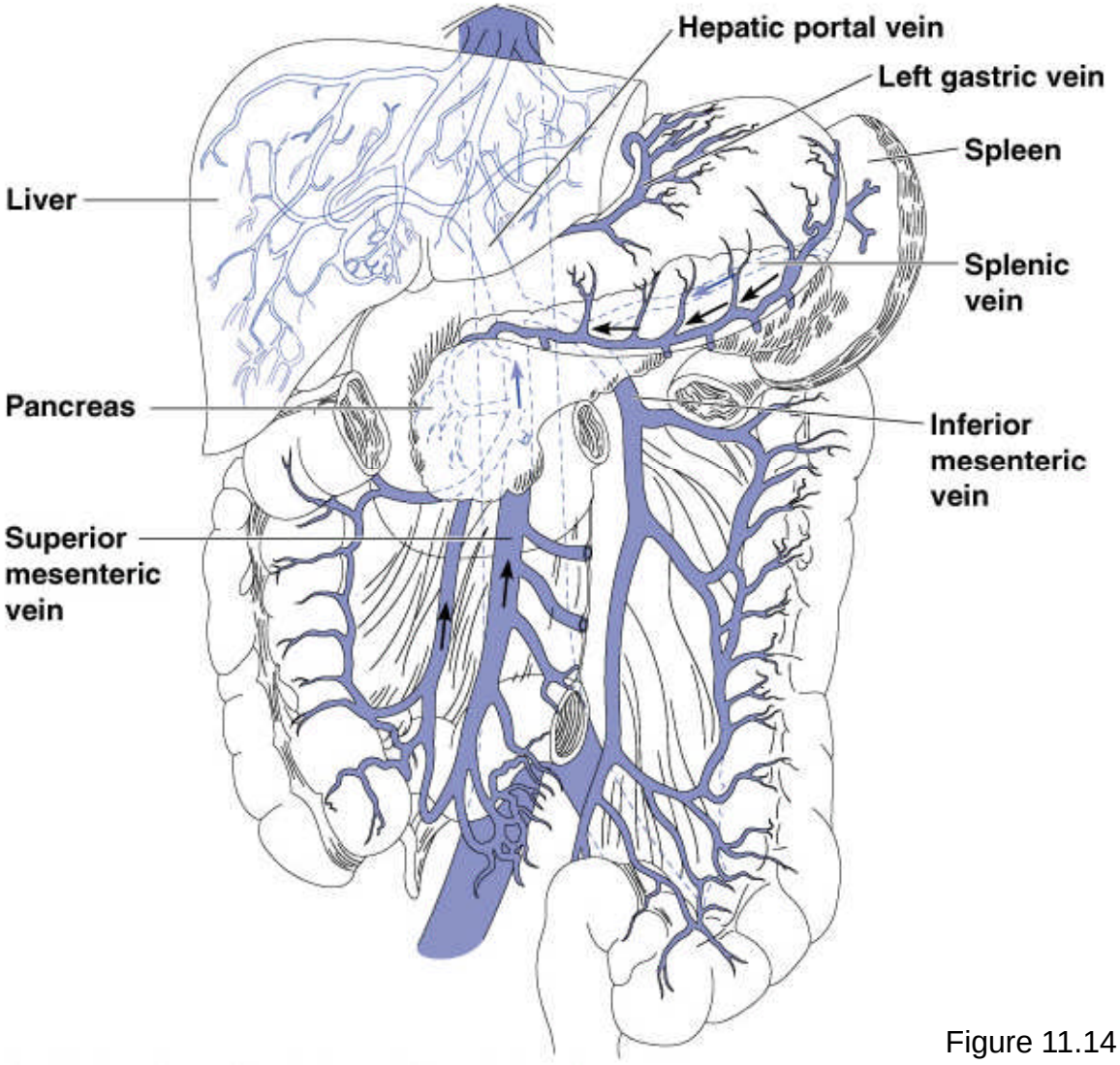

Figure 11.14

Circulation to the Fetus

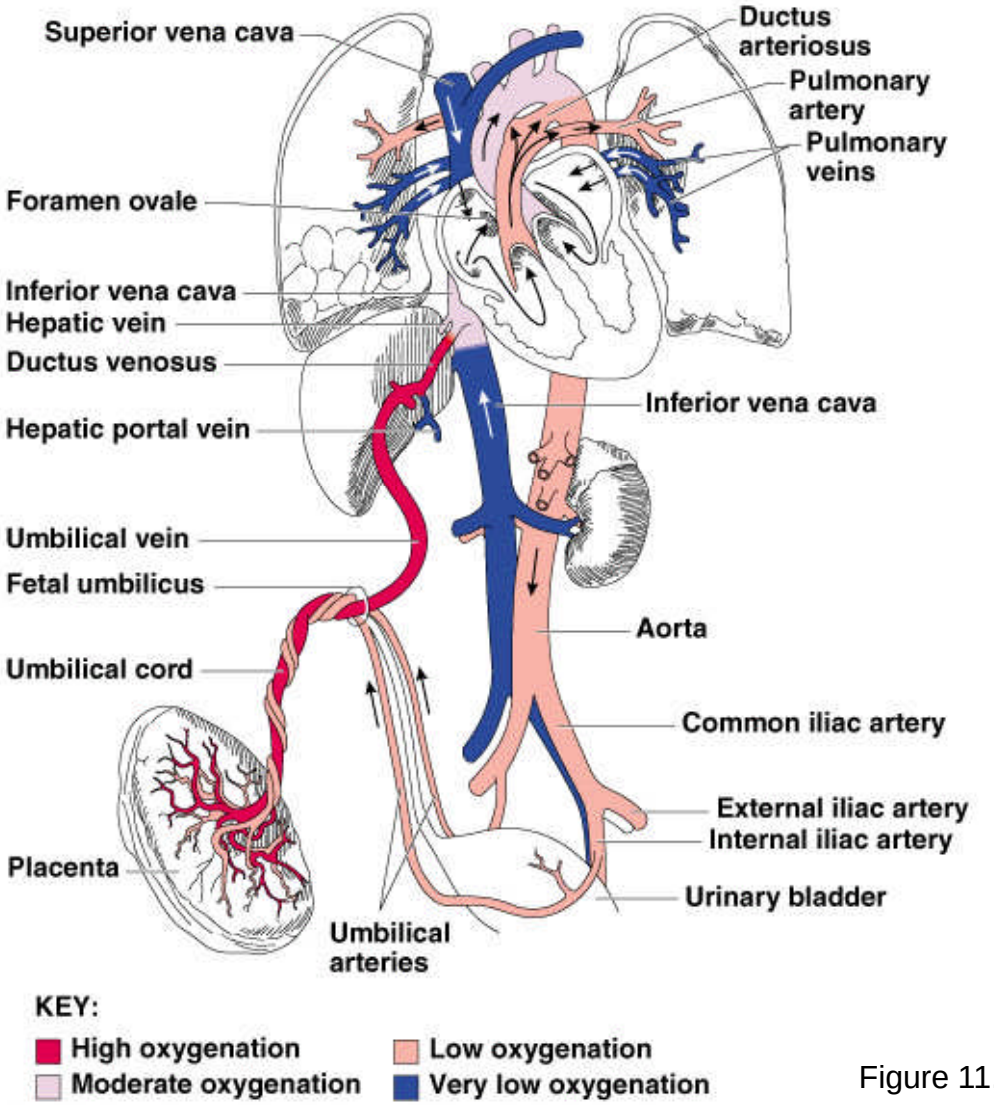

Figure 11.15

