TEACHER BACKGROUND INFORMATION

BODY SYSTEMS

CHAPTER'S BIG IDEAS:

- Structure and function are generally correlated at all levels of biological organization.
- The Human Body is made up of systems with structures and functions that are related (SC.F.1.2.1)
- Human organ systems:
  - Skeletal system
  - Muscular system
  - Circulatory system
  - Respiratory system
  - Digestive system
  - Nervous system

All humans have a complex system of cells that are organized into tissues. A collection of tissues that function together are called an organ. When organs work together to perform a function they are classified into one organ system. Every person has a set of organ systems that work together to "run" the body. There are a total of 10 organ systems; skeletal, muscular, circulatory, respiratory, digestive, nervous, reproductive, endocrine, excretory and lymphatic. Within each of these systems there are a group of organs responsible for the proper "running" of the system. The first six organ systems are discussed here.

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The main role of the **skeletal system** is to provide support for the body, to protect internal organs and to provide attachment sites for the organs. The organs that make up the skeletal system are: bones, cartilage, tendons and ligaments.

The function of the **muscular system** is to provide movement. Muscles work to move limbs and provide mobility. Muscles also control the movement of substances through some organs, such as the movement of food through the stomach and intestine, and blood through the heart and circulatory system. Skeletal muscles and smooth muscles make up the organs of the muscular system.

The main job of the **circulatory system** is to transport nutrients, gases (such as oxygen and CO_2), hormones and wastes through the body. The heart, blood vessels and blood make up the organs of the circulatory system.

The function of the **respiratory system** is to provide gas exchange between the blood and the environment. Primarily, oxygen is absorbed from the atmosphere into the body and carbon dioxide is expelled from the body. The organs that make up the respiratory system are: nose, trachea and lungs.

The **digestive system**'s function is the breakdown and absorption of nutrients that are necessary for growth and maintenance. The organs that make up the digestive system are: mouth, esophagus, stomach, small and large intestines.

The responsibility of the **nervous system** is to relay electrical signals through the body. The nervous system directs behavior and movement and aides in the control of all biological functions such as digestion and circulation. The organs that make up the nervous system are: brain, spinal cord and nerves.

The Skeletal System

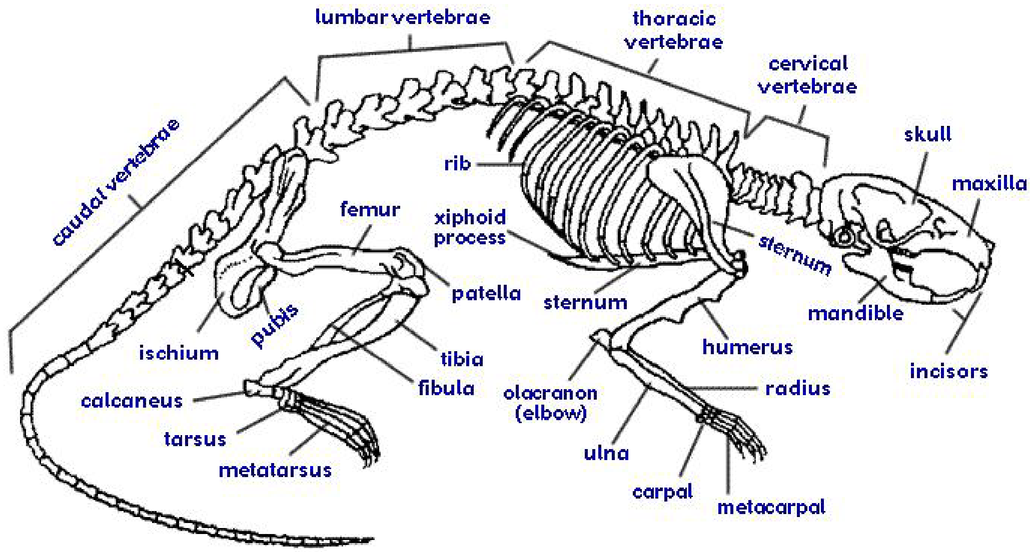

Figure 1: Diagram of rat skeleton. www.biologycorner.com/bio3/rat_external.html

Functions of the Skeletal System:

- **Support** - Without the skeletal system, the mammalian body would be unable to hold its shape and would collapse.
- **Protection** - Many bones protect vital components of other body systems by creating a sturdy barrier between soft tissues and outside injury. For example, the skull and spine prevent injury to the brain and spinal cord. In addition, the ribs and sternum help to minimize damage to the heart and lungs due to outside forces.
- **Red blood cell production** - Red blood cells, necessary for gas exchange, are produced in the marrow of certain bones.
- **Storage** - When excess levels of certain minerals, such as calcium and

phosphorous, are present in the bloodstream, bone cells can incorporate them into the structure of the bone tissue. At a later time, these minerals can be released from the bone back into the bloodstream to elevate low mineral levels.

- **Movement** - The presence of joints between bones allow body parts to move with the help of the muscular system.

Structure of the Skeletal System:

The main components of the skeletal system are bones and connective tissues, including tendons (connect muscles to bones) and ligaments (connect bones to other bones). Figure 1 illustrates a general mammalian skeletal system, while figure 2 shows how although mammals are capable of many different forms of locomotion, the underlying skeletal structure often remains very similar. Bone itself is comprised of several different types of tissues. The outermost tissue is very compact and dense, yet flexible, which gives bone its ability to support the body. This layer is formed by specific bone cells which secrete a highly mineralized substance which hardens around them, but the presence of collagen fibers within this layer prevents the bone from being brittle. Under the dense outer bone lies a spongy bone layer where most bone remodeling occurs. In the interior of bones resides the bone **marrow**. Fatty yellow colored bone marrow contains large amounts of blood vessels which reach outer bone cells via small canals through the bone tissue. Additionally, certain bones contain red bone marrow where red blood cell production occurs.

