

Unit 2: Anatomy and Physiology of Organ Systems

A. Introduction

1. **Anatomy** is the branch of science that deals with the structure of living things.
2. **Physiology** is the branch of science that deals with the functions of living things.

B. Body Planes

1. Body plane is a flat surface resulting from a real or imaginary cut through a body in the anatomic position.
2. The *anatomic position* is a way of referring to the body regardless of the actual body position, parts of the body are referred to as if the patient is standing erect, arms at the side with palms facing forward.
3. **Frontal (or coronal) plane** divides the body vertically into front and back portions.
4. **Sagittal plane** divides the body vertically into right and left portions, if division results in equal right and left portions it is called **midsagittal (or medial) plane**.
5. **Transverse plane** divides the body horizontally into upper and lower portions.

C. Body Directional Terms

1. **Anterior (ventral)** refers to the front.
2. **Posterior (dorsal)** refers to the back.
3. **Medial** means toward the midline or middle.
4. **Lateral** means toward the side.
5. **Proximal** means the nearest to the center of the body, origin, or point of attachment.
6. **Distal** means farthest from the center of the body, origin, or point of attachment.
7. **Superior (cranial)** means higher, above, or toward the head.
8. **Inferior (caudal)** means beneath, lower, or away from the head.

D. Body Cavities

1. **Cranial cavity** houses the brain.
2. **Spinal cavity** encases the spinal cord.

3. **Ventral cavities** are located in the front of the body and include:
 - a. **Thoracic cavity** houses the heart and lungs.
 - b. **Abdominal cavity** houses numerous organs including the stomach, liver, pancreas, gallbladder, spleen and kidneys; it is separated from the thoracic cavity by a muscle called the diaphragm.
 - c. **Pelvic cavity** houses the urinary bladder and reproductive organs.

E. Organ / Body systems - Introduction

1. Study of the anatomy and physiology of the body generally centers on study of the body systems.
 - a. A **system** is defined as a group of organs working together to perform related functions.
 - b. Many medical specialties concentrate on one body system, i.e., neurology is the study of the nervous system.
2. Usually the organs in a system are anatomically connected, but in some cases, as with the endocrine system, the tissues are widely distributed.
3. All body systems work together at all times and constantly interact to maintain a state of internal balance known as **homeostasis**.
 - a. Literal meaning “remaining the same”.
 - b. It is a condition in which a health body, although constantly changing and functioning, remains in a normal healthy condition.
 - c. Allows the body to compensate for changes.
4. A disturbance in any organ or system may affect other systems of the body.

F. Structural Organization

1. Human body can be divided into eight structural units.
 - a. atoms
 - b. molecules
 - c. organelles
 - d. cells
 - e. tissues
 - f. organs

- g. organ systems
 - h. organism
2. Similar cells combine into tissues which form organs.
 3. Organ systems work together simultaneously.
 4. Human cell structure.
 - a. Size and shape depends on function.
 - b. Cell membrane.
 - c. Nucleus
 - 1) Nuclear membrane
 - 2) Nucleolus
 - 3) Chromatin
 - d. Cytoplasm which contains the following:
 - 1) Mitochondria
 - 2) Ribosomes
 - 3) Endoplasmic reticulum
 - 4) Lysosomes
 - 5) Golgi apparatus
 - 6) Centriole
 - e. DNA contains thousands of genes which determine the genetic makeup of the organism
 5. Metabolism is an important function.
 - a. **Metabolism** allows the formation of substances for the purposes of using energy.
 - b. **Catabolism** is the process by which cells break down complex substances into simpler ones causing the release of energy.
 - c. **Anabolism** is the process by which cells use energy to make simple compounds into complex ones.

