Biology 112
Study Notes Exam 5

Chapter 13: Cardiovascular System

Introduction
Cardiovascular system: a pump (the **heart**) that delivers blood to vessels (**arteries**) that circulate blood throughout the body; materials in blood are exchanged with cells through tiny vessels (**capillaries**); blood is returned to the heart by another group of vessels (**veins**)

- **pulmonary circuit:** blood vessels that carry blood to & from the lungs
  - sends deoxygenated blood to lungs to pick up oxygen & unload carbon dioxide
- **systemic circuit:** blood vessels that carry oxygenated blood to body tissues & return deoxygenated blood with wastes to heart

Structure of Heart
- heart size varies; an average adult heart is about 14 cm long x 9 cm wide
- heart is within *mediastinum*; bordered laterally by lungs, posteriorly by vertebral column & anteriorly by sternum
- extends 12-14 cm within mediastinum, from 2nd rib to 5th intercostal space
- ***base***: attaches to large vessels; superior/posterior aspect of heart
- ***apex***: pointed inferiolateral aspect of heart; pointed slightly to left
- **pericardium**: double-walled sac enclosing heart
- ***fibrous pericardium:*** outer dense connective tissue layer
  - anchors heart to surrounding structures (diaphragm, vessels)
- ***serous pericardium:*** deep to fibrous pericardium
  - ***parietal layer:*** lines internal surface of fibrous pericardium
  - ***visceral layer (epicardium)*** – deep to parietal layer; outer layer of heart wall
- *skeleton of the heart:* fibrous connective tissue anchored to vessels & septum; strengthens & holds tissue together

Layers of heart wall:
- **epicardium**: visceral layer of serous pericardium; often accumulates fat
- **myocardium**: cardiac muscle deep to epicardium; bulk of heart tissue
  - branched cardiac muscle cells linked by connective tissue fiber bundles (collagen & elastin) – fibrous skeleton of heart
- **endocardium**: thin inner myocardial surface; sheet of endothelium (squamous epithelium) resting on connective tissue
- lines chambers & valves; continuous with endothelial linings of major vessels

Heart Chambers & Valves
- **atria**: upper chambers; receiving chambers for blood
  - ***auricles***: small protruding appendages that slightly increase atrial volume

    - ***right atrium*** receives deoxygenated blood from ***superior vena cava*** (from areas above diaphragm), ***inferior vena cava*** (from areas below diaphragm), & ***coronary sinus*** (from myocardium)
    - ***left atrium*** receives oxygenated blood from ***pulmonary veins*** (4, from lungs)
- **ventricles**: lower chambers; discharging (pumping) chambers for blood
    - ***papillary muscles***: conelike muscle bundles in ventricular cavity; attached to tendon (*chordae tendineae*) that play a role in valve function
    - ***right ventricle*** pumps blood into ***pulmonary trunk*** (to lungs)
    - ***left ventricle*** pumps blood into ***aorta*** (to systemic circulation/body tissues)
- ***septum***: separates atria & ventricle on left side from right side
- **atrioventricular (AV) valves**: prevent backflow of blood from ventricles to atria
    - ***tricuspid valve***: right AV valve; has 3 cusps (flaps of endocardium reinforced with CT)
    - ***bicuspid (mitral) valve***: left AV valve
    - *chordae tendineae*: collagen cords attached to AV valve flaps; anchor cusps to papillary muscles
- **semilunar (SL) valves**: prevent backflow of blood from great vessels to ventricles
    - ***aortic valve***: prevents blood from flowing back into *left* ventricle following ventricular contraction
    - ***pulmonary valve***: prevents blood from flowing back into *right* ventricle following ventricular contraction

Pathway of blood through heart:
- **pulmonary circuit:** blood vessels that carry blood to & from the lungs
- **systemic circuit:** blood vessels that carry oxygenated blood to & from body tissues
- **superior & inferior vena cava and coronary sinus → right atrium → (tricuspid valve) → right ventricle → (pulmonary semilunar valve) → pulmonary trunk → pulmonary arteries → lungs → pulmonary veins → left atrium → (bicuspid valve) → left ventricle → (aortic semilunar valve) → aorta → body tissues**

Coronary Circulation: functional blood supply of heart (myocardium)
- ***coronary arteries***: arise from the base of the *aorta*; carry oxygenated blood to myocardium of atria & ventricles
- ***cardiac veins***: carry deoxygenated blood from myocardium to ***coronary sinus***, which empties into *right atrium*
- proper circulation (constant blood supply) to myocardium is critical; blockage of coronary arterial circulation can be serious/fatal
    - ***collateral circulation***: smaller branches of coronary arteries have connections (anastomoses) for alternate blood pathways
    - *angina pectoris*: chest pain due to short block of blood supply to myocardium
    - ***myocardial infarct (MI, heart attack or coronary)***: can result from prolonged blockage

Heart Actions & Cardiac Cycle
- **Cardiac cycle**: all events associated with blood flow through heart
    - ***systole***: contraction

- ***diastole***: relaxation (dilation or expansion)
- sequence:
  - ventricular filling (mid to late ventricular diastole)/atrial systole
  - ventricular systole/atrial diastole
  - early ventricular diastole
  - relaxation

