Functions of Circulatory System
• Carry O₂, nutrients, and hormones to cells throughout the body
• Transport white blood cells throughout the body
• Remove CO₂ and waste products from the body

Overview of Blood Circulation (c 102)
• Systemic circulation
  o Oxygen-rich blood leaves the heart via arteries that branch repeatedly until they become capillaries
  o Oxygen (O₂) and nutrients diffuse across capillary walls and enter tissues
  o Carbon dioxide (CO₂) and wastes move from tissues into the blood
  o Oxygen-deficient blood leaves the capillaries and flows through veins to the heart
• Pulmonary circulation
  o Oxygen-deficient blood leaves the heart and flows to the lungs where it releases CO₂ and picks up O₂
  o The oxygen-rich blood leaves the lungs and returns to the heart, where the whole process repeats

Cardiovascular Overview
• Circulation of Blood
  o Systemic circulation moves blood between the heart and the rest of the body.
  o Pulmonary circulation carries blood between the heart and the lungs.
• Heart
  o Contains four muscular chambers:
    - Right atrium and right ventricle
    - Left atrium and left ventricle

Blood Vessels (c 103)
• 60,000 miles of arteries and veins
• Arteries
  o Carry blood away from heart.
  o Up to 1 inch (2.5 cm) in diameter.
  o Branch into smaller units called arterioles (30 µm).
• Veins
  o Carry blood toward heart.
  o Walls thinner than those of arteries.
  o One-way valves prevent backflow.
  o Branch from smaller vessels called venules.
• Capillaries
  o Single layer of endothelial cells (8 µm).
  o Interconnected networks called capillary beds.
  o Contact tissue cells and directly serve cellular needs.

Capillary Anatomy
• Capillary Beds
  o Arteries and veins interconnect and exchange blood at capillary beds.
  o RBCs squeeze through in single file.
• Capillaries: Exchange of Interstitial Fluid
  o Fluid diffuses out from arterial capillaries.
  o Driving force—Blood pressure from heart contraction.
  o No cell further than 2 or 3 cells away;
  o Pick up oxygen, glucose, and other nutrients and remove carbon dioxide and nitrogenous waste.
  o Interstitial fluid picked up again by venous end of capillary bed due to osmosis; higher concentration of proteins within venous capillaries.
Systemic Circulation

- Muscles and venous valves in limbs work to return blood to heart.
  - Muscle contractions in extremities squeeze veins, pushing blood within.
  - Blood can flow only toward heart because of one-way valves in veins.

VAVA-VAVA (c 105)

- Vena Cava
- Atrium R
- Ventricle R
- Artery Pulmonary
- LUNGS
- Vein Pulmonary
- Atrium L
- Ventricle L
- Aorta

The Heart

- Cardiac muscle, nonvoluntary
- Cardiac conduction system
- R Atrium, R Ventricle, L Atrium, L Ventricle

Major Vessels of the Heart

- Vessels returning blood to the heart include:
  - Superior and inferior vena cava (systemic)
  - Right and left pulmonary veins (pulmonary)
- Vessels conveying blood away from the heart include:
  - Pulmonary trunk, which splits into right and left pulmonary arteries
  - Ascending aorta (three branches) – brachiocephalic, left common carotid, and subclavian arteries

Heart Valves Control Blood Flow

- One-way valves — Blood flow in single direction from atria to ventricles; prevent backflow when ventricles contract.
- One-way valves between ventricles and arteries prevent backflow when ventricles contract.
- “Lub” sound in heartbeat made when valves between atria and ventricles close;
- “Dub” sound produced by closing of valves between ventricles and arteries.
- Valves may be damaged due to disease/genetic abnormality; “heart murmur” occurs as some blood flows back into atrium.

Heart Valves

- Heart valves ensure unidirectional blood flow through the heart
- Atrioventricular (AV) valves lie between the atria and ventricles. Prevent backflow into the atria when ventricles contract
- Semilunar valves lie between the ventricles and vessels
  - Aortic semilunar valve lies between the left ventricle and the aorta
  - Pulmonary semilunar valve lies between the right ventricle and pulmonary trunk
  - Semilunar valves prevent backflow of blood into the ventricles

Blood Pressure

- Baroreceptors
- Systole (contraction) vs. Diastole (relaxation)
- ‘120/80 = normal pressure
- 140/90 = high blood pressure

