Unit 5: Human Biology

The Digestive System

Overview: The digestive system is crucial for breaking down food into nutrients that the body can use. This process involves ingestion, digestion, absorption, and egestion.

1. Ingestion:

- **Location:** Mouth
- **Process:** The intake of food. Chewing (mastication) and saliva break down food physically and chemically.

2. Digestion:

- **Physical Digestion:** Begins in the mouth where food is chewed into smaller pieces.
- **Chemical Digestion:** Starts in the mouth with saliva enzyme (salivary amylase) breaking down starches. This process continues in the stomach and small intestine with various enzymes.

3. Absorption:

- **Location:** Small intestine
- **Process:** Digested nutrients are absorbed through the villi and microvilli in the small intestine. Nutrients enter the bloodstream or lymphatic system.

4. Egestion:

- **Process:** The elimination of indigestible waste from the body as feces through the rectum and anus.

Detailed Digestive Processes

Oral Cavity:

- **Functions:**
  - Chewing breaks food into smaller pieces.
  - Saliva contains amylase to begin starch digestion.
  - Saliva also lubricates food and helps in tasting.

- **Teeth:**
  - **Incisors:** Cutting
  - **Canines:** Tearing
  - **Premolars:** Grinding
  - **Molars:** Crushing
  - **Dental Formula:** Adult teeth - (2123 / 2123) * 2 = 32 teeth; Child teeth - (2102 / 2102) * 2 = 20 teeth.

Esophagus:

- **Function:** Transports food from the mouth to the stomach using peristalsis (rhythmic contractions).

Stomach:

- **Functions:**
  - **Physical:** Churning food with gastric juices.
  - **Chemical:** Pepsin breaks down proteins; hydrochloric acid creates an acidic environment.
  - **Gastric Fluids:** Include mucus, hydrochloric acid, and pepsinogen.
- **Chyme:** The semi-liquid mixture of food and gastric juice.

Small Intestine:

- **Parts:**
  - **Duodenum:** Receives bile and pancreatic juices for digestion.
  - **Jejunum:** Further digestion and nutrient absorption.
  - **Ileum:** Final absorption of nutrients.
- **Functions:**
  - **Bile:** Produced by the liver and stored in the gallbladder; emulsifies fats.
  - **Pancreatic Juices:** Contain enzymes (trypsin, amylase, lipase) for protein, carbohydrate, and fat digestion.

Large Intestine:

- **Parts:** Cecum, colon (ascending, transverse, descending, sigmoid), rectum.
- **Functions:** Absorbs water and minerals; stores and compacts waste into feces.
- **Bacteria:** Intestinal flora (e.g., E. coli) aid in synthesizing vitamins and breaking down cellulose.

Accessory Organs:

- **Salivary Glands:** Produce saliva.
- **Liver:** Produces bile, processes nutrients, detoxifies substances.
- **Gallbladder:** Stores and concentrates bile.
- **Pancreas:** Produces digestive enzymes and bicarbonate.

Key Concepts

- **Peristalsis:** Wave-like muscle contractions that move food through the digestive tract.
- **Villi and Microvilli:** Increase surface area for nutrient absorption in the small intestine.

Understanding these processes and structures is essential for grasping how the body breaks down food and absorbs nutrients efficiently.

The Circulatory and Lymphatic System

Overview:

The circulatory system is essential for maintaining homeostasis in the body. It ensures that nutrients, oxygen, and hormones are delivered to cells and waste products are removed. Additionally, it helps regulate body temperature, maintain fluid balance, and support the immune system.

Functions of the Circulatory System:

1. **Nutrient and Oxygen Delivery:** Transports essential nutrients and oxygen to cells for cellular respiration.
2. **Waste Removal:** Carries away metabolic waste products from cells.
3. **Hormone Transport:** Delivers chemical messages (hormones) from endocrine glands to target tissues.
4. **Temperature Regulation:** Distributes heat throughout the body.
5. **Fluid Balance:** Along with the kidneys, helps maintain body fluid levels.
6. **Immune Defense:** Transports immune cells to combat pathogens.

Heart Structure and Function:

- **Heart Anatomy:** The heart is a muscular organ about the size of a fist, weighing approximately 300 grams. It continuously pumps blood through 96,000 km of blood vessels. It beats about 70 times per minute, circulating 5 liters of blood each minute.
- **Layers of the Heart:**
    - **Endocardium:** The thin inner lining of the heart.