- **Heart sounds**: lub-dup sound
  - ***AV valves close*** (lub)**; *SL valves close*** (dup)
  - ***murmurs***: sounds often indicative of valve problems

Cardiac Conduction System

- **sequence of excitation**:
  - **sinoatrial (SA) node**: ***autorhythmic cells*** here are the fastest to generate impulses (~75/min, called sinus rhythm); hence, this is the heart's **pacemaker**
  - **atrioventricular (AV) node**: receives impulses from SA node; fewer connections between cells delay impulse long enough for atria to complete contraction; also autorhythmic cells here, but slower impulses (~50-60/min, called junctional rhythm), so these cells do not set the pace unless there is damage to SA node cells
  - **atrioventricular (AV) bundle (bundle of His)**: electrical connection between atria & ventricles; transmits impulse to ventricles
  - **right & left bundle branches**: sends impulse along cells of interventricular septum toward apex
  - **Purkinje fibers**: extend from inferior aspect of interventricular septum to apex & into outer walls of ventricles

- **Electrocardiography**
  - ***Electrocardiograph***: measures electrical currents generated during heart contraction with a series of electrodes placed on 12 body regions
  - **Electrocardiogram (ECG or EKG)**: recording from electrocardiograph
    - ***P wave***: atrial depolarization
    - ***QRS complex***: ventricular depolarization
    - ***T wave***: ventricular repolarization
    - P-Q interval: beginning of atrial depolarization until beginning of ventricular depolarization
    - Q-T interval: beginning of ventricular depolarization until beginning of ventricular repolarization

- **Regulation of heart rate**:
  - ***Sympathetic division of ANS***: increases heart rate
    - stimulated by cardioacceleratory center in medulla oblongata
  - ***Parasympathetic division of ANS*** (vagus nerve): decreases heart rate
    - stimulated by cardioinhibitory center in medulla oblongata
  - **hormones**:
    - ***epinephrine*** & ***norepinephrine***: increases heart rate
    - *thyroxine*: slow sustained increase in heart rate
  - *ions*: calcium, sodium & potassium

Blood Vessels

Structure of Blood Vessel Walls:

- **tunica interna (*tunica intima)***: innermost tunic (layer)
  - endothelium (simple squamous epithelium) lining lumen of all vessels
- **tunica media**: middle tunic
  - mostly smooth muscle cells & sheets of elastin fibers
  - generally thickest layer in arteries
  - smooth muscle innervated by vasomotor fibers of sympathetic division of ANS
    - **vasoconstriction**: reduced lumen diameter due to smooth muscle contraction
    - **vasodilation**: increase in lumen diameter due to smooth muscle relaxation
- **tunica externa (*tunica adventitia*)**: outermost tunic
  - mostly loose collagen fibers; protect & reinforce vessel wall & anchor it to surrounding structures
  - contains nerve fibers, lymphatic vessels, & elastin in larger veins

Arteries: transport blood <u>*away from*</u> the heart

- ***elastic (conducting) arteries***: thick-walled arteries near heart (aorta & branches)
- ***muscular (distributing) arteries***: branch from elastic arteries to distribute blood to body organs; includes most named arteries
- ***arterioles***: vary in size; lead from muscular arteries to capillary beds
  - blood flow into capillary beds determined by arteriole diameter
  - if arterioles constrict, tissue is largely bypassed

Capillaries: smallest blood vessels; exchange materials (gases, nutrients, hormones, etc.) in blood with tissues

- only tunica interna (endothelium)
- ***microcirculation***: flow of blood from arteriole to venule
- ***precapillary sphincter***: at root of metarteriole & capillary; acts as valve to regulate blood flow into capillary (constricts to send blood through bed (using vascular shunt))
- capillary exchange of respiratory gases & nutrients: oxygen, carbon dioxide, most nutrients & cellular wastes pass between blood & interstitial fluid by ***diffusion***
- ***fluid movement***: pressure & capillary pores allow fluid to leave capillaries at arterial end of capillary bed, but most returns at venous end
  - **hydrostatic pressure**: force exerted by fluid pressing against a wall
    - in capillaries, same as capillary blood pressure
    - *capillary hydrostatic pressure* tends to force fluids through capillary walls
    - *interstitial fluid hydrostatic pressure* pushes fluid back in
- colloid osmotic pressure: large non-diffusible molecules (proteins) draw fluid toward them through osmosis
  - capillary colloid osmotic pressure: large molecules cannot move through capillary membrane; draw fluid in

Veins: transport blood <u>*toward*</u> heart

- ***venules***: smallest veins; range from postcapillary venules (only tunica interna) to larger venules with additional one or two layers of smooth muscle cells & thin tunica externa

- ***veins***: large vessels with all 3 tunics; vessel walls smaller & larger lumens than corresponding arteries
    - *capacitance vessels (blood reservoirs)*: at any given time, most blood in the body is within veins
    - ***venous valves:*** formed from folds of tunica externa; flaps that prevent backflow of blood, especially in limbs

