The Cardiovascular System

The Blood Vessels

The Structure of Blood Vessels

Blood Vessel Review

- *Arteries* carry blood *away* from the heart
  - Pulmonary trunk to lungs
  - Aorta to everything else
- Microcirculation is where exchange occurs
  - *Arterioles* to feed the capillaries
  - *Capillaries* exchange with the tissues
  - *Venules* to receive capillary blood
- *Veins* bring it back (visit) to the heart

The Structure of Blood Vessels

Arteries and Veins Have Three Layers

- *Tunica interna*
  - Innermost layer (*endothelium*) in contact with blood
- *Tunica media*
  - Middle layer of smooth muscle
    - *Vasoconstrict* or *vasodilate*
- *Tunica externa*
  - Outer layer of loose connective tissue

The Structure of Blood Vessels

A Comparison of a Typical Artery and a Typical Vein

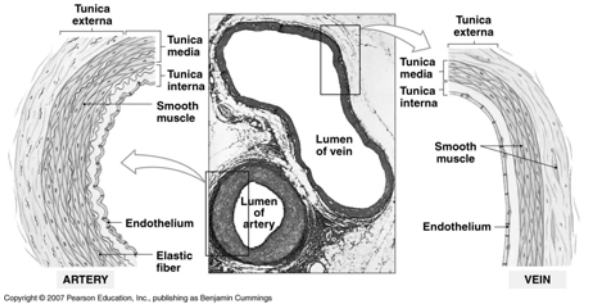


Figure 13-1

The Structure of Blood Vessels

Types of Arteries

- *Elastic* arteries
  - Largest
  - Closest to heart
  - Stretch during systole
  - Recoil during diastole
- *Muscular* arteries
- *Arterioles*
  - Tiny branches of small arteries
  - Feeders of capillary networks

This creates the diastolic pressure reading

The Structure of Blood Vessels

The Structure of the Various Types of Blood Vessels

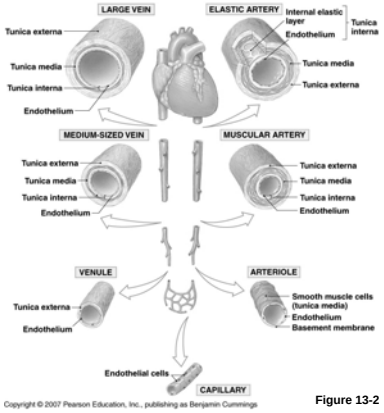


Figure 13-2

The Structure of Blood Vessels

Properties of Capillaries

- Where exchange between blood and cells takes place
- Organized into interconnected capillary *beds*
- *Vasomotion* of *precapillary sphincters* (bands of smooth muscle) controls flow

The Structure of Blood Vessels

The Organization of a Capillary Bed

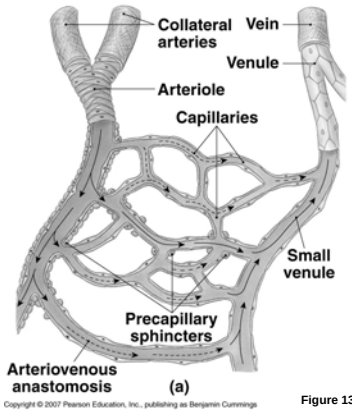


Figure 13-4(a)

The Structure of Blood Vessels

The Organization of a Capillary Bed

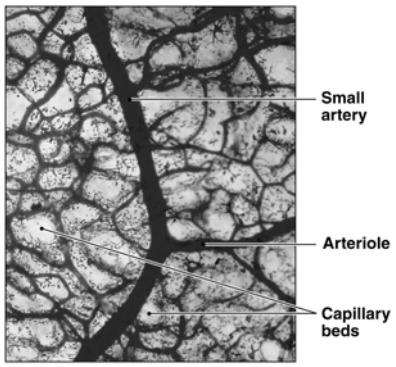
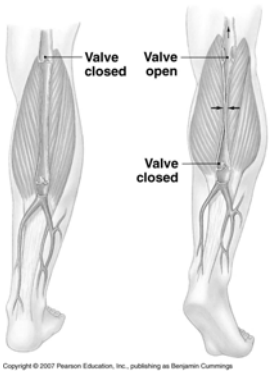