G. Integumentary System

1. Consists of skin and associated tissues.
 - a. ***Epidermis*** - outermost layer of skin
 - b. ***Dermis*** is located directly underneath the epidermis and rests on top of the subcutaneous layer.
 - c. ***Subcutaneous layer*** is composed of connective tissue and adipose tissue.
2. The skin is supplied with blood vessels and a variety of receptors for senses such as *touch, pressure, pain and temperature*.
3. Also associated with the skin are hair follicles, nails, sweat glands and sebaceous glands which secrete an oily lubricant called sebum.
4. The integumentary system protects underlying tissues, prevents dehydration, keeps out foreign organisms, and is used to regulate body temperature.
5. Melanin provides skin color and protects from UV light.
6. Laboratory testing of the skin may include
 - a. Biopsy
 - b. Skin scrapings for fungal culture.
 - c. Tissue cultures and microbiology cultures.

H. Skeletal System

1. Comprised of all bones and joints of the body.
2. It is the framework which gives the body structure, protects vital organs and works with the muscular system to provide movement and leverage.
3. The skeletal system is responsible for calcium and phosphorous storage and hematopoiesis, the production of blood cells.
4. Comprised of two types of tissue bone and cartilage.
 - a. **Bone** is composed of cells surrounded by calcified substances that allow for a rigid structure.
 - b. **Cartilage** is composed of similar cells, but these are surrounded by a gelatinous material instead of calcified substances, thus allowing for more flexibility.

5. Laboratory assessment can include (**red or gold stoppered tube unless otherwise noted**):
 - a. Calcium and phosphate levels
 - b. Erythrocyte Sedimentation rate (**black or lavender**) and CBC (**lavender**)
 - c. Microscopic and microbial analysis of the bone marrow and synovial fluid.

I. Muscular System

1. Includes all muscles of the body including those attached to bone and along the walls of internal structures such as the heart.
2. Three types of muscle tissue:
 - a. **Visceral** (smooth) makes up the walls of hollow organs and the blood vessels, is **nonstriated** and is under **involuntary** or unconscious control.
 - b. **Skeletal** is attached to bone, has **striated** or banded muscle fibers, and is under **voluntary** (conscious) control.
 - c. **Cardiac** forms the wall of the heart, is a special kind of **striated** muscle, and is under **involuntary** control.
3. Muscles provide movement, maintain posture and produce heat.
4. The main property of muscle tissue is the ability to contract in response to stimulation by the nervous tissue.
5. To function they need glucose for energy, oxygen to release the energy from the nutrient, and calcium.
6. In addition to body movement muscles cause propulsion of blood through veins and passage of food through intestines.
7. Laboratory testing of the muscular system involves:
 - a. Clinical assays of **serum** for specific muscle enzymes such as creatine kinase (CK)
 - b. Lactate Dehydrogenase (LDH)
 - c. Analysis for autoimmune antibodies
 - d. Microscopic examination or culture of biopsy tissue.

J. Nervous System

1. The nervous system regulates, controls, coordinates and organizes activities of the various body systems by means of electrical impulses and chemical substances sent to and received from all parts of the body.

2. The nervous system is composed of specialized nerve cells (**neurons**), brain, spinal cord, brain and cord coverings, fluid, and the nerve impulse itself.
 - a. **Sensory neurons** transmit nerve impulses to the spinal cord or brain from muscle tissues.
 - b. **Motor neurons** transmit impulses to muscles from the spinal cord or brain.
3. **Meninges** are the protective membrane covering the spinal cord and brain.
4. The space between the meninges and brain and spinal cord is filled with cerebrospinal fluid (CSF), which provides a cushion.
5. The nervous system detects changes in the internal and external environments and responds to coordinate an appropriate response.
6. Two main structural divisions of the nervous system:
 - a. **Central nervous system** (CNS) consists of the brain and spinal cord.
 - b. **Peripheral nervous system** (PNS) consists of all the nerves that connect the CNS to every part of the body.
7. Two *functional* divisions of the nervous system are:
 - a. Sensory or afferent division carries impulses to the CNS from sensory receptors in various parts of the body.
 - b. Motor or efferent division carries impulses from the CNS to organs, glands and muscles and can be further subdivided:
 - 1) **Voluntary or somatic** nervous system conducts impulses from the CNS that allow an individual to consciously control skeletal muscles.
 - 2) **Involuntary or autonomic** nervous system plays an important role in maintaining homeostasis by conducting impulses that affect involuntary activities of the smooth muscle, cardiac, muscle and glands.
8. Laboratory diagnosis of nervous disorders is not very specific.
 - a. Chemical assays can reveal drug interactions, as well as hormonal, protein and enzyme alterations.
 - b. Acetylcholine receptor antibody found in the blood of people with myasthenia gravis.
 - c. Cerebral spinal fluid (CSF) analysis
 - 1) cell count
 - 2) glucose

