Biology Study Notes
SNC2DE

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May or may not include material about cell cycle, mitosis, etc.

- Cancer: the name given to a large group of diseases that result in uncontrolled cell division
- Results from mutations in the cell's DNA
- Apoptosis: the normal death of a cell that isn't useful.
- Cancer cells are irregularly shaped, e.g. less cytoplasm, thicker chromosomes and do not fit together well
- Cancer cells appear to be "immortal" because they do not stop dividing (telomerase is produced in these cells and it tells them to keep on dividing)
- Tumour: a mass of cells that continues to grow, but does not have any function in the body, and uses up valuable energy that regular cells need
    - Benign: a tumour that does not affect the surrounding tissues
    - Malignant: a tumour that interferes with the function of surrounding cells
- Metastasis: when cancer cells from one tumour break off and form another tumour
- Causes of cancer:
    - A mutation in the DNA
    - Carcinogens, environmental factors (X-rays, UV rays, tobacco smoke, asbestos)
    - Viral infections (HPV, hepatitis B)
    - Certain chemicals in plastics, many organic solvents
    - Hereditary defect
- Carcinogen: any environmental factor that causes cancer
- Mutagens: are chemicals or other forces that cause mutations in the DNA
- Cancer screening: checking for cancer regardless of symptoms
    - Medical checkup, specialist appointments, self-examination, pap test (women), blood test called PSA, screen for prostate cancer for men, blood test for colon cancer, skin test by doctor or dermatologist to look at moles, new growth and sores
- Moles ABCD—asymmetry, border, colour, diameter
- Treatment:
    - Surgery: involves cutting out the cancerous tissue. Works well where the tissue is well defined.
    - Chemotherapy: employs drugs to kill cancer cells or to stop them from growing and reduces the size of the tumour.
    - Radiation therapy: uses high-energy radiation to kill cells and reduces the size of the tumour, leaving surrounding healthy tissue intact.

	Rate of cell division	Level of specialization	Length of mitosis	Appearance of cell	Ability to move
Healthy cell	Low	High	Long cycle	Regular	Do not usually migrate
Cancer cells	High	None	Short cycle	Irregular, odd shaped	Able to migrate

- Specialized cell: a cell that can perform a specific function
- Cell specialization: the process by which cells develop from similar cells into cells that have specific functions within a multicellular organism.
- Cell differentiation: a stage of development of a living organism during which specialized cells form.
- Almost all cells are specialized in some way, e.g. muscle cells have a lot of mitochondria, and mucus cells in the stomach have many Golgi bodies.

Stem Cells

- Any multicellular organism will start its life as a zygote or a fertilized egg, which is a combination of a sperm cell and an egg cell.
    - This zygote will go through a series of cell divisions so that many cells can be generated.
    - When the zygote divides into a mass of cells, it is called an embryo.
        - At this stage daughter cells will begin to show differences in their shapes, functions and contents. The cells will start to transform into specialized cells (specialized cells from tissue and organs such as bone, heart, liver and skin). This transformation is called cellular differentiation.
            - Cellular Differentiation: The process by which a cell becomes develops or matures to perform a specific task/function. Cellular Differentiation is genetic information encoded in the cell's DNA (deoxyribonucleic acid)

        - In animals a cell that can differentiate into many different cell types is referred to as a stem cell.
- As the embryonic stem cells divide through the cell cycle, the resulting daughter cells can mature into different types of cells depending on which DNA they have switched on and off.
- Stem cells will then clump back together to form a tissue layer such as epithelial tissue, muscle tissue, etc.
- There are two types of stem cells that can differentiate.
    - Embryonic Stem Cells: These cells come from an embryo in the earliest stage of cell division (less than a week old). Embryonic stem cells have the capability into differentiating into any kind of cell but they are only found during the blastocyst stage of development (about 5 days after fertilization). Embryonic Stem Cells have the potential to regrow, repair or replace damaged or diseased cell, tissues or organs.
    - Adult Stem Cells: These cells exist within already specified tissue. These stem cells can only differentiate into certain types of cells.
- Under regular lab conditions, stem cells will keep dividing for as long as a year without ever differentiating.
- Scientists can obtain embryonic stem cells from eggs fertilized in vitro (outside the womb).
- There are complications from transplanting donated stem cells because the body can reject these tissues grown from stem cells. To overcome this scientists can clone the cells, which will produce cells that are genetically identical to the cells of the recipient, and so the immune system would not reject these tissues. There are two types of cloning that can be used:
    - Therapeutic Cloning: To clone embryos so that scientists can create stem cells.
    - Reproductive Cloning: To create a fully formed cloned organism.
- The blood found in the umbilical cord has a lot of stem cells. These stem cells are much like tissue stem cells because they can only differentiate into certain kinds of blood cells. This blood can be banked or stored for future use by a child or a sibling.
- Stem blood cells together with bone marrow stem cells can treat diseases such as leukemia or bone marrow cancer. Bone marrow is a tissue that creates cells that are involved in the body's defenses against the pathogens.
- In a bone marrow transplant the diseased white blood cells as well the bone marrow must be removed and killed respectively. Bone marrow is then injected into the person who would then start creating cancer-free new blood cells.
- Regeneration is the ability of a tissue to repair itself. Many animals have the ability to regenerate large parts of their bodies or their limbs. Humans can only regenerate our liver tissue and our fingertips.
- Tissue Engineering is a field of research that is dedicated to discovering ways to regenerate human body tissues and parts that do not normal regenerate.