Figure 13-4(b)

The Structure of Blood Vessels

Properties of Veins

- Collect blood from capillaries
- Merge into medium-sized veins
- Merge then into large veins
  - Blood pressure is low here
  - *Valves* keep blood flowing toward the heart



Circulatory Physiology

Factors Affecting Blood Flow

- *Pressure*
  - Flow goes *up* as pressure difference goes *up*
  - Flow goes from higher to lower pressure
    - Remember where pressure is highest and lowest in the cardiovascular system!
  - Regulated by nervous and endocrine systems
- *Peripheral resistance*
  - Flow goes *down* as resistance goes *up*

Circulatory Physiology

Control of Peripheral Resistance

- Consists of three components:
  - Vascular resistance
    - Goes up as diameter is reduced
      Arteriole diameter is the main factor in vascular resistance
    - Goes up as vessel length increases
  - Viscosity of blood
    - Depends on *hematocrit*
  - Turbulence
    - Cause of pathological sounds

Circulatory Physiology

Pressures in the Systemic Circuit

- Arterial pressure
  - Overcomes peripheral resistance to maintain flow to the organs
  - Rises during ventricular systole
  - Falls during ventricular diastole
  - *Pulse pressure* is difference between systolic pressure and diastolic pressure
    - Lessens with distance from heart
- Capillary pressure
  - Excessive pressure causes *edema*
- Venous pressure
  - Low pressure that drives venous return
  - Affects cardiac output and peripheral flow

Circulatory Physiology

Pressures Within the Circulatory System

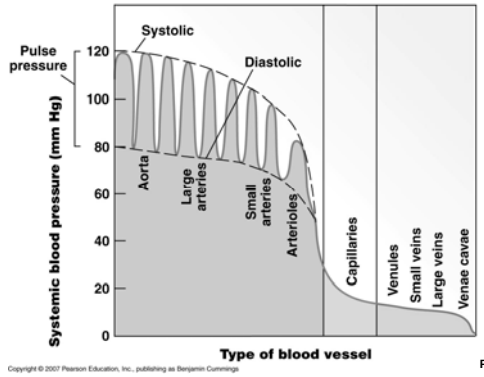


Figure 13-6

Circulatory Physiology

Checking the Pulse and Blood Pressure

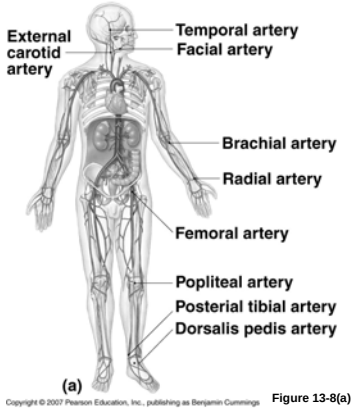


Figure 13-8(a)

Circulatory Physiology

Functions of Capillary Exchange

- Maintain communication between plasma and interstitial fluid
- Speed the distribution of nutrients, hormones, and dissolved gases
- Flush antigens to lymphoid tissue
- Aid movement of proteins

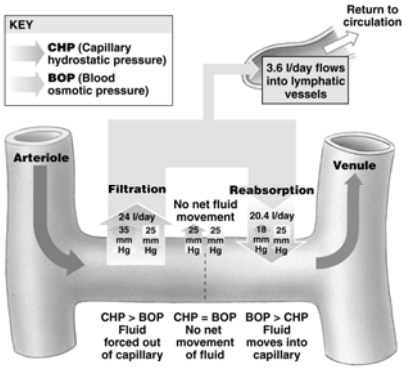
Circulatory Physiology

Dynamics of Capillary Exchange

- Small molecules diffuse across endothelium
- Water follows osmotically
- Balance of forces determines *direction* of filtration
  - Capillary pressure forces fluid *out*
  - Protein osmotic pressure pulls fluid *in*

