Recognise Healthy Body Systems

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What makes up a healthy human body?

Anatomy and physiology

ANATOMY is the study, classification, and description of structures and organs of the body.

PHYSIOLOGY is the study and process of the function of the human.

The human body is a single structure but it is made up of billions of smaller structures.

Basic structure and functions of the body systems and associated components, include:

- Cells, tissues and organs
- Body systems:
  - Cardiovascular system
  - Respiratory system
  - Musculo-skeletal system
  - Endocrine system
  - Digestive system
  - Urinary system
  - Reproductive system
  - Integumentary system
  - Lymphatic system
  - Nervous system, including sensory systems – eye and ear
  - Immune system
- The special senses – smell, taste, vision, equilibrium and hearing

Cells

Cells have long been recognised as the simplest units of living matter that can maintain life and reproduce themselves. The human body, which is made up of numerous cells, begins as a single, newly fertilised cell.

Tissues

Tissues are somewhat more complex units than cells. By definition, a tissue is an organisation of a great many similar cells with varying amounts and kinds of nonliving, intercellular substance between them.

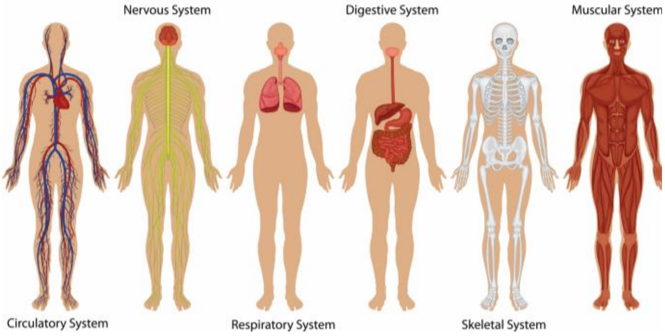
Organs

Organs are more complex units than tissues. An organ is an organisation of several different kinds of tissues so arranged that together they can perform a special function. For example, the stomach is an organisation of muscle, connective, epithelial, and nervous tissues. Muscle and connective tissues form its wall, epithelial and connective tissues form its lining, and nervous tissue extends throughout both its wall and its lining.

Systems

Systems are the most complex of the component units of the human body. A system is an organisation of varying numbers and kinds of organs so arranged that together they can perform complex functions for the body.

Cells combine to form tissues, tissues combine and form organs, a group of organs combine to form a body system, a body system is a group of organs that work together to accomplish a bodily function. When a person is injured or becomes ill, it effects one or more of the body systems.



Body systems working together

The human body works similarly to a machine. It has 11 different systems that allow it to run effectively. Like a machine, if one system is not running properly, the whole body will be affected. These systems perform different tasks in the body and encompass different organs. Each system will be explain in full later in this manual. The following is a brief description of the systems that work directly together.

Most tasks in the body need the support of two or more organ systems working together.

For example:

Cardiovascular and respiratory systems — the cardiovascular system's central organ is the heart, which pumps blood to the different parts of the body. The blood travels from the heart to the lungs, where the respiratory system supplies the blood with oxygen. Air is inhaled through the nose or mouth; it passes through the pharynx, larynx, trachea and finally to the lungs, where it diffuses in the blood through the alveoli.

Digestive and excretory systems — the digestive system is responsible for transforming food into energy. The food enters the digestive system, absorption takes place and the food is transformed into enzymes, glucose and nutrients that the body uses as energy. The excretory system includes the kidneys, which filter wastes and purify the blood. This waste is transformed into urine and flows down two tubes, called ureters, which deliver the urine to the bladder. The urinary bladder is a large structure, similar to a sack, which collects the urine and then releases when full. The urine travels out of the body through a hole called the urethra.

Endocrine and immune systems — the endocrine system uses hormones, chemical compounds that regulate metabolic function of cells, to stimulate the metabolic activity of cells. The hormones are released into the bloodstream. The immune system is a network of cells, tissues and organs that work together to attack any pathogens that try to enter your body. The human body is a perfect host for bacteria, parasites and fungi, which cause infection. If any of these organisms gain entry to the body, the immune system works to destroy them and rid your body of illness.

Nervous and endocrine systems — the nervous and endocrine systems exert the ultimate control over homeostasis because they coordinate the functions of the body's systems. Regulation of body temperature, blood pressure, pH, and glucose concentration are four examples of how the body maintains homeostasis.

Integumentary and nervous systems — skin is called the integumentary system, which is the body's first line of defense. It regulates body temperature, protects underlying layers of tissue from sun damage and prevents pathogens from freely entering the body. The integumentary system is also home to millions of nerves that respond to touch, pressure and pain. There are two interconnected nervous systems: the central nervous system and the peripheral nervous system. The central nervous system includes the spinal cord and the brain, which gets the information from the body and sends out instructions. The peripheral nervous system includes all of the nerves and sends messages from the brain to the rest of the body.

Skeletal and muscular systems — the system that provides the body's shape is the skeletal system, it is made up of cartilage and bone. There are 206 bones in the human skeleton that provide a hard framework able to support the body and protect the organs that they surround. Cartilage provides support with flexibility and resistance and acts as padding to soften the pressure that is exerted from the bones. Movement in the body is the result of muscle contraction; when muscles combine with the action of joints and bones, obvious movements are performed, such as jumping and walking. The contraction of muscles provides the body posture, joint stability and heat production.

All of the systems work together

All the systems have to perform their role for the overall task to be completed successfully. In this way, the organ systems are like the runners in a relay race. Each runner needs to pick up the baton from another runner, run with it and then pass it to the next runner to complete the race. In the body, organ systems work together in a similar way to complete tasks.

Take cellular respiration, for instance — this task requires oxygen and food. The respiratory system brings oxygen into the lungs when you breathe. The digestive system breaks food down into nutrients such as glucose. Now the circulatory system enters the picture. It transports glucose and other nutrients from the digestive system to the cells. The circulatory system also transports oxygen from the lungs to the cells. Now the cells have what they need for cellular respiration: oxygen and glucose.

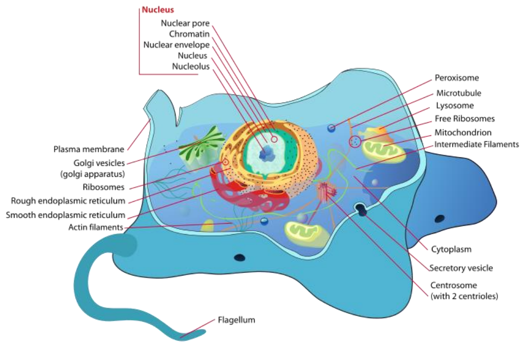
The teamwork doesn't end there — the circulatory system also transports carbon dioxide waste from the cells to the lungs of the respiratory system. Through gas exchange in the lungs, the carbon dioxide waste is removed from the body when breathing out. After the digestive system breaks down food and absorbs nutrients, it eliminates solid waste.

Cells

Cells, the smallest structures capable of maintaining life and reproducing, compose all living things, from single-celled plants to multibillion-celled animals. The human body, which is made up of numerous cells, begins as a single, newly fertilised cell.

Almost all human cells are microscopic in size. To give you an idea how small a cell is, one average-sized adult body, according to one estimate, consists of 100 trillion cells!

There are many different types, sizes, and shapes of cells in the body. For descriptive purposes, the concept of a "generalised cell" is introduced. It includes features from all cell types.



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Structure

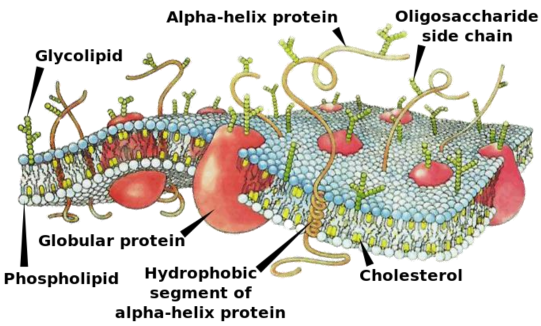
A cell consists of three parts: the cell membrane, the nucleus, and between the two, the cytoplasm. Within the cytoplasm lie intricate arrangements of fine fibres and hundreds or even thousands of miniscule but distinct structures called organelles.