Coronary Circulation

- Heart attack — Blood supply to heart muscle reduced due to blockage or narrowing of arteries that supply blood to heart.
- Plaques in coronary arteries reduce diameter, reducing or cutting off blood supply to cardiac cells (myocardial cells).
- Myocardial infarction — Cells receive insufficient oxygen, start to die.
- Oxygen-starved heart muscle, unable to contract strongly, produces irregular rhythm (ventricular fibrillation).
- May stop contracting altogether, resulting in sudden death.
Nature of Blood (c 101)
- 4-6 liters of it in human body (7% of body weight)
- 38°C (100.4 °F)
- pH 7.4 (6.95=death, 7.7=convulsions)
- Five times more viscous than water
- Composed of
  - liquid plasma (55%)-92% water, 100 solutes
  - formed elements (45%)
    - Red Blood Cells (RBCs)--99.9%
    - White Blood Cells (WBCs)
    - Platelets

Blood Composition (c 101)

- **Red Blood Cells: Erythrocytes**
  - Each RBC contains 280 million molecules of iron-binding protein, hemoglobin, and 1 billion O₂ molecules.
  - Life span of 120 days (700 miles)
  - Every minute, 1 round trip and 180 million new ones
  - 1/3 of all human cells
  - No nuclei, ribosomes, or mitochondria (don’t use O₂)
  - All produced in (Red) Bone Marrow

- **White Blood Cells: Leukocytes**
  - Most found in body’s tissues, rather than blood.
  - Play role in immune defense and repair of tissues.
  - Can exit blood vessels by squeezing between cells of vessel walls.
  - Types: Granulocytes (Neutrophils, Eosinophils, Basophils), Agranulocytes (Lymphocytes (25% of WBCs), Monocytes
  - Problems: leukemia
  - Some produced in (Yellow) Bone Marrow

- **Platelets: Cell Fragments**
  - Clump together at sites of injury to form plug that slows bleeding.

Veins and Arteries (c 110-111, 118)

- **Arteries**
  - Head – carotid, occipital temporal
  - Arms – subclavian, axillary, brachial, ulnar, radial
  - Legs – iliac, gluteal, femoral, popliteal, tibial (ant/post)
  - Torso – Aorta, Pulmonary, celiac, superior mesenteric, renal, gonadal, inferior mesenteric

- **Veins**
  - Head – jugular
  - Arms – subclavian, axillary, brachial, basilic, cephalic
  - Legs – iliac, gluteal, femoral, saphenous, popliteal, tibial (ant/post)
  - Torso – Pulmonary, Vena Cava (sup/inf), renal, hepatic portal

Effects of Tobacco

- **Adverse Lipid Profile**: Nicotine increases bad fats (LDL, cholesterol, triglycerides) and decreases good fats (HDL) in bloodstream, resulting in blood vessel narrowing and thus an increased risk for stroke, heart disease, and heart attack.
- **Atherosclerosis**: Nicotine and other cigarette chemicals cause plaques to form on blood vessel walls, reducing blood flow and elasticity. Just 30 minutes of exposure to 2nd-hand smoke reduces elasticity of coronary vessels in nonsmokers.
- **Thrombosis**: highly increased rate of clot formation. Sudden death is 4 times more likely to occur in a smoker than a nonsmoker for this reason.
- **Blood vessel constriction**: smoking decreases nitric oxide (which expands vessels) and increases ET-1 (which contracts vessels), thus constricting vessels. Consider: plaques plus clots plus constriction…
- **Increased heart rate and BP**: a heart that is working harder is a heart that tires faster. Increased pressure damages organs where blood is filtered (e.g. kidneys).
- **Reduced oxygen carrying capacity** of blood due to carbon monoxide adhering to hemoglobin
Respiratory System

Functions of Respiratory System
• Capture oxygen; dispose of carbon dioxide.
• Defend against invasion of airborne microorganisms.
• Produce sounds that make speech possible.
• Regulate blood volume and pressure.
• Assist in controlling body fluid pH.

Respiratory System Anatomy (c 129)
• Nasal Cavity
• Pharynx (throat)
• Larynx (Vocal folds)
• Pleural cavity: Lungs, Trachea, Bronchii, Bronchioles, Alveoli
• Muscles (c 135)
  o Diaphragm (75% of inhalation effort, increases thoracic cavity volume in downward direction)
  o External Intercostals (brings sternum anterior and superior), Scalenes, and Serratus Posterior Superior
  o Exhalation via Internal Intercostals, Obliques, Serratus Posterior Inferior, and Quadratus Lumborum

Alveoli
• Respiratory bronchioles lead to alveolar ducts, then to terminal clusters of alveolar sacs composed of alveoli
• Approximately 300 million alveoli: Account for most of the lungs’ volume.