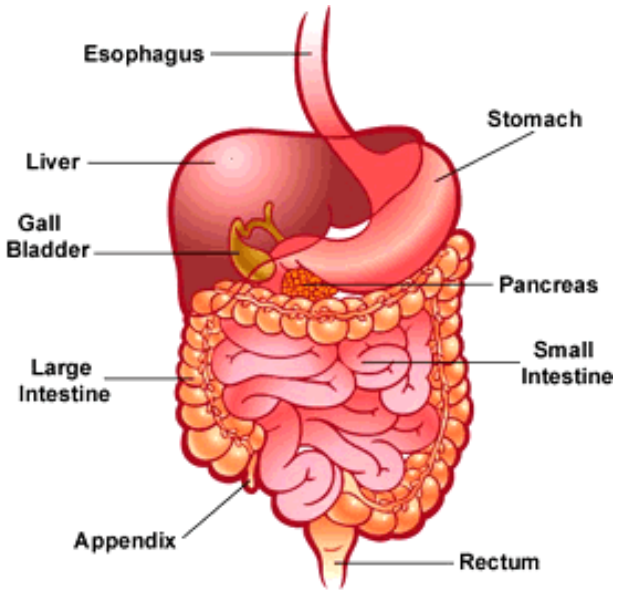
Animal Systems

- Hierarchy: an organizational structure, with more complex or more important things at the top and simpler or less important things below it.
    - Organism, made of:
    - Organ systems, made of:
    - Organ, made of:
    - Tissue made of:
    - Cell(s)
- Organism: several organ systems form an organism
- Organ System: organs can work together with other organs to form an organism, (i.e. an organ system is composed of two or more organs), e.g. cardiovascular system: heart, lungs, blood vessels, blood
- Organ: two or more tissues working together, e.g. brain, kidney, heart, lungs, stomach, etc. (The largest organ in the human body is skin: skin is made up of many different kinds of specialized cells and tissues, e.g. nervous tissue, hair, sweat and oil glands, and as a result has many different functions.)
- Tissue: a group of cells with similar structure and function, that is, tissue is composed of many cells, all of the same cell type.
- Systems: are groups of tissues and/or organs that work together. An organ system is a group of organs that has related structures or functions.
- Connective tissue: a specialized tissue that provides support and protection for various parts of the body.
- Epithelial tissue: a thin sheet of tightly packed cells that covers body surfaces and lines internal organs and body cavities.
- Nerve tissue: specialized tissue that conducts electrical signals from one part of the body to another.
- Muscle tissue: a group of specialized tissues containing proteins that can contract and enable the body to move.
- The link between specialized cells and tissues is that tissues are made up of SC's that work together.

Organ System	Musculoskeletal	Nervous	Digestive	Circulatory	Respiratory
Function	Movement support	Sends messages to the body	Breaks down food	Transports nutrients, gasses	Gas exchange
Organs and tissues involved	Bones, muscles	Brain, nerves, spinal cord	Esophagus, gallbladder, stomach, intestines, pancreas, liver	Heart, blood vessels (arteries, veins, capillaries)	Lungs, trachea, blood vessels