Circulatory Physiology

Forces Acting Across Capillary Walls



Circulatory Physiology

Factors Assisting Venous Return

- Low venous resistance
- Valves in veins
- Compression of veins by muscular contraction
- Respiratory pump pulls blood into thorax
- Atrial suction, as the atria relax, pressure within the atria may drop below zero
  - This just increases the pressure differential and aids in flow

Circulatory Physiology

Key Note

Blood flow is the goal. Total peripheral blood flow is equal to cardiac output. Blood pressure is needed to overcome friction to sustain blood flow. If blood pressure is too low, vessels collapse, blood flow stops, and tissues die; if too high, vessel walls stiffen and capillary beds may rupture.

Cardiovascular Regulation

Factors Affecting Tissue Blood Flow

- Cardiac output
  - Recall – C.O. = S.V. x H.R. (bpm)
- Peripheral resistance
  - Arteriole diameter, vessel length
- Blood pressure
  - Determined by blood volume, viscosity and peripheral resistance

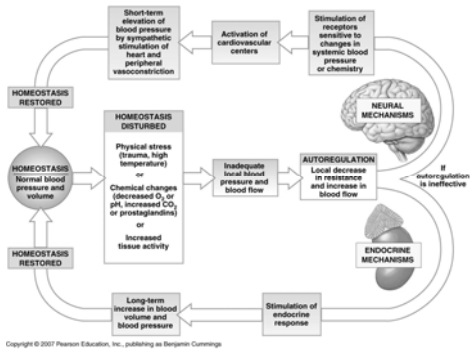
Cardiovascular Regulation

Homeostasis of Tissue Perfusion

- *Autoregulation*
  - Local control of pre-capillary sphincters
- CNS control
  - Responds to blood pressure, blood gases
- Hormone control
  - Short-term adjustments
    - Blood pressure
    - Peripheral resistance
  - Long-term adjustments
    - Blood volume

Cardiovascular Regulation

Local, Neural, and Endocrine Adjustments That Maintain Blood Pressure and Blood Flow



Cardiovascular Regulation

Neural Control of Blood Flow and Pressure

- *Baroreceptor reflexes*
  - Adjust cardiac output and peripheral resistance to maintain normal blood pressure
  - Driven by baroreceptors
    - *Aortic sinus*
    - *Carotid sinus*
    - *Atrial baroreceptors*
- *Chemoreceptor reflexes*
  - Respond to changes in CO_2, O_2 and pH
  - Sense blood and cerebrospinal fluid
  - Impact cardioacceleratory, cardioinhibitory and vasomotor centers