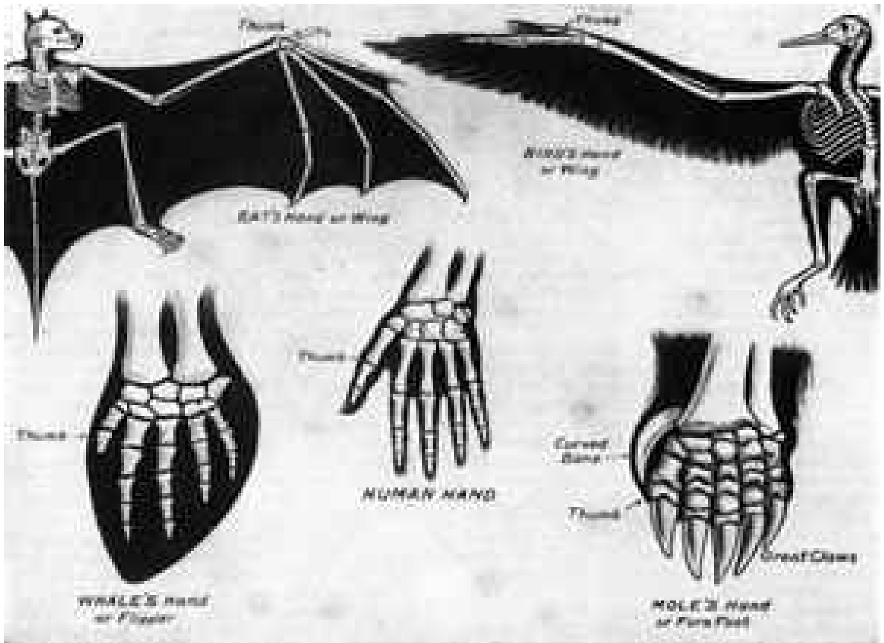

Figure 2: Comparison of similarities of hand morphology.

www.ftexploring.com/askdrg/askdrgalapagos3.html

Joints:

Joints occur in many areas where separate bones are joined together. The type of joint determines the kinds of movement allowed between the joined bones when muscles are attached by tendons. Some joints, such as those found within the cranium or pelvis, are fused and do not allow for movement. Other joints, including the knee and shoulder, allow for several different types of motion. These joints require the presence of cartilage and other connective tissues to cushion movements and to hold joints together. Of the movable joints, there are four types, as follows:

- **ball and socket** - Found in the shoulder and hip, the ball and socket joint allows for the widest range of motion. A group of bones and tendons form a pocket shaped structure (the "socket") in which the rounded end of a bone (the "ball") is inserted and secured by connective tissues. Because of this type of attachment, the ball and socket joint allows for motion in many different directions or axes.

- **hinge** - Hinge joints, such as knees and elbows, functionally resemble door hinges. Just as hinges limit door movements to being opened or closed only, the connective tissues of hinge joints restrict the movement of the joint to one axis. For example, the knee allows the lower leg to move forward and backward but not side to side.
- **pivot** - A pivot joint also only allows for movement in one axis. However, unlike hinge joints, pivot joints allow for rotational motion. A pivot joint can be found between the first and second cervical vertebrae which makes it possible for the head to be rotated from side to side.
- **gliding** - Gliding joints permit minimal movement in one axis. These joints occur in areas, such as between the shoulder blade and the clavicle, where two flat bone surfaces glide over one another.

The Muscular System

Functions of the Muscular System:

- **Voluntary movement -** Voluntary movements are those which animals can consciously control, such as running or climbing. The brain sends signals via nerves to muscle fibers attached to the skeleton which then cause the body to move in the desired way.
- **Involuntary movement -** Involuntary movement involves movements which do not require an animals conscious control. These movements, including those of the heart and stomach, are still controlled by signals sent to the muscles from the brain; however, these signals occur automatically and may be beyond the conscious control of the animal.

Structure of the Muscular System:

The muscular system is composed of three different types of muscle, as follows:

- **Striated muscle -** Striated muscle, also called **skeletal muscle**, attaches to bones with tendons and moves the skeleton. Striated muscle is composed of multinucleated muscle cells (also called fibers) which appear to have many stripes or striations running through them (see figure 3). The striations are caused by the regular arrangement of protein filaments within the cell which appear as a pattern of dark and light bands.

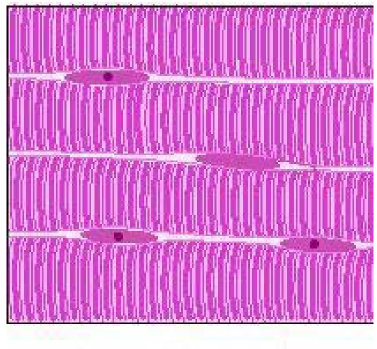

Figure 3: Striated muscle cells.

www.dmacc.org/instructors/rbwollaston/cells_and_tissues/muscle_cells.gif

- **Smooth muscle** - Smooth muscle cells lack the striations of skeletal muscle cells because their protein filaments are not arranged in regular bands (see figure 4). Smooth muscle composes portions of blood vessel and digestive tract organ walls where their gentle contractions move materials through the systems.

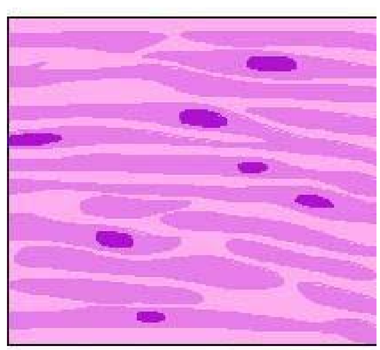

Figure 4: Smooth muscle cells.

www.dmacc.org/instructors/rbwollaston/cells_and_tissues/muscle_cells.gif

- **Cardiac muscle** - Cardiac muscle fibers form the heart. Cardiac muscle is striated like skeletal muscle; however, cardiac muscle cells are unique because they have cell membranes which allow electrical signals to travel from one cardiac muscle cell to another causing the entire heart to contract when only a small area of the heart has been stimulated (see figure 5).