Digestive System

- Digestion occurs to obtain energy from food, by breaking it down ("digesting" it)
- Made up of the mouth, esophagus, stomach, intestines, liver, pancreas and gall bladder.
- Purpose is to break down food into smaller pieces, both mechanically (teeth) and chemically (saliva, gastric acids, small intestine).
- Entire digestive system is ~9m
- Digestion process can take anywhere from 9~72 hours
- Digestive tract is lined with epithelial tissue, which is made up of many different cells, e.g. goblet cells, which secrete mucous to protect the digestive tube from digestive enzymes and to allow for the smooth passage of material through the tube.
- Also made up of smooth muscle tissue, which expands and contracts involuntarily to allow food to pass through.
- In the mouth, there are two processes occurring:
    - Mechanical digestion, via the teeth and tongue
    - Chemical digestion, via saliva (contains the enzyme "amylase" which breaks down some starches into sugars)
- Esophagus: a long muscular tube that connects your mouth to your stomach
- Contains smooth muscle tissue, which expands and contracts involuntarily to allow the smooth passage of food down to the stomach, known as peristalsis, which prevents choking.
- When digestive acids from the stomach back up into the esophagus, this results in heartburn. This irritates the esophagus because it doesn't have a thick mucous layer like the stomach.
- Stomach: holds the food and squishes and mixes it, combining it with digestive acids to break it down.
- Lining of the stomach contains cells that produce digestive enzymes and hydrochloric acid.
- The purpose of these acids is not to break down food, but rather to kill bacteria and other microorganisms.
- The mucous that lines the stomach prevents the acids from harming the tissue.
- The intestine is made up of two parts:
    - Small intestine: ~6m, named small because it is narrower in diameter. This is where the digestion process is completed. Enzymes from the liver, gallbladder and pancreas are added. Food is broken down at the molecular level so that it can pass through the walls of the small intestine and into the bloodstream by the circulatory system.
    - Large intestine: ~1.5m, named large because it is larger in diameter. This is where any indigestible food passes out from the small intestine to. The lining of the large intestine absorbs any water left in the indigestible food and waste is removed from the body
- When *too much* water is absorbed from the large intestine, the result is constipation.
- When *not enough* water is absorbed from the large intestine, the result is diarrhea.
- Liver: secretes a fluid called bile, which helps to break down the fats in food.
- Pancreas: secretes pancreatic juice, enzymes and produces insulin, which regulates the concentration of glucose (a type of sugar) in the blood. If there is a lack or excess of insulin, then diabetes results.
- Gall bladder: stores the bile produced by the liver.
- Anus and rectum: storage of waste material until elimination occurs.
- When toxins are ingested, the body quickly tries to get rid of them, through vomiting or diarrhea.



Diseases

- Appendicitis: caused when stool, a foreign body or cancer blocks the appendix. Can cause the appendix to burst and cause infection. Cure is to cut out appendix immediately and/or treat with strong antibiotics.
- Celiac disease: a disease that causes intolerance of gluten (a protein in wheat, rye and barley). Usually genetic. Only cure is to avoid gluten products.
- Dysentery: inflammatory disorder of the intestine that results in severe, watery diarrhea (sometimes with blood and mucous), fever, abdominal pain and nausea. It is contagious, and can be prevented by practicing good hygiene. Main cure is rest and lots of fluids; in some cases antibiotics may be needed.
- Gallstones: small, pebble-like substances in the gallbladder. 2 main types: cholesterol stones and pigment stones. Cholesterol stones are made of hardened cholesterol and pigment stones are made of hardened bilirubin. Gallstones vary in size. Symptoms include prolonged pain (>5 hours), nausea, fever/chills, clay-coloured stools, and yellowish colour of the skin or eyes. Cured by surgery, oral dissolution therapy or contact dissolution therapy.
- Gastroesophageal reflux disease (GERD): caused when digestive acids from the stomach back up into the esophagus. Symptoms include heartburn, even during sleep. Can be cured by eating less acidic foods, eating slower or taking medicines such as H2 blockers (limit acid secretion in stomach).
- Gingivitis: inflammation of the gums surrounding the teeth. Caused by poor dental hygiene, weak immune system, etc. Cured by practicing good oral hygiene.
- Hiatus Hernia: when part of the stomach slides through the diaphragm. Symptoms include severe pain or discomfort in the chest, belching, hiccups and/or gurgling noises in your chest. Cures include eating frequent smaller meals, wearing comfortable loose clothing, losing weight, quitting smoking, etc, sometimes medicines and very rarely surgery.
- Ulcerative Colitis: when inflammation is present in the lining of the rectum and colon. Ulcers form at the site of inflammation, which then bleed and produce pus. Symptoms include fatigue, rectal bleeding, loss of appetite and loss of body fluids and nutrients. Cure is to take drug therapy, be hospitalized, or even surgery to remove the colon. Can lead to colon cancer in some cases.
- The 4 stages of food processing
    - Ingestion: the taking of nutrients
    - Digestion: the breakdown of complex organic molecules into smaller components by physical and chemical means.
    - Absorption: the taking up of digested molecules into the cells of the digestive tract
    - Egestion: the removal of waste food materials from the body