- **Myocardium:** The thick, muscular middle layer responsible for contraction.
- **Epicardium:** The thin outer layer, which also houses coronary arteries.
- **Pericardium:** A protective sac surrounding the heart, often containing fluid.

Heart Valves:

1. **Atrioventricular Valves:**
   - **Tricuspid Valve:** Separates the right atrium from the right ventricle.
   - **Bicuspid (Mitral) Valve:** Separates the left atrium from the left ventricle.
2. **Semilunar Valves:**
   - **Pulmonary Valve:** Separates the right ventricle from the pulmonary artery.
   - **Aortic Valve:** Separates the left ventricle from the aorta.

Circulatory Pathways:

1. **Pulmonary Circulation:**
   - Blood from the body returns to the right atrium through the superior and inferior vena cavae.
   - It is pumped into the right ventricle, then through the pulmonary valve into the pulmonary artery.
   - Blood travels to the lungs for oxygenation and returns to the left atrium via the pulmonary veins.
2. **Systemic Circulation:**
   - Oxygenated blood from the left atrium is pumped into the left ventricle, then through the aortic valve into the aorta.
   - The aorta branches into major arteries, distributing blood throughout the body.
   - Blood returns to the right atrium via the veins.

Cardiac Cycle:

- **Systole:** Contraction phase where the heart pumps blood.
- **Diastole:** Relaxation phase where the heart fills with blood.

Heart Sounds:

- **Lub:** The sound of the atrioventricular valves closing.
- **Dub:** The sound of the semilunar valves closing.
- **Murmurs:** Abnormal sounds caused by turbulent blood flow.

Blood Pressure:

- **Systolic Pressure:** Pressure during heart contraction (normal <120 mmHg).
- **Diastolic Pressure:** Pressure during heart relaxation (normal <80 mmHg).

Blood Vessels:

- **Arteries:** Carry blood away from the heart.
- **Capillaries:** Sites of gas and nutrient exchange.
- **Veins:** Return blood to the heart.

Blood Components:

- **Plasma:** Liquid part of blood that transports cells and nutrients.
- **Red Blood Cells (Erythrocytes):** Carry oxygen and carbon dioxide.
- **White Blood Cells (Leukocytes):** Fight infections.
- **Platelets:** Aid in blood clotting.

Blood Groups:

- **ABO System:** Based on the presence of A and B antigens.
- **Rh Factor:** Determines if blood is positive (Rh+) or negative (Rh-).

Rhesus Factor:

- Important in pregnancies. Rh incompatibility can lead to erythroblastosis fetalis if an Rh- mother carries an Rh+ baby.

Practical Activities:

1. **Pulse Rate Measurement:** Assess changes in heart rate before and after exercise.
2. **Cardiac Cycle Dissection:** Study the external and internal structure of the heart.

Understanding these concepts is crucial for appreciating how the circulatory system supports life and maintains health.

5.2.1 Blood Donation

Blood Donation and Transfusion

Blood is crucial for human survival. In situations like severe injuries, illnesses, or surgeries where a large volume of blood is lost, a blood transfusion may be necessary. This involves transferring blood from a healthy individual (donor) to someone in need (recipient). Proper care is essential during this process to prevent complications.

Blood Group Compatibility

Blood compatibility is vital for safe transfusions. Blood groups are classified based on the presence of specific antigens and antibodies. If incompatible blood

types are mixed, agglutination occurs, where red blood cells clump together, potentially blocking blood vessels.

Here are key points on blood compatibility:

- **Type O:** Lacks antigens and has both anti-A and anti-B antibodies. It can be given to any blood group (universal donor) but can only receive type O blood.
- **Type AB:** Has both A and B antigens and no antibodies. It can receive any blood type (universal recipient).
- **Type A:** Has A antigens and anti-B antibodies. It can receive type A and O blood.
- **Type B:** Has B antigens and anti-A antibodies. It can receive type B and O blood.

The Lymphatic System

The lymphatic system maintains fluid balance, absorbs fats, and defends against disease. Here's an overview:

- **Function:**
  - Returns excess fluid from tissues to the bloodstream.
  - Absorbs fats and fat-soluble vitamins from the digestive system.
  - Defends against pathogens through lymph nodes and other organs.
- **Components:**
  - **Lymph:** A clear to white fluid containing lymphocytes and white blood cells, involved in immune responses and nutrient transport.
  - **Lymphatic Vessels:** Transport lymph from tissues to the venous system, featuring one-way valves to prevent backflow.
  - **Lymph Nodes:** Filter lymph and house immune cells that fight infection.
  - **Tonsils:** Protect against pathogens entering through the mouth and nose.
  - **Spleen:** Filters blood, removes old cells, and helps fight infection.
  - **Thymus:** Matures T-lymphocytes (T-cells), crucial for immune response.