Cell membrane

Every cell in the body is enclosed by a cell (Plasma) membrane. The cell membrane separates the material outside the cell, extracellular, from the material inside the cell, intracellular. It maintains the integrity of a cell and controls passage of materials into and out of the cell. All materials within a cell must have access to the cell membrane (the cell's boundary) for the needed exchange.

The cell membrane is a double layer of phospholipid molecules. Proteins in the cell membrane provide structural support, form channels for passage of materials, act as receptor sites, function as carrier molecules, and provide identification markers.

Molecular structure of a cell membrane



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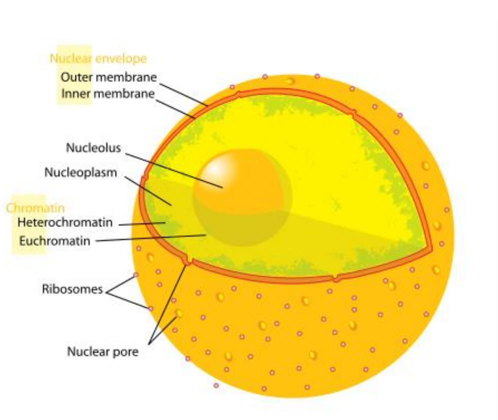
Nucleus and nucleolus

The nucleus, formed by a nuclear membrane around a fluid nucleoplasm, is the control centre of the cell. Threads of chromatin in the nucleus contain deoxyribonucleic acid (DNA), the genetic material of the cell. The nucleolus is a dense region of ribonucleic acid (RNA) in the nucleus and is the site of ribosome formation. The nucleus determines how the cell will function, as well as the basic structure of that cell.

Cytoplasm

The cytoplasm is the gel-like fluid inside the cell. It is the medium for chemical reaction. It provides a platform upon which other organelles can operate within the cell. All of the functions for cell expansion, growth and replication are carried out in the cytoplasm of a cell. Within the cytoplasm, materials move by diffusion, a physical process that can work only for short distances.



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Cytoplasmic organelles

Cytoplasmic organelles are "little organs" that are suspended in the cytoplasm of the cell. Each type of organelle has a definite structure and a specific role in the function of the cell. Examples of cytoplasmic organelles are mitochondrion, ribosomes, endoplasmic reticulum, golgi apparatus and lysosomes. The structural and functional characteristics of different types of cells are determined by the nature of the proteins present. Cells of various types have different functions because cell structure and function are closely related. It is apparent that a cell that is very thin is not well suited for a protective function. Bone cells do not have an appropriate structure for nerve impulse conduction. Just as there are many cell types, there are varied cell functions. The generalised cell functions include movement of substances across the cell membrane, cell division to make new cells, and protein synthesis.

Movement of substances across the cell membrane

The survival of the cell depends on maintaining the difference between extracellular and intracellular material. Mechanisms of movement across the cell membrane include simple diffusion, osmosis, filtration, active transport, endocytosis, and exocytosis. Simple diffusion is the movement of particles (solutes) from a region of higher solute concentration to a region of lower solute concentration. Osmosis is the diffusion of solvent or water molecules through a selectively permeable membrane. Filtration utilises pressure to push substances through a membrane. Active transport moves substances against a concentration gradient from a region of lower concentration to a region of higher concentration. It requires a carrier molecule and uses energy. Endocytosis refers to the formation of vesicles to transfer particles and droplets from outside to inside the cell. Secretory vesicles are moved from the inside to the outside of the cell by exocytosis.

Cell division

Cell division is the process by which new cells are formed for growth, repair, and replacement in the body. This process includes division of the nuclear material and division of the cytoplasm. All cells in the body (somatic cells), except those that give rise to the eggs and sperm (gametes), reproduce by mitosis. Egg and sperm cells are produced by a special type of nuclear division called meiosis in which the number of chromosomes is halved. Division of the cytoplasm is called cytokinesis.

Somatic cells reproduce by mitosis, which results in two cells identical to the one parent cell. Interphase is the period between successive cell divisions. It is the longest part of the cell cycle. The successive stages of mitosis are prophase, metaphase, anaphase, and telophase. Cytokinesis, division of the cytoplasm, occurs during telophase.

Meiosis is a special type of cell division that occurs in the production of the gametes, or eggs and sperm. These cells have only 23 chromosomes, one-half the number found in somatic cells, so that when fertilisation takes place the resulting cell will again have 46 chromosomes, 23 from the egg and 23 from the sperm.

DNA replication and protein synthesis

Proteins that are synthesised in the cytoplasm function as structural materials, enzymes that regulate chemical reactions, hormones, and other vital substances. DNA in the nucleus directs protein synthesis in the cytoplasm. A gene is the portion of a DNA molecule that controls the synthesis of one specific protein molecule. Messenger RNA carries the genetic information from the DNA in the nucleus to the sites of protein synthesis in the cytoplasm.

Tissues in the body

Tissues can be grouped into four basic types: connective, muscle, nervous and epithelial. Multiple tissue types compose organs and body structures.

Connective tissues – are fibrous tissues. They are made up of cells separated by non-living material, which is called an extracellular matrix. Connective tissue gives shape to organs and holds them in place. Both blood and bone are examples of connective tissue. As the name implies, these support and bind other tissues. Unlike epithelial tissue, connective tissue typically has cells scattered throughout an extracellular matrix.

Muscle tissue – muscle cells form the active contractile tissue of the body known as muscle tissue. Muscle tissue functions to produce force and cause motion, either locomotion or movement within internal organs. Muscle tissue is separated into three distinct categories: skeletal muscle, smooth muscle and cardiac muscle. They are the longest group of cells in the human body.

Nervous tissue – cells comprising the central nervous system and peripheral nervous system are classified as neural tissue. In the central nervous system, neural tissue forms the brain and spinal cord, and in the peripheral nervous system forms the cranial nerves and spinal nerves, inclusive of the motor neurons.

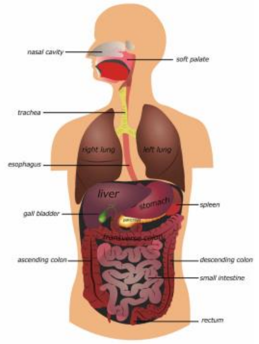
The epithelial tissues – are formed by cells that cover the organ surfaces such as the surface of the skin, the airways, the reproductive tract, and the inner lining of the digestive tract. The cells comprising an epithelial layer are linked via semi-permeable, tight junctions; hence, this tissue provides a barrier between the external environment and the organ it covers. In addition to this protective function, epithelial tissue may also be specialised to function in secretion and absorption. Epithelial tissue helps to protect from microorganisms, injury and fluid loss.

Soft tissue – includes muscles, tendons, ligaments, fascia, nerves, fibrous tissues, fat, blood vessels, and synovial membranes. A soft tissue injury generally involves one or more of the following structures via sprain, strain or direct blows.

Organs

There are almost 78 organs in a human body which vary according to their sizes, functions or actions. **An organ is a collection of millions of cells which group together to perform single functions in our body.** The cells in these body organs are highly specialised and form for all the necessary actions for some specific time. Out of these 78 organs of a male or female body, skin (integumentary system) is the largest organ with respect to its size and weight.

Humans have five **vital organs** that are essential for survival. These are the brain, heart, kidneys, liver and lungs.



The human brain is the body's control centre, receiving and sending signals to other organs through the nervous system and through secreted hormones. It is responsible for our thoughts, feelings, memory storage and general perception of the world.

The human heart is a responsible for pumping blood throughout our body.

The job of the kidneys is to remove waste and extra fluid from the blood. The kidneys take urea out of the blood and combine it with water and other substances to make urine.

The liver has many functions, including detoxifying of harmful chemicals, breakdown of drugs, filtering of blood, and secretion of bile and production of blood-clotting proteins.

The lungs are responsible for removing oxygen from the air we breathe and transferring it to our blood where it can be sent to our cells. The lungs also remove carbon dioxide, which we exhale.

The organs of the body are given in the following list:

- Adrenal Glands
- Anus
- Appendix
- Bladder
- Bones
- Brain
- Bronchi
- Ears
- Eyes
- Gall Bladder
- Genitals
- Heart
- Hypothalamus
- Kidneys
- Large Intestine
- Larynx (voice box)
- Liver
- Lungs
- Lymph Nodes
- Mouth
- Nose
- Oesophagus
- Pancreas
- Parathyroid Glands
- Pituitary Gland
- Prostate
- Rectum
- Salivary Glands
- Skeletal Muscles
- Skin
- Small Intestine
- Spinal Cord
- Spleen
- Stomach
- Thymus Gland
- Trachea
- Thyroid
- Ureters
- Urethra

ILLNESS AND INFECTION

What happens when we are sick?