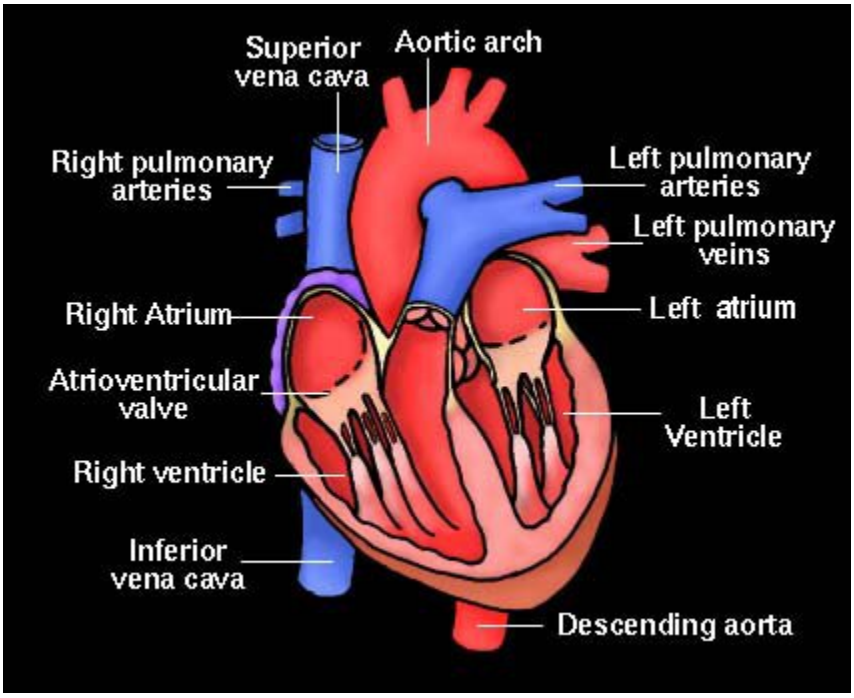
Circulatory System

- The Circulatory System has many functions across the body that it must fulfill for the body to function
    - The Circulatory System transports oxygen and nutrients to the body, while transporting carbon dioxide to the lungs and waste to the kidney.
    - The Circulatory System regulates the internal temperature of the body.
    - The Circulatory System transports hormones to parts of the body.

- The Circulatory System stops any infection in the body with its white blood cells.
- There are 3 main components of the circulatory system, the blood, the heart and the blood vessels.

Heart

- Circulation begins at the right side of the heart where blue blood enters from veins into the right atrium. The blood is then pumped to the right ventricle and then to the pulmonary arteries (which go to the lungs) to oxygenate the blood.
- The blood than comes back through the pulmonary veins with oxygenated blood to the left atrium. From here the blood goes to the left ventricle and then to the aorta, where the blood will go to different areas of the body to transport this oxygen.
- The heart is composed of four types of tissue, cardiac muscle tissue, nerve tissue, epithelial tissue and connective tissue.
  - The epithelial tissue is outside the heart to reduce any friction between the lungs and the heart when the lungs expand. It is also inside the heart to allow blood to flow more easily.
  - The cardiac muscle tissue contracts and expands involuntarily, so that the blood can move to the appropriate exit and entrance of the heart.
- The heart beats with a regular beat and the amount of times that the heart beats will increase based on factors such as physical activity, stress, temperature etc.
  - The heart's pulse is how many times the heart beats per minute. Typically a teenager will have a pulse rate of 60-80 beats per minute but this can change due to some factors like the ones listed above.



Blood

- Blood is composed of four different classifications of blood
  - Red Blood Cells: Makes up about 45% of our blood. It has a protein in it called hemoglobin (which gives the blood its red color), which carries oxygen. The Red blood cell is disc shaped and it has no nucleus. The main function of the red blood cell is the exchange of oxygen and carbon dioxide by the process of diffusion.
  - White Blood Cells: Makes up less than 1% of our blood. They are the only blood cell with a nucleus. The main function of the white blood cell is to fight off infections within the body.
  - Platelets: Makes up less than 1% of our blood. They do not contain a nucleus. The main function of the platelets is to clot the blood. They do this by creating a fibrous mesh called fibrin to stop the flow of blood. This clotting is to prevent any blood loss from occurring.
    - If you have too many platelets, then blockages will happen within blood vessels causing health issues.
    - If you don't have enough platelets then more severe hemorrhaging (bleeding) will occur, which could lead to death.

- Plasma: Makes up about 55% of our blood. It is a protein liquid that carries the blood cells. Plasma will also transport nutrients, waste, hormones, enzymes, sugar (glucose) and water.
- It is a common misconception that arteries always have red blood and veins will always have blue blood. For example the pulmonary arteries have blue blood because the blood is going to the lungs to get oxygen. The pulmonary veins have red blood because the blood is going from the lungs, which just supplied the oxygen to the blood, back to the heart.

- Blood is considered a connective tissue because it links all the cells and organs of the body.
- Blood is classified into types of blood; depending on how much oxygen it has in it.
  - Red Blood is oxygenated blood that goes all over the body to exchange oxygen for carbon dioxide by process of diffusion.
  - Blue Blood is deoxygenated blood that will go to the lungs so that the blood can exchange carbon dioxide for oxygen by process of diffusion.

