Chapter 4: Organization and Regulation of Body Systems

4.1 Types of tissues

Tissues are made of specialized cells of the same type that perform a common function. Human tissues are categorized into four groups: connective, muscular, nervous, and epithelial.

4.2 Connective tissue connects and supports

Connective tissues have cells separated by a matrix that contains ground substance and fibers. Examples of fibers include collagen fibers, reticular fibers, and elastic fibers. There are three general classes of connective tissue:

- Fibrous connective tissue contains cells called fibroblasts. An example of loose connective tissue is adipose tissue, which contains cells called adipocytes. Dense fibrous connective tissue is found in tendons and ligaments.
- Supportive connective tissue consists of cartilage and bone. The matrix for cartilage is solid yet flexible. The cells are found in chambers called lacunae. Examples are hyaline cartilage, elastic cartilage, and fibrocartilage. The matrix for bone is solid and rigid. Examples are compact bone and spongy bone.
- Fluid connective tissue is found in the blood and lymph. The cells of blood include red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes) in an interstitial fluid called plasma.

4.3 Muscular Tissue moves the body

Muscular tissue is of three types: skeletal, smooth, and cardiac.

- Skeletal muscle and cardiac muscle are striated.
- Cardiac and smooth muscle are involuntary.
- Skeletal muscle is found in muscles attached to bones.
- Smooth muscle is found in internal organs.
- Cardiac muscle makes up the heart.

4.4 Nervous tissue communicates

- Nervous tissue is composed of neurons and several types of neuroglia.
- Each neuron has dendrites, a cell body, and an axon. Axons conduct nerve impulses.
- Neurons may be organized into nerves, which are surrounded by connective tissue.

4.5 Epithelial tissue protects

Epithelial tissue covers the body and lines its cavities.

- Types of simple epithelia are squamous, cuboidal, columnar, and pseudostratified columnar.
- Certain epithelial tissues may have cilia or microvilli.
- Stratified epithelia have many layers of cells, with only the bottom layer touching the basement membrane.
- Epithelia may be structured as a gland, which secretes a product either into ducts (exocrine glands) or into the blood (endocrine glands).

4.6 Integumentary System

Organs comprise two or more tissues working together for a common function. An organ system involves multiple organs cooperating for a specific function. Skin and its accessory organs constitute the integumentary system. Skin has two regions:

- The epidermis contains stem cells, which produce new epithelial cells, and Langerhans cells, which provide protection against infectious agents. Melanocytes produce the coloration of the skin. Within the epidermis, vitamin D may be synthesized from cholesterol.
- The dermis contains epidermally derived glands and hair follicles, nerve endings, blood vessels, and sensory receptors.
- A subcutaneous layer (hypodermis) lies beneath the skin.
- Accessory organs of the skin include the nails, hair follicles, oil glands, and sweat glands.

4.7 Organ systems, body cavities and body membrane

Organs make up organ systems, summarized in Table 4.1. Some organs are found in particular body cavities. Body cavities are lined by membranes, such as the mucous membranes, serous membranes, synovial membranes, and meninges.

Table 4.1 Organ Systems

Transport Cardiovascular (heart and blood vessels) Lymphatic and immune (lymphatic vessels)	**Integumentary** Skin and accessory organs
Maintenance Digestive (e.g., stomach, intestines) Respiratory (tubes and lungs) Urinary (tubes and kidneys)	**Motor** Skeletal (bones and cartilage Muscular (muscles)
Control Nervous (brain, spinal cord, and nerves) Endocrine (glands)	**Reproduction** Reproductive (tubes and testes in males; tubes and ovaries in females)

4.8 Homeostasis

Homeostasis is the relative constancy of the internal environment, interstitial fluid, and blood. All organ systems contribute to homeostasis.

- The cardiovascular, respiratory, digestive, and urinary systems directly regulate the amount of gases, nutrients, and wastes in the blood, keeping interstitial fluid constant.
- The lymphatic system absorbs excess interstitial fluid and functions in immunity.
- The nervous system and endocrine system regulate the other systems.

Negative Feedback:

Negative feedback mechanisms keep the environment relatively stable. When a sensor detects a change above or below a set point, a control center brings about an effect that reverses the change and returns conditions to normal. Examples include the following:

- Regulation of blood glucose level by insulin
- Regulation of room temperature by a thermostat and furnace
- Regulation of body temperature by the brain and sweat glands.

Positive Feedback:

In contrast to negative feedback, a positive feedback mechanism brings about rapid change in the same direction as the stimulus and does not achieve relative stability. These mechanisms are useful under certain conditions, such as during birth.