Infection with a pathogen does not necessarily lead to disease. Infection occurs when viruses, bacteria, or other microbes enter the body and begin to multiply. Disease, which typically happens in a small proportion of infected people, occurs when the cells in the body are damaged as a result of infection, and signs and symptoms of an illness appear.

Many of the symptoms that make a person suffer during an infection—fever, malaise, headache, rash—result from the activities of the immune system trying to eliminate the infection from the body.

In response to infection, the immune system springs into action. White blood cells, antibodies, and other mechanisms go to work to rid the body of the foreign invader. Indeed, many of the symptoms that make a person suffer during an infection—fever, malaise, headache, rash—result from the activities of the immune system trying to eliminate the infection from the body.

Pathogenic microbes challenge the immune system in many ways. Viruses make us sick by killing cells or disrupting cell function. Our bodies often respond with fever (heat inactivates many viruses), the secretion of a chemical called interferon (which blocks viruses from reproducing), or by marshalling the immune system's antibodies and other cells to target the invader. Many bacteria make us sick the same way, but they also have other strategies at their disposal. Sometimes bacteria multiply so rapidly they crowd out host tissues and disrupt normal function. Sometimes they kill cells and tissues outright. Sometimes they make toxins that can paralyse, destroy cells' metabolic machinery, or precipitate a massive immune reaction that is itself toxic.

Health issues will be described further in the body systems section.

BODY STRUCTURE

Anatomical planes

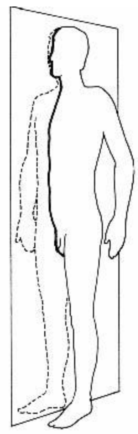
Planes of the body

Coronal or frontal plane: Runs vertically through the body and divides the body into front (anterior) and rear (posterior) sections. Also called the frontal plane.

Horizontal or transverse plane: Runs horizontally through the body and divides the body into a superior (or upper) and an inferior (or lower) section. Also called the transverse plane.

Median or midsagittal plane: Runs vertically through the body and divides the body into right and left halves. Also called the midsagittal plane.

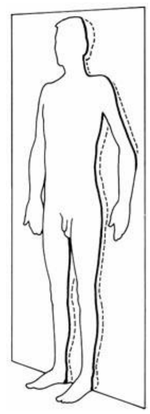
Median plane



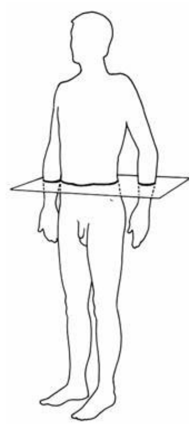
Direction and location

Anterior: front side of the body, also known as ventral.
Caudal: in quadrupeds, the tail end [see inferior].
Cranial: above or near the head, also known as superior.
Distal: farthest end from the trunk or head.
Dorsal: back side of the body, also known as the posterior.
Inferior: below also, toward the feet.
Lateral: away from the midline.
Medial: toward the midline.
Posterior: back side of the body, also known as the dorsal.
Proximal: closest part nearest the trunk or head.
Superior: above or near the head, also known as cranial.
Ventral: front side of the body, also known as anterior.

Coronal plane



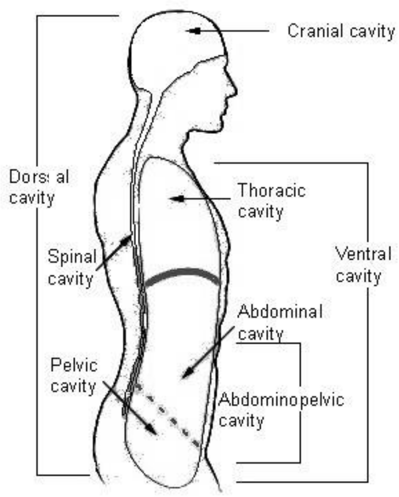
Transverse plane



Body cavities

The cavities, or spaces, of the body contain the internal organs, or viscera. The two main cavities are called the ventral and dorsal cavities.

The **ventral cavity** is the larger cavity and is subdivided into two parts (thoracic and abdominopelvic cavities) by the diaphragm, a dome-shaped respiratory muscle.



Thoracic cavity: The upper ventral, thoracic, or chest cavity contains the heart, lungs, trachea, oesophagus, large blood vessels, and nerves. The thoracic cavity is bound laterally by the ribs (covered by costal pleura) and the diaphragm caudally (covered by diaphragmatic pleura).

Abdominal and pelvic cavity: The lower part of the ventral (abdominopelvic) cavity can be further divided into two portions: abdominal portion and pelvic portion. The abdominal cavity contains most of the gastrointestinal tract as well as the kidneys and adrenal glands. The abdominal cavity is bound cranially by the diaphragm, laterally by the body wall, and caudally by the pelvic cavity. The pelvic cavity contains most of the urogenital system as well as the rectum. The pelvic cavity is bounded cranially by the abdominal **cavity, dorsally by the sacrum, and laterally by the pelvis.**

Dorsal cavity: The smaller of the two main cavities is called the dorsal cavity. As its name implies, it contains organs lying more posterior in the body. The dorsal cavity, again, can be divided into two portions. The upper portion, or the cranial cavity, houses the brain, and the lower portion, or vertebral canal houses the spinal cord.

BIOMECHANICS OF BODY MOVEMENT

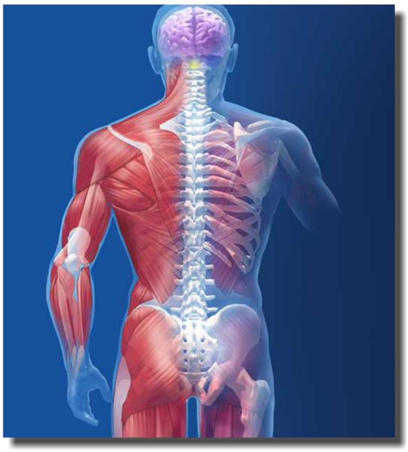
'The study of the causes of human motion'.

Muscle work

Dynamic work is muscle contraction as well as movement of a body part. For example, lifting stock and placing it on a shelf. The shoulder muscles contract and the arms are raised.

Dynamic action is when the blood pumped to the muscle flows through the muscle, flushing out the lactic acid and carbon dioxide (waste products of muscle work). Thus the chemical balance of the muscle is maintained, and it can work for lengthy periods without discomfort. Over longer periods of time, if the dynamic muscle work involves repetitive movements, this can increase the risk of injury.

Static work is muscle contraction, but with no movement of body parts. For example, a mechanic bending over to work in a car engine. The flexed posture of the spine is held there by the back muscles working statically.



Static action is when the sustained muscle contraction acts like a tourniquet on the blood vessels. This results in a loss of blood flow to the working muscle and a build-up of the waste products in the muscle itself. The chemical imbalance is detected by the brain as discomfort, fatigue or heaviness. This occurs even after very short periods of static muscle work and can increase the risk of injury.

Many tasks involve both static and dynamic muscle work. In the example of the mechanic working in a car engine, there is static work for the back muscles and dynamic work for the wrist and forearm muscles as he/she uses tools.

Principles of levers

For our bodies to move, the muscles have to pull on the bones of our arms, legs and back. The bones are therefore like levers. A weight at a short distance from the body requires less effort to move than the same weight at a longer distance from the body, where the lever arm is longer. When lifting a load, the closer it is to the person's body, the less stress there is on the body, and therefore the lower the risk of injury. If the load is further away, there is greater strain on the person handling the load.

The spine can sometimes be used as a lever, but it was not designed to be used like a crane. The spine becomes a very long lever arm, with a load being handled at the end. The muscles of the back have to support not only the weight of the load being handled, but also the weight of the trunk as it is bent over. The force exerted by the spinal muscles can be up to ten times greater than the weight of the load handled.