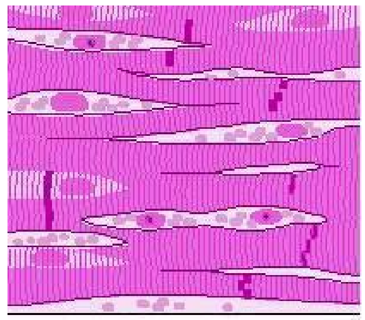

Figure 5: Cardiac muscle cells.

www.dmacc.org/instructors/rbwollaston/cells_and_tissues/muscle_cells.gif

How Muscles Contract:

- **skeletal muscle** - A skeletal muscle cell needs to be directly stimulated by a motor neuron of the nervous system for it to contract. Motor neuron signals cause sarcoplasmic reticulums (specialized type of endoplasmic reticulum) to release calcium ions into the cytoplasm of skeletal muscle cells. The increase of calcium ions effects binding sites on the protein filaments of the muscle cell, causing them to move over one another and resulting in the overall shortening of the muscle fiber. The shortening of the muscle fibers causes the muscle to contract. How long a muscle contracts for depends on how quickly the sarcoplasmic reticulums can remove the calcium ions from the cell's cytoplasm. Once the excess calcium ions are removed, the muscle filaments slide apart and the muscle relaxes. The duration, strength, and speed of muscle contraction can all be varied based on the number of muscle cells stimulated, the blood supply available for the muscle cells, muscle length, and attachment sites on the skeleton for muscles, as well as several other factors.

- **smooth muscle** - The contraction of smooth muscle cells occurs very similarly to that of skeletal muscles, but with the exception stimulation by a motor neuron causes calcium ions to enter the cytoplasm via crossing the plasma membrane instead of being released by the sarcoplasmic reticulum.
- **cardiac muscle -** Cardiac muscle cells are unique because each cell does not need to be stimulated by a neuron in order for it to contract. Details of how cardiac muscles contract are included in the section on the circulatory system.

The Circulatory System

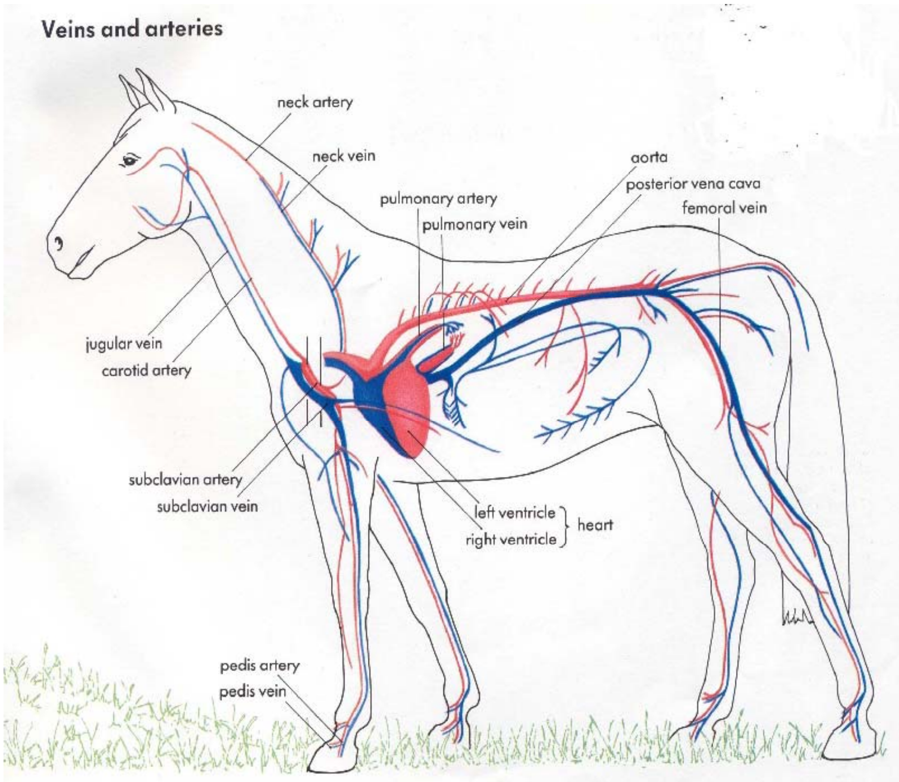

Figure 6: Circulatory system of the horse. www.irishhorsesociety.co.uk/circulatorysystem.htm

Functions of the Circulatory System:

- **Transport** - The blood stream carries nutrients harvested by the digestive system and oxygen brought in by the respiratory system to the cells of the body and moves waste materials, including carbon dioxide, away from cells. In addition, the circulatory system provides a way for cells of the immune system to reach damaged and infected areas of the body.

Structure of the Circulatory System:

(see figure 6)

- **Heart** - Composed of cardiac muscle cells, the mammalian heart is divided into four chambers: right atrium, right ventricle, left atrium, and left ventricle. The left ventricle is much more muscular than the right because it pumps blood out of the heart to the rest of the body, while the right ventricle only pumps blood out to the lungs. Atrioventricular valves exist between the atria and ventricles, and semilunar valves are present at the two exits of the heart. These valves prevent blood from flowing the wrong direction through the heart.

- **Vessels -** The vessels are hollow tubes which allow blood to be carried throughout the body. The three main vessel types are arteries, veins, and capillaries.
    - **Arteries** - The walls of arteries have three layers: an outer layer of elastic connective tissue, a middle layer of smooth muscle tissue, and an inner endothelial layer which smoothes the inside of the vessel and minimizes blood flow resistance. Arteries carry blood away from the heart, so the outer and middle layers are thicker than in veins because they must stretch and constrict in response to the increase in blood pressure when the heart beats. This arterial stretching is what is felt when taking an animal's pulse. The blood in arteries is oxygenated except for the pulmonary artery which carries blood away from the heart to the lungs.
    - **Capillaries**- Arteries branch becoming smaller and smaller until forming capillaries. Capillaries are very small (some so tiny that red blood cells can only fit through single file) and have very thin walls

composed of an endothelial layer. The thin capillary walls allow for nutrients, gases, and wastes to pass from cells into and out of the bloodstream.