Chapter 9: Digestive System and nutrition

9.1 Overview of digestion

- The purpose of the digestive system is to hydrolyze macromolecules to their smallest subunits. The organs of the digestive system are located within the GI tract.
- The processes of digestion require ingestion, digestion, movement (peristalsis), absorption, and elimination.
- All parts of the tract have four layers, called the mucosa, submucosa, serosa, and muscularis. These layers surround the lumen, or interior space of the GI tract.
- A disorder of the muscularis called diverticulosis can affect any organ of the GI tract but primarily occurs in the large intestine.

9.2 The mouth, pharynx, and esophagus

- In the mouth (oral cavity), teeth chew the food. The salivary glands produce saliva, which contains salivary amylase for digesting starch, and the tongue forms a bolus for swallowing.
- Both the mouth and the nose lead into the pharynx. The pharynx opens into both the esophagus (food passage) and the trachea (air passage). During swallowing, the opening into the nose is blocked by the soft palate, and the epiglottis covers the opening to the trachea (glottis). Food enters the esophagus, and peristalsis begins. The esophagus moves food to the stomach by peristalsis. Sphincters control the movement of the bolus.
- Disorders of the mouth include dental caries (cavities) of the teeth and gingivitis and periodontitis of the gums.
- Heartburn occurs when the contents of the stomach enter the esophagus. During vomiting, the abdominal muscles and diaphragm propel the food through the esophagus and out the mouth.

9.3 The stomach and small intestine

- The stomach expands and stores food and churns, mixing food with the acidic gastric juices. The stomach contains an oblique layer of smooth muscle, and folds called rugae, to assist in mixing the food. Gastric glands produce gastric juice, which contains pepsin, an enzyme that digests protein. The material leaving the stomach is called chyme.
- The duodenum of the small intestine receives bile from the liver and pancreatic juice from the pancreas. Bile emulsifies fat and readies it for digestion by lipase.
- The pancreas produces enzymes that digest starch (amylase), protein (proteases, such as trypsin), and fat (lipase). The intestinal enzymes finish the process of chemical digestion.
- Brush border enzymes of the small intestine complete the digestive process. Small nutrient molecules are absorbed at the villi and microvilli in the walls of the small intestine. The nutrients enter the capillaries of the circulatory system and lacteals of the lymphatic system. People with lactose intolerance are missing the lactase enzyme in the small intestine.

9.4 The accessory organs and regulation secretions

Three accessory organs of digestion send secretions to the duodenum via ducts. These organs are the pancreas, liver, and gallbladder.

- The pancreas produces pancreatic juice, which contains digestive enzymes for carbohydrate, protein, and fat. The pancreas also releases the hormone insulin, which regulates blood glucose levels.
- The liver produces bile, destroys old blood cells, detoxifies blood, stores iron, makes plasma proteins, stores glucose as glycogen, breaks down glycogen to glucose, produces urea, and helps regulate blood cholesterol levels.
- The gallbladder stores bile, produced by the liver. The secretions of digestive juices are controlled by the nervous system and by hormones.
- Gastrin produced by the lower part of the stomach stimulates the upper part of the stomach to secrete pepsin. Secretin and CCK produced by the duodenal wall stimulate the pancreas to secrete its juices and the gallbladder to release bile.
- Disorders of the liver include jaundice, hepatitis, and cirrhosis. Gallstones may affect the operation of the gallbladder.

9.5 The large intestine and defecation

- The large intestine consists of the cecum; the colon (including the ascending, transverse, and descending colon); the appendix; and the rectum, which ends at the anus.
- The large intestine absorbs water, salts, and some vitamins; forms the feces; and carries out defecation. Fiber provides bulk to the feces. The color of the feces is the result of bilirubin (a waste product).
- Disorders of the large intestine include diarrhea, constipation, hemorrhoids, diverticulosis, irritable bowel syndrome, inflammatory bowel disease, polyps, and cancer.

9.6 Nutrition and weight control

The nutrients released by the digestive process should provide us with adequate energy, essential amino acids and fatty acids, and all necessary vitamins and minerals.

- The body mass index (BMI) may be used to determine the percent body fat. Obesity is associated with many illnesses, including type 2 diabetes and cardiovascular disease. The new MyPlate dietary guidelines provide a visual representation of dietary proportions to maintain good health.
- Carbohydrates are necessary in the diet, but simple sugars and refined starches cause a rapid release of insulin that can lead to type 2 diabetes. Fiber is undigested carbohydrate. The

glycemic index may be used to predict which foods will release carbohydrates quickly into the blood.