Strength

A display of *strength* (e.g. lifting a weight) is a result of three factors that overlap:

1. **Physiological strength** (muscle size, cross sectional area, available cross-bridging, responses to training)
2. **Neurological strength** (how strong or weak is the signal that tells the muscle to contract)
3. **Mechanical strength** (muscles force angle on the lever, joint capabilities)

These three factors affect muscular strength simultaneously and muscles never work individually.

Humans are genetically predisposed with a larger percentage of one type of muscle group over another. An individual born with a greater percentage of Type I muscle fibres would theoretically be more suited to endurance events, such as triathlons, whereas a human born with a greater percentage of Type II muscle fibres would be more likely to excel at anaerobic events such as a 200 meter dash, or weightlifting.

SYSTEMS OF THE BODY

The Cardiovascular System

Also known as the circulatory system.

Location

The entire body, with heart being the central organ, located in the chest cavity medial to the lungs along the body's midline in the thoracic region. Circulatory Loops - There are 2 primary circulatory loops in the human body: the pulmonary circulation loop and the systemic circulation loop.

Structure

The cardiovascular system is sometimes called the blood-vascular or simply the circulatory system. It consists of the heart, which is a muscular pumping device, and a closed system of vessels called arteries, veins, and capillaries.

Development

As in the adult, survival of the developing embryo depends on the circulation of blood to maintain homeostasis and a favourable cellular environment. In response to this need, the cardiovascular system makes its appearance early in development and reaches a functional state long before any other major organ system. Incredible as it seems, the primitive heart begins to beat regularly early in the fourth week following fertilisation The vital role of the cardiovascular system in maintaining homeostasis depends on the continuous and controlled movement of blood through the thousands of miles of capillaries that permeate every tissue and reach every cell in the body. It is in the microscopic capillaries that blood performs its ultimate transport function. Nutrients and other essential materials pass from capillary blood into fluids surrounding the cells as waste products are removed.

Numerous control mechanisms help to regulate and integrate the diverse functions and component parts of the cardiovascular system in order to supply blood to specific body areas according to need. These mechanisms ensure a constant internal environment surrounding each body cell regardless of differing demands for nutrients or production of waste products.

Function

As the name implies, the heart around a closed circle or circuit of vessels pumps blood contained in the circulatory system as it passes again and again through the various "circulations" of the body. Its job is to deliver nutrients to the body and remove by-products from the tissues.

The cardiovascular system has three major functions: transportation of materials, protection from pathogens, and regulation of the body's homeostasis.

Transportation: The cardiovascular system transports blood to almost all of the body's tissues. The blood delivers essential nutrients and oxygen and removes wastes and carbon dioxide to be processed or removed from the body. Hormones are transported throughout the body via the blood's liquid plasma.

Protection: The cardiovascular system protects the body through its white blood cells. White blood cells clean up cellular debris and fight pathogens that have entered the body. Platelets and red blood cells form scabs to seal wounds and prevent pathogens from entering the body and liquids from leaking out. Blood also carries antibodies that provide specific immunity to pathogens that the body has previously been exposed to or has been vaccinated against.

Regulation: The cardiovascular system is instrumental in the body's ability to maintain homeostatic control of several internal conditions. Blood vessels help maintain a stable body temperature by controlling the blood flow to the surface of the skin. Blood vessels near the skin's surface open during times of overheating to allow hot blood to dump its heat into the body's surroundings. In the case of hypothermia, these blood vessels constrict to keep blood flowing only to vital organs in the body's core. Blood also helps balance the body's pH due to the presence of bicarbonate ions, which act as a buffer solution. Finally, the albumins in blood plasma help to balance the osmotic concentration of the body's cells by maintaining an isotonic environment.

The heart

Structure

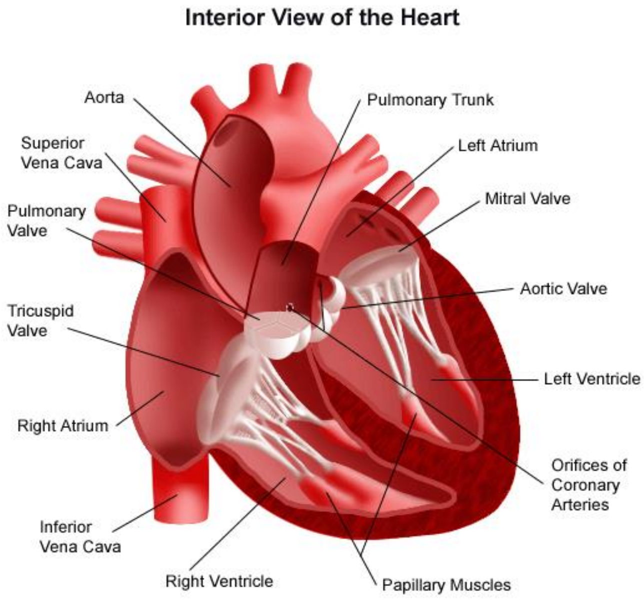
The human heart is a four-chambered muscular organ, shaped and sized roughly like a man's closed fist with two-thirds of the mass to the left of midline.

The heart is enclosed in a pericardial sac that is lined with the parietal layers of a serous membrane. The visceral layer of the serous membrane forms the epicardium.

Layers of the heart wall - Three layers of tissue form the heart wall. The outer layer of the heart wall is the epicardium, the middle layer is the myocardium, and the inner layer is the endocardium.

Chambers of the heart - The internal cavity of the heart is divided into four chambers:

1. Right atrium
2. Right ventricle
3. Left atrium
4. Left ventricle



The two atria are thin-walled chambers that receive blood from the veins. The two ventricles are thick-walled chambers that forcefully pump blood out of the heart. Differences in thickness of the heart chamber walls are due to a variation in the amount of myocardium present, which reflects the amount of force each chamber is required to generate.

The right atrium receives deoxygenated blood from systemic veins; the left atrium receives oxygenated blood from the pulmonary veins.

Valves of the heart - Pumps need a set of valves to keep the fluid flowing in one direction and the heart is no exception. The heart has two types of valves that keep the blood flowing in the correct direction. The valves between the atria and ventricles are called atrioventricular valves (also called cuspid valves), while those at the bases of the large vessels leaving the ventricles are called semilunar valves.

The right atrioventricular valve is the tricuspid valve. The left atrioventricular valve is the bicuspid, or mitral, valve. The valve between the right ventricle and pulmonary trunk is the pulmonary semilunar valve. The valve between the left ventricle and the aorta is the aortic semilunar valve.

When the ventricles contract, atrioventricular valves close to prevent blood from flowing back into the atria. When the ventricles relax, semilunar valves close to prevent blood from flowing back into the ventricles.

Function

The heart is a muscular pump that provides the force necessary to circulate the blood to all the tissues in the body. Its function is vital because, to survive, the tissues need a continuous supply of oxygen and nutrients, and metabolic waste products have to be removed.

Deprived of these necessities, cells soon undergo irreversible changes that lead to death. While blood is the transport medium, the heart is the organ that keeps the blood moving through the vessels. The normal adult heart pumps about 5 litres of blood every minute throughout life. If it loses its pumping effectiveness for even a few minutes, the individual's life is jeopardised.

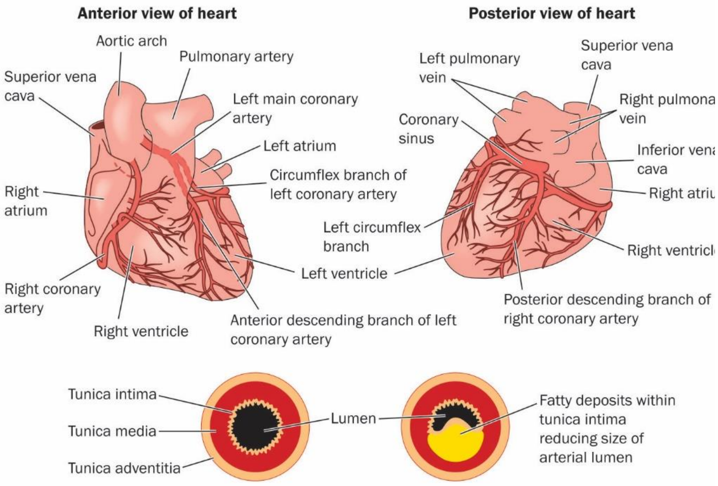
Physiology of the heart

The work of the heart is to pump blood to the lungs through pulmonary circulation and to the rest of the body through systemic circulation. This is accomplished by systematic contraction and relaxation of the cardiac muscle in the myocardium.