  - **Veins** - Blood flows through capillaries and into veins which carries blood back to the heart. Venous blood is deoxygenated except for the blood in the pulmonary vein which carries freshly oxygenated blood from the lungs back to the heart. Although venous walls have three layers like arterial walls, their outer and middle layers are not as thick because of the reduced amount of pressure of blood in veins compared to arteries. Veins also require a reduced muscular layer because skeletal muscles pinch veins as mammals move which pushes blood through the veins while venous valves prevent the back flow of blood.

- **Blood** - Blood makes possible the transport of materials through the vessels and is comprised of the following main components:

  - **Plasma -** Plasma is the fluid portion of the blood. A clear liquid, composed of 90% water, plasma contains dissolved ions which are necessary for the function of the muscular and nervous systems. In addition, it contains many proteins, such as clotting factors and antibodies, as well as hormones and other chemicals necessary for bodily function and communication.

  - **Red blood cells** - Red blood cells are responsible for the transport of oxygen in the body. Shaped like a biconcave disc, red blood cells contain a protein called hemoglobin which oxygen binds to when it dissolves across capillaries in contact with the lungs. Hemoglobin contains iron which makes red blood cells look red, and because animals such as humans can have 25 trillion red blood cells in their blood stream at any given time, blood itself appears red. Red blood cells are unique because they lack not only nuclei, but also mitochondria, and they do not require oxygen to make energy.

- **White blood cells** - White blood cells are part of the immune system and help to protect the body from foreign materials and from abnormal body cells. Many different types of white blood cells exist, some of which actually ingest foreign materials to destroy them, but all use the bloodstream in order to travel through and patrol the whole body for viruses, bacteria, cancerous cells, and other materials which can harm healthy body cells.
- **Platelets** - Platelets clot blood with the aid of certain proteins called clotting factors. Like red blood cells, platelets are formed in the red bone marrow and lack nuclei.

Circulation:

Blood enters the heart from the venous system through the right atrium. Once in the right atrium, blood flows past an atrioventricular valve into the right ventricle. The right ventricle pumps blood past a semilunar valve to the pulmonary artery which leads to the capillary beds of the lungs where blood becomes oxygenated. Then blood returns to the heart via the pulmonary vein and enters the left atrium of the heart. After passing another atrioventricular valve, blood flows into the left ventricle which pumps blood through a semilunar valve and out of the heart. Blood travels through arteries to the rest of the body, eventually returning to the heart in the veins (see figure 7).

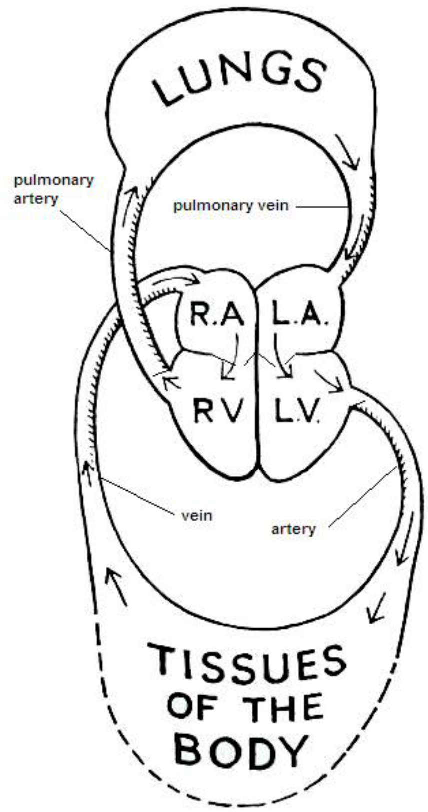

Figure 7: Simplified diagram of blood circulation. www.classroomclipart.com

How the heart pumps:

As mentioned in the section on the muscular system, cardiac muscle cells are unique compared to other muscle cells because they do not require nervous stimulation to contract. In fact, a muscle cell removed from the heart will continue to contract if kept alive. Additionally, cardiac muscle cells are electrically coupled with one another, meaning if one area of the heart contracts, it will cause the cells around it to contract as well. As a result, the contraction will flow through the entire heart, causing the cardiac muscle cell contractions to be coordinated. An area of specialized muscle tissue in the wall of the right atrium, called the **sinoatrial (SA) node** functions as the pacemaker for the heart. The SA node generates an electrical signal which causes the muscle cells in that region to contract, and the contraction is propagated across and down the heart. When the signal reaches the wall between the right atrium and right ventricle, another node, the **atrioventricular (AV) node**, delays the signal long enough for the atrium to completely empty the blood into the ventricle before the ventricle contracts and pumps the blood out of the heart. The speed at which the heart contracts depends on nerve and hormone influences on the SA node. For instance, if low oxygen levels in the bloodstream are detected by the brain, a signal can be sent to the SA node to speed contraction.