Blood Vessels

- In the circulatory system there are three types of vessels where blood is transported.
  - Arteries: Transport blood from the heart to the rest of the body. Arteries have thick walls and a large diameter so that they can withstand pressure from the heart. As the arteries get closer to the capillaries, the arteries get smaller and are called artrioles.
  - Veins: Transports blood from the rest of the body to the heart. Veins have thinner walls than the arteries as well as a smaller diameter because they do not have to withstand as much pressure. As the veins get closer to the capillaries, the veins get smaller and are called venuoles.
  - Capillaries: A very thin blood vessel, where the diffusion of oxygen and carbon dioxide occurs. The capillaries are thin with a small diameter so that one blood cell can pass through at a time when diffusing. The capillaries also have a large surface area because it is more efficient for capillaries to have wider vessels.

Diseases

- The first three diseases listed here are considered types of atherosclerosis, which is when plaque blocks the arteries. This leads to the arteries' passageways thinning, which means less oxygen-rich blood can get to the areas that need it.

1. Coronary Artery Disease: When the coronary arteries (arteries that supply blood to the heart itself), gets clogged or blocked with plaque (which is the buildup of fat, cholesterol, etc.). The person will generally become tired or dizzy from this. To diagnose this an angiogram is used.
   - An angiogram is when fluorescent dye is injected so that any blockages will show up on an x-ray, where blockages normally wouldn't show.
   - If the blockage gets severe, then a heart attack will occur. A heart attack is when not enough oxygen and nutrients are getting to the heart so the heart tissue starts to die.
     - The symptoms are dizziness, anxiety, chest pains/pressure, nausea, abdominal/stomach pains, fatigue and upper body pain.
     - Heart attacks are diagnosed by an electrocardiogram (ECG), which measures the electrical signal created by the heart when it beats.
     - An angina attack can be a warning sign of a heart attack. An angina attack happens when you are doing a physical activity or are under stress and you have atherosclerosis. This is called stable angina and typically only lasts 15-20 minutes and can be treated with nitroglycerin. There is also unstable angina, which is when the chest pain gets increasingly worse, and to treat that, a doctor would send you to the hospital to get blood thinners and rest.
2. Carotid Artery Disease: When the arteries in the neck get blocked with plaque. This means that oxygen rich blood cannot get to your brain. This can lead to a stroke, which is when the brain cannot get any oxygen so the brain cells start to die. Unlike a heart attack, a stroke can actually leave permanent brain damage
3. Peripheral Artery Disease: When the arteries leading to your legs, arms and pelvis get blocked with plaque. This will generally lead to numbness, pain and even an infection in these places.
4. Blood Clot Disorders: Diseases that involve the platelets ability to clot. See Platelets under Blood for more details.
5. Anemia: A disease that occurs when you have too little red blood cells. People with this disease often have less energy.
6. Aneurysm: The rupture or splitting of the arteries. Aneurysms happen when the blood pressure gets so high that the artery bulges and split. People who are aging, smokers, and people with a history of aneurysms in their family. Aneurysms lead to major bleeding which can be fatal if not surgically treated.

Blood Pressure

- Blood pressure is the pressure of blood hitting against the walls of the artery.
- Blood pressure is split into two numbers the systolic pressure and the diastolic pressure
  - The systolic pressure is the pressure against the walls of the artery when the heart is beating.
  - The diastolic pressure is the pressure against the walls of the artery when the heart is resting.
- The typical blood pressure of a teenager is 120/80 but if someone's blood pressure is constantly above 140/90 then it can lead to hypertension.
- Hypertension can lead to many diseases listed above such as stroke, heart attack and other types of atherosclerosis.

More Information

- The circulatory system relies on many other systems to run, and in turn many other systems rely on the circulatory system to keep themselves running.
  - E.g. the circulatory system relies on the respiratory system to supply the deoxygenated blood with oxygen so that the oxygen can be given to the rest of the body. Likewise the respiratory system relies on the circulatory system for obtaining carbon dioxide to exhale.
  - The circulatory system also relies on the excretory system to dispose of the waste that the blood takes from the cells across the body.
  - The circulatory system relies on the digestive system to provide the nutrients for the circulatory system to use.
  - Every system in the body relies on the circulatory system to distribute the nutrients and oxygen to the cells of the body.

