DOMAIN I. PERSONAL HEALTH

COMPETENCY 1.0 UNDERSTAND HUMAN GROWTH AND DEVELOPMENT AND HUMAN BODY SYSTEMS, AND THEIR RELATIONSHIPS TO PERSONAL HEALTH AND DISEASE PREVENTION

For example:

- **stages and processes of human growth and development**
- **characteristics and processes of aging**
- **the location and function of body systems; the effects of various factors (e.g., family history, age, disease, behavioral choices, exercise) on body systems and development**
- **interdependence among body systems; the relationship of personal health to body systems and their functioning.**

STAGES AND PROCESSES OF HUMAN GROWTH AND DEVELOPMENT

Physical development – Small children (ages 3-5) have a propensity for engaging in periods of a great deal of physical activity, punctuated by a need for a lot of rest. Children at this stage lack fine motor skills and cannot focus on small objects for very long. Their bones are still developing. At this age, girls tend to be better coordinated, and boys tend to be stronger.

The lag in fine motor skills continues during the early elementary school years (ages 6-8).

Pre-adolescent children (ages 9-11) become stronger, leaner, and taller. Their motor skills improve, and they are able to sit still and focus for longer periods of time. Growth during this period is constant. This is also the time when gender physical predispositions will begin to manifest. Pre-adolescents are at risk of obesity without proper nutritional and adequate activity.

Young adolescents (ages 12-14) experience drastic physical growth (girls earlier than boys do), and are highly preoccupied with their physical appearance.

As children proceed to the later stages of adolescence (ages 15-17), girls will reach their full height, while boys will still have some growth remaining. The increase in hormone levels will cause acne, which coincides with a slight decrease of preoccupation with physical appearance. At this age, children may begin to initiate sexual activity (boys generally more motivated by hormones, and girls more by peer pressure). There is a risk of teen pregnancy and sexually transmitted diseases.

Cognitive development – Language development is the most important aspect of cognitive development in small children (ages 3-5). Allowing successes, rewarding mature behavior, and allowing the child to explore can improve confidence and self-esteem at this age.

Early elementary school children (Ages 6-8) are eager to learn and love to talk. Children at this age have a very literal understanding of rules and verbal instructions and must develop strong listening skills.

Pre-adolescent children (ages 9-11) display increased logical thought, but their knowledge or beliefs may be unusual or surprising. Differences in cognitive styles develop at this age (e.g. field dependant or independent preferences).

In early adolescence (ages 12-14), boys tend to score higher on mechanical/spatial reasoning, and girls on spelling, language, and clerical tasks. Boys are better with mental imagery, and girls have better access and retrieval of information from memory. Self-efficacy (the ability to self-evaluate) becomes very important at this stage.

In later adolescence (ages 15-17), children are capable of formal thought, but don't always apply it. Conflicts between teens' and parents' opinions and worldviews will arise. Children at this age may become interested in advanced political thinking.

LOCATION AND FUNCTION OF BODY SYSTEMS

Major systems of the human body consist of organs working together to perform important physiological tasks. In this section, we will discuss several major body systems including the musculoskeletal system, the cardiovascular system, the respiratory/excretory system, the nervous system, the endocrine system, the reproductive system, and the immune system. In addition, we will discuss how these systems adapt to physical activity, produce movement, and contribute to fitness.

Structures, locations, and functions of the three types of muscular tissue

The main function of the muscular system is movement. There are three types of muscle tissue: skeletal, cardiac, and smooth.

Skeletal muscle is voluntary. These muscles are attached to bones and are responsible for their movement. Skeletal muscle consists of long fibers and is striated due to the repeating patterns of the myofilaments (made of the proteins actin and myosin) that make up the fibers.

Cardiac muscle is found in the heart. Cardiac muscle is striated like skeletal muscle, but differs in that the plasma membrane of the cardiac muscle causes the muscle to beat even when away from the heart. The action potentials of cardiac and skeletal muscles also differ.

Smooth muscle is involuntary. It is found in organs and enables functions such as digestion and respiration. Unlike skeletal and cardiac muscle, smooth muscle is not striated. Smooth muscle has less myosin and does not generate as much tension as skeletal muscle.