The Respiratory System

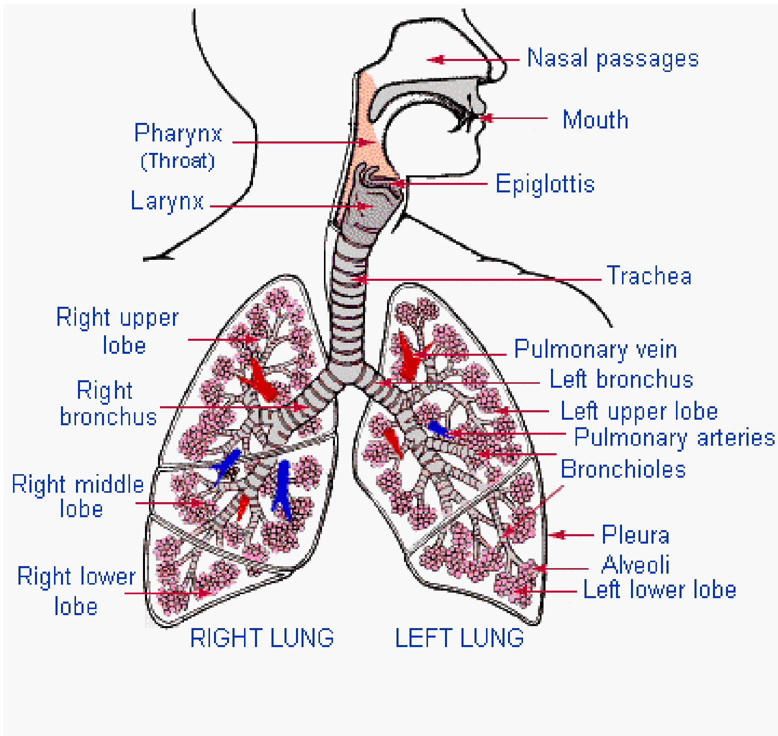

Figure 8: Structures of the respiratory system. webschoolsolutions.com/patts/systems/lungs.gif

Functions of the Respiratory System:

- **Gas Exchange** - The lungs provide an area for oxygen, a material necessary for respiration, to pass from the atmosphere into the blood stream and for carbon dioxide, a waste product of respiration, to pass out of the body.

Structure of the Respiratory System:

The respiratory system is composed of the trachea, bronchi, and lungs. Air enters the body through the mouth or through the nose and sinuses where air is filtered, warmed, and moisturized, making it safer for the lungs. Next the air travels through a tube called the **trachea** to the lungs. The trachea is surrounded by sturdy cartilaginous rings which keeps the tube open while a special flap near the top of the trachea helps prevent foreign materials, such as food, from getting into the trachea and stopping air flow. The likelihood of an animal choking on a piece of food also depends on the location of the trachea in relation to the esophagus. Humans have an arrangement which is advantageous for speech, but which also makes them more prone to choking than any other mammal. After passing through the trachea, air enters the **bronchi** of the lungs. The bronchi are a pair of tubes which split from the trachea and enter the left and right lung. The bronchi continue branching into many smaller and smaller tubes with each tiny tube ending in a grouping of tiny sacs called **alveoli** where gas exchange occurs (see figure 8).

Breathing:

Breathing, the process of getting air into and out of the lungs, cannot occur properly without the aid of the muscular and nervous systems. The lungs passively expand and contract as air moves in and out of them as a result of muscle activity in the ribcage and diaphragm. During **inspiration**, the process of breathing air into the lungs , small muscles between the ribs push the ribcage up and outward, while the diaphragm pulls downward. This results in the air pressure in the lungs to be lower than the atmospheric pressure, causing air to rush into the lungs. On the other hand, in **expiration**, the means of breathing air out of the body, the muscles between the ribs pull the ribcage down and inward, as the diaphragm pushes upward. This process causes the air pressure in the lungs to be higher than the atmospheric air pressure, so air from inside the lungs moves out of the body. In addition, air can be voluntarily forced out of the body by using the muscles between the ribs and the abdominal muscles, but this usually causes a feeling of being out of breath. Although breathing can be voluntarily controlled at times, it is ultimately controlled by the nervous system. The brain monitors oxygen levels in the blood and stimulates the muscles between the ribs and the diaphragm in order to maintain or alter the rate of inspiration and expiration.

Gas Exchange and Respiration:

Gas exchange, taking place in the alveoli, is the intake of oxygen and removal of carbon dioxide from the body. The alveoli in the lungs have extremely thin membranes, allowing for oxygen to pass from the air in the lungs through the alveoli walls into small capillaries surrounding the alveoli (see figure 9). Once in the capillaries, oxygen attaches to a hemoglobin protein on red blood cells. The oxygenated red blood cells move through the heart and are pumped to the rest of the body cells where their oxygen is removed. Body cells require oxygen for a very important process called respiration. **Respiration** is the chemical process in which cells use oxygen to turn nutrients provided by the digestive system into energy to keep cells running. Besides producing energy, respiration also produces carbon dioxide, a waste product which cells cannot use. Most carbon dioxide leaves the body by first being dissolved in the plasma of the blood. Then when the blood reaches the lungs again, the carbon dioxide crosses the alveolar membrane and is exhaled from the body.

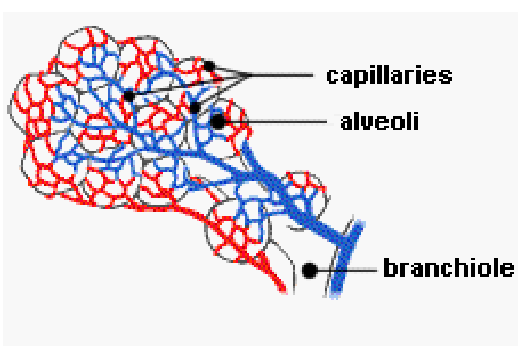

Figure 9: Area of gas exchange with alveoli surrounded by capillary beds.