- Proteins supply essential amino acids.
- Unsaturated fatty acids, particularly the omega-3 fatty acids, are protective against cardiovascular disease. Saturated fatty acids and Trans fats contribute to heart disease. Essential fatty acids must be supplied by the diet.
- Minerals are also required by the body in certain amounts. Osteoporosis is an example of a disease caused by a mineral deficiency (calcium).
- Vitamins are organic compounds that act as metabolic assistants.
- Eating disorders include anorexia nervosa, bulimia nervosa, binge-eating disorder, and muscle dysmorphia.

Chapter 5: Cardiovascular System: heart and blood vessels

5.1 Overview of the cardiovascular system

The cardiovascular system consists of the heart and blood vessels. The heart pumps blood, and blood vessels take blood to and from capillaries, where exchanges of nutrients for wastes occur with tissue cells. Blood is refreshed at the lungs, where gas exchange occurs; at the digestive tract, where nutrients enter the blood; and at the kidney, where wastes are removed from blood. The lymphatic system removes excess fluid from around the tissue and returns it to the cardiovascular system.

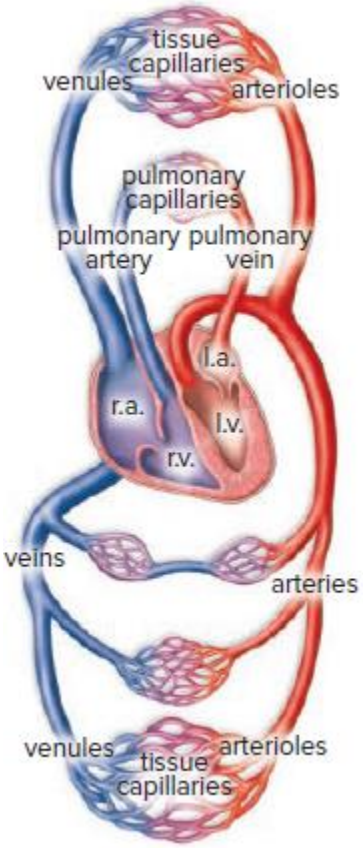
5.2 The types of blood vessels

Arteries: Arteries and arterioles move blood away from the heart. Arteries have the thickest walls, which allows them to withstand blood pressure. Capillaries: Exchange of substances occurs in the capillaries. Precapillary sphincters and arteriovenous shunts help control the flow of blood within the capillaries. Veins: Veins and venules move blood toward the heart. Veins have relatively weak walls with valves that keep the blood flowing in one direction.

- The genetic material of the cell is organized as chromosomes. Chromosomes contain a combination of proteins and DNA called chromatin.
- Most human cells are diploid—therefore, chromosomes occur in pairs.
- Prior to mitosis, or duplication division, the chromosomes are replicated, forming sister chromatids. The sister chromatids are joined at the centromere.
- A karyotype is a visual display of an individual's chromosomes.

5.3 The heart is a double pump

The heart is the pump of the circulatory system and consists of a right and left side separated by a septum. Each side has an atrium and a ventricle. Valves, such as the atrioventricular (AV) valves and semilunar valves, keep the blood moving in the correct direction. The tissue of the heart, the myocardium, is contained within a sac called the pericardium. At the cellular level, the tissues interact using gap junctions and desmosomes. The heart supplies itself with blood using the coronary arteries.



- Passage of blood through the heart

○ The right atrium receives O2-poor blood from the vena cava, and the right ventricle pumps it into the pulmonary circuit via the pulmonary arteries.

○ The left atrium receives O2-rich blood from the lungs (pulmonary veins), and the left ventricle pumps it into the aorta of the systemic circuit.

- The hearbeat is controlled
- During the cardiac cycle, the SA (sinoatrial) node (pacemaker) initiates the heartbeat by causing the atria to contract. The AV (atrioventricular) node conveys the stimulus to the ventricles, causing them to contract (systole). The heart sounds, “lub-dub,” are due to the closing of the atrioventricular valves, followed by the closing of the semilunar valves. The muscles of the heart relax (diastole) between contractions. An electrocardiogram (ECG) may be used to measure the activity of the heart.