5.2.2 Diseases of the Circulatory and Lymphatic Systems

Leukemia Leukemia is a cancer affecting blood-forming tissues, leading to abnormal blood cell production. It includes various types, such as acute lymphoblastic leukemia and chronic lymphocytic leukemia. Symptoms can vary from fatigue and weight loss to frequent infections. Treatment often involves chemotherapy, radiation, and stem-cell transplants.

Varicose Veins Varicose veins are swollen, twisted veins due to faulty valves. Symptoms include aching legs and swollen ankles. Treatment options range from home remedies to surgical procedures if severe.

Elephantiasis Elephantiasis is caused by parasitic worms obstructing lymphatic flow, leading to severe swelling, particularly in limbs and external genitals. It is transmitted by mosquitoes and causes fluid buildup in affected areas.

Cardiovascular Diseases

- **Heart Disease:** Often involves atherosclerosis, where plaque builds up in arteries, narrowing them and potentially causing heart attacks or strokes.
- **Heart Attack:** Results from a blockage in blood flow to the heart, leading to muscle damage. Recovery involves lifestyle changes and medication.
- **Stroke:** Occurs when blood flow to the brain is interrupted, either by a blockage (ischemic stroke) or a bleed (hemorrhagic stroke). Effects can range from temporary impairments to permanent disabilities.
- **Heart Failure:** The heart fails to pump blood effectively, requiring careful management to avoid worsening.
- **Arrhythmia:** Refers to irregular heartbeats, which can be too fast, too slow, or erratic, impacting the heart's ability to pump blood efficiently.

Understanding these concepts is crucial for recognizing and managing issues related to blood donation, lymphatic health, and cardiovascular diseases.

The Breathing System

Introduction Breathing is essential for life, as it provides the oxygen necessary for cellular respiration and removes carbon dioxide, a waste product. The respiratory system, which includes various organs and structures, ensures that oxygen is delivered to the blood and carbon dioxide is expelled from the body.

Main Components and Functions

1. **Nose and Nasal Cavities**
    - **Function:** Air enters the respiratory system through the nostrils. The nasal cavities are lined with tiny hairs and mucus that filter, warm, and moisten the air, trapping foreign particles.
    - **Structure:** The nasal cavity is divided by the nasal septum into two sections. Mucous membranes with goblet cells produce mucus to trap debris, and cilia help sweep the mucus toward the throat.
2. **Pharynx (Throat)**

    - **Function:** The pharynx connects the nasal cavity to the larynx and also receives air from the oral cavity. It serves both the respiratory and digestive systems.
    - **Structure:** It is a muscular tube that extends from the base of the skull to the sixth cervical vertebra. It includes the pharyngeal, palatine, and lingual tonsils, which help trap pathogens.
3. **Larynx (Voice Box)**
    - **Function:** The larynx connects the pharynx to the trachea and regulates airflow. It contains vocal cords that produce sound.
    - **Structure:** The larynx is made of cartilage and includes the epiglottis, which covers the trachea during swallowing to prevent food from entering the airway. The vocal cords vibrate to produce sound, and their size affects the pitch of the voice.
4. **Trachea (Windpipe)**
    - **Function:** The trachea conducts air from the larynx to the bronchi.
    - **Structure:** It is supported by cartilage rings that prevent collapse and is lined with a mucous membrane that traps debris.
5. **Bronchi and Bronchioles**
    - **Function:** The bronchi branch from the trachea into the lungs and further divide into smaller bronchioles.
    - **Structure:** The bronchi are larger airways with cartilage support, while bronchioles are smaller and lack cartilage but have smooth muscle that regulates airflow.
6. **Alveoli**
    - **Function:** Alveoli are the sites of gas exchange where oxygen is absorbed into the blood and carbon dioxide is released.
    - **Structure:** Alveoli are tiny, sac-like structures with elastic walls that expand and contract. They are surrounded by capillaries to facilitate gas exchange.

