Anatomy & Physiology

The Circulatory System

The Circulatory System is designed to deliver oxygen and nutrients to all parts of the body and pick up waste materials and toxins for elimination. This system is made up of the heart, the veins, the arteries, and the capillaries.

Circulation is achieved by a continuous one-way movement of blood throughout the body. The network of blood vessels that flow through the body is so extensive that blood flows within close proximity to almost every cell.

Heart
The heart is a muscular pump that propels blood throughout the body. The heart is located between the lungs, slightly to the left of center in the chest. The heart is broken down into four chambers including:

- The right atrium, which is a chamber which receives oxygen-poor blood from the veins.
- The right ventricle which pumps the oxygen-poor blood from the right atrium to the lungs.
- The left atrium which receives the now oxygen-rich blood that is returning from the lungs.
- The left ventricle, which pumps the oxygenated blood through the arteries to the rest of the body.

This process occurs about 72 times per minute, every day of our lives.

Blood Vessels
Blood vessels are broken down into three groups: the arteries which carry blood out of the heart to the capillaries, the veins which transport oxygen-poor blood back to the heart, and the capillaries which transfer oxygen and other nutrients into the cells and removes carbon dioxide and other metabolic waste from these body tissues.

Blood Pressure
Blood pressure is the force exerted by the blood against the walls of the blood vessels. The output or direct pumping of the heart and the resistance to blood flow in the vessels determines blood pressure. Resistance is determined by blood viscosity and by friction between the blood and the wall of the blood vessel.

\[ \text{Blood pressure} = \text{blood flow} \times \text{resistance} \]
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The Respiratory System

The respiratory system is an intricate arrangement of spaces and passageways that conduct air from outside the body into the lungs and finally into the blood as well as expelling waste gases. This system is responsible for the mechanical process called breathing, with the average adult breathing about 12 to 20 times per minute.

When engaged in strenuous activities, the rate and depth of breathing increases in order to handle the increased concentrations of carbon dioxide in the blood. Breathing is typically an involuntary process, but can be consciously stimulated or inhibited as in holding your breath.

Nostrils/Nasal Cavities
During inhalation, air enters the nostrils and passes into the nasal cavities where foreign bodies are removed, the air is heated and moisturized before it is brought further into the body. It is this part of the body that houses our sense of smell.

Sinuses
The sinuses are small cavities that are lined with mucous membrane within the bones of the skull.

Pharynx
The pharynx, or throat carries foods and liquids into the digestive tract and also carries air into the respiratory tract.

Larynx
The larynx or voice box is located between the pharynx and trachea. It is the location of the Adam's apple, which in reality is the thyroid gland and houses the vocal cords.

Trachea
The trachea or windpipe is a tube that extends from the lower edge of the larynx to the upper part of the chest and conducts air between the larynx and the lungs.

Lungs
The lungs are the organ in which the exchange of gasses takes place. The lungs are made up of extremely thin and delicate tissues. At the lungs, the bronchi subdivides, becoming progressively smaller as they branch through the lung tissue, until they reach the tiny air sacks of the lungs called the alveoli. It is at the alveoli that gasses enter and leave the blood stream.
**Bronchi**
The trachea divides into two parts called the bronchi, which enter the lungs.

**Bronchioles**
The bronchi subdivide creating a network of smaller branches, with the smallest one being the bronchioles. There are more than one million bronchioles in each lung.

**Alveoli**
The alveoli are tiny air sacks that are enveloped in a network of capillaries. It is here that the air we breathe is diffused into the blood, and waste gasses are returned for elimination.
The Urinary System

The function of the urinary system is to remove waste products from the blood and eliminate them from the body. The principal waste products being eliminated are water, carbon dioxide and nitrogenous wastes including urea, uric acid and creatinine.

Other functions of the urinary system include the regulation of the volume of body fluids, the balance of pH and the electrolyte composition of these fluids.

Kidneys
The kidneys are located in the back of the upper abdomen and are protected by the lower ribs and rib cartilage of the back. The kidneys are involved with a number of bodily functions which include:

- The filtering and excretion of unwanted waste products such as urea from the body.
- The maintenance of water balance, the regulation of the acid-base balance of body fluids. The production of rennin, which is important in the regulation of blood pressure.
- The production of the hormone erythropoietin, which stimulates the production of red blood cells.

Ureters
The ureters are two slender tubes that run from the sides of the kidneys to the bladder. Their function is to transport urine from the kidneys to the bladder.