Pathway of blood through the heart - While it is convenient to describe the flow of blood through the right side of the heart and then through the left side, it is important to realise that both atria contract at the same time and both ventricles contract at the same time. The heart works as two pumps, one on the right and one on the left, working simultaneously. Blood flows from the right atrium to the right ventricle, and then is pumped to the lungs to receive oxygen. From the lungs, the blood flows to the left atrium, then to the left ventricle. From there it is pumped to the systemic circulation.

Blood supply to the myocardium - The myocardium of the heart wall is a working muscle that needs a continuous supply of oxygen and nutrients to function with efficiency. For this reason, cardiac muscle has an extensive network of blood vessels to bring oxygen to the contracting cells and to remove waste products.

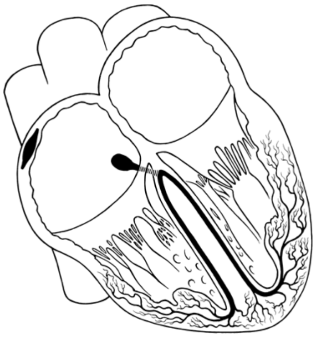
The right and left coronary arteries, branches of the ascending aorta, supply blood to the walls of the myocardium. After blood passes through the capillaries in the myocardium, it enters a system of coronary (cardiac) veins. Most of the cardiac veins drain into the coronary sinus, which opens into the right atrium.



Conduction system - An effective cycle for productive pumping of blood requires that the heart be synchronised accurately. Both atria need to contract simultaneously, followed by contraction of both ventricles.

Specialised cardiac muscle cells that make up the conduction system of the heart coordinate contraction of the chambers.

The conduction system includes several components. The first part of the conduction system is the sinoatrial node. Without any neural stimulation, the sinoatrial node rhythmically initiates impulses 70 to 80 times per minute. Because it establishes the basic rhythm of the heartbeat, it is called the pacemaker of the heart. Other parts of the conduction system include the atrioventricular node, atrioventricular bundle, bundle branches, and conduction myofibres. All these components coordinate the contraction and relaxation of the heart chambers.



Conduction system of the heart

Cardiac cycle - The cardiac cycle refers to the alternating contraction and relaxation of the myocardium in the walls of the heart chambers, coordinated by the conduction system, during one heartbeat. Systole is the contraction phase of the cardiac cycle, and diastole is the relaxation phase. At a normal heart rate, one cardiac cycle lasts for 0.8 second.

Heart sounds - The sounds associated with the heartbeat are due to vibrations in the tissues and blood caused by closure of the valves. Abnormal heart sounds are called heart murmurs.

Heart rate - The sinoatrial node, acting alone, produces a constant rhythmic heart rate. Regulating factors are reliant on the atrioventricular node to increase or decrease the heart rate to adjust cardiac output to meet the changing needs of the body. Most changes in the heart rate are mediated through the cardiac centre in the medulla oblongata of the brain. The centre has both sympathetic and parasympathetic components that adjust the heart rate to meet the changing needs of the body.

Peripheral factors such as emotions, ion concentrations, and body temperature may affect heart rate. These are usually mediated through the cardiac centre.

Blood

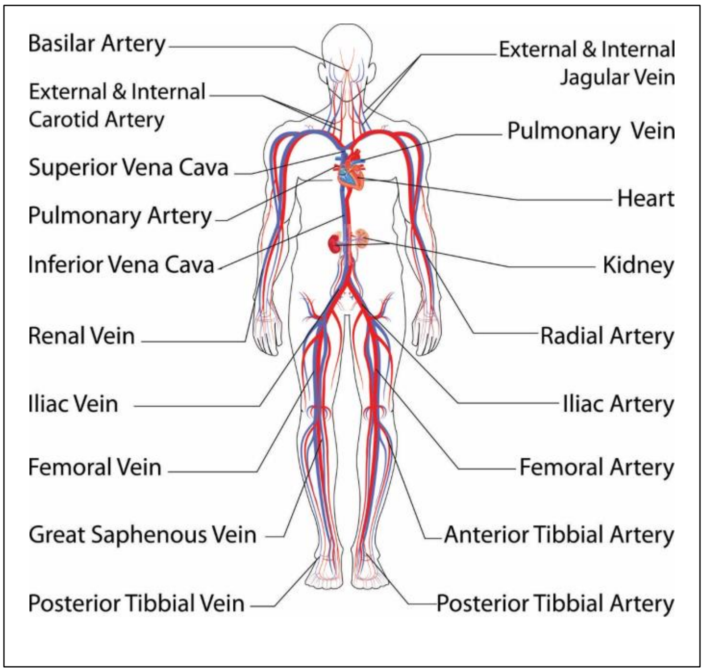
Blood is the fluid of life, transporting oxygen from the lungs to body tissue and carbon dioxide from body tissue to the lungs. Blood is the fluid of growth, transporting nourishment from digestion and hormones from glands throughout the body. Blood is the fluid of health, transporting disease fighting substances to the tissue and waste to the kidneys. Because it contains living cells, blood is alive. Red blood cells and white blood cells are responsible for nourishing and cleansing the body. Without blood, the human body would stop working.

Blood vessels

Blood vessels are the channels or conduits through which blood is distributed to body tissues. The vessels make up two closed systems of tubes that begin and end at the heart. One system, the pulmonary vessels, transports blood from the right ventricle to the lungs and back to the left atrium. The other system, the systemic vessels, carries blood from the left ventricle to the tissues in all parts of the body and then returns the blood to the right atrium.

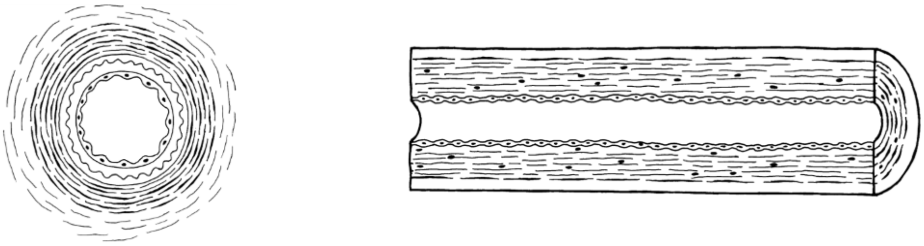
Based on their structure and function, blood vessels are classified as either arteries, capillaries, or veins.

Arteries



Arteries carry blood away from the heart. Pulmonary arteries transport blood that has a low oxygen content from the right ventricle to the lungs. Systemic arteries transport oxygenated blood from the left ventricle to the body tissues. Blood is pumped from the ventricles into large elastic arteries that branch repeatedly into smaller and smaller arteries until the branching results in microscopic arteries called arterioles. The arterioles play a key role in regulating blood flow into the tissue capillaries. About 10 percent of the total blood volume is in the systemic arterial system at any given time.

The wall of an artery consists of three layers. The innermost layer, the tunica intima (also called tunica interna), is simple squamous epithelium surrounded by a connective tissue basement membrane with elastic fibres. The middle layer, the tunica media, is primarily smooth muscle and is usually the thickest layer. It not only provides support for the vessel but also changes vessel diameter to regulate blood flow and blood pressure. The outermost layer, which attaches the vessel to the surrounding tissue, is the tunica externa or tunica adventitia. This layer is connective tissue with varying amounts of elastic and collagenous fibres. The connective tissue in this layer is quite dense where it is adjacent to the tunic media, but it changes to loose connective tissue near the periphery of the vessel.