Pulse

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

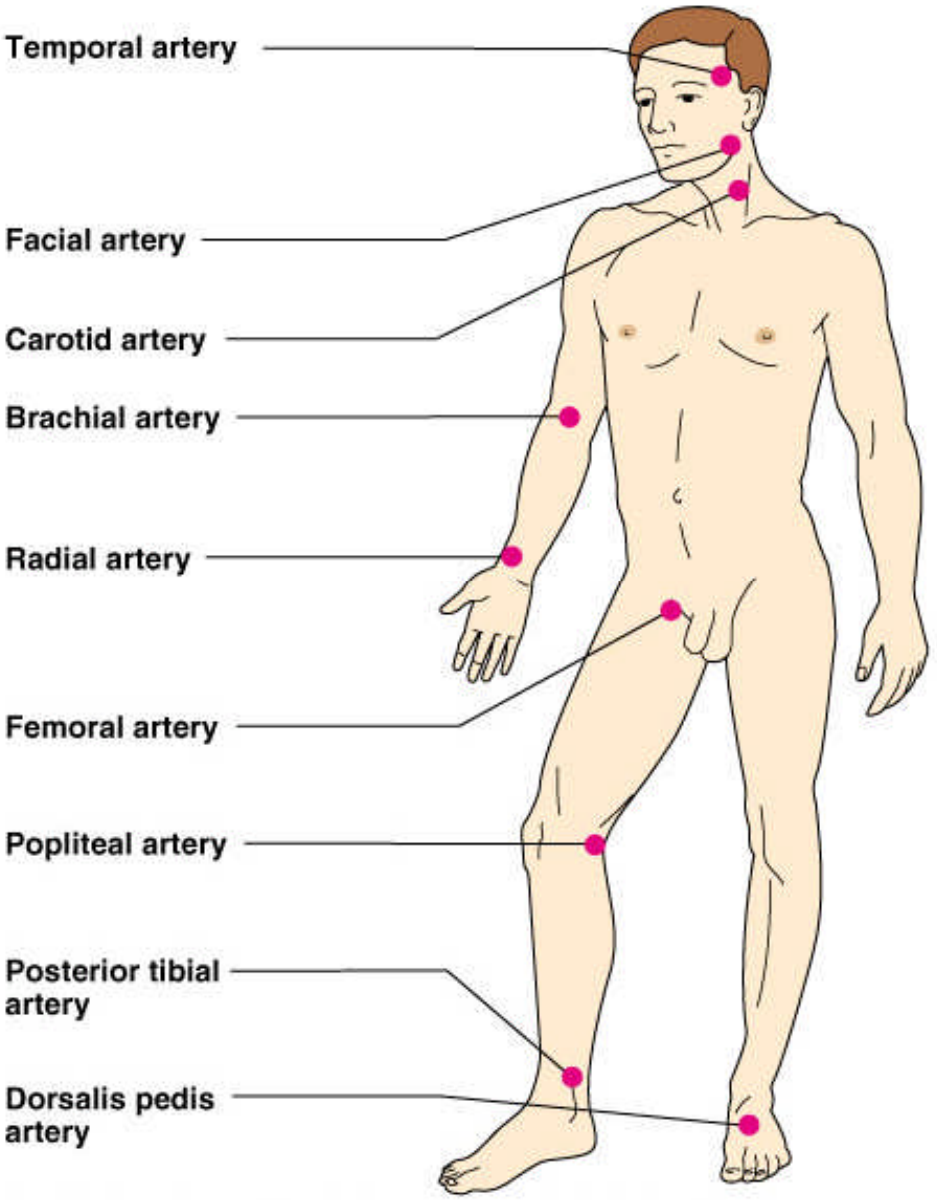

Figure 11.16