Mechanism of skeletal muscle contraction

A nerve impulse strikes a muscle fiber. This causes calcium ions to flood the sarcomere. Calcium ions allow ATP to expend energy. The myosin fibers creep along the actin, causing the muscle to contract. Once the nerve impulse has passed, calcium is pumped out and the contraction ends.

Movement of body joints

The axial skeleton consists of the bones of the skull and vertebrae. The appendicular skeleton consists of the bones of the legs, arms and tail, and shoulder girdle. Bone is a connective tissue. Parts of the bone include compact bone that gives strength, spongy bone that contains red marrow to make blood cells and yellow marrow in the center of long bones to store fat cells, and the periosteum that is the protective covering on the outside of the bone.
A joint is a place where two bones meet. Joints enable movement. Ligaments attach bone to bone. Tendons attach bone to muscle. Joints allow great flexibility in movement. There are three types of joints:

1. Ball and socket – allows for rotational movement. An example is the joint between the shoulder and the humerus. Ball and socket joints allow humans to move their arms and legs in many different ways.

2. Hinge – movement is restricted to a single plane. An example is the joint between the humerus and the ulna.

3. Pivot – allows for the rotation of the forearm at the elbow and the hands at the wrist.

Human nervous and endocrine systems

The **central nervous system (CNS)** consists of the brain and spinal cord. The CNS is responsible for the body's response to environmental stimuli. The spinal cord is located inside the spine. It sends out motor commands for movement in response to stimuli. The brain is where responses to more complex stimuli occur. The meninges are the connective tissues that protect the CNS. The CNS contains fluid filled spaces called ventricles. These ventricles are filled when cerebrospinal fluid which is formed in the brain. This fluid cushions the brain and circulates nutrients, white blood cells, and hormones. The CNS's response to stimuli is a reflex. A reflex is an unconscious, automatic response.

The **peripheral nervous system (PNS)** consists of the nerves that connect the CNS to the rest of the body. The sensory division brings information to the CNS from sensory receptors and the motor division sends signals from the CNS to effector cells. The motor division consists of somatic nervous system and the autonomic nervous system. The body consciously controls the somatic nervous system in response to external stimuli. The hypothalamus in the brain unconsciously controls the autonomic nervous system to regulate the internal environment. This system is responsible for the movement of smooth muscles, cardiac muscles, and the muscles of other organ systems.

Major endocrine glands and the function of their hormones

The function of the **endocrine system** is to manufacture proteins called hormones. **Hormones** circulate in the bloodstream and stimulate actions when they interact with target tissue. There are two classes of hormones, steroid and peptide. Steroid hormones come from cholesterol and include the sex hormones. Amino acids are the source of peptide hormones. Hormones are specific and fit receptors on the target tissue cell surface. The receptor activates an enzyme that converts ATP to cyclic AMP. Cyclic AMP (cAMP) is a second messenger from the cell membrane to the nucleus. The genes found in the nucleus turn on or off to cause a specific response.

Endocrine cells, which make up endocrine glands, secrete hormones. The major endocrine glands and their hormones include:

Hypothalamus – located in the lower brain; signals the pituitary gland.

Pituitary gland – located at the base of the hypothalamus; releases growth hormones and antidiuretic hormone (retention of water in kidneys).

Thyroid gland – located on the trachea; lowers blood calcium levels (calcitonin) and maintains metabolic processes (thyroxine).

Gonads – located in the testes of the male and the ovaries of the female; testes release androgens to support sperm formation and ovaries release estrogens to stimulate uterine lining growth and progesterone to promote uterine lining growth.

Pancreas – secretes insulin to lower blood glucose levels and glucagon to raise blood glucose levels.

Role of nerve impulses and neurons

The **neuron** is the basic unit of the nervous system. It consists of an axon, which carries impulses away from the cell body to the tip of the neuron; the dendrite, which carries impulses toward the cell body; and the cell body, which contains the nucleus. Synapses are spaces between neurons. Chemicals called neurotransmitters are found close to the synapse. The myelin sheath, composed of Schwann cells, covers the neurons and provides insulation.