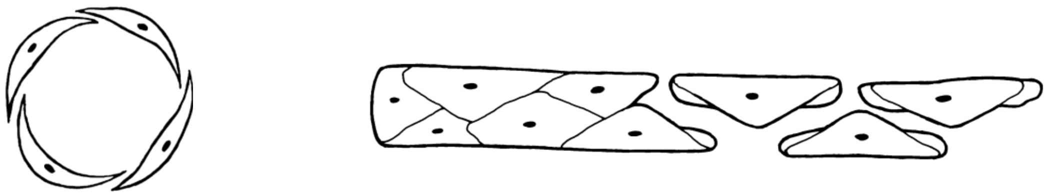


Capillaries

Capillaries, the smallest and most numerous of the blood vessels, *form the connection between the vessels that carry blood away from the heart (arteries) and the vessels that return blood to the heart (veins).*

Capillary distribution varies with the metabolic activity of body tissues. Tissues such as skeletal muscle, liver, and kidney have extensive capillary networks because they are metabolically active and require an abundant supply of oxygen and nutrients. Other tissues, such as connective tissue, have a less abundant supply of capillaries. The epidermis of the skin and the lens and cornea of the eye completely lack a capillary network. About 5 percent of the total blood volume is in the systemic capillaries at any given time. Another 10 percent is in the lungs. Smooth muscle cells in the arterioles where they branch to form capillaries regulate blood flow from the arterioles into the capillaries.

The primary function - Capillaries have a vital role in the exchange of gases, nutrients, and metabolic waste products between the blood and the tissue cells. Substances pass through the capillaries wall by diffusion, filtration, and osmosis. Oxygen and carbon dioxide move across the capillary wall by diffusion. Fluid movement across a capillary wall is determined by a combination of hydrostatic and osmotic pressure. The net result of the capillary microcirculation created by hydrostatic and osmotic pressure is that substances leave the blood at one end of the capillary and return at the other end.

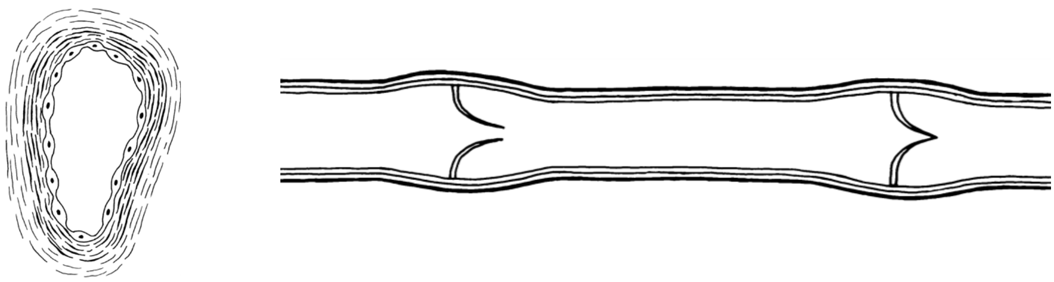


Veins

Veins carry blood toward the heart. After blood passes through the capillaries, it enters the smallest veins, called venules. From the venules, it flows into progressively larger and larger veins until it reaches the heart. In the pulmonary circuit, the pulmonary veins transport blood from the lungs to the left atrium of the heart. This blood has a high oxygen content because it has just been oxygenated in the lungs. Systemic veins transport blood from the body tissue to the right atrium of the heart. This blood has a reduced oxygen content because the oxygen has been used for metabolic activities in the tissue cells.

The walls of veins have the same three layers as the arteries. Although all the layers are present, there is less smooth muscle and connective tissue. This makes the walls of veins thinner than those of arteries, which is related to the fact that blood in the veins has less pressure than in the arteries. Because the walls of the veins are thinner and less rigid than arteries, veins can hold more blood. Almost 70 percent of the total blood volume is in the veins at any given time.

Medium and large veins have venous valves, similar to the semilunar valves associated with the heart that help keep the blood flowing toward the heart. Venous valves are especially important in the arms and legs, where they prevent the backflow of blood in response to the pull of gravity.



Physiology of circulation

Blood flow

Blood flow refers to the movement of blood through the vessels from arteries to the capillaries and then into the veins.

Pressure is a measure of the force that the blood exerts against the vessel walls as it moves the blood through the vessels. Like all fluids, blood flows from a high-pressure area to a region with lower pressure. Blood flows in the same direction as the decreasing pressure gradient: arteries to capillaries to veins.

The rate, or velocity, of blood flow varies inversely with the total cross-sectional area of the blood vessels. As the total cross-sectional area of the vessels increases, the velocity of flow decreases. Blood flow is slowest in the capillaries, which allows time for exchange of gases and nutrients.

Resistance is a force that opposes the flow of a fluid. In blood vessels, most of the resistance is due to vessel diameter. As vessel diameter decreases, the resistance increases and blood flow decreases.

Very little pressure remains by the time blood leaves the capillaries and enters the venules. Blood flow through the veins is not the direct result of ventricular contraction. Instead, venous return depends on skeletal muscle action, respiratory movements, and constriction of smooth muscle in venous walls.

Pulse and blood pressure

Pulse refers to the rhythmic expansion of an artery that is caused by ejection of blood from the ventricle. It can be felt where an artery is close to the surface and rests on something firm. *Pulse pressure* is the difference between systolic pressure and diastolic pressure.

Blood pressure - In common usage, the term blood pressure refers to arterial blood pressure, the pressure in the aorta and its branches.

Systolic pressure is due to ventricular contraction.

Diastolic pressure occurs during cardiac relaxation.

Blood pressure is measured with a sphygmomanometer and is recorded as the systolic pressure over the diastolic pressure.

Four major factors interact to affect blood pressure: cardiac output, blood volume, peripheral resistance, and viscosity. When these factors increase, blood pressure also increases.

Arterial blood pressure is maintained within normal ranges by changes in cardiac output and peripheral resistance.

Baroreceptors (pressure receptors), located in the walls of the large arteries in the thorax and neck, are important for short-term blood pressure regulation.

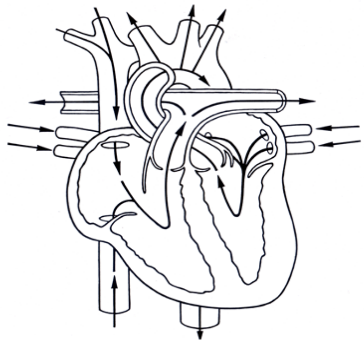
Circulatory pathways

The blood vessels of the body are functionally divided into two distinctive circuits:

1. Pulmonary circuit and 2. Systemic circuit. The pump for the pulmonary circuit, which circulates blood through the lungs, is the right ventricle. The left ventricle is the pump for the systemic circuit, which provides the blood supply for the tissue cells of the body.

1. Pulmonary circuit

Pulmonary circulation transports oxygen-poor blood from the right ventricle to the lungs where blood picks up a new blood supply. Then it returns the oxygen-rich blood to the left atrium.



Pulmonary circulation

2. Systemic circuit

The systemic circulation provides the functional blood supply to all body tissue. It carries oxygen and nutrients to the cells and picks up carbon dioxide and waste products. Systemic circulation carries oxygenated blood from the left ventricle, through the arteries, to the capillaries in the tissues of the body. From the tissue capillaries, the deoxygenated blood returns through a system of veins to the right atrium of the heart.

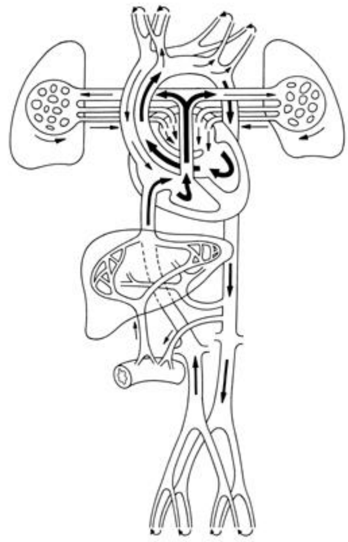
The coronary arteries are the only vessels that branch from the ascending aorta. The brachiocephalic, left common carotid and left subclavian arteries branch from the aortic arch. The internal carotid and vertebral arteries provide Blood supply for the brain. The subclavian arteries provide the blood supply for the upper extremity. The celiac, superior mesenteric, suprarenal, renal, gonadal, and inferior mesenteric arteries branch from the abdominal aorta to supply the abdominal viscera. Lumbar arteries provide blood for the muscles and spinal cord. Branches of the external iliac artery provide the blood supply for the lower extremity. The internal iliac artery supplies the pelvic viscera.

Major systemic arteries

All systemic arteries are branches, either directly or indirectly, from the aorta. The aorta ascends from the left ventricle, curves posteriorly and to the left, and then descends through the thorax and abdomen. This geography divides the aorta into three portions: ascending aorta, aortic arch, and descending aorta. The descending aorta is further subdivided into the thoracic aorta and abdominal aorta.