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

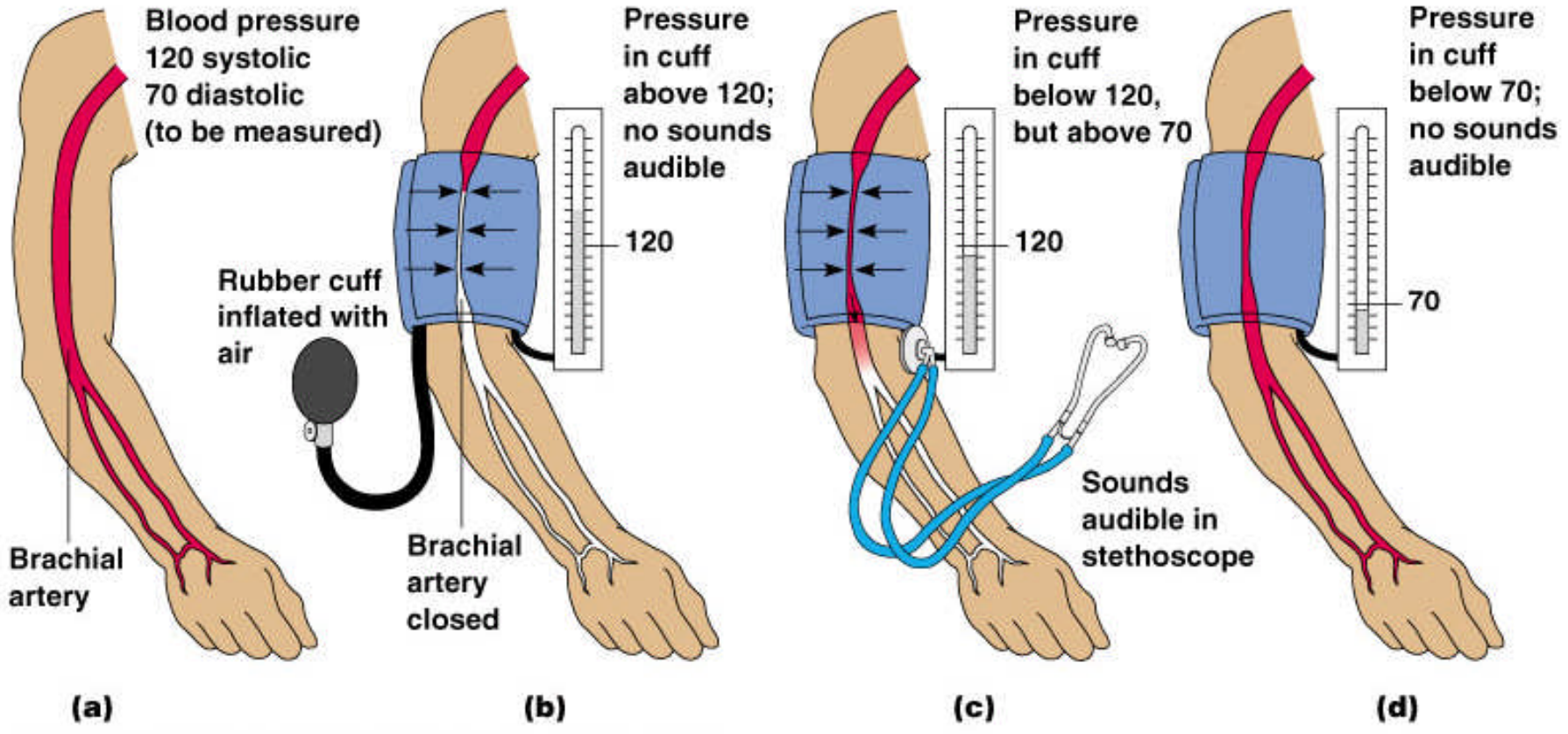

Figure 11.18

Comparison of Blood Pressures in Different Vessels