Steps in Respiration
• Pulmonary ventilation: respiratory cycle of movement of air into/out of lungs.
  – Inhalation (Inspiration)
    • Contraction of diaphragm & external intercostals enlarge thoracic cavity.
    • Drop in pressure brings air into lungs.
    • Tidal Volume (half liter) & lung capacity (6 liters)
  – Exhalation (Expiration)
    • Respiratory muscles relax, elastic fibers in lung tissue recoil, reducing thoracic cavity.
    • Lungs expel air due to higher air pressure within.
• External respiration: gas exchange between the lungs and the blood
• Transport: transport of oxygen and carbon dioxide between the lungs and tissues
• Internal respiration: gas exchange between systemic blood vessels and tissues

Lung Volume
• Tidal Volume = amount of air exchanged in one breath
• Normal tidal vol = 500 ml. (150 ml left in lungs)
• Full inhale = 3.5 liters more than normal inhale. Full exhale = 1 liter more than normal exhale
• Total lung capacity = 6 liters

Effects of Tobacco
• Bronchospasm: irritated airways tighten.
• Increased Phlegm Production: Normally, mucus traps chemical and toxic substances, and the cilia, along with coughing, clears this mucus from the lungs. Tobacco paralyzes cilia and increases mucus production.
• Persistent Cough: In smokers, increased mucus production plus no help from cilia leaves coughing as the only means of clearing the lungs.
• Decreased Physical Performance: In smokers, bronchospasm plus increased phlegm production equals airway obstruction, which results in poor physical performance.
• Pneumonia: swelling of inner lining of lungs, resulting in accumulation of fluid deep in the lungs, much to the delight of common bacteria that smokers are already more susceptible to without cilia activity.
• Also Chronic Obstructive Pulmonary Disease (COPD), including emphysema and bronchitis.
• Lung cancer.
Lymphatic System Composition
- Lymph (similar to plasma)
- Lymphatic vessels (from tissues to veins)
- Lymphocytes (T-cells, B-cells, NK cells)
- Lymphoid Tissues (includes tonsils)
- Lymphoid Organs (nodes, thymus, spleen)

Lymphatic System Functions
- Produce, maintain, and distribute lymphocytes
  - (produced and stored in spleen, thymus, and marrow)
- Return of fluid and solution from tissues to blood
  - Safety net--catches what capillaries miss
- Distribute hormones, nutrients, and waste products from origin of circulation (Ex: lipids)
- Combined with other systems = immune system

Lymphatic Vessels (c 121)
- Capillaries
  - Not present in bone marrow, CNS, and nonvascular tissues
  - Walls like one-way valves
  - Interstitial fluid, osmotic pressure, hydrostatic pressure
- Small
  - One-way valves
  - More numerous than veins, but smaller
- Major
  - Thoracic duct
    - From everywhere below diaphragm and leftside above diaphragm to left subclavian vein
  - Right lymphatic duct
    - Upper right to right subclavian vein

Lymphocytes
- Represents 20-30% of white blood cells
- Most don’t circulate
- 10’12, 1kg in body
- Provide specific defense (immune response)
- Respond to
  - Invading pathogens (bacteria and viruses)
  - Abnormal body cells (infected or cancer cells)
  - Foreign proteins (toxins from bacteria)
- Types
  - Cytotoxic
  - Helper
  - Suppressor

Lymphocyte Types (c 122)
- T cells
  - From thymus
  - 80% of lymphocytes
  - 30 min in blood, 5-6 hrs in spleen, 15-20 hrs in lymph node
- B cells
  - From bone marrow
  - 10-15%
  - Change to plasma cells
  - Produce and secrete antibodies, which bind to antigens
- NK cells (natural killer)

Imune Response
- Nonspecific (fever, inflammation, constriction, etc)
- Specific
  - Cell-mediated (T-cells, phagocytes)
  - Antibody mediated (B-cells)

Lymphatic Tissues (c 127)
- MALT & Peyer’s Patches (in intestines)
- Tonsils (5, including adenoid)
- Appendix

Lymphatic Organs (c 122)
- Lymph nodes
  - ‘swollen glands’--extra lymphocytes
  - Filters 99% of antigens out
  - Groin, Axillae, Base of neck
- Thymus
  - Produces T-Cells
  - Maximum size before puberty
- Spleen
  - Filters blood
  - Stores iron
  - Initiates immune response

Laughter
- Increases T cells, B cells, NK cells, gamma interferone, salivary immunoglobulin A, lung capacity, blood oxygen levels, diaphragm strength
- Decreases epinephrine and cortisol

Effects of Tobacco
- Otitis Media: second-hand smoke significantly interferes with normal clearing mechanism in middle ear (behind ear drum), resulting in infections and possible hearing loss. Common in children of smokers.
- Sinusitis: smoking paralyzes cilia that line the sinuses and keep it clean, resulting in swelling and infection, which leads to fever, sore throat, bad breath, running nose, etc.
- Rhinitis: paralysis of cilia in nose results in swelling and infection. Effects are immediate and long-lasting.
- Influenza: smokers have it more often, more severely, and for longer periods of time.