Breathing Mechanism

- **Inspiration (Inhaling):** The diaphragm contracts and moves downward, increasing chest volume and decreasing pressure in the lungs. This causes air to flow into the lungs.
- **Expiration (Exhaling):** The diaphragm relaxes and moves upward, decreasing chest volume and increasing pressure in the lungs, pushing air out.

Disorders of the Breathing System

1. **Bronchitis:** Inflammation of the bronchial tubes, leading to narrowed airways and excess mucus production.

2. **Emphysema:** Damage to alveolar walls, reducing gas exchange efficiency and trapping air in the lungs.
3. **Asthma:** Inflammation and constriction of the bronchioles, causing difficulty in exhaling.

Collaboration with the Circulatory System The respiratory and circulatory systems work together to deliver oxygen to the cells and remove carbon dioxide. The circulatory system transports oxygen-rich blood from the lungs to the tissues and returns carbon dioxide-rich blood to the lungs for exhalation.

Summary of Breathing Movements

Part of Respiratory System	Inspiration	Expiration
Diaphragm	Contracts and moves downward	Relaxes and moves upward
External Intercostal Muscles	Contract to expand the ribcage	Relax to allow the ribcage to return to normal
Internal Intercostal Muscles	Relax	Contract to help push air out
Ribcage and Sternum	Move upward and outward	Move downward and inward
Thorax Volume	Increases	Decreases
Air Pressure	Decreases inside thorax and lungs	Increases inside thorax and lungs
Air Movement	Air flows into the lungs	Air is forced out of the lungs

This system ensures the continuous exchange of gases, essential for maintaining cellular function and overall health.

5.4 The Human Urinary System

Introduction: The human urinary system is essential for maintaining homeostasis, which includes regulating blood pH, producing erythropoietin (EPO) for red blood cell formation, and synthesizing vitamin D. This system also plays a crucial role in filtering blood and removing waste products.

External Structure of the Kidney:

- **Shape and Location:** The kidneys are bean-shaped organs located in the abdominal cavity, just below the liver. Each kidney is accompanied by an adrenal gland on top.

- **Functions:** The primary function of the kidneys is to filter blood, removing waste products and producing urine. They consume over 25% of the oxygen inhaled to facilitate this process.

Urine Transport:

- **Ureters:** Urine flows from the kidneys through the ureters, which are about 30 cm long. Peristalsis (smooth muscle contractions) helps drive urine to the urinary bladder.
- **Bladder:** The bladder stores urine. During pregnancy, the growing uterus compresses the bladder, leading to more frequent urination.
- **Urethra:** The urethra transports urine from the bladder to the outside of the body. It differs between sexes; females have a shorter urethra (about 4 cm), making them more susceptible to urinary tract infections (UTIs). In males, the urethra also serves as a conduit for sperm.

Internal Structure of the Kidney:

- **Kidney Regions:** The kidney has three main regions:
    - **Cortex:** The outer layer, granular due to the presence of renal corpuscles.
    - **Medulla:** The middle region with renal pyramids, where the urine is collected.
    - **Renal Pelvis:** The central region where urine drains into the ureters.

Nephron Structure:

- **Nephron:** The functional unit of the kidney, each kidney contains over one million nephrons. A nephron consists of:
    - **Renal Corpuscle:** Includes the glomerulus (a network of capillaries) and Bowman's capsule (a cup-shaped structure surrounding the glomerulus).
    - **Renal Tubule:** Comprises three segments:
        - **Proximal Convoluted Tubule (PCT):** Reabsorbs nutrients and ions, and regulates blood pH.
        - **Loop of Henle:** Has descending and ascending limbs; crucial for concentrating urine.
        - **Distal Convoluted Tubule (DCT):** Involved in further reabsorption and secretion.
    - **Capillary Network:** Includes afferent arterioles (entering the glomerulus) and efferent arterioles (exiting the glomerulus), with peritubular capillaries surrounding the renal tubule.

Urine Formation: The process involves three main steps:

1. **Glomerular Filtration:** Blood is filtered in the glomerulus, separating solutes (except proteins) into the filtrate.
2. **Tubular Reabsorption:** In the PCT and Loop of Henle, essential solutes and water are reabsorbed back into the blood.
3. **Tubular Secretion:** Additional solutes and wastes are secreted into the tubules, with the final filtrate collected in the collecting ducts and transported to the renal pelvis.

