The Cardiovascular System

- Vessels and circulation

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

Blood Vessels: The Vascular System

Blood Vessels: Microscopic Anatomy

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

Blood Vessels: The Vascular System

Differences Between Blood Vessels

- Walls of arteries are the thickest
- Lumens of veins are larger
- Larger veins have valves to prevent backflow
- 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

Blood Vessels: The Vascular System

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
Capillary Beds

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

The Heart

Major Arteries of Systemic Circulation
- Arterial branches of the aorta 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
    - In the axilla, the subclavian artery becomes the axillary artery → brachial artery → radial and ulnar arteries

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

20  **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

21  **Major Arteries of Systemic Circulation**

22  **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

23  **The Heart**

24  **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)

25  **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

26  **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

27  **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

### 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

### 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

### Arterial Supply of the Brain
- Posterior cerebral arteries form from the division of the basilar artery
  - These arteries supply the posterior cerebrum

### 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
- 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)
Fetal Circulation

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

Hepatic Portal Circulation

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

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

Comparison of Blood Pressures in Different Vessels

Measuring Arterial Blood Pressure

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
51 **Blood Pressure: Effects of Factors**
- Neural factors
  - Autonomic nervous system adjustments (sympathetic division)
- Renal factors
  - Regulation by altering blood volume
  - Renin—hormonal control

52 **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

53 **Factors Determining Blood Pressure**

54 **Variations in Blood Pressure**
- Normal human 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

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

56 **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

57 **Capillary Exchange: Mechanisms**

58 **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

59 **Fluid Movements at Capillary Beds**

60 **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