5.4 Features of the cardiovascular System

The pulse indicates the heartbeat rate. Blood pressure caused by the beating of the heart accounts for the flow of blood in the arteries. The systolic pressure is the maximum pressure in the arteries, while the diastolic pressure is the minimum. The reduced velocity of blood flow in capillaries facilitates exchange of nutrients and wastes in the tissues. Blood flow in veins is caused by skeletal muscle contraction (skeletal muscle pump), the presence of valves, and respiratory movements (respiratory pump).

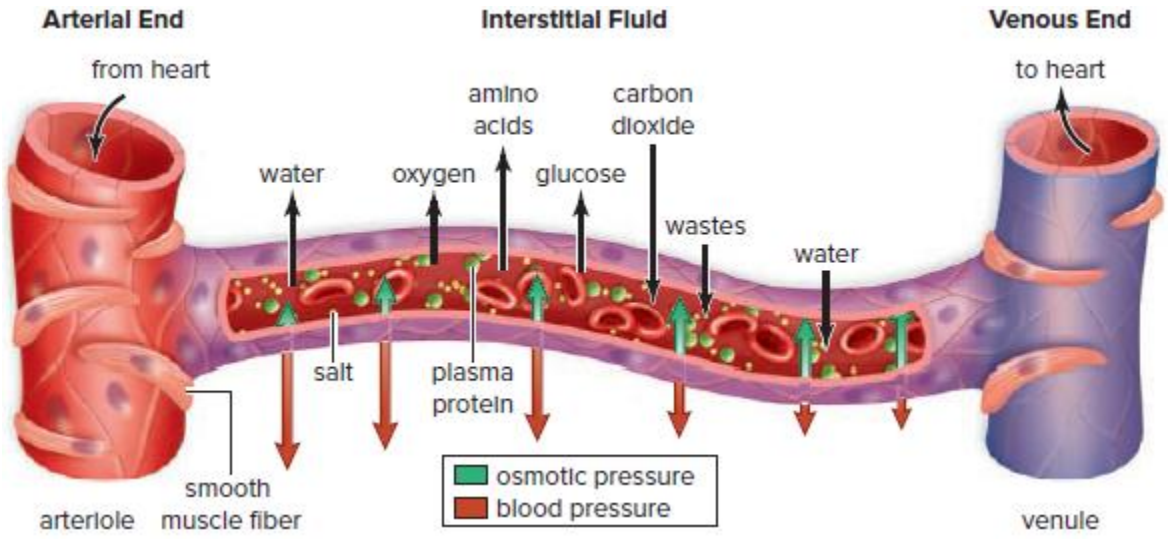
5.5 Two cardiovascular Pathways

The cardiovascular system is divided into the pulmonary circuit and the systemic circuit.

- The Pulmonary Circuit: Exchange of Gases:
  In the pulmonary circuit, blood travels to and from the lungs.
- The Systemic Circuit: Exchanges with Interstitial Fluid:
  In the systemic circuit, the aorta divides into blood vessels that serve the body's organs and cells. The vena cava returns O2-poor blood to the heart. The hepatic portal system moves blood between the capillary beds of the digestive system and liver. This system consists of the hepatic portal vein and the hepatic vein.

5.6 Exchange at the capillaries

The following diagram illustrates capillary exchange in the tissues of the body—not including the gas exchanging surfaces of the lungs.



- At the arterial end of a cardiovascular capillary, blood pressure is greater than osmotic pressure; therefore, fluid leaves the capillary.
- In the midsection, oxygen and nutrients diffuse out of the capillary, and carbon dioxide and other wastes diffuse into the capillary.
- At the venous end, osmotic pressure created by the presence of proteins exceeds blood pressure, causing most of the fluid to reenter the capillary. Some fluid remains as interstitial (tissue) fluid.

Excess fluid not picked up at the venous end of the cardiovascular capillary enters the lymphatic capillaries:

- Lymph is interstitial fluid within lymphatic vessels.
- The lymphatic system is a one-way system. Its fluid is returned to blood by way of a cardiovascular vein.

5.7 Cardiovascular Disorders

Cardiovascular disease is the leading cause of death in Western countries:

- Hypertension and atherosclerosis can lead to stroke, heart attack, angina pectoris (chest pain), or an aneurysm. Atherosclerotic plaques increase the risk of these conditions. If these plaques dislodge in the circulatory system, a thromboembolism may result.
- Following a heart-healthy diet, getting regular exercise, maintaining a proper weight, and not smoking reduce cardiovascular disease risk.