Nerve action depends on depolarization and an imbalance of electrical charges across the neuron. A polarized nerve has a positive charge outside the neuron. A depolarized nerve has a negative charge outside the neuron. Neurotransmitters turn off the sodium pump which results in depolarization of the membrane. This wave of depolarization (as it moves from neuron to neuron) carries an electrical impulse. This is actually a wave of opening and closing gates that allows for the flow of ions across the synapse. Nerves have an action potential. There is a threshold of the level of chemicals that must be met or exceeded in order for muscles to respond. This is the "all or nothing" response.

Structure and function of the skin

The skin consists of two distinct layers, the epidermis and the dermis. The epidermis is the thinner outer layer and the dermis is the thicker inner layer. Layers of tightly packed epithelial cells make up the epidermis. The tight packaging of the epithelial cells supports the skin's function as a protective barrier against infection.

The top layer of the epidermis consists of dead skin cells and contains keratin, a waterproofing protein. The dermis layer consists of connective tissue. It contains blood vessels, hair follicles, sweat glands, and sebaceous glands. The body releases an oily secretion called sebum, produced by the sebaceous gland, to the outer epidermis through the hair follicles. Sebum maintains the pH of the skin between 3 and 5, which inhibits most microorganism growth.

The skin also plays a role in thermoregulation. Increased body temperature causes skin blood vessels to dilate, causing heat to radiate from the skin's surface. Increased temperature also activates sweat glands, increasing evaporative cooling. Decreased body temperature causes skin blood vessels to constrict. This results in blood from the skin diverting to deeper tissues and reduces heat loss from the surface of the skin.

Human respiratory and excretory systems

The lungs are the respiratory surface of the human respiratory system. A dense net of capillaries contained just beneath the epithelium form the respiratory surface. The surface area of the epithelium is about $100m^2$ in humans. Based on the surface area, the volume of air inhaled and exhaled is the tidal volume. This is normally about 500mL in adults. Vital capacity is the maximum volume the lungs can inhale and exhale. This is usually around 3400mL.

The kidneys are the primary organ in the excretory system. Each of the two kidneys in humans is about 10cm long. Despite their small size, they receive about 20% of the blood pumped with each heartbeat. The function of the excretory system is to rid the body of nitrogenous wastes in the form of urea.

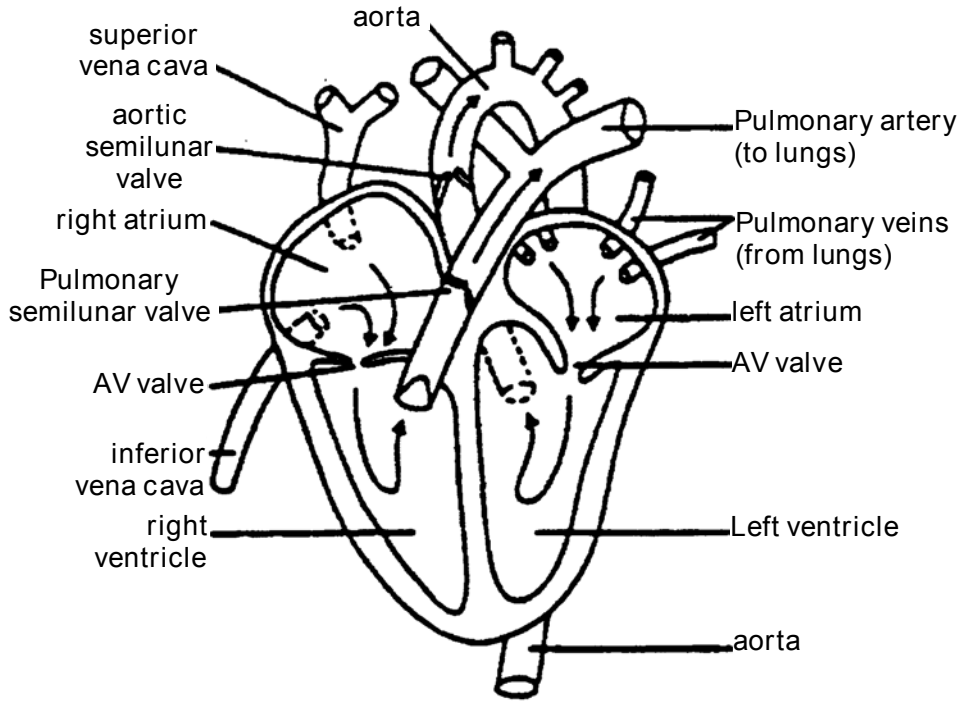
Knowledge of process of breathing and gas exchange