Bladder
The bladder is a muscular organ and serves as a reservoir for urine. Located just behind the pubic bone, it can extend well up into the abdominal cavity when full. Near the outlet of the bladder is a small muscle called the internal sphincter, which contract involuntarily to prevent the emptying of the bladder.

Urethra
The urethra is a tube that extends from the bladder to the outside world. It is through this tube that urine is eliminated from the body.
Conditions both within the body and in the environment are constantly changing. The nervous system directs the complex processes of the body's internal environment and also provides a link to the external world. This allows us to respond to changes both from internal sources as well as form external stimuli.

The nervous system is broken down into two major parts: the central nervous system, which includes the brain and spinal cord, and the peripheral nervous system, which includes all nerves, which carry impulses to and from the brain and spinal cord. These include our sense organs, the eyes, the ears, our sense of taste, smell and touch, as well as our ability to feel pain.

Central Nervous System

Spinal Cord
The spinal cord is a long bundle of neural tissue continuous with the brain that occupies the interior canal of the spinal column and functions as the primary communication link between the brain and the rest of the body. The spinal cord receives signals from the peripheral senses and relays them to the brain.

Brain Stem
The brain stem is the part of the brain that connects the cerebrum and diencephalons with the spinal cord.

Medulla Oblongata
The medulla oblongata is located just above the spinal cord. This part of the brain is responsible for several vital autonomic centers including:

- the respiratory center, which regulates breathing.
- the cardiac center that regulates the rate and force of the heartbeat.
- the vasomotor center, which regulates the contraction of smooth muscle in the blood vessel, thus controlling blood pressure.

The medulla also controls other reflex actions including vomiting, sneezing, coughing and swallowing.

Pons
Continuing up the brain stem, one reaches the Pons. The Pons lie just above the medulla and acts as a link between various parts of the brain. The pons connects the two halves of the cerebellum with the brainstem, as well as the cerebrum with the spinal cord. The Pons, like the medulla oblongata, contains certain reflex actions, such as some of the respiratory responses.
Midbrain
The midbrain extends from the Pons to the diencephalon. The midbrain acts as a relay center for certain head and eye reflexes in response to visual stimuli. The midbrain is also a major relay center for auditory information.

Diencephalon
The diencephalon is located between the cerebrum and the mid brain. The diencephalons houses important structures including the thalamus, the hypothalamus and the pineal gland.

Thalamus
The thalamus is responsible for "sorting out" sensory impulses and directing them to a particular area of the brain. Nearly all sensory impulses travel through the thalamus.

Hypothalamus
The hypothalamus is the great controller of body regulation and plays an important role in the connection between mind and body, where it serves as the primary link between the nervous and endocrine systems. The hypothalamus produces hormones that regulate the secretion of specific hormones from the pituitary. The hypothalamus also maintains water balance, appetite, sexual behavior, and some emotions, including fear, pleasure and pain.

Cerebellum
The functions of the cerebellum include the coordination of voluntary muscles, the maintenance of balance when standing, walking and sitting, and the maintenance of muscle tone ensuring that the body can adapt to changes in position quickly.

Cerebrum
The largest and most prominent part of the brain, the cerebrum governs higher mental processes including intellect, reason, memory and language skills. The cerebrum can be divided into 3 major functions:

- Sensory Functions - the cerebrum receives information from a sense organ; i.e., eyes, ears, taste, smell, feelings, and translates this information into a form that can be understood.
- Motor Functions - all voluntary movement and some involuntary movement.
- Intellectual Functions - responsible for learning, memory and recall.

Meninges
The meninges are made up of three layers of connective tissue that surround and protect both the brain and spinal cord. The layers include the dura mater, the arachnoid and the pia matter.

Cerebrospinal Fluid
The cerebrospinal fluid is a clear liquid that circulates in and around the brain and spinal cord. Its function is to cushion the brain and spinal cord, carry nutrients to the cells and remove waste products from these tissues.

Peripheral Nervous System

Nerves
Nerves are made up of specialized cells, which act as little wires, transmitting information to and from the central nervous system and brain. Nerves form the network of connections that receive signals (known as sensory input) from the environment and within the body, and transmit the body's responses, or instructions for action, to the muscles, organs, and glands. Nerve cells are located outside the central nervous system or spinal cord.
**Eyes**
The eyes are organs that provide us with visual information from the external world, which is transmitted and interpreted by the brain.