www.benessere.com/fitness_e_spirt/images/resp_alveoli.gif

The Digestive System

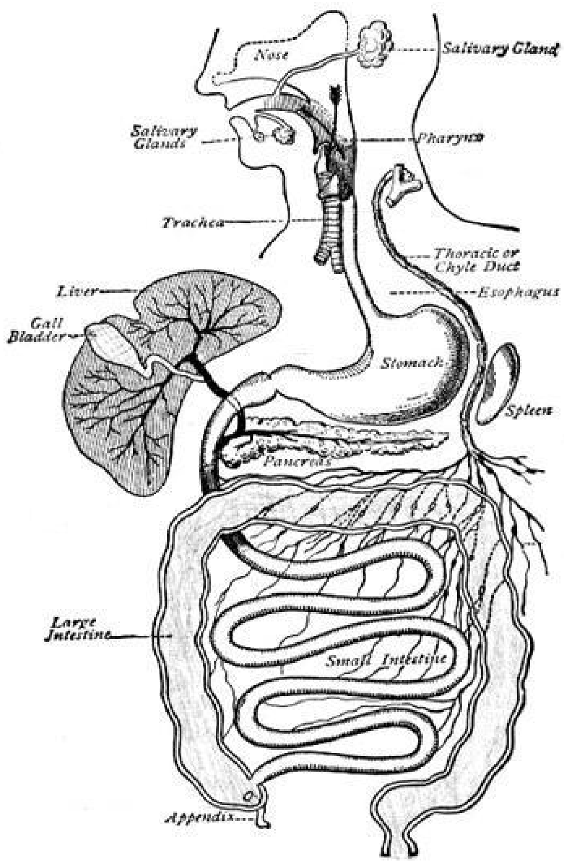

Figure 10: Diagram of human digestive system. www.classroomclipart.com

Functions of the Digestive System:

- **Break down of food** - Cells cannot use hamburgers, grass, or other foods directly for energy, so the digestive system must break these materials into smaller, simpler components which can get inside cells
- **Absorption of nutrients** - Once food is broken down, the digestive system provides an area for nutrients to be absorbed into the blood stream for transport to body cells.

- **Waste removal** - The digestive system removes solid waste materials from the body.

The Structure of the Digestive System and Digestion:

The digestive system consists of many different organs (see figure 10), each with a specific function related to the break down of food, absorption of nutrients, and/or removal of wastes.

- **Brain** - Although not an organ of the digestive system, the brain controls when food enters the digestive system. The brain actively monitors nutrient levels in the blood stream to determine when an animal needs to eat. Once an animal is hungry and finds food, sensory input from the nose and taste buds determine whether food is safe for the animal to consume.
- **Mouth** - The first place digestion begins to occur is the mouth. The teeth physically break down food by tearing and grinding it into smaller pieces. Meanwhile, **saliva**, secreted by the mouth and containing special proteins called enzymes, begins to chemically digest the food. The **tongue**, a muscle, aids in digestion by moving the food toward the teeth while chewing and toward the back of the throat for swallowing.
- **Esophagus** - Swallowed food enters the esophagus. The **esophagus**, a hollow tube made of smooth muscle, rhythmically contracts and forces food down toward the stomach.
- **Stomach** - In the stomach, food is broken down by both the movements of the stomach and the strong acids produced by the stomach. The wall of the stomach consists of several layers of different tissue types, including smooth

muscle and glandular tissue. The smooth muscle layer of the stomach, when stimulated by the nervous system, causes the stomach to move and grind the contents of the stomach into small pieces. (A growling stomach results when stomach walls move while the stomach is empty.) Meanwhile, the inner layer of the stomach contains special glands which produce acidic gastric juices which chemically break down foods while they are being ground into a soup-like mixture. Some animals, such as cows, which primarily eat grasses or similar foods need multiple chambers in their stomachs due to the difficulty in breaking cellulose down enough to extract their nutrients (see figure 11). After processing, the contents of the stomach are released in small amounts to the small intestine.

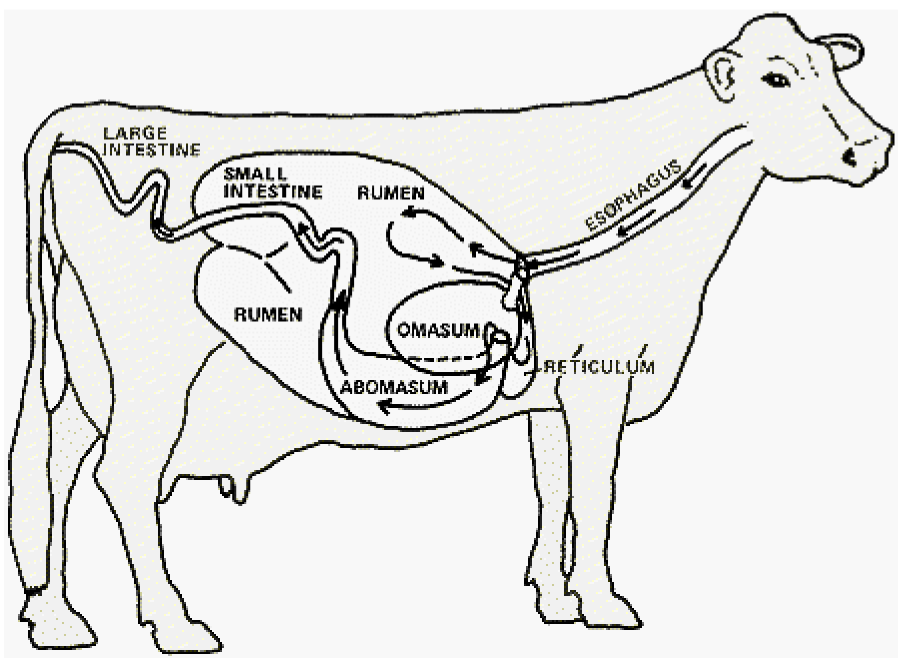

Figure 11: Diagram of four chambered ruminant stomach.

www.extension.umn.edu/distrobution/livestocksystems/images

- **Small intestine** - The **small intestine** is where the greatest amount of digestion and nutrient absorption occurs. In the small intestine, the stomach contents are exposed to many types of digestive enzymes and other digestive materials produced by the pancreas and liver. The **pancreas** produces materials which aid in the digestion of carbohydrates, while the **liver** makes **bile**. Bile aids in the digestion and absorption of fats and contains brown pigments resulting from the breakdown of red blood cells by the liver which gives feces its characteristic color. Once produced by the liver, bile is stored in the **gall bladder** until it is needed. The wall of the small intestine is covered with finger-like projections called **villa** and smaller projections called microvilla which create a large area for nutrients to pass into the numerous capillaries surrounding the small intestine (see figure 12).