Systemic Blood Pressure: blood pressure = cardiac output x peripheral resistance
- measured from *brachial artery* with ***sphygmomanometer***
    - uses *auscultatory method* (listening for filling of artery as pressure in cuff drops below arterial pressure)
    - normal resting ranges: systolic BP: 110-140 mm Hg; diastolic BP: 75-80 mm Hg
    - **hypotension**: low blood pressure (systolic BP below 100 mm Hg)
    - **hypertension**: high blood pressure (sustained arterial pressure > 140/90)
- ***systolic pressure***: pressure generated in aorta following (left) ventricular systole (~120 mm Hg)
- ***diastolic pressure***: pressure in aorta following ventricular diastole (70-80 mm Hg)
- ***pulse pressure***: systolic pressure – diastolic pressure
- **cardiac output (CO)**: CO = Stroke Volume (SV) x Heart Rate (HR)
    - normal resting values: SV = 70 ml/beat; HR = 75 beats/min; CO = 5250 ml/min
- ***resistance***: opposition to blood flow (friction)
    - ***peripheral resistance (PR)***: resistance in systemic circulation; contributed by ***blood vessel diameter, blood viscosity & blood vessel length***
    - ***blood viscosity***: thickness of blood; more viscosity = greater resistance
    - ***blood vessel length***: longer vessel length = greater resistance
        - ***blood vessel diameter***: most likely to alter resistance; decreased diameter = greater resistance
        - smooth muscle fibers control blood vessel diameter

Maintaining Blood Pressure:
- **Short Term Regulation**
    - ***neural controls***:
        - vasomotor center: sympathetic neurons in ***medulla oblongata*** integrate blood pressure control by altering cardiac output & blood vessel diameter
        - baroreceptor-initiated reflexes: **baroreceptors** = pressure-sensitive mechanoreceptors that respond to changes in arterial pressure & stretch
        - chemoreceptor-initiated reflexes: ***chemoreceptors*** respond to changing blood levels of oxygen, carbon dioxide & acidity
        - higher brain centers: hypothalamus (e.g.: fight or flight response) via medulla
    - ***chemical controls***:
        - adrenal medulla hormones; atrial natriuretic peptide (ANP); antidiuretic hormone; angiotensin II; nitric oxide (NO); inflammatory chemicals; alcohol
- **Long Term Regulation: Renal regulation**
    - direct renal mechanism: blood volume altered through filtration in kidneys
    - indirect renal mechanism: renin-angiotensin mechanism leads to aldosterone production

Systemic Circulation:

- **major systemic arteries**:
  - **aorta, aortic arch, descending aorta** (thoracic & abdominal aorta)
  - ***3 branches from aortic arch***: brachiocephalic artery, left common carotid artery & left subclavian artery
  - ***common carotid arteries***: serve head
    - *vertebral & internal carotid arteries* give off branches to form ***Circle of Willis*** in brain (several paths for blood to brain tissue)
  - ***subclavian arteries:*** serve arms
  - ***common iliac arteries***: branch to *internal iliac arteries* (serve pelvic organs) & *external iliac arteries* (serve legs)
- **major systemic veins**:
  - ***external & internal jugular veins***: drain blood from brain, head & neck
  - ***subclavian arteries***: drain blood from arms
  - ***brachiocephalic arteries***: receive blood from jugular & subclavian veins & enter ***superior vena cava***
  - ***hepatic portal vein***: receives blood from abdominal (digestive) organs & enters liver (metabolism & detoxification)
  - ***common iliac veins***: receive blood from *internal iliac veins* (from pelvic organs) & *external iliac veins* (from legs)
    - *common iliac veins* merge to form ***inferior vena cava***

Chapter 14: Lymphatic System & Immunity

Introduction/Functions of the Lymphatic System
- *draining excess interstitial fluid*: lymphatic vessels drain excess fluid from tissue spaces & return it to the blood
- *transporting dietary lipids*: lymphatic vessels transport lipids & lipid-soluble vitamins (A,D,E & K) absorbed by GI tract to the blood
- *carrying out immune responses*: lymphatic tissue initiates specific immune responses to microbes or abnormal cells

Lymphatic Pathways: lymphatic capillaries → lymphatic vessels → subclavian veins
- **lymphatic capillaries**: microscopic closed-ended tubes that extend into interstitial spaces & receive **lymph** through their walls
- **lymphatic vessels**: walls similar to veins (thinner) with valves to prevent backflow
- large lymphatic vessels pass through lymph nodes & merge into *lymphatic trunks*
- ***lymphatic trunks*** lead to 2 collecting ducts: thoracic duct & right lymphatic duct
- collecting ducts join **subclavian veins**

Tissue Fluid & Lymph
- tissue fluid is formed from blood plasma; includes smaller proteins (excludes large)
- increased protein concentration in tissue fluid increases ***colloid osmotic pressure***
- pressure increase forces some tissue fluid into lymphatic capillaries → **lymph**
- ***lymph*** returns proteins with fluid to bloodstream & transports foreign particles to lymph nodes
- movement of lymph is generally slow due to low pressure; contraction of skeletal muscles & pressure due to breathing accelerates lymph movement

Lymphoid Organs: Thymus & Spleen
Thymus: located in mediastinum above heart
- composed of lymphatic tissue subdivided into lobules
- size is large at birth; shrinks during aging following puberty
- T lymphocytes mature (become fully active) in the thymus; the mature T cells then may migrate to other lymphoid tissues to provide immunity