Major systemic veins

After blood delivers oxygen to the tissues and picks up carbon dioxide, it returns to the heart through a system of veins. The capillaries, where the gaseous exchange occurs, merge into venules and these converge to form larger and larger veins until the blood reaches either the superior vena cava or inferior vena cava, which drain into the right atrium.



Systemic circuit

Foetal circulation

Most circulatory pathways in a foetus are like those in the adult but there are some notable differences because the lungs, the gastrointestinal tract, and the kidneys are not functioning before birth. The foetus obtains its oxygen and nutrients from the mother and also depends on maternal circulation to carry away the carbon dioxide and waste products.

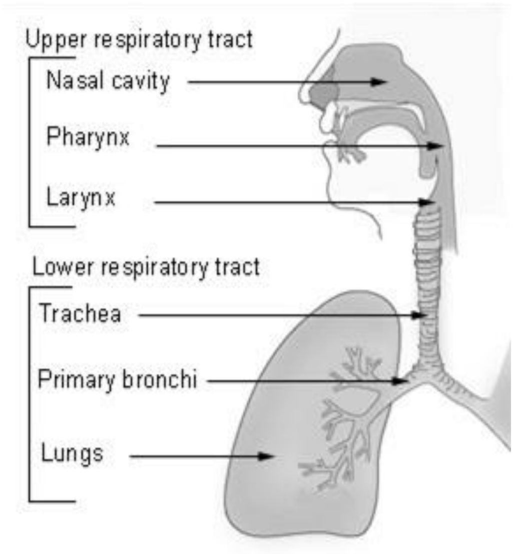
The umbilical cord contains two umbilical arteries to carry foetal blood to the placenta and one umbilical vein to carry oxygen-and-nutrient-rich blood from the placenta to the foetus. The ductus venosus allows blood to bypass the immature liver in foetal circulation. The foramen ovale and ductus arteriosus are modifications that permit blood to bypass the lungs in foetal circulation.

Health issues of the cardiovascular or circulatory system

- Coronary artery disease - clogging of the arteries supplying the heart.
- Atherosclerosis, arteriosclerosis, and arteriolosclerosis.
- Stroke. Shock. Hypertension. Vasculitis. Heart failure and disease.
- Aortic dissection, a tear of the inner lining (tunica intima) of the aorta.
- Aneurysm - a balloon-like dilation of a vessel wall.
- Myocarditis and pericarditis - inflammation of the heart muscle and the fibrous sac surrounding the heart
- Cardiomyopathy encompasses a group of diseases in which the myocardium (heart muscle) is unable to contract, leading to cardiac dysfunction.
- Pathological rhythms - supraventricular tachycardia, atrial fibrillation, and ventricular tachyardia

The Respiratory System

Location



- The *upper respiratory tract* contains the respiratory organs located *outside the chest cavity*: the nose and the nasal cavities, pharynx, larynx and upper trachea.
- The *lower respiratory tract* consists of organs located *in the chest cavity*: the lower trachea, bronchi, bronchioles, alveoli and the lungs.

When the respiratory system is mentioned, people generally think of breathing, but breathing is only one of the activities of the respiratory system. The body cells need a continuous supply of oxygen for the metabolic processes that are necessary to maintain life.

Function

The respiratory system works with the circulatory system to provide a continuous supply of oxygen and to remove the waste products of metabolism. It also helps to regulate pH of the blood.

Respiration - The sequence of events resulting in the exchange of oxygen and carbon dioxide between the atmosphere and the body cells.

- Every 3 to 5 seconds, nerve impulses stimulate the breathing process, or ventilation, which moves air through a series of passages into and out of the lungs.
- After this, there is an exchange of gases between the lungs and the blood.
- This is called external respiration. The blood transports the gases to and from the tissue cells. The exchange of gases between the blood and tissue cells is internal respiration.
- Finally, the cells utilise the oxygen for their specific activities. This is cellular metabolism, or cellular respiration.

Together these activities constitute respiration.

Mechanics of ventilation

Ventilation, or breathing, is the movement of air through the conducting passages between the atmosphere and the lungs. The air moves through the passages because of pressure gradients that are produced by contraction of the diaphragm and thoracic muscles.

Pulmonary ventilation

Pulmonary ventilation is commonly referred to as breathing. It is the process of air flowing into the lungs during inspiration (inhalation) and out of the lungs during expiration (exhalation). Air flows because of pressure differences between the atmosphere and the gases inside the lungs.

Air, like other gases, flows from a region with higher pressure to a region with lower pressure. Muscular breathing movements and recoil of elastic tissues create the changes in pressure that result in ventilation.

Pulmonary ventilation involves three different pressures:

1. Atmospheric pressure
2. Intraalveolar (intrapulmonary) pressure
3. Intrapleural pressure

Atmospheric pressure is the pressure of the air outside the body. Intraalveolar pressure is the pressure inside the alveoli of the lungs. Intrapleural pressure is the pressure within the pleural cavity. These three pressures are responsible for pulmonary ventilation.

Inspiration

Inspiration (inhalation) is the process of taking air into the lungs. It is the active phase of ventilation because it is the result of muscle contraction. During inspiration, the diaphragm contracts and the thoracic cavity increase in volume. This decreases the intraalveolar pressure so that air flows into the lungs. Inspiration draws air into the lungs.

Expiration

Expiration (exhalation) is the process of letting air out of the lungs during the breathing cycle. During expiration, the relaxation of the diaphragm and elastic recoil of tissue decreases the thoracic volume and increases the intraalveolar pressure. Expiration pushes air out of the lungs.

Respiratory volumes and capacities

Under normal conditions, the average adult takes 12 to 15 breaths a minute. A breath is one complete respiratory cycle that consists of one inspiration and one expiration.

An instrument called a spirometer is used to measure the volume of air that moves into and out of the lungs, and the process of taking the measurements is called spirometry. Respiratory (pulmonary) volumes are an important aspect of pulmonary function testing because they can provide information about the physical condition of the lungs. Respiratory capacity (pulmonary capacity) is the sum of two or more volumes. Factors such as age, sex, body build, and physical conditioning have an influence on lung volumes and capacities. Lungs usually reach their maximum in capacity in early adulthood and decline with age after that.

Conducting passages

The respiratory conducting passages are divided into the upper respiratory tract and the lower respiratory tract. The upper respiratory tract includes the nose, pharynx, and larynx. The lower respiratory tract consists of the trachea, bronchial tree, and lungs. These tracts open to the outside and are lined with mucous membranes. In some regions, the membrane has hairs that help filter the air. Other regions may have cilia to propel mucus.

Structure

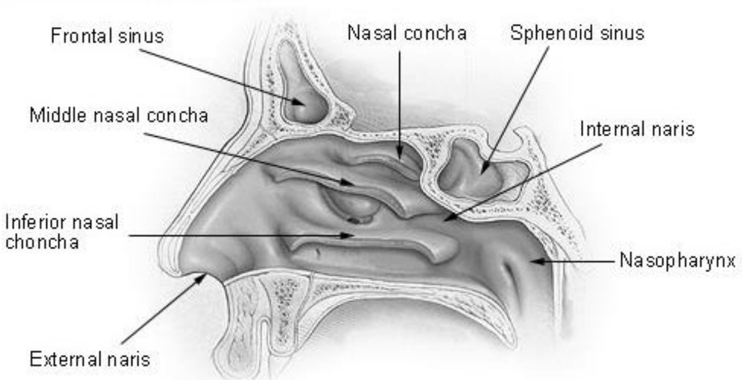
Nose and nasal cavities

The framework of the nose consists of bone and cartilage. Two small nasal bones and extensions of the maxillae form the bridge of the nose, which is the bony portion. The remainder of the framework is cartilage and is the flexible portion. Connective tissue and skin cover the framework. Air enters the nasal cavity from the outside through two openings, the nostrils, or external nares. The openings from the nasal cavity into the pharynx are the internal nares. Nose hairs at the entrance to the nose trap large inhaled particles.

Paranasal sinuses

Paranasal sinuses are air-filled cavities in the frontal, maxilla, ethmoid, and sphenoid bones. These sinuses, which have the same names as the bones in which they are located, surround the nasal cavity and open into it.

They function to reduce the weight of the skull, to produce mucus, and to influence voice quality by acting as resonating chambers.