- 3) protein
- 4) C&S
- d. Cholinesterase-level serves as an indicator of exposure and risk of toxicity to certain chemicals.
- e. Drug levels

K. Respiratory System

1. Function is to supply the body with oxygen (O_2) needed for metabolism of food and to eliminate carbon dioxide (CO_2), the gaseous waste product of metabolism.
2. The respiratory system is lined with cilia which filters the air breathed in.
3. Air drawn (breathed) in and passes through nose, throat, larynx (voice box), trachea (wind pipe), bronchi and smaller bronchioles.
 - a. Once air reaches alveoli (the tiny air sacs at the end of the respiratory passageway), O_2 binds to the hemoglobin in the red blood cells and is transported and released to the cells.
 - b. The cells produce CO_2 which is picked up by the red blood cells, returned to the lungs, where it is discharged in the air exhaled.
4. Inefficiency can lead to alteration of the pH of body fluids.
5. Laboratory analysis includes:
 - a. **Arterial blood gases** (ABG) to make sure oxygen (O_2) is delivered and carbon dioxide (CO_2) is adequately released.
 - b. Lung biopsies, throat swabs, sputum and bronchial washings can be examined microscopically or cultured for pathogenic microorganisms such as fungi, bacteria such as acid fast bacilli which cause respiratory disease.
 - c. Pleural (lung) fluid can be analyzed microscopically and microbiologically.
6. Diseases
 - a. Seeing increase in tuberculosis (TB).
 - b. *Pneumocystis carinii* pneumonia is appearing frequently in AIDS patients.
 - c. Elderly patients very prone to pneumonia.

L. Digestive System

1. Receives food which is broken down chemically and physically into nutrients that can be absorbed and used by the body cells to generate energy and manufacture needed substances, and eliminates waste products of digestion.
2. Gastrointestinal (GI) tract is made up of the following:
 - a. mouth
 - b. pharynx
 - c. esophagus
 - d. stomach
 - e. intestines
 - f. accessory organs include salivary glands, teeth, liver, gallbladder, pancreas and appendix.
3. Circular muscles surrounding the intestines contract to assist the movement of food through the body; these wavelike contractions are called **peristalsis**.
4. Digestive system begins with mouth, ends with anus, and the average length is approximately 27 feet.
5. Laboratory tests (**red or gold or green stoppered tube** unless indicated otherwise):
 - a. Amylase
 - b. Bilirubin – **must be protected from light**
 - c. Carcinoembryonic antigen (CEA)
 - d. Carotene
 - e. Cholesterol/Triglycerides
 - f. CBC (**lavender**)
 - g. Glucose (**may also be collected in gray stoppered tube**)
 - h. Lipase
 - i. Occult blood (sample collected by patient)
 - j. Ova and parasite – performed on feces, special collection kit used

M. Urinary System

1. Kidney functions & responsibilities

- a. Filtering and eliminating waste products of metabolism from the blood.
 - 1) Example: Urea – a nitrogenous waste product of protein metabolism.
 - 2) If the kidneys are not functioning properly, dangerous toxins accumulate in the blood and a mechanical filtering process (dialysis) must be used or a kidney transplanted.
- b. Maintaining body hydration / water and electrolyte (sodium, potassium, chloride) balance.
- c. Assist the lungs in maintaining body pH by retaining bicarbonate (a base substance) to offset body acids and maintain the blood pH at 7.40.
- d. Serve in an endocrine capacity. The kidneys secrete two hormone-like substances:
 - 1) Renin – an enzyme which acts to increase blood pressure.
 - 2) Erythropoietin – a hormone that stimulates the production of RBCs in the bone marrow.