Spleen: located in upper left quadrant of abdominopelvic cavity; under diaphragm & posterolateral to stomach
- resembles large lymph node subdivided into lobules
- islands of *white pulp* contains lymphocytes; surrounding *red pulp* contains red blood cells & some leukocytes
- ***sinuses*** within splenic lobules filled with blood; spleen is primary site for red blood cell breakdown
- **macrophages** in spleen filter foreign particles & begin breakdown of damaged RBCs

Body Defenses Against Infection: ***innate (nonspecific) & adaptive (specific)***
- **pathogens** (bacteria, viruses, fungi, parasites, etc.) cause **infection**

Innate (Nonspecific) Defenses: includes species resistance, mechanical & chemical barriers, fever, inflammation & phagocytosis

- **species resistance**: each species is resistant to diseases that affect other species
- **mechanical barriers**: skin & mucous membranes; block entry of pathogens
- **chemical barriers**: enzymes & acid (low pH) in gastric juice kill pathogens; antimicrobials (lysozyme) in tears kills some pathogens
    - **interferons**: proteins released by virus-infected cells that stimulate uninfected cells to synthesize antiviral proteins
        - stimulates phagocytosis, blocks viral replication, enhances WBC activity & slows tumor growth
- **fever**: increase in body temperature due to infection
    - decreases blood iron level (slows bacterial growth) & increases phagocyte activity
- **inflammation**: tissue response to injury or infection
    - **4 signs**: localized redness, swelling, heat & pain
    - chemicals released by damaged tissues attract WBCs to site
    - *inflammatory mediators*: **histamine** from mast cells & basophils & other chemicals that cause vasodilation & increased blood vessel permeability
    - fibrous CT may form a sac around injured tissue & block pathogen spread
- **phagocytosis**: ***neutrophils*** & ***macrophages*** destroy bacteria & foreign particles
    - neutrophils enter infected tissue from blood; monocytes exit bloodstream & transform into macrophages that stay in tissues
    - phagocytes associated with lining of blood vessels, bone marrow, liver, spleen, lungs & lymph nodes

Adaptive (Specific) Defenses: immune responses to specific pathogens & unwanted cells by ***antibodies*** from **B lymphocytes & T lymphocytes**

- **antigens**: molecules (especially proteins) that provoke an immune response
    - during development, body learns to distinguish self antigens from nonself
    - nonself antigens combine with surface receptors on B cells & T cells and stimulate an immune reaction
    - ***haptens***: small molecules that need carrier (larger molecule) to become antigenic
- lymphocytes are produced in ***red bone marrow*** & released into blood
    - **T cells** mature in the ***thymus***
    - **B cells** mature in the ***bone marrow***
    - lymphatic tissues contain both T cells & B cells
- **T cells** interact with antigens *directly* → **cellular immune response**
    - T cells secrete ***cytokines*** (***interleukins***) that enhance cellular responses to antigens
    - T cells may also secrete toxic substances that destroy target cells
- **B cells** interact with antigens *indirectly* → **humoral immune response**
- T cells & B cells can form millions of different varieties to react against a wide variety of possible antigens
    - each individual variety can interact with only one specific antigen
    - members of each variety form a **clone**
- **T cells & cellular immune response**
    - T cells activate when an ***antigen-presenting cell (APC)*** displays a foreign antigen

- macrophages phagocytize pathogen or large antigen, partially digests proteins & displays antigens on cell surface in association with ***major histocompatibility complex (MHC or HLA)*** protein
- **helper T cell**: activated by binding antigen/HLA complex on APC
  - when helper T cell binds antigen/HLA complex on B cell, it releases **cytokines** that stimulate B cell & T cell proliferation & attracts macrophages for phagocytosis
- **cytotoxic T cells** recognize antigen/HLA complexes on **tumor cells or virus-infected cells** & destroy these cells with ***perforin*** proteins
- **memory T cells** respond quickly to subsequent antigen exposure

- **B cells & humoral immune response**
  - a B cell becomes ***activated*** when ***antigen*** binds to cell surface receptors; activation may be enhanced by *helper T cell stimulation*
  - an activated B cell generates a **clone** that produces ***memory B cells*** & ***plasma cells*** that secrete **antibodies**
  - **antibodies** bind to & generally inactivate the *antigen*
  - B cells & their antibodies can defend against millions of different antigens by forming different *antigen-binding sites* on antibodies
- **5 classes of antibodies (immunoglobulins)**
  - **antibodies** are soluble proteins consisting of 4 polypeptide chains (2 heavy chains, 2 light chains) that form a Y-shaped structure
  - each antibody has ***2 antigen-binding sites*** at *variable* regions of chains
  - **IgD**: B cell antigen receptor
  - **IgM**: pentamer in blood; first Ig class secreted; agglutinating agent; activates complement
  - **IgG**: most abundant antibody in blood; protects against bacteria, viruses & toxins; activates complement; crosses placenta
  - **IgA**: dimer found in secretions (mucus, saliva, sweat intestinal juice, milk), helps to prevent pathogens from entering body
  - **IgE**: normally rare in blood (increase during allergic reaction), binds to mast cells & basophils & causes release of histamine & other mediators of inflammation
- **antibody actions**
  - antibodies bind to antigens, activate complement, & stimulate tissue inflammation
  - antigen binding results in ***agglutination***, ***precipitation*** or ***neutralization***
  - activated **complement** attracts phagocytes, makes foreign cells more susceptible to phagocytosis & ruptures foreign cell membranes (***lysis***)
- **primary & secondary immune responses**
  - ***primary immune response*** is body's first response to antigen; ***antibodies*** are produced for several weeks & long-lived ***memory cells*** are produced
  - ***secondary immune response*** uses memory cells to react quickly to subsequent exposure to previously encountered antigen
- **practical classification of immunity**
  - ***active immunity***: produce own antibodies; ***passive immunity***: given antibodies
  - ***naturally acquired active immunity:*** produced through antigens from *infections*
  - ***artificially acquired active immunity:*** produced through antigens from *vaccines*
  - ***naturally acquired passive immunity:*** antibodies pass from *mother* to child