The respiratory system functions in the gas exchange of oxygen and carbon dioxide waste. It delivers oxygen to the bloodstream and picks up carbon dioxide for release from the body. Air enters the mouth and nose, where it is warmed, moistened and filtered of dust and particles. Cilia in the trachea trap and expel unwanted material in mucus. The trachea splits into two bronchial tubes and the bronchial tubes divide into smaller and smaller bronchioles in the lungs. The internal surface of the lung is composed of alveoli, which are thin walled air sacs. These allow for a large surface area for gas exchange. Capillaries line the alveoli. Oxygen diffuses into the bloodstream and carbon dioxide diffuses out of the capillaries and is exhaled from the lungs due to partial pressure. Hemoglobin, a protein containing iron, carries the oxygenated blood to the heart and all parts of the body.

The thoracic cavity holds the lungs. The diaphragm muscle below the lungs is an adaptation that makes inhalation possible. As the volume of the thoracic cavity increases, the diaphragm muscle flattens out and inhalation occurs. When the diaphragm relaxes, exhalation occurs.

Human circulatory system

The function of the closed circulatory system (**cardiovascular system**) is to carry oxygenated blood and nutrients to all cells of the body and return carbon dioxide waste to the lungs for expulsion. The heart, blood vessels, and blood make up the cardiovascular system. The following diagram shows the structure of the heart:



The atria are the chambers that receive blood returning to the heart and the ventricles are the chambers that pump blood out of the heart. There are four valves, two atrioventricular (AV) valves and two semilunar valves. The AV valves are located between each atrium and ventricle. The contraction of the ventricles closes the AV valve to keep blood from flowing back into the atria. The semilunar valves are located where the aorta leaves the left ventricle and the pulmonary artery leaves the right ventricle. Ventricular contraction opens the semilunar valves, pumping blood out into the arteries, and ventricular relaxation closes the valves.

The cardiac output is the volume of blood per minute that the left ventricle pumps. This output depends on the heart rate and stroke volume. The **heart rate** is the number of times the heart beats per minute and the **stroke volume** is the amount of blood pumped by the left ventricle each time it contracts. Humans have an average cardiac output of about 5.25 L/min. Heavy exercise can increase cardiac output up to five times. Epinephrine and increased body temperature also increase heart rate and, thus, the cardiac output.
Cardiac muscle can contract without any signal from the nervous system. The sinoatrial node is the pacemaker of the heart. It is located on the wall of the right atrium and generates electrical impulses that make the cardiac muscle cells contract in unison. The atrioventricular node briefly delays the electrical impulse to ensure the atria empty before the ventricles contract.

Structure, function, and regulation of the immune system

The immune system is responsible for defending the body against foreign invaders. There are two defense mechanisms: non-specific and specific.

The **non-specific** immune mechanism has two lines of defense. The first line of defense is the physical barriers of the body. These include the skin and mucous membranes. The skin prevents the penetration of bacteria and viruses as long as there are no abrasions on the skin. Mucous membranes form a protective barrier around the digestive, respiratory, and genitourinary tracts. In addition, the pH of the skin and mucous membranes inhibit the growth of many microbes. Mucous secretions (tears and saliva) wash away many microbes and contain lysozyme that kills microbes.

The second line of defense includes white blood cells and the inflammatory response. **Phagocytosis** is the ingestion of foreign particles. Neutrophils make up about seventy percent of all white blood cells. Monocytes mature to become macrophages, which are the largest phagocytic cells. Eosinophils are also phagocytic. Natural killer cells destroy the body's own infected cells instead of the invading the microbe directly.

The other second line of defense is the inflammatory response. The blood supply to the injured area increases, causing redness and heat. Swelling also typically occurs with inflammation. Basophils and mast cells release histamine in response to cell injury. This triggers the inflammatory response.

The **specific** immune mechanism recognizes specific foreign material and responds by destroying the invader. These mechanisms are specific and diverse. They are able to recognize individual pathogens. An **antigen** is any foreign particle that elicits an immune response. The body manufactures **antibodies** that recognize and latch onto antigens, hopefully destroying them. They also discriminate between foreign material versus self material. Memory of the invaders provides immunity upon further exposure.