2. Anatomy

- a. At the macroscopic level, the urinary system consists of two kidneys, two ureters, one bladder and one urethra.
 - 1) In females, the urinary system is entirely separated from the reproductive system.
 - 2) In males, the urethra carries both urine and semen, and the two systems are sometimes studied together as the urogenital system.
- b. At the microscopic level are the working units, called the **nephrons**.
 - 1) The nephrons filter the blood and selectively remove substances to be eliminated in the urine.
 - 2) Although a great deal of water and small molecules leaves the blood initially, most are returned to the circulation by the process of reabsorption.

3. Laboratory Tests (**red or gold or green stoppered** tube unless indicated otherwise)

- a. albumin and total protein
- b. ammonia – **green stoppered tube**, must be placed on ice immediately
- c. blood urea nitrogen (BUN)

- d. creatinine clearance – blood and urine required
- e. electrolytes
- f. osmolality
- g. urinalysis – urine sample required
- h. urine C&S – urine sample required

N. Reproductive System

1. The reproductive system produces the **gametes**, or sex cells, that are needed to form a new human being.
2. Male reproductive system includes: testes, seminal vesicles, prostate, epididymis, seminal ducts, urethra, scrotum, penis and spermatic cords.
 - a. Primary function is spermatogenesis, storage, maintenance and excretion of seminal fluid, and secretion of hormones (testosterone).
 - b. Sperm is one of the smallest cells in the body, containing a nucleus with 23 chromosomes.
 - c. Sperm contains either X or Y chromosome, and will determine the sex of the baby.
3. Female reproductive structures include ovaries, fallopian tubes, uterus, vagina and vulva.
 - a. These structures play a role in ovulation, fertilization, menstruation, pregnancy, labor and secretion of hormones (estrogen and progesterone).
 - b. The mature egg (ova) is the largest cell in the body, containing a nucleus with 23 chromosomes.
 - c. The egg contains only an X chromosome.
4. When the egg is fertilized by a sperm, the 46 combined chromosomes will contain the DNA coded blueprint for the new baby.
5. Laboratory Tests (**red or gold** stoppered tube unless indicated otherwise):
 - a. acid phosphatase
 - b. estrogen
 - c. follicle-stimulating hormone (FSH)
 - d. human chorionic gonadotropin (HCG)
 - e. luteinizing hormone (LH)

- f. RPR – (red or gold or lavender)
- g. Testosterone
- h. Progesterone Alpha Fetoprotein (AFP)
- i. Microbiologic cultures – sample collected by physician
- j. PAP smears – sample collected by physician
- k. Viral tissue studies – sample collected by physician
- l. Semen analysis – sample collected and submitted by patient

O. Endocrine System

1. Endocrine is from the Greek words “endon”, meaning within, and “krinein”, meaning to secrete.
2. The endocrine system consists of glands that secrete substances that affect other cells.
3. These substances, called *hormones*, are released into the bloodstream to be carried to the target cells.
4. The hormones secreted by these glands are powerful chemical substances that have a profound effect on metabolism, growth and development, reproduction, personality, and the ability of the body to react to stress and resist disease.
5. Two types of glands.
 - a. *Exocrine* glands discharge through ducts or tubes either into the intestines or outside of the body and consist of tear, sweat, salivary, mucous and mammary glands.
 - b. *Endocrine* glands release their products directly into the bloodstream and are often called ductless or internal glands. They consist of the pituitary, thyroid, parathyroid and adrenal glands.
6. Glands of the endocrine system
 - a. Pituitary (sometimes called the “master gland”) is located in the brain and releases hormones that stimulate other glands.
 - 1) Adrenocorticotrophic hormone (ACTH) stimulates the adrenal glands
 - 2) Antidiuretic hormone (ADH) which decreases urine secretion
 - 3) Follicle stimulating hormone (FSH) which affects the ovaries
 - 4) Growth hormone (GH) which is important in regulating growth