Respiratory System

- Main function is to inhale oxygen to be used by the circulatory system and to exhale carbon dioxide that was used by the cells across the body.
- Has many different structures within it that serve different functions.
  - Nasal Cavity: The entrance and exit to the respiratory system, where air comes in and out. In the nasal cavity is mucus, which filters out any foreign material such as dust, pollen bacteria, etc. There are also cilia in the nasal cavity, which propels the mucus out of the nose in a process called sneezing. The mucus and cilia also warm up the air coming in to the respiratory system, which means that the diffusion occurring in the alveolus will be more efficient. The warm air also means the structures inside the respiratory system will not get damaged by cold air.
  - Mouth: Another entrance to the respiratory system. There is no mucus or cilia in the mouth so foreign material can get in the respiratory system if you "mouth breathe". The air is also not warmed when entering the mouth meaning diffusion will not be as efficient and cold air can damage the delicate organs of the respiratory system.
  - Pharynx: The throat, where the air moves to after going through the nasal cavity or the mouth.
  - Larynx: Just below the pharynx is the larynx, where sound is produced, which can be manipulated into becoming speech. The larynx also contains the epiglottis, which closes when eating to prevent choking. When you are not eating the epiglottis will open to resume breathing.
  - Trachea: A tube that contains ciliated epithelial tissue. This tissue will filter out any foreign material with the mucus it secretes. It will then expel this mucus with cilia in a process called sneezing.
  - Bronchus: The initial tube that divulged from the trachea and is the entrance to the lungs.
  - Bronchioles: A network of smaller tubes within the lungs that get smaller and smaller and lead to alveoli.
  - Alveoli: Tiny air sacs with thin walls and surrounded by capillaries. This is where the gas exchange of carbon dioxide and oxygen take place. There are quite a lot of alveoli, which means a larger surface area to diffuse oxygen to the blood. There are 300 million alveoli in two adult lungs and in total have a surface area of $160m^2$.
- The gas exchange of carbon dioxide and oxygen between the alveoli and the blood occurs by process of diffusion.
  - The blood will have more carbon dioxide in it then the alveolus, so the blood will diffuse out its carbon dioxide to the alveolus.
  - The alveolus will have more oxygen in it than the blood, so the alveolus will diffuse out the oxygen to the blood, making it red blood.
- Breathing is the intake of oxygen and output of carbon dioxide.
  - To breathe, muscles move the ribs making the rib cage expand and contract. The diaphragm then

moves up and down forcing air to go into the lungs and expand into the space provided by the expanded rib cage.
    - When the diaphragm moves up carbon dioxide is exhaled but, when the diaphragm moves down, oxygen is inhaled so that internal and external air pressure can stay constant.
    - If the diaphragm becomes irritated it can create muscle spasms called hiccups, which force air out quickly through the larynx.

Diseases of the Respiratory System

- There are many diseases that involve the respiratory system. The respiratory system is quite vulnerable to diseases because the respiratory system is always in contact with external factors such as pollution, and other pathogens.

1. Asthma: A lung disease that involves the inflammation and narrowing of airways. The airways narrow because the smooth muscle in the bronchioles contracts and the bronchioles can secrete mucus, therefore making the diameter narrower. The symptoms of asthma are repeated periods of wheezing, shortness of breath, chest tightness and coughing. If these symptoms become worse it can lead to an asthma attack. People with asthma will have days where they can barely breathe while on other days they can breathe normally. There is no definite cure and cause of asthma but scientists believe asthma is hereditary. Finally there are many factors that can trigger an asthma attack such as inhaling dust, pollen or mold.
2. Pneumonia: A lung disease that occurs when bacteria moves down the trachea, through the bronchus and into the bronchioles and alveoli. This causes the bronchioles and alveoli, to get filled with fluid and white blood cells. This means a reduced surface area and less oxygen can be diffuse to the red blood cells. This can create severe consequences such as death.
    - SARS or Severe Acute Respiratory Syndrome is a type of pneumonia caused by a corona virus. SARS is highly contagious and was responsible for many deaths around the world during 2003 and 2004.
3. Cystic Fibrosis: A hereditary disease that tells the lungs and pancreas to create thick and sticky fluids in the bronchioles and pancreas respectively. Cystic Fibrosis can lead to other respiratory and digestive diseases such as pneumonia and diabetes.

