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
  - Less than 1 lb.
Figure 11.1

The Heart
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

- Brachiocephalic artery
- Superior vena cava
- Right pulmonary artery
- Ascending aorta
- Pulmonary trunk
- Right pulmonary veins
- **Right atrium**
  - Right coronary artery (in right atrioventricular groove)
  - Anterior cardiac vein
- **Right ventricle**
  - Marginal artery
  - Small cardiac vein
  - Inferior vena cava
  - (a)
- Left common carotid artery
- Left subclavian artery
- Aortic arch
- Ligamentum arteriosum
- Left pulmonary artery
- Left pulmonary veins
- **Left atrium**
  - Auricle
  - Circumflex artery
  - Left coronary artery (in left atrioventricular groove)
- **Left ventricle**
  - Great cardiac vein
  - Anterior interventricular artery
  - Apex

Figure 11.2a  
Slide 11.5
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
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

Operation of the AV valves

1. Blood returning to the heart fills atria, putting pressure against atroventricular valves; the atroventricular valves are forced open
2. As the ventricles fill, atroventricular valve flaps hang limply into ventricles
3. Atria contract, forcing additional blood into ventricles
4. Ventricles contract, forcing blood against atroventricular valve cusps
5. Atrioventricular valves close
6. Chordae tendineae tighten, preventing valve flaps from evert ing into atria

Operation of the semilunar valves

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

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

Figure 11.4 (a) AV valves open (b) AV valves closed
Valve Pathology

- Incompetent valve = backflow and repump
- Stenosis = stiff= heart workload increased
- May be replaced
- Lup Dub Heart Sound
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
Cardiac Pathology

- Rapid heart beat
- = Inadequate blood
- = Angina Pectoris
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 (right atrium)
    - Pacemaker
  - Atrioventricular node (junction of r&l atria and ventricles)
  - Atrioventricular bundle (Bundle of His)
  - Bundle branches (right and left)
  - Purkinje fibers
Heart Contractions

Superior vena cava

Sinoatrial node (pacemaker)

Atrioventricular node

Left atrium

Atrioventricular bundle (Bundle of His)

Right atrium

Bundle branches

Purkinje fibers

Interventricular septum

Figure 11.5
Electrocardiograms (EKG/ECG)

- Three formations
  - P wave: impulse across atria
  - QRS complex: spread of impulse down septum, around ventricles in Purkinje fibers
  - T wave: end of electrical activity in ventricles
Electrocardiograms (EKG/ECG) (cont.)

(b) A normal ECG recording

(c) Ventricular fibrillation
Pathology of the Heart

- Damage to AV node = release of ventricles from control = slower heart beat
- Slower heart beat can lead to fibrillation
- Fibrillation = lack of blood flow to the heart
- Tachycardia = more than 100 beats/min
- Bradychardia = less than 60 beats/min
The Heart: Cardiac Cycle

- Atria contract simultaneously
- Atria relax, then ventricles contract
- Systole = contraction
- Diastole = relaxation
Filling of Heart Chambers – the Cardiac Cycle

Figure 11.6
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, cont.

- CO = HR x SV
- 5250 ml/min = 75 beats/min x 70 mls/beat
- Norm = 5000 ml/min
- Entire blood supply passes through body once per minute.
- CO varies with demands of the body.
Cardiac Output Regulation

Parasympathetic nervous system controls (via vagus nerves)

Heart rate (beats/min)

Stroke volume (ml/beat)

Decreased venous return

Crisis has passed

High blood pressure or blood volume

Sympathetic nervous system activity

Hormones: epinephrine, thyroxine

Increased contractile force of cardiac muscle

Increased venous return

Decreased blood volume (hemorrhage)

Low blood pressure

Crisis stressors (physical or emotional trauma, increased body temperature; exercise)

Activation of skeletal muscle and respiratory “pumps”

Exercise

KEY:
- Promotes/enhances
- Reduces

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
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
- In Congestive Heart Failure the heart is worn out and pumps weakly. Digitalis works to provide a slow, steady, but stronger beat.
Congestive Heart Failure (CHF)

• Decline in pumping efficiency of heart
• Inadequate circulation
• Progressive, also coronary atherosclerosis, high blood pressure and history of multiple Myocardial Infarctions
• Left side fails = pulmonary congestion and suffocation
• Right side fails = peripheral congestion and edema
Blood Vessels: The Vascular System

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

- Arterial pulse
- Blood pressure
- Respiratory Rate
- Body Temperature
- All indicate the efficiency of the system
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