Baroreceptor reflexes

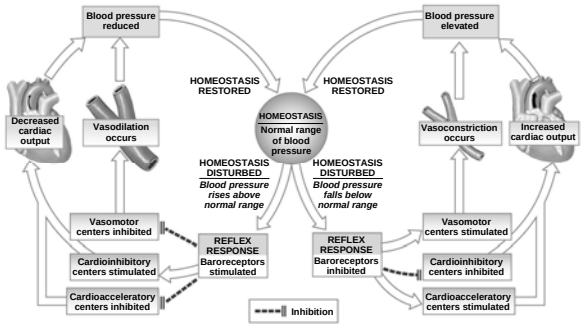


Figure 13-10
1 of 12

Chemoreceptor reflexes

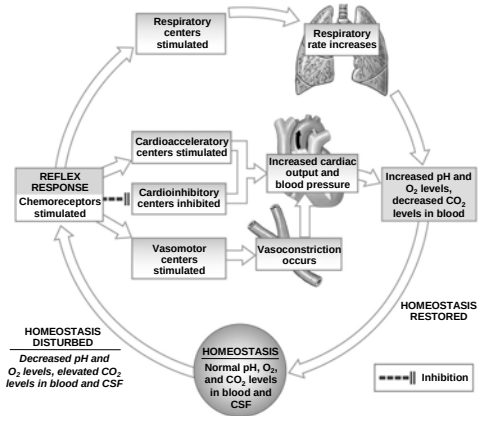


Figure 13-11
1 of 6

Cardiovascular Regulation

The Hormonal Regulation of Blood Pressure and Blood Volume

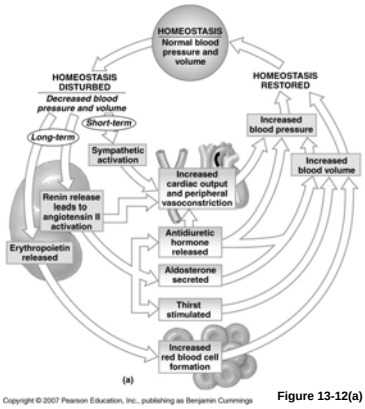


Figure 13-12(a)

Cardiovascular Regulation

The Hormonal Regulation of Blood Pressure and Blood Volume

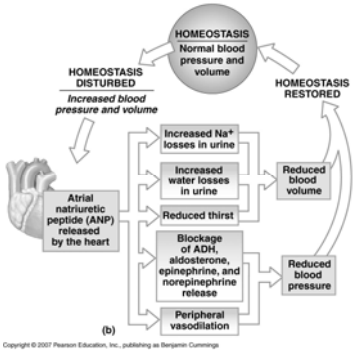


Figure 13-12(b)

Cardiovascular Regulation

Hormonal CV Regulation

- Short-term regulation
  - Epinephrine from adrenal medulla
  - Cardiac output and peripheral resistance
- Long-term regulation
  - Antidiuretic Hormone (ADH)
  - Angiotensin II
  - Erythropoietin (EPO)
  - Atrial natriuretic peptide (ANP)

Cardiovascular Regulation

Hormone Effects on CV Regulation

- ADH, angiotensin II promote vasoconstriction
- ADH, aldosterone promote water, salt retention
- EPO stimulates RBC production
- ANP promotes sodium, water loss

Patterns of CV Response

Exercise and the Cardiovascular System

- Cardiac output rises
- Blood flow to skeletal muscle increases
- Flow to non-essential organs falls
- Exercise produces long-term benefits
  - Larger stroke volumes
  - Slower resting heart rates
  - Greater cardiac reserves

Patterns of CV Response

Response to Hemorrhage (Blood Loss)

- Increase in cardiac output
- Mobilization of venous reserves
- Peripheral vasoconstriction
- Release of hormones that defend blood volume

The Blood Vessels

A Flow Chart Showing the Arterial Distribution to the Head, Chest, and Upper Limbs

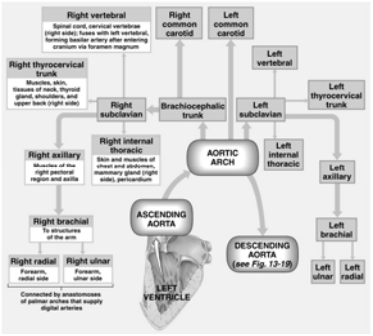


Figure 13-17

The Blood Vessels

Major Arteries of the Trunk

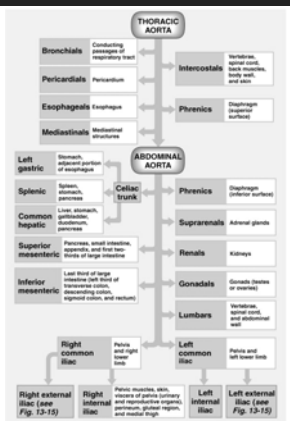


Figure 13-19(b)

The Blood Vessels

A Flow Chart of the Circulation to the Superior and Inferior Venae Cavae

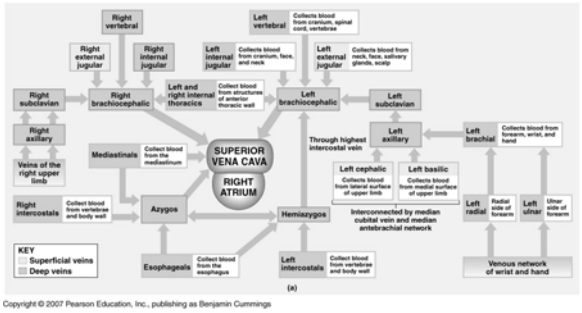


Figure 13-23(a)