Musculoskeletal System

- Is made up of bones and skeletal muscle
- Supports the body, protects delicate organs, makes movement possible
    - Also is responsible for protection, blood cell production and mineral storage
- Babies are born with ~300 bones, later fuse into ~206 bones by adulthood
- Bones are:
    - Part of the skeletal and musculoskeletal systems
    - The muscles that make the bones are also part of the musculoskeletal system
- Skull protects the brain, ribs protect the heart and lungs, bones of the vertebral protect the spinal chord
- Bone marrow is responsible for production of blood cells and releases them into the bloodstream
    - Contains many stem cells that can develop into other cells, e.g. RBCs and WBCs
- Minerals like calcium and phosphorus give bones strength and rigidity, and are also necessary to maintain healthy muscles
- Bone tissue:
    - Is hard and is made of bone cells and collagen fibres (collagen: a network of protein fibres)
    - Interior of bones is composed of nerves and blood vessels
    - Connected to other structures via tendons and ligaments
    - Tendons: large inflexible strips of connective tissue. Muscles contract, becoming shorter and thicker and when signaled by the nerve cells they exert a force, which moves the bone(s) to which the skeletal muscle is attached.
    - Ligaments: long fibres of connective tissue that can stretch. Made of long collagen fibres that hold the bones of movable joints together. Allows joints to move only in the correct direction.
    - Cartilage: semi-solid, flexible connective tissue, found at the tip of the nose, esophagus and disks between the vertebrae and joints. Provides strong, flexible, low-friction support for bones and other tissue. Serves as shock absorber between joints. Embryos' skeletons begin as networks of cartilage that eventually grow into bones by adulthood.
    - Muscle tissue: bundles of long cells called muscle fibres that contain specialized proteins capable of shortening/contracting. Attached to bones via tendons and allow movement of bones when signaled by the nerve cells.

        - Cardiac muscle: found only in the heart; responsible for making the heart beat—contracts and relaxes automatically.
        - Smooth muscle: found in the lining of the stomach, esophagus, intestines, uterus, walls of blood vessels. Moves substances through the organs. Controlled automatically.
        - Skeletal muscles: attached to bones by tendons. Allow for movement of the body. Voluntary movements. These muscles can pull, but cannot push—therefore, the muscles must work in opposing pairs.
    - Muscles can only pull, never push, and so opposite pairs must contract.
    - The skeleton's role is to provide (S.A.M.S.):
        - Structure for the body
        - Anchor points for muscles
        - Movement for the body
        - Support for the body
    - Diseases:
        - Osteoporosis: when there is a loss of calcium in the bones, which makes the bones brittle and weak. Common in older women. Diagnosis is difficult because of few symptoms. Bone density test must be done to diagnose it. Treatment is to take calcium.
        - Stress of the muscles and bones also causes these parts to weaken and cause pain.
        - Arthritis: inflammation of bursa (fluid filled sacs between bones). Joints become stiff, deformed and swell. No known cause but is treatable by anti-inflammatory drugs, steroids and physiotherapy.
        - Gout: affects toes, fingers and knees. Mostly common in males. Caused by excess uric acid in joints. Treatments include anti-inflammatory drugs, physiotherapy, controlling uric acid levels and joint rest.

Nervous System

- Main functions include:
    - Responding to the environment
    - Controlling involuntary movements (e.g. heart, smooth muscle tissue)
    - Voluntary movements
    - Senses: sight, sound, smell, touch, taste
    - Thinking and perceiving the surrounding environment
- Main organs are brain, spinal chord and the sensory organs
    - Brain: a network of nerves that carries messages to the body so that it can interact with itself and its environment. Its function is to control movement, regulate body functions, interpret/respond to sensory input. Responsible for thinking, memory and language.
    - Spinal cord: transmit nerve impulses to and from body
    - Sense organs: to bring information in so that the brain can process it.
- Central nervous system (CNS): the command system of the body. Thoughts, perceptions, voluntary movements originate here.
- CNS is shielded by bones, e.g. skull for the brain; spine for the spinal cord
- Cerebrospinal fluid: surrounds the brain and spinal cord, helps to cushion from injury, transport chemicals and remove wastes from the brain.
- Peripheral nervous system: consists of nerves, which carry signals between the CNS and the rest of the body. Function is to transmit information in both directions between the body and CNS.
    - Nerves that control voluntary muscles
    - Nerves that carry information from the sensory organs
    - Nerves that regulate involuntary functions (breathing, heartbeat, digestion)
- Nerve cells: have a cytoplasm, various organelles, and a nucleus. They make up nerve tissue. Nerve cell and neuron are synonymous. Main function is to send electrical signals to the body. They can only transmit electrical signals in one direction. Do not regenerate unlike most other cells.
    - Sensory neurons: carry information from the body back to the brain/spinal cord. Located in the skin so they can pick up information from the environment so the brain can process it.
    - Motor neurons: carry instructions from the brain/spinal cord to another part of the body (e.g. muscles, glands). Usually these instructions tell these body parts to act.
    - Interneurons: connect the sensory and motor neurons. Carry information between 2 other neurons. Brain and spinal cord are made up of interneurons.
- Signals between the brain and the body can travel more than 100m/s