Immunity is the body's ability to recognize and destroy an antigen before it causes harm. Active immunity develops after recovery from an infectious disease (e.g. chicken pox) or after a vaccination (e.g. mumps, measles, rubella). Passive immunity may be passed from one individual to another and is not permanent. A good example is the immunities passed from mother to nursing child. A baby's immune system is not well developed and the passive immunity they receive through nursing keeps them healthier.

There are two main responses made by the body after exposure to an antigen:

1. **Humoral response** - Free antigens activate this response and B cells (lymphocytes from bone marrow) give rise to plasma cells that secrete antibodies and memory cells that will recognize future exposures to the same antigen. The antibodies defend against extracellular pathogens by binding to the antigen and making them an easy target for phagocytes to engulf and destroy. Antibodies are in a class of proteins called immunoglobulins. There are five major classes of immunoglobulins (Ig) involved in the humoral response: IgM, IgG, IgA, IgD, and IgE.

2. **Cell mediated response** – Infected cells activate T cells (lymphocytes from the thymus). These activated T cells defend against pathogens in the cells or cancer cells by binding to the infected cell and destroying them along with the antigen. T cell receptors on the T helper cells recognize antigens bound to the body's own cells. T helper cells release IL-2, which stimulates other lymphocytes (cytotoxic T cells and B cells). Cytotoxic T cells kill infected host cells by recognizing specific antigens.

Vaccines are antigens given in very small amounts. They stimulate both humoral and cell mediated responses. After vaccination, memory cells recognize future exposure to the antigen so the body can produce antibodies much faster.

Human digestive system

The function of the digestive system is to break food down into nutrients, absorb them into the blood stream, and deliver them to all cells of the body for use in cellular respiration.

Essential nutrients are those nutrients that the body needs but cannot make. There are four groups of essential nutrients: essential amino acids, essential fatty acids, vitamins, and minerals.

There is about eight essential amino acids humans need. A lack of these amino acids results in protein deficiency. There are only a few essential fatty acids.

Vitamins are organic molecules essential for a nutritionally adequate diet. Scientists have identified thirteen vitamins essential to humans. There are two groups of vitamins: water-soluble (includes the vitamin B complex and vitamin C) and water insoluble (vitamins A, D and K). Vitamin deficiencies can cause severe problems.

Unlike vitamins, minerals are inorganic molecules. Calcium is important in bone construction and maintenance. Iron is important in cellular respiration and is a major component of hemoglobin.

Carbohydrates, fats, and proteins are fuel for the generation of ATP. Water is necessary to keep the body hydrated. We discussed the importance of water in previous sections.

Essential Amino Acids	**Essential Vitamins**
• Arginine • Histidine • Isoleucine • Leucine • Lysine • Methionine • Phenylalanine • Threonine • Tryptophan • Valine	• Vitamin A • Vitamin B complex (8 vitamins) • Vitamin C • Vitamin D • Vitamin E • Vitamin K

Mechanical and chemical digestion

The teeth and saliva begin digestion by breaking food down into smaller pieces and lubricating it to allow swallowing. The lips, cheeks, and tongue form a bolus or ball of food. The process of peristalsis (wave-like contractions) carries the food down the pharynx where it enters the stomach through the sphincter, which closes to keep food from going back up. In the stomach, pepsinogen and hydrochloric acid form pepsin, the enzyme that hydrolyzes proteins. This chemical action breaks the food down further and churns into a semifluid mass called acid chyme. The pyloric sphincter muscle opens to allow the food to enter the small intestine. Most nutrient absorption occurs in the small intestine. Its large surface area, resulting from its length and protrusions called villi and microvilli, allow for a great absorptive surface into the bloodstream. Neutralization of the chyme after arrival from the acidic stomach allows the local enzymes to function. Accessory organs function in the production of necessary enzymes and bile. The pancreas makes many enzymes to break down food in the small intestine. The liver makes bile, which breaks down and emulsifies fatty acids. Any food left after the trip through the small intestine enters the large intestine. The large intestine functions to reabsorb water and produce vitamin K. The feces, or remaining waste, pass out through the anus.