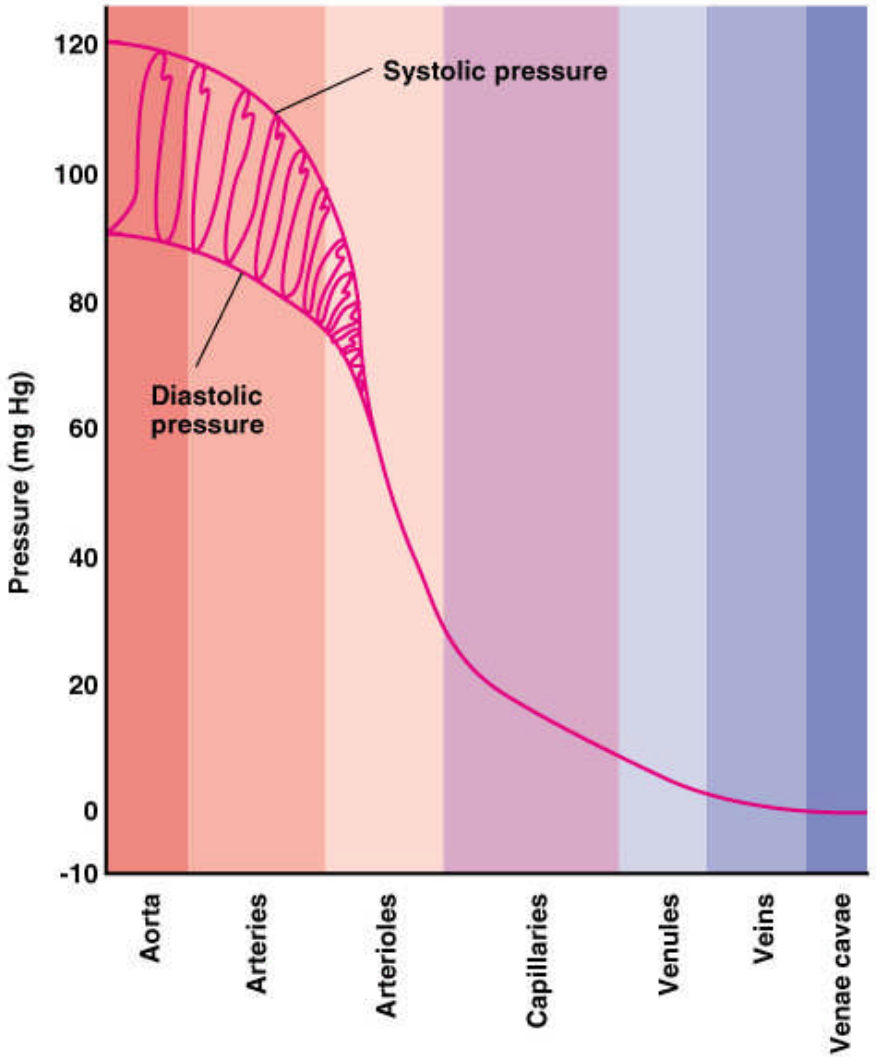

Figure 11.17

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