- Neurons/nerve cells have long thin structures that extend from the cell body. These allow electrical signals to rapidly and efficiently move throughout the body.
- A nerve cell's body is composed of the nucleus and mainly the cytoplasm.
- Dendrites: spiny nerve endings that branch from cell body. Carry signals *toward* the cell's body, therefore they are receivers of information.
- Axon: a long thin fibre that also extends from the cell body. It carries signals *away* from the cell's body; therefore it is an information transmitter.
- Myelin sheath: a white fatty material that covers the axon. Its function is similar to that of insulation around an electrical cable in that it prevents electrical signals from inadvertently going to places they shouldn't, such as a neighboring neuron. Also allows signal to travel faster.
- Nerve cells usually have several dendrites but only one axon.
- Nerves: allow information to be transmitted both ways.
- A nerve cell/ neuron passes information on the next neuron (in this case, to contract a muscle):
    1. Dendrites receive stimulation from external environment/within body
    2. Nerve impulse (or message) is generated in and travels along the axon away from the cell's body
    3. The signal approaches the neuron and causes chemicals, known as neurotransmitters to be released at the ends of the axons
    4. Neurotransmitters stimulate the next neuron to "fire" and pass the signal to that neuron's axon to its dendrites, which carry the signal *towards* the cell body
    5. The signal finally ends on the muscle and causes it to contract.
- Other arrangements of neurons also exists, e.g. sensory neurons which send signals to the brain that we interpret as sight
- Sensory receptors: main function is to tell the body what is happening in the outside world
    - Eyes contain light sensitive cells
    - Ears contain hair cells that are sensitive to sound vibrations
    - Tongue contains taste buds (these work with the nose to detect taste and smell)
- All this information is sent to specific parts of the brain to be processed.
- Multiple sclerosis: when the myelin sheaths are destroyed by the immune cells, which results in a loss of nerve function
- In some sports you are likely to get a concussion which can affect the brain negatively over the long term
- Physical trauma, e.g. a fall or a blow to the spinal cord can result in paralysis.
- A pinched/damaged nerve can cause loss of feeling, numbness in extremities, pain and can potentially lead to partial/complete paralysis
- CT scans or MRI scans are used to determine exact location of brain/spinal cord injuries. Advantageous because they require minimal invasion of the body and are safe for the patient.

Interaction of Systems

Digestive System's Contributions

- The digestive system's main function is to break down food and absorbs its nutrients. These nutrients are distributed to the rest of the body. The circulatory system is the system that transports them to the rest of the body.
- The digestive system also rids the body of the solid waste (feces not urine)

Circulatory System's Contributions

- The circulatory's system's function is to transport gases (which is inhaled and exhaled by the respiratory system), nutrients (supplied by the digestive system), waste (specifically urine, which is excreted through the urinary system) and hormones (created by the endocrine system).
- The circulatory system also fights off infection in the body as well as regulating the body's temperature.
- The circulatory system has to interact with every system in the body so that it can supply them with blood and so that it can fight off any infection.

Respiratory System's Contributions

- The respiratory system's function is to exchange gases in the blood. Oxygen is exchanged from Carbon Dioxide. This oxygen is then transported by the circulatory system to the rest of the body, so that the body can gain the oxygen it needs.

Musculoskeletal System's Contributions

- The skeletal system is the base in which the muscular system is attached (by tendons). The skeletal system also protects any vital organs within the body. Bone marrow also creates blood cells, which are used by the circulatory system. The skeletal system also stores minerals, which are absorbed by the digestive system and transported by the circulatory system.
- The muscular systems move the body parts such as the arms and organs such as the stomach or the diaphragm, which are both part of the respiratory and digestive system respectively. The muscular system also maintains the posture of the humans. The muscular system is always commanded by the nervous system to move.

Nervous System's Contributions

- The nervous system gathers and interprets sensory information from outside and inside the body as well as coordinating the rest of the organ system's functions. This means that all systems work with the nervous system. For example the nervous system controls breathing (part of the respiratory system), appetite (digestive system) and heart beat (circulatory).
- If one system in the body slows down, other systems can be affected by it. For example if a person has heart disease, the other systems that interact with the circulatory system, especially the respiratory and excretory system will feel the direct effect.
    - Homeostasis is the state of a healthy balance of internal conditions and processes (body temperature, blood pressure, heart rate, breathing rate).
    - The circulatory system for example increases the flow of blood to maintain heat, fights off an increased amount of bacteria within the body with increased white blood cells.
    - The digestive system will have the pancreas secrete more insulin for sugary food and has acidity in the stomach to prevent bacteria from getting in the body.
    - The respiratory system maintains the amount of oxygen and carbon dioxide in the body by inhaling and exhaling them out respectively.
    - The nervous system will signal the heart, and the nose to start beating faster, pumping out faster or inhaling and exhaling faster respectively.
    - The Musculoskeletal system will create blood in the bone marrow to increase a certain blood cell's count.