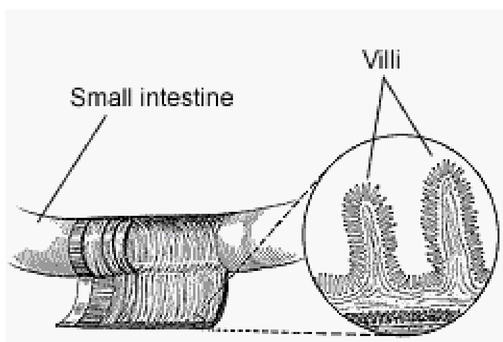

Figure 12: Cross section of small intestine showing numerous villi.

digestive.niddle.nih.gov/ddiseases/pubs/celiac/images/villi.gif

- **Large intestine** - The large intestine (also called the colon) is similar to the small intestine, except that it contains much fewer and less pronounced villa. At the junction of the small and large intestine there is a pouch called the **cecum**. Humans have an extremely small cecum that has a narrow projection called the **appendix.** Other mammals, like the koala, have cecums which are two meters long and contain bacteria that make ingested food more nutritious. The primary function of the large intestine is to absorb water from the material passing out of the small intestine before it enters the rectum. The **rectum** is the end of the large intestine where feces are stored until eliminated.

The Nervous System

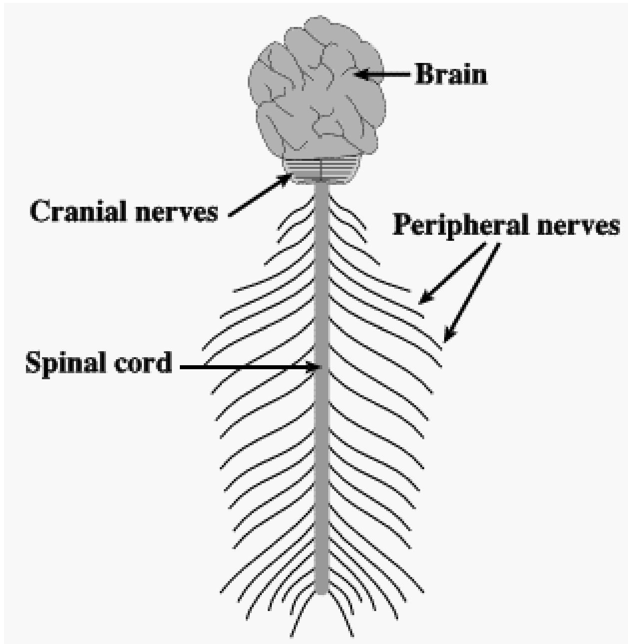

Figure 13: Simplified diagram of CNS and PNS. www.suslik.org/FirstAid/Icons/Misc/nervous.gif

Functions of the Nervous System:

- **Sensory input** - Nerves relay information from the outside environment and from inside the body to the spinal cord and brain for analysis.
- **Integration** - The brain allows sensory data from different sources to be integrated, stored, and interpreted so that correct responses can be made.
- **Motor output** - Nerves carry signals to muscles and glands throughout the body in order to stimulate contractions or hormone production.

Cells of the Nervous System:

Neurons are the signal transmitting cells of the nervous system. Neurons can dramatically differ in size and shape based on their functions, but they all share certain similar structural features (see figure ?). Each neuron consists if a large **cell body** with **dendrites** and **axons**. Dendrites direct signals originating from outside the cell down to the cell body. Signals then pass down axons to synaptic terminals. Synaptic terminals are the ends of axons where neurons **synapse** (or "connect") with other nerve, muscle, or gland cells. Generally, neurons are divided into three types: sensory neurons which communicate sensory information and synapse primarily with interneurons except in reflex reactions; interneurons which integrate sensory information and motor output but only synapse with other neurons; and motor neurons which conduct impulses from interneurons to muscle and gland cells. Neurons are aided by **glia** ("glue") cells which protect, insulate, support, and provide structure for neurons. The speed of nerve signals can be altered by the presence (myelinated) or absence (unmylinated) of glial cells along the axon (see figure 14). Myelinated axons appear as white matter, while cell bodies, dendrites, and unmyelinated axons are gray.

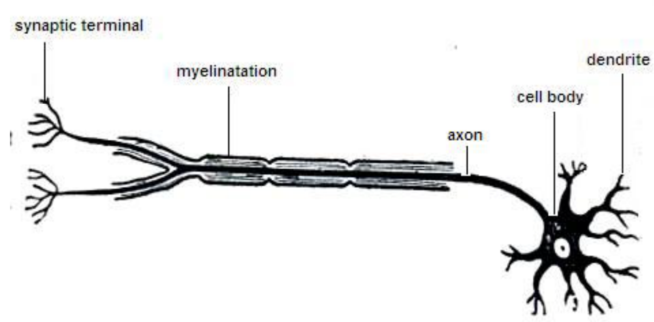

Figure 14: Diagram of generalized neuron. www.classroomclipart.com

Structure of the Nervous System:

The nervous system is divided into two general categories, the central and peripheral nervous systems (see figure 13).

- **Central nervous system (CNS)** - Consisting of the brain and the spinal cord, the central nervous system is composed of interneurons.