The Blood Vessels

A Flow Chart of the Circulation to the Superior and Inferior Venae Cavae

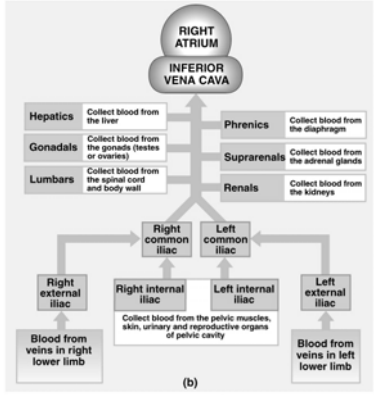


Figure 13-23(b)

The Blood Vessels

The Hepatic Portal System

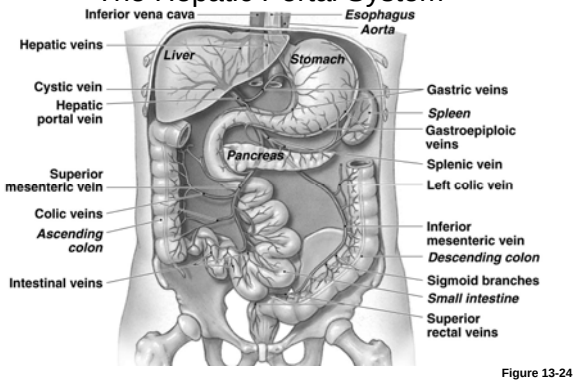


Figure 13-24

The Blood Vessels

Fetal Circulation

- Placenta
  - Receives two *umbilical arteries* from fetus
  - Drained by one *umbilical vein* to the fetus
    - Joins *ductus venosus* in liver

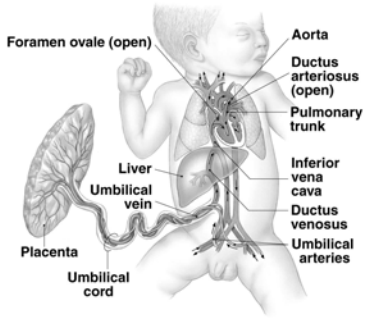
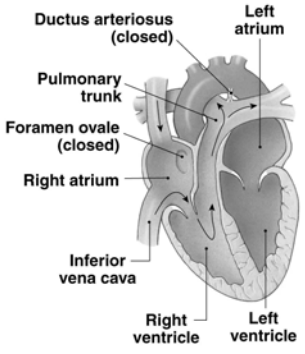


Figure 13-25(a)

The Blood Vessels

Fetal Circulation

- Pulmonary bypass
  - Lets blood flow skip the lungs
  - *Foramen ovale*
    - Between atria in *interatrial septum*
    - Becomes *fossa ovalis* in adult
  - *Ductus arteriosus*
    - Between pulmonary trunk and aorta
    - Becomes the *ligamentum arteriosum* in adult
  - Both pathways should close after birth



(b) After delivery

Aging and the CV System

Age Related Changes in the Blood

- Decreased *hematocrit*
- Vessel blockage by a *thrombus* (blood clot)
- Pooling in the legs resulting from faulty valves

Aging and the CV System

Age Related Changes in the Heart

- Reduction in maximal cardiac output
- Impaired nodal and conduction function
- Stiffening of *cardiac skeleton*
- Retricted coronary flow due to *atherosclerosis*
- Fibrous replacement of damaged myocardium

Aging and the CV System

Age Related Changes in Blood Vessels

- Embrittlement of arterial walls by *arteriosclerosis*
  - Increased risk of aneurism
- Calcium deposits in lumen
  - Increased risk of thrombus
- *Thrombus* formation at *atherosclerotic* plaques