    - ***artificially acquired passive immunity:*** antibodies acquired from *immune serum*
- **allergic reactions**
    - ***allergic reactions*** are excessive immune responses to antigens (***allergens***) that may damage tissue
    - repeated exposure to antigens can result in ***delayed hypersensitivity*** that can cause skin inflammation
    - ***immediate hypersensitivity*** results from overproduction of **IgE** against allergen
    - **allergy** results from ***mast cells*** releasing ***histamine***, *prostaglandin & leukotrienes* that cause tissue ***inflammation***, contraction of bronchial & intestinal smooth muscles & increased mucus production
    - allergy symptoms include hives, hay fever, asthma, eczema & gastric disturbance
- **transplantation & tissue rejection**
    - ***tissue rejection*** occurs when immune system of transplant recipient reacts against donated tissue
    - *matching* donor & recipient tissue antigens (**MHC** antigens (***HLA*** in humans) on cell surface of tissue cells) & ***immunosuppression*** can minimize tissue rejection
    - immunosuppressive drugs may, however, increase likelihood of infection
- **autoimmunity**
    - in ***autoimmune disorders***, the immune system produces ***autoantibodies*** that attack a person's own body tissues
    - autoimmunity may result from a previous viral infection, faulty T cell development or a nonself antigen that resembles self antigen

Chapter 15: Digestion & Nutrition

Introduction
- **digestion**: mechanical & chemical breakdown of food & absorption of nutrients
- **alimentary canal**: continuous passageway (8m long) created by organs of digestion
  - mouth, pharynx, esophagus, stomach, small intestine, large intestine, rectum, anus
- ***accessory organs***: organs that are not part of the ***GI tract***, but participate in digestion
  - salivary glands, liver, gallbladder, pancreas

General Characteristics of Alimentary Canal
- wall of GI tract consists of 4 layers
  - **mucosa**: innermost layer, lines lumen***; stratified squamous or simple columnar epithelium*** with *mucus-secreting glands*; folded in stomach & intestine to increase surface area for absorption; lined with thin layers of connective tissue & smooth muscle
  - **submucosa**: loose CT, glands, blood vessels, lymphatics & nerves (plexuses)
  - **muscularis externa**: 2 layers of smooth muscle (inner circular & outer longitudinal layers) that produce movements of tube to propel food
  - **serosa**: visceral peritoneum; fibrous CT; secretes serous fluid to reduce friction
- *mixing movements* by rhythmic contractions of smooth muscle to crush food & mix *with enzymes*
- *propelling movements*: wavelike contraction (***peristalsis***) of alternate smooth muscle layers to propel food along tube

Mouth: receives food & begins mechanical & chemical digestion; includes ***oral cavity*** & *vestibule* (between teeth & cheeks/lips)
- **cheeks**: outer layers of skin, pads of fat, muscles associated with expression & chewing & inner lining epithelium
- **lips**: highly mobile with skeletal muscle, sensory receptors & rich blood supply
- **tongue**: rough surface for gripping food & mixing with saliva
  - surface contains *papillae* with ***taste buds***
  - lingual tonsils (immune cells) at root of tongue
- **palate**: roof of oral cavity has ***hard palate*** formed from bone & mucosal ***soft palate***
  - ***uvula*** at tip of soft palate closes off nasal cavity during swallowing
  - ***palatine tonsils:*** at either side of opening to throat at back of oral cavity
- **teeth**: begin mechanical digestion by breaking food into smaller pieces to increase surface area for chemical digestion
  - 20 primary & 32 secondary teeth
  - each tooth consists of ***crown*** (above gums) & ***root*** (below gums) & composed of **enamel** (*calcium phosphate* coating over crown), *dentin* (bulk of tooth), *pulp*, nerves & blood vessels
  - ***periodontal ligament*** attaches tooth to alveolar process in maxilla or mandible

Salivary Glands: secrete ***saliva***, which moistens food & begins chemical digestion of carbohydrates, dissolves food chemicals for taste & cleanses mouth

- **salivary glands** include serous glands that secrete digestive enzymes & mucous glands that secrete mucus
- ***parotid glands*** (anterior/inferior to ear) secrete ***amylase***, an enzyme that digests carbohydrates
- ***submandibular gland*** secrete viscous saliva (serous fluid & mucus)
- ***sublingual gland*** secretes mucus