**Ears**
The ears are the organs used for both hearing and equilibrium. The ear can be divided into three sections: the outer that includes the parts of the ear we see, and the ear canal, which connects the external ear to the middle ear. It is separated from the middle ear by the tympanic membrane or eardrum. The middle ear contains three small bones that conduct sound waves. The inner ear contains sensory receptors and the mechanisms responsible for equilibrium.

**Taste**
The sense of taste is perceived through the taste buds, which are located in various parts of the mouth, but are primarily concentrated on the tongue. Taste is experienced in four different ways - sweet, sour, salty or bitter. It is interesting to note, that only substances in solution can be perceived by the taste buds.

**Smell**
The receptors for smell are located in the upper part of the nasal cavity in the olfactory epithelium. The sense of smell can distinguish a greater variety of substances than the sense of taste. Here too, substances that are detected by these receptors must be in solution.

**Tactile Sensation**
There are several other types of receptors located throughout the body. They are considered general senses and provide us with tactile sensations including the feeling of pressure, heat, cold, pain and touch.
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The Digestive & Intestinal System

Each cell of the body requires a constant supply of nutrients to use as the basic building blocks of the body and for the hundreds of biochemical process that are continuously going on within the body. The digestive system is the way in which the body transforms food into the energy it needs to build, repair and fuel itself. To be absorbed and used by the body, however, food substances must first be broken down into pieces small enough to cross the cellular membrane. The first step in this process is digestion. Digestion begins in the mouth. Food, once chewed, travels through the throat or pharynx to the esophagus and then on to the stomach. From the stomach, it passes into the small, then large intestines where it is further digested with the aid of bile and enzymes from the pancreas and liver, and finally absorbed. Any waste materials of this process exit the body through the colon and rectum.

Mouth
The mouth is the oral cavity where foods are received and prepared for digestion. The mouth is responsible for the secretion of salivary amylase, which begins the digestion process by converting starches into sugars.

Pharynx
The pharynx, or throat, is a muscular tube that serves as a vehicle for both respiration and digestion. When we swallow, reflex movements of muscles in the pharynx propel food into the esophagus.

Esophagus
The esophagus is a tube that carries swallowed foods to the stomach.

Stomach
The stomach is a muscular organ that is located in the central/upper left hand region of the abdominal cavity. The function of the stomach is to break down food items. The stomach secretes digestive juices, such as hydrochloric acid and pepsin, to aid in this process. Its muscular walls churn the food until it is in a semi-liquid form.

Small Intestines
The small intestines digest and absorb many of the foods we eat. In addition to secreting a strong mucus membrane to protect it’s walls from the strong acid food mixture that passes into it from the stomach, the small intestines (along with the liver and pancreas) secrete enzymes that help to digest proteins and carbohydrates and break them down into their simplest form. Once digested, nutrients are extracted and are absorbed by the body.

Large Intestines
The large intestine is responsible for the elimination of food materials that cannot be digested and
assimilated by the body. It is also responsible for the re-absorption of water used during the digestive process. As food materials pass through the large intestine, friendly bacteria that live in the colon act upon this waste, producing vitamin K and some of the B-vitamins.

Liver
The liver is the largest gland in our bodies. It is located in the upper right portion of the abdominal cavity, with the lower edge of the liver extending just below the rib cage. The liver is responsible for a multitude of different functions, including:

- The synthesis of lipoproteins such as cholesterol.
- Synthesis of bile, which is necessary for fat digestion and absorption.
- Manufactures carnitine for use in cell mediated fat transport.
- Regulation of the amount of cholesterol circulating in the blood.
- The storage and releasing of glucose.
- Converts lactic acid into glycogen.
- Converts B vitamins into their active co-enzyme form.
- Coverts ammonia into urea, which is excreted by the kidneys.
- The production or synthesis of specific proteins such as albumin and blood clotting factors.
- The storage of substances such as glucose, fat soluble vitamins, including A, B12, D, E & K, foliate, and minerals such as copper and iron.
- Modification and inactivation of hormones; i.e., the breakdown of hormones that have served their function.
- Detoxification of chemical elements whether ingested or inhaled.
- Removal of harmful substances from the blood and converts them into less harmful substances that can be eliminated.

Pancreas
The pancreas is a gland that is located in the upper left hand quadrant of the abdominal cavity. The pancreas houses the Islets of Lander horn, which are responsible for regulating blood sugar levels. It also produces enzymes that digest fats, proteins and carbohydrates. In addition, the pancreas also produces an alkaline fluid, which neutralizes the acidity of foods as they exit the stomach and proceed into the small intestines.