- 5) Thyroid stimulating hormone (TSH) which controls thyroid activity
- b. Thyroid gland produces calcitonin which regulates the amount of calcium (**red or gold/green**) in the blood and thyroxine which increase the metabolic rate.
 - c. Parathyroid glands regulate calcium (**red or gold**) and phosphorous (**red or gold/green/lavender**) in the blood and bones.
 - d. Thymus gland affects the lymphoid system.
- e. The adrenals (2 glands) produce the hormones epinephrine and as a result of emotions like fright or anger (“fright or flight”) causing increase in blood pressure, widened pupils and heart stimulation, cortisol which suppresses inflammation and aldosterone which is involved in regulating the amount of sodium and potassium in the blood stream.
 - f. Ovaries secrete the hormones estrogen and progesterone responsible for growth and functioning of the female reproductive system as well as the development of female sexual characteristics.
 - g. Testes secrete testosterone which is responsible for the growth and functioning of the male reproductive system as well as development of male sexual characteristics.
 - h. Pancreas produces insulin which is necessary for normal movement of glucose in the bloodstream and glucagon which stimulates the liver to release stored glucose into the bloodstream.
7. Kidneys secrete rennin which increases blood pressure and erythropoietin which stimulates the production of red blood cells.
8. Laboratory tests are available to detect abnormalities for all types of hormones and provide very specific and sensitive patient results.
- a. ACTH – **lavender on ice**
 - b. Aldosterone – **red or gold or lavender on ice**, patient may be required to be upright or lying down for 15-30 minutes prior to blood draw.
 - c. ADH – **lavender on ice**
 - d. Calcitonin – **red or gold**
 - e. Catecholamines – **lavender on ice**
 - f. Cortisol – **green or red or gold**
 - g. Erythropoietin – **red or gold**

- h. Estrogen – **red or gold/green**
- i. FSH – **red or gold**
- j. GH – **red or gold**
- k. Glucagon – **lavender, chilled**
- l. Glucose tolerance test (GTT) – **red or gold, green, or gray**
- m. Insulin level – **red or gold**
- n. Progesterone – **red or gold**
- o. Renin – **lavender on ice**, patient may be required to be upright or lying down for 15-30 minutes prior to blood draw.
- p. Serotonin
- q. Testosterone – **red or gold**
- r. Thyroid function studies (i.e., T3, T4, TSH) – **red or gold**
- s. Thyroxine – **red or gold**
- t. TSH – **red or gold**

P. Lymphatic System

1. Has a close and interrelated connection to the cardiovascular system.
2. Consists of lymph, lymphocytes, lymph vessels, lymph nodes, tonsils, spleen, bone marrow and thymus gland.
3. Three main functions
 - a. Maintain fluid balance by filtering blood and lymph fluid
 - b. Defend and provides immunity against disease through lymphocytes.
 - c. Distributes nutrients and hormones into bloodstream, removes waste and absorbs fats and other substances from digestive tract.
4. Lymph fluid is clear, colorless fluid consists of blood proteins, salts, sugar, lymphocytes, monocytes and waste product of metabolism, NOT RBCs or platelets.
5. Pass 30 liters of lymph fluid from blood to tissue space each day.
6. Fluid from capillaries enters tissue fluid and flows into lymph vessels and then to lymph nodes.

7. Pathogens or foreign substances in lymph nodes are filtered out and destroyed by white cells.
8. Fluid flows from nodes to collecting ducts and back into blood stream.
9. If more than 3 liters retained in body's tissue, edema will occur.
10. Enlarged or swollen lymph nodes are common after infections; nodes work hard to remove waste and products produced as a result of infection.
11. Spleen filters blood, removes microorganisms and other foreign substances.
12. Diseases associated with the lymphatic system include lymphoma, Hodgkin's disease, immune disorders and infectious processes.
13. Laboratory Tests
 - a. Surgically removed or aspirated lymph node tissue
 - b. HIV – this disease attacks the immune system
 - c. Analysis of markers on surface of cellular material.