Pharynx & Esophagus: food passageways to stomach
- **pharynx** is divided into *nasopharynx, oropharynx & laryngopharynx*
- *swallowing stages*: food mixed with saliva & forced into pharynx; involuntary reflexes move food into esophagus; peristalsis transports food to stomach
- **esophagus**: passes through diaphragm & joins stomach at *cardiac sphincter*
- ***cardiac sphincter:*** smooth muscle valve that prevents backflow of food from stomach

Stomach: receives food, mixes it with *acidic gastric juice*, begins *chemical digestion of proteins*, absorbs limited materials, & moves food into small intestine
- stomach divided into *cardiac, fundic, body & pyloric* regions
- ***pyloric sphincter***: valve to prevent backflow between stomach & small intestine
- gastric glands secrete ***gastric juice*** containing ***pepsin*** (protease; digests proteins), ***hydrochloric acid (HCl)*** and *intrinsic factor* (required for vitamin B12 absorption)
- parasympathetic impulses & the hormone ***gastrin*** enhance gastric secretion
- reflexes due to food in small intestine inhibit gastric secretion
- a few substances (water, small molecules) may be absorbed from the stomach wall
- mixing movements help produce chyme; peristalsis moves chyme into pyloric region & then small intestine
- rate of emptying depends on fluidity of chyme & type of food present

Pancreas: produces ***pancreatic juice*** containing *digestive enzymes* that is moved into the duodenum of the small intestine through the pancreatic duct
- pancreatic juice contains enzymes that digest carbohydrates (amylase), proteins, fats & nucleic acids
- pancreatic juice has a high ***bicarbonate ion*** concentration (***alkaline***) that helps neutralize chyme
- the hormone ***secretin*** stimulates release of pancreatic juice with bicarbonate ions
- the hormone ***cholecystokinin*** (CCK) stimulate release of pancreatic juice with enzymes

Liver: *metabolizes carbohydrates, lipids and proteins*; stores some substances; filters blood; destroys toxins & *secretes bile*
- left & right lobes contain hepatic lobules that secrete ***bile***; bile is carried to hepatic ducts & flows into either *cystic duct* into **gallbladder** (storage) or ***common bile duct*** into duodenum of small intestine
- in small intestine, bile salts act as an ***emulsifier*** (mix lipids & water) to help *digestion* & absorption of ***lipids*** (fatty acids & cholesterol) & fat-soluble vitamins
- bile contains ***bile salts*** made from ***cholesterol***, bile pigments (*bilirubin*), & electrolytes

- **gallbladder** *stores bile* between meals; gallbladder located under right lobe of liver
- the hormone ***cholecystokinin*** (CCK) stimulate release of bile
- *sphincter muscle* at base of common bile duct controls bile flow into duodenum

Small Intestine: receives pancreatic juice from pancreas & bile from liver &/or gallbladder, *completes digestion* of food, *absorbs nutrients*, and transports residues to large intestine
- small intestine consists of ***duodenum, jejunum & ileum***
- wall is lined with ***villi*** (folds) that increase surface area & aid in mixing & absorption
- *intestinal glands* located between villi
- secretes *mucus* & *digestive enzymes* (break down sugars, proteins & fats)
- gastric juice, chyme & stretch reflexes stimulate secretions
- enzymes on microvilli of mucosal cells complete digestion
- villi *absorb* ***monosaccharides, amino acids, fatty acids & glycerol***; nutrients move through mucosal cells & into *capillaries*
- *long-chain fatty acids* absorbed by ***lacteals*** (lymphatic capillaries*); short-chain fatty acids* absorbed by blood capillaries
- *mixing movements & peristalsis* propel material through small intestine
- ***ileocecal sphincter*** controls movement of materials into large intestine

Large Intestine: *reabsorbs water & electrolytes*; forms, stores & *eliminates* fecal *waste*
- large intestine consists of ***cecum, colon, rectum & anal canal***
- colon divided into ***ascending, transverse, descending & transverse colon***
- tissue of wall similar to stomach & small intestine, but longitudinal muscle layer arranged in distinct bands (teniae coli); muscle tension forms pouches (haustra)
- forms mucus; little to no digestive function
- movements similar to small intestine; mass movements 2-3 times daily
- defecation reflex stimulates defecation to remove waste
- *internal anal sphincter* (smooth muscle) & *external anal sphincter* (skeletal muscle) control removal of waste
- ***feces*** consist of water, undigested material, electrolytes, mucus & bacteria
- color of feces due to bilirubin pigment of bile converted to dark pigment by bacteria

Nutrition: study of **nutrients** & how the body utilizes them
- ***macronutrients*** (carbohydrates, lipids & proteins) required in large amounts; ***micronutrients*** (vitamins & minerals) required in smaller amounts
- **calories** measure potential energy in foods
  - ***calorie*** is amount of energy needed to raise temperature of 1g of water by 1˚C
  - kilocalories (***Cal***) are used to measure potential energy in macronutrients
  - *carbohydrates & proteins* yield ~ 4 Cal/gram; *lipids* yield ~ 9 Cal/gram
- **carbohydrates**: used primarily to supply ***energy*** for cellular processes
  - carbohydrates include ***sugars*** (monosaccharides & disaccharides) & ***complex carbohydrates*** (starch, glycogen & cellulose)
  - starch from grains & vegetables; glycogen from meats; disaccharides from cane sugar; monosaccharides from honey & fruit