Factors Determining Blood Pressure

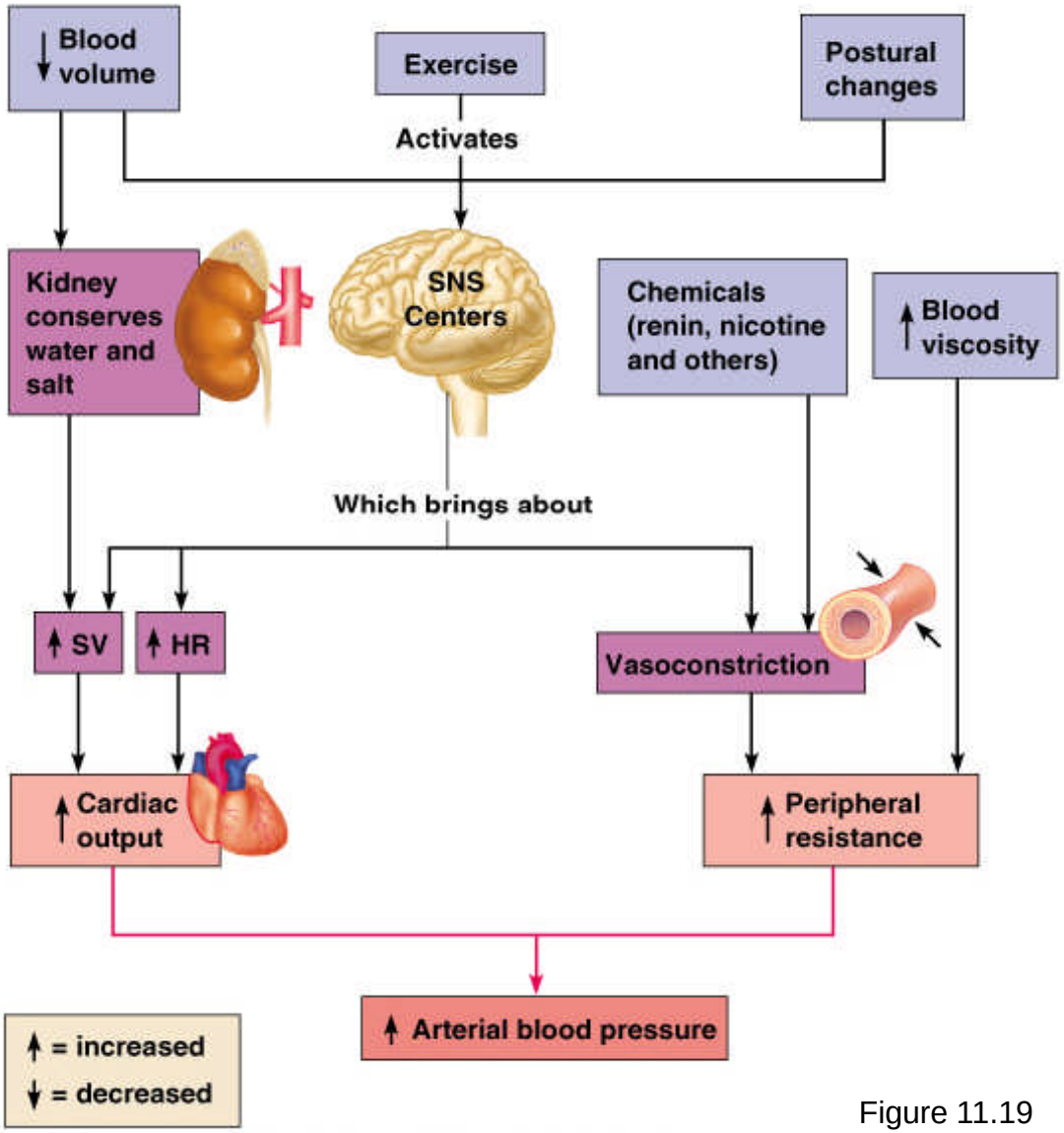

Figure 11.19

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