- **Spinal cord** - Protected by the bony spine, the spinal cord is a bundle of neurons responsible for relaying nerve signals to and from the brain, as well as integrating simple motor responses. Damage to the spinal cord can result in loss of function of all body areas with nerves originating below the damaged level.
- **Brain** - The brain is the primary sensory integration center of the body and generates complex responses to sensory information. Consisting of bundles of neurons, the brain is protected by the cranium and cerebrospinal fluid. Glia cells provide a barrier between the brain and the blood, so the cerebrospinal fluid provides nutrients for the brain instead. The brain can be divided into several areas with shared functions, as follows (see figure 15):

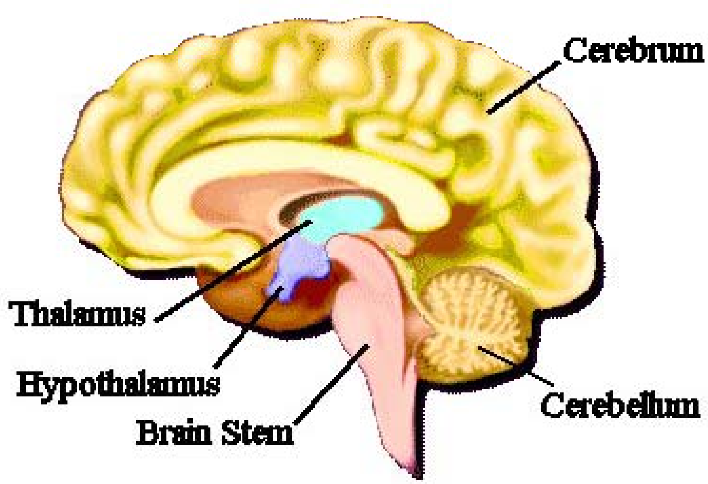

Figure 15: Brain divisions. www.starsandseas.com

  - **brainstem** - One of the primary functions of the brainstem, consisting of the medulla oblongata, pons, and midbrain, is to maintain homeostasis. The brainstem regulates breathing, digestion, vomiting, swallowing, blood vessels and heart activity. In addition, the brain stem also aids in coordinated movements, such as walking, and integrating sensory input to be sent to the cerebrum.

- **cerebellum** - The cerebellum is responsible for coordinating movements and learning motor responses. Integrating information from the audio and visual systems with signals indicating muscle lengths and joint positions, the cerebellum coordinates muscle contractions in order to maintain balance.
- **thalamus** - The thalamus is the primary integrative path for sensory signals traveling to the cerebrum and motor signals traveling out of the cerebrum. Additionally, the thalamus is related to emotion and arousal.
- **hypothalamus** - Although a small portion of the brain, the hypothalamus is extremely important in regulating many bodily functions. The hypothalamus regulates body temperature, hunger, thirst, and mating. In addition, it controls the flight or fight response and may regulate sleeping.
- **cerebrum** - The integrating center of the brain is the cerebrum. The cerebrum integrates and interprets sensory information and generates responses to that information. The cerebrum also has

the ability to store information. In general, the cerebrum is one of the most highly varied portions of the brain in respect to different mammalian species with the extent of its development being tied to the range of complex behaviors a particular organism can perform.

- **Peripheral nervous system (PNS)** - The peripheral nervous system consists of sensory and motor neurons. It relays sensory information to the CNS and transmits signals from the CNS to muscles and glands via motor neurons. The PNS is divided into the somatic and autonomic nervous systems. The **somatic nervous system** encompasses parts of the PNS which stimulate voluntary muscles. On the other hand, the **autonomic nervous system** ennervates viscera, such as intestines and vessels, which are usually not under conscious control.

Nerve Signals:

A nerve signal begins with a nerve's dendrites being stimulated by sensory information or another neuron. The stimulation results in a change in the ion concentration within the neuron, causing a chain reaction with the signal moving down the dendrites to the cell body. If the cell sends a signal or fires, then an ion change, recorded as a depolarization, within the neuron moves down the axon to the synaptic terminal where the neuron synapses with another cell. Synapses can be electrical where the terminal synapse actually touches another cell, but they are usually chemical. If a chemical synapse exists, when the depolarization reaches the synaptic terminal of the firing neuron, a chemical called a **neurotransmitter** is released (see figure 16). The neurotransmitter than travels across a short distance where it then binds to and stimulates another cell.

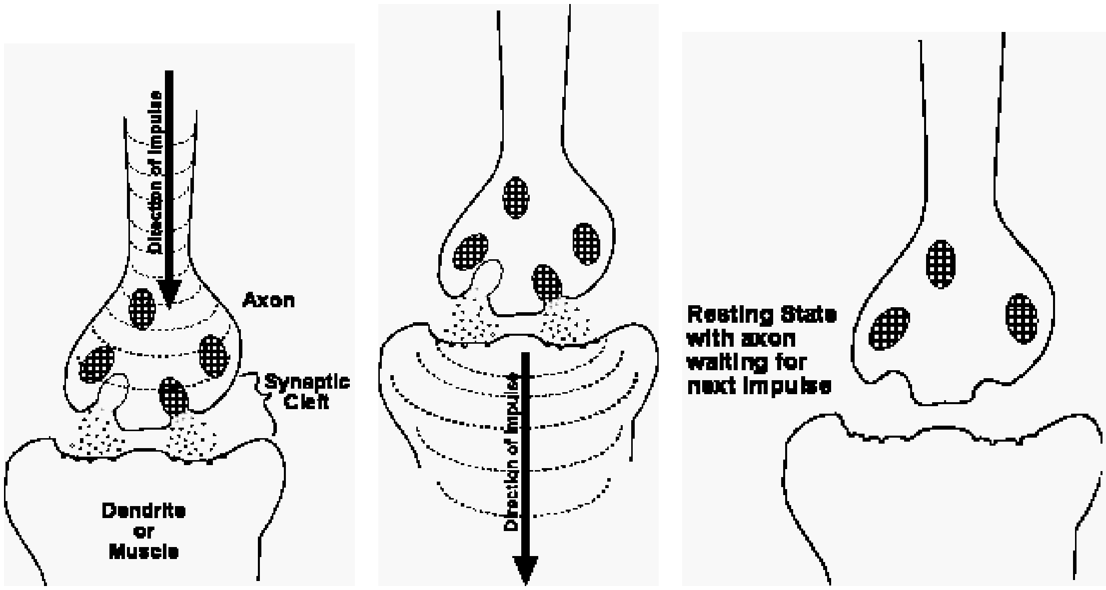

Figure 16: Diagram shows impulse causing release of neurotransmitter from chemical synapse followed by excitation of post synaptic dendrite or muscle and rest of presynaptic neuron.

www.gluhm.com/Pages/Nervous%20System/Nerve%20Page.htm