- *cellulose* (in plant cell walls) cannot be digested by humans → ***fiber***; provides bulk that assists movement through GI tract
- ***energy*** is released from glucose through ***oxidation*** (*aerobic cellular respiration*)
- *lipids* & *proteins* can be utilized for energy in most cells if glucose levels low
- *neurons require constant supply of glucose*
- excess glucose is *stored* as ***glycogen*** or *converted to fat* (stored in adipose tissue)
- carbohydrates required to synthesize nucleic acids & breast milk
- carbohydrate requirements vary for different people depending on activity

- **lipids**: supply *energy* for cellular processes & aid in building structures such as cell membrane & molecules such as steroids
  - lipids include ***fats*** (mostly ***triglycerides***), ***phospholipids*** & ***cholesterol***
  - *saturated fats* found in meats, eggs, milk & some oils; *unsaturated fats* found in seeds, nuts & plant oils (monounsaturated fats in olive, peanut & canola oils considered healthiest); cholesterol in egg yolk, milk, butter, cheese & meats
  - digestion breaks down *triglycerides* to ***fatty acids & glycerol***
  - ***beta oxidation*** releases *acetyl coA* from fatty acids; acetyl coA can be used for energy or converted to ketone bodies (acetone)
  - excess fatty acids & glycerol stored in *adipose tissue*
  - *linoleic acid, linolenic acid & arachidonic acid* are ***essential fatty acids*** (required in diet)
  - *liver* synthesizes triglycerides, phospholipids, lipoproteins (transport lipids in blood) & cholesterol
  - ***cholesterol*** used in synthesis of bile salts, steroid hormones, membranes & vitamin D
  - fat intake requirements also vary for individuals; must be sufficient to carry fat-soluble vitamins (A, D, E & K)
- **proteins**: wide variety of functions... enzymes control metabolism in cells; clotting factors clot blood; structural proteins include keratin of skin & collagen of connective tissue; plasma proteins regulate water balance; actin & myosin in muscle cells; hormones & antibodies in blood
  - proteins can be broken down for ***energy***; must be converted to *amino acids* & amino acids ***deaminated*** (removes amino group; converted to *urea* waste) & converted to acetyl coA
  - proteins found in meats, fish, poultry, cheese, milk, nuts, eggs, cereals & legumes
  - 8 amino acids (10 in children) are ***essential amino acids*** (required from diet)
  - ***complete proteins*** provide all essential amino acids; meats provide complete proteins; vegetables must be combined for complete proteins (grain & legume)
  - protein requirements: must have sufficient protein to supply all essential amino acids & to provide nitrogen for synthesis of nitrogen-containing compounds
- **vitamins**: organic molecules that are essential nutrients required for metabolism
  - ***fat-soluble vitamins*** (vitamins A, D, E & K) are absorbed with lipids
  - ***water-soluble vitamins*** (vitamin C & B vitamins) absorbed with water
  - **vitamin A** can be synthesized from ***beta-carotene*** (*antioxidant* in orange vegetables) required for *synthesis of visual pigments*, normal development of bones, teeth & maintenance of epithelia
  - **vitamin D** required for *calcium & phosphorus absorption* during digestion

  - **vitamin E** is *antioxidant* (prevents oxidation of vitamin A & polyunsaturated fatty acids)
  - **vitamin K** required for *blood clotting*
  - **B vitamins** (B1-B12) required for cellular metabolism
  - **vitamin C** (ascorbic acid) required for collagen production, storage of folic acid, & metabolism of some amino acids; promotes iron absorption & synthesis of steroid hormones
- **adequate diets**: provide sufficient energy & essential nutrients to support growth, maintenance & repair of tissues
  - *food guide pyramids* can help to personalize diets
  - *malnutrition* is poor nutrition due to lack of food or failure to utilize food

Chapter 16: Respiratory System

Introduction

- ***respiratory system*** includes tubes that remove particles from incoming air & transport air to & from lungs and air sacs where gases (oxygen & carbon dioxide) are exchanged
- **respiration** is entire process of gas exchange between atmosphere & body cells
  - *ventilation (breathing)*: moving air into & out of lungs
  - *external respiration*: gas exchange between blood & air in lungs
  - transport of gases in blood between lungs & body cells
  - *internal respiration*: gas exchange between blood & tissue cells