Chapter 6: Cardiovascular System: Blood

6.1 Blood: an overview

- Blood
    - Transports hormones, oxygen, and nutrients to cells
    - Transports carbon dioxide and other wastes from cells
    - Fights infections by transporting antibodies and cells of the immune system
    - Maintains blood pressure and regulates body temperature
    - Keeps the pH of body fluids within normal limits.
    - These functions help maintain homeostasis. Blood has two main components: plasma and formed elements (red blood cells, white blood cells, and platelets).
- Plasma
    - Plasma is a fluid connective tissue, 91% of which is water. Plasma Proteins (albumins, globulins, and fibrinogen) are mostly produced by the liver. These proteins maintain osmotic pressure and help regulate pH. Albumins transport other molecules, globulins function in immunity, and prothrombin and fibrinogen enable blood clotting.

6.2 Red blood cells and transport of oxygen

Red blood cells (erythrocytes) lack a nucleus and other organelles. They contain hemoglobin (Hb), which combines with oxygen and transports it to the tissues. Hemoglobin assists in carbon dioxide transport, as well. Red blood cell (RBC) production is controlled by the blood oxygen concentration. When oxygen concentration decreases, the kidneys increase production of the hormone erythropoietin (EPO). In response, more red blood cells are produced by the bone marrow. Diseases involving RBCs include anemia (not enough hemoglobin to transport oxygen), hemolysis (rupturing of RBCs), and sickle-cell disease (malformed RBCs).

6.3 White blood cells and defense against diseases

White blood cells (leukocytes) are larger than red blood cells. They have a nucleus and are translucent unless stained. White blood cells are either granular leukocytes or agranular leukocytes. White blood cells are an important part of the immune system, which protects the body from infection. They often use phagocytosis to ingest foreign compounds or cells called antigens.

- The granular leukocytes are eosinophils, basophils (and mast cells), and neutrophils. Neutrophils are abundant, respond first to infections, and phagocytize pathogens.
- The agranular leukocytes include monocytes and lymphocytes. Monocytes are the largest white blood cells. They can become macrophages that phagocytize pathogens and cellular debris. Lymphocytes (B cells and T cells) are responsible for specificimmunity.

Diseases associated with white blood cells include severe combined immunodeficiency (SCID; inability to fight infections), leukemia (white blood cell cancer), and infectious mononucleosis (produced by infection with the EBV virus).

6.4 Platelets and blood clotting

Platelets (thrombocytes) result from fragmentation of megakaryocytes in the red bone marrow and function in blood clotting. Blood Clotting Platelets and the plasma proteins, prothrombin (and thrombin) and fibrinogen, function in blood clotting (coagulation), an enzymatic process. Fibrin threads that trap red blood cells result from the enzymatic reaction. Diseases associated with improper blood clotting include thrombocytopenia (insufficient number of platelets), a thromboembolism (movement of the blood clot into the heart, lungs, or brain), and hemophilia (loss of a specific clotting factor).

6.5 Human blood types

Blood typing usually involves determining the ABO blood group and whether the person is Rh– or Rh+. Determining blood type is necessary for transfusions, so that agglutination (clumping) of red blood cells does not occur.

- ABO blood Groups

  ABO blood typing determines the presence or absence of type A antigen and type B antigen on the surface of red blood cells:

  - Type A blood Type A surface antigens; plasma has anti-B antibodies
  - Type B blood Type B surface antigens; plasma has anti-A antibodies
  - Type AB blood Both type A and type B surface antigens; plasma has neither anti-A nor anti-B antibodies (universal recipient)
  - Type O blood Neither type A nor type B surface antigens; plasma has both anti-A and anti-B antibodies (universal donor)
  - Agglutination Agglutination occurs if the corresponding antigen and antibody are mixed (i.e., if the donor has type A blood and the recipient has type B blood)

- Rh Blood Groups

  The Rh antigen must also be considered when transfusing blood. It is very important during pregnancy, because an Rh-negative mother may form antibodies to the Rh antigen while carrying or after the birth of an Rh-positive child. These antibodies can cross the placenta to destroy the red blood cells of an Rh-positive child.

6.6 Homeostasis

Homeostasis depends on the cardiovascular system, because it serves the needs of the cells. Other body systems are also critical to cardiovascular system function:

- The digestive system supplies nutrients.
- The respiratory system supplies oxygen and removes carbon dioxide from the blood.
- The nervous and endocrine systems help maintain blood pressure. Endocrine hormones regulate red blood cell formation and calcium balance.
- The lymphatic system returns interstitial fluid to the veins.
- Skeletal muscle contraction (skeletal system) and breathing movements (respiratory system) propel blood in the veins.