Functions of Nephron Segments:

- **Glomerulus:** Filters small solutes from blood.
- **PCT:** Reabsorbs ions, nutrients, and water; regulates blood pH.
- **Loop of Henle:** Concentrates urine by reabsorbing water and salt.
- **DCT:** Regulates electrolyte balance and blood pH by selective reabsorption and secretion.
- **Collecting Duct:** Final reabsorption of water and solutes, leading to the formation of urine.

The Immune System

Immunity is the body's defense mechanism against pathogens such as viruses, bacteria, fungi, and parasites. The immune system includes both innate and adaptive (acquired) defenses, and is closely linked with the lymphatic system.

a) Innate Immune System

The **innate immune system** is the body's first line of defense against pathogens. It operates through:

1. **Physical and Chemical Barriers:** Skin, mucous membranes, and secretions like saliva and stomach acid act as barriers to prevent pathogen entry.
2. **Pattern Recognition Receptors (PRRs):** These receptors are found on innate immune cells and help recognize and respond to pathogens. They regulate inflammation and cell death.
3. **Cytokines and Chemical Signals:** These substances attract immune cells to sites of infection and inflammation.
4. **Complement Cascade:** A series of proteins that recognize bacteria, stimulate immune cells, and help clear pathogens and dead cells.
5. **Specialized White Blood Cells:** These include neutrophils and macrophages, which identify and destroy foreign substances.

b) Adaptive (Acquired) Immune System

The **adaptive immune system** provides a targeted response to specific pathogens after initial exposure. Key features include:

1. **Antigen Recognition:** The immune system identifies "non-self" antigens (foreign substances) through antigen presentation.
2. **Targeted Response:** The adaptive immune system develops specific responses to eradicate pathogens or infected cells.
3. **Immunological Memory:** Memory cells "remember" previous infections, allowing for a faster and stronger response upon re-exposure.
    - **Vaccination** leverages this memory to provide immunity against diseases.

Cells of the Immune System

1. **Lymphocytes:** White blood cells crucial for immune responses. Types include:
    - **T Cells:** Mature in the thymus and help destroy infected or cancerous cells.
    - **B Cells:** Produce antibodies that target specific antigens.
    - **Natural Killer (NK) Cells:** Destroy infected or tumor cells.
2. **Neutrophils:** The most common white blood cells, important in the innate immune response. They engulf and digest pathogens and debris.
3. **Macrophages:** Phagocytes involved in both innate and adaptive immunity. They engulf pathogens and help activate other immune cells.
4. **Dendritic Cells:** Antigen-presenting cells that link the innate and adaptive immune systems. They process antigens and present them to T and B cells in lymph nodes.

Antigens and Antibodies

- **Antigens:** Foreign substances that provoke an immune response.
- **Antibodies (Immunoglobulins):** Y-shaped proteins produced by B cells that bind to antigens and help eliminate them.

Hormones and the Immune System

- **Lymphokines:** Hormones produced by immune cells that regulate immune responses.
- **Steroids and Corticosteroids:** Can suppress immune function.

Renowned Physicians in Ethiopia

1. Prof. Asrat Woldeyes (1928-1999)

- **Background:** Prof. Asrat Woldeyes was a prominent Ethiopian surgeon and medical educator. He was the first Ethiopian to achieve a medical qualification in the West, studying at Edinburgh University.
- **Contributions:** He dedicated most of his career to surgery at Addis Ababa's major hospitals and served as the Dean of the Faculty of Medicine at Addis Ababa University.
- **Legacy:** His work significantly advanced surgical practice and medical education in Ethiopia.

2. Dr. Widad Hidane Mariam

- **Background:** Dr. Widad Hidane Mariam was born to Ethiopian emigrant parents in Palestine during the Italian occupation of Ethiopia. She pursued her medical education at the American University of Beirut.
- **Contributions:** She became Ethiopia's first female medical practitioner and held a leading role in the Ministry of Health as a physician administrator in the 1960s-1970s. Dr. Mariam was instrumental in establishing the Ethiopian Family Planning Association and contributed to maternal and child health services in Addis Ababa.
- **Legacy:** Her efforts in family planning and maternal health have had a lasting impact on public health in Ethiopia.

Summary: The immune system consists of two main components: the innate and adaptive immune systems. Innate immunity provides immediate, non-specific defense, while adaptive immunity offers a targeted and memory-based response to specific pathogens. Understanding these systems and their cellular components is crucial for comprehending how the body protects itself from infections and diseases.