Organs of Respiratory System

- **nose**: supported by bone (posteriorly) & cartilage (anteriorly)
  - nostrils: openings for air
- **nasal cavity**: mucosa-lined passageway for air into nasopharynx; divided into left & right halves by ***nasal septum***
  - *mucous membrane* filters, warms & moistens incoming air
  - ***nasal conchae*** divide nasal cavity into passageways & increase surface area to warm & moisten air
  - ciliary action carries particles trapped in mucus to pharynx, where they are generally swallowed
- **paranasal sinuses**: spaces in bones of the skull lined by mucous membrane that open into nasal cavity
  - located in *maxillary, frontal, sphenoid & ethmoid bones*
- **pharynx**: passageway for air & food behind nasal cavity (nasopharynx), oral cavity (oropharynx) & larynx (laryngopharynx)
- **larynx (**voice box): conducts air, helps prevent foreign objects from entering trachea & produces sounds of speech
  - composed of muscles & cartilage; lined with mucous membrane
  - contains ***vocal cords***, which vibrate from side to side & produce sounds when air from lungs passes through them
  - ***glottis***: opening in larynx that serves as a passageway for air
  - ***epiglottis***: elastic cartilage at top of larynx that closes off larynx during swallowing
- **trachea**: extends into thoracic cavity to bronchi entering lungs; anterior to esophagus
  - lined with C-rings of hyaline cartilage that helps keep airway open; cartilage incomplete at back, allows room for expansion of esophagus during swallowing
  - divides into ***left & right bronchi*** that enter lungs
- **bronchial tree**: branched air passages that lead from trachea to air sacs in lungs called ***alveoli***
  - **alveoli** are at the distal end of *alveolar ducts*, the narrowest tubes of tree
- **lungs**: soft, spongy cone-shaped organs on either side of thoracic cavity
  - *mediastinum* separates left & right lungs; diaphragm & thoracic cage enclose them
  - *left lung* has 2 lobes & cardiac notch (space for heart); *right lung* has 3 lobes

- ***visceral pleura*** attaches to surface of lungs; ***parietal pleura*** lines thoracic cavity
- each lobe of lungs composed of alveoli, blood vessels & supporting tissues

Breathing Mechanism

- **inspiration**: atmospheric pressure forces air into lungs
  - *pressure* in alveoli *decreases* due to contraction of breathing muscles ***(diaphragm & intercostals***) & expansion of thoracic cavity
  - when breathing muscles contract, thoracic cage moves upward & outward, increasing volume (decreases pressure)
  - *surface tension* aids lung expansion
- **expiration**: increased pressure in lungs forces air out of lungs
  - elastic recoil of lung tissues & surface tension within alveoli provide forces of expiration
  - when breathing muscles relax. thoracic cage moves downward & inward, decreasing volume (increases pressure)
- **respiratory air volume & capacities**
  - ***respiratory cycle***: one inspiration followed by one expiration
  - respiratory volumes measured with **spirometer**
  - ***tidal volume (TV):*** air volume that moves into & out of the lungs with each breath (~ 500 ml)
  - ***inspiratory reserve volume (IRV):*** air volume that can be forcibly inspired beyond tidal volume (~ 1900-3100 ml)
  - ***expiratory reserve volume (ERV):*** air volume that can be forcibly expired beyond tidal volume (~ 700-1200 ml)
  - ***residual volume (RV):*** air remaining in lungs after forced exhalation (~ 1200 ml)
  - ***inspiratory capacity (IC):*** TV + IRV
  - ***functional residual capacity (FRC):*** RV + ERV
  - ***vital capacity (VC):*** TV + IRV + ERV
  - ***total lung capacity (TLC):*** VC + RV

Control of Breathing

- normal breathing is rhythmic & involuntary
- ***respiratory center*** in brainstem includes portions of pons & medulla oblongata
  - medulla rhythmicity center includes 2 groups of neurons
    - *dorsal respiratory group* controls basic rhythm of breathing
    - *ventral respiratory group* increases inspiratory & expiratory respiratory movements during forceful breathing
  - ***pneumotaxic area*** regulates breathing rate (normally ~ 12 breaths/minute)
- **factors affecting breathing**: chemicals, stretching of lung tissues, emotional states
  - ***central chemoreceptors*** associated with respiratory center
    - blood concentrations of *carbon dioxide & hydrogen ions* affect chemoreceptors; stimulation of receptors increases breathing rate
  - ***peripheral chemoreceptors*** are in walls of certain large arteries
    - these chemoreceptors sense low ***oxygen*** levels; when oxygen levels are low, breathing rate increases
  - overstretching lung tissue triggers *inflation reflex*

        - reflex shortens duration of respiratory movements & prevents overinflation of lungs during forceful breathing
    - ***hyperventilation*** decreases blood carbon dioxide levels, *but is very dangerous when done before swimming underwater*

Alveolar Gas Exchange

- gas exchange between blood & air occurs at ***alveoli***, tiny air sacs clustered at distal ends of alveolar ducts
- **respiratory membrane**: consists of alveolar & capillary walls
    - site of gas exchange between blood & alveoli
- **diffusion across respiratory membrane**
    - ***partial pressure*** of gas is proportional to concentration of that gas in a mixture or concentration dissolved in a liquid
    - gases ***diffuse*** from regions of higher partial pressure to regions of lower partial pressure
    - ***oxygen*** diffuses from alveolar air into blood
    - ***carbon dioxide*** diffuses from blood into alveolar air

Gas Transport

- **oxygen** is primarily transported ***in red blood cells*** bound to ***hemoglobin*** protein (oxygen binds to ***iron*** of the heme group of hemoglobin)
    - ***oxyhemoglobin*** is unstable & releases oxygen in regions where partial pressure of oxygen is low
    - *more oxygen is released as blood levels of carbon dioxide increase, as blood becomes more acidic, and as blood temperature increases*
- **carbon dioxide** may be carried in blood, bound to hemoglobin, or as bicarbonate ion in blood
    - most carbon dioxide is transported as bicarbonate ion
    - enzyme ***carbonic anhydrase*** forms ***carbonic acid*** from carbon dioxide & water
    - carbonic acid dissociates to release hydrogen ions & bicarbonate ions; *buffering system in blood*