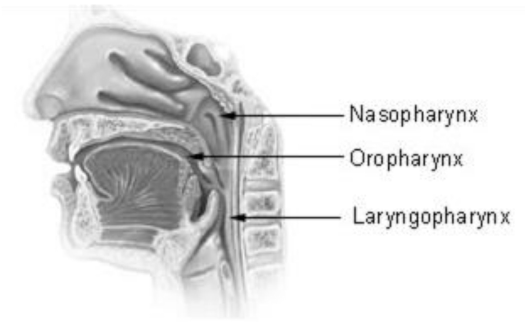


Pharynx

The pharynx, commonly called the throat, is a passageway that extends from the base of the skull to the level of the sixth cervical vertebra. It serves both the respiratory and digestive systems by receiving air from the nasal cavity and air, food, and water from the oral cavity. Inferiorly, it opens into the larynx and oesophagus. The pharynx is divided into three regions according to location: the nasopharynx, the oropharynx, and the laryngopharynx (hypopharynx).

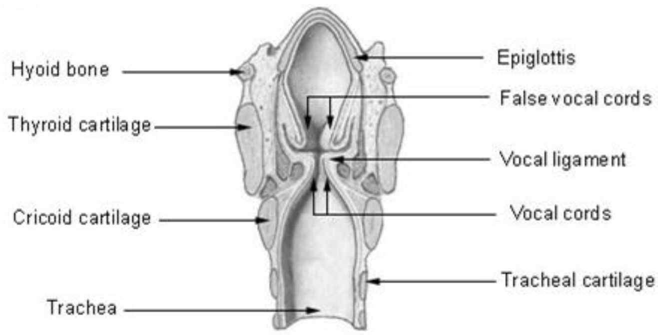
The nasopharynx is the portion of the pharynx that is posterior to the nasal cavity and extends inferiorly to the uvula. The oropharynx is the portion of the pharynx that is posterior to the oral cavity. The most inferior portion of the pharynx is the laryngopharynx that extends from the hyoid bone down to the lower margin of the larynx.

The upper part of the pharynx (throat) lets only air pass through. Lower parts permit air, foods, and fluids to pass. The pharyngeal, palatine, and lingual tonsils are located in the pharynx. They are also called Waldereyer's Ring. The retromolar trigone is the small area behind the wisdom teeth.



Larynx

The larynx, commonly called the voice box or glottis, is the passageway for air between the pharynx above and the trachea below. It extends from the fourth to the sixth vertebral levels. The larynx is often divided into three sections: sublarynx, larynx, and supralarynx. Nine cartilages that are connected to each other by muscles and ligaments form it. The larynx plays an essential role in human speech. During sound production, the vocal cords close together and vibrate as air expelled from the lungs passes between them. The false vocal cords have no role in sound production, but help close off the larynx when food is swallowed. The thyroid cartilage is the Adam's apple. The epiglottis acts like a trap door to keep food and other particles from entering the larynx.



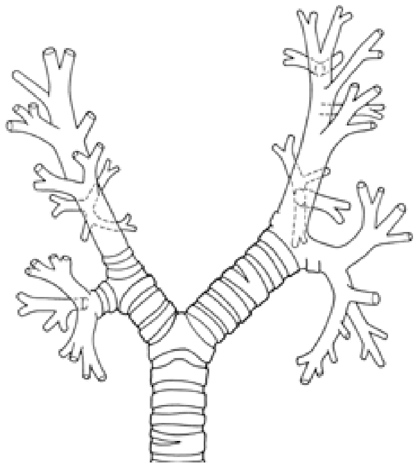
Larynx and Trachea

Trachea

The trachea, commonly called the windpipe, is the main airway to the lungs. It divides into the right and left bronchi at the level of the fifth thoracic vertebra, channelling air to the right or left lung.

The hyaline cartilage in the tracheal wall provides support and keeps the trachea from collapsing. The posterior soft tissue allows for expansion of the oesophagus, which is immediately posterior to the trachea.

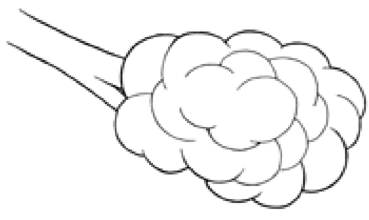
The mucous membrane that lines the trachea is ciliated pseudostratified columnar epithelium similar to that in the nasal cavity and nasopharynx. Goblet cells produce mucus that traps airborne particles and micro-organisms, and the cilia propel the mucus upward, where it is either swallowed or expelled.



Bronchial tree and Bronchi

Bronchi and bronchial tree

In the mediastinum, at the level of the fifth thoracic vertebra, the trachea divides into the right and left primary bronchi. The bronchi branch into smaller and smaller passageways until they terminate in tiny air sacs called alveoli.



The cartilage and mucous membrane of the primary bronchi are similar to that in the trachea. As the branching continues through the bronchial tree, the amount of hyaline cartilage in the walls decreases until it is absent in the smallest bronchioles. As the cartilage decreases, the amount of smooth muscle increases. The mucous membrane also undergoes a transition from ciliated pseudostratified columnar epithelium to simple cuboidal epithelium to simple squamous epithelium. The alveolar ducts and alveoli consist primarily of simple squamous epithelium, which permits rapid diffusion of oxygen and carbon dioxide. Exchange of gases between the air in the lungs and the blood in the capillaries occurs across the walls of the alveolar ducts and alveoli.

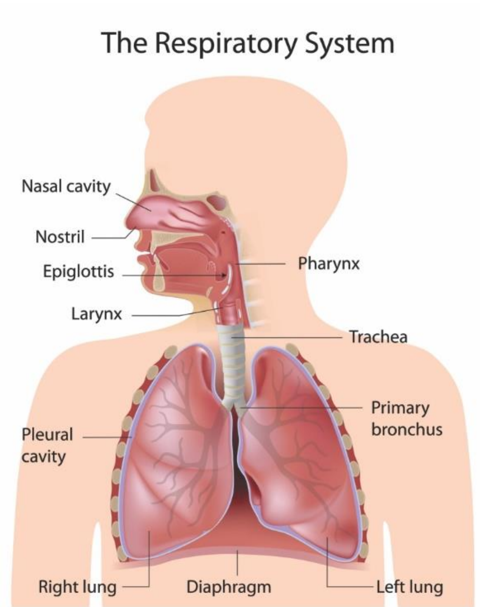
Lungs

The two lungs, which contain all the components of the bronchial tree beyond the primary bronchi, occupy most of the space in the thoracic cavity. The lungs are soft and spongy because they are mostly air spaces surrounded by the alveolar cells and elastic connective tissue. They are separated from each other by the mediastinum, which contains the heart. The only point of attachment for each lung is at the hilum, or root, on the medial side. This is where the bronchi, blood vessels, lymphatics, and nerves enter the lungs.

The right lung is shorter, broader, and has a greater volume than the left lung. It is divided into three lobes and each lobe is supplied by one of the secondary bronchi. The left lung is longer and narrower than the right lung. It has an indentation, called the cardiac notch, on its medial surface for the apex of the heart. The left lung has two lobes.

Each lung is enclosed by a double-layered serous membrane, called the pleura. The visceral pleura is firmly attached to the surface of the lung. At the hilum, the visceral pleura is continuous with the parietal pleura that lines the wall of the thorax. The small space between the visceral and parietal pleurae is the pleural cavity. It contains a thin film of serous fluid that is produced by the pleura. The fluid acts as a lubricant to reduce friction as the two layers slide against each other, and it helps to hold the two layers together as the lungs inflate and deflate.

Health issues of the respiratory system



The lungs can have a wide range of problems that can stem from genetics, bad habits, an unhealthy diet and viruses.

Lung infections, such as bronchitis or pneumonia, are usually caused by viruses, but can also be caused by fungal organisms or bacteria. Some severe or chronic lung infections can cause fluid in the lungs and other symptoms such as swollen lymph nodes, coughing up blood and a persistent fever.

Being overweight can adversely affect the lungs because it increases the work and energy expenditure to breath. In the most extreme form, it acts like a constricting process or vest around the chest such as that seen in the 'Pickwickian syndrome'.

Reactive airways or asthma - a lung disease where the air passageways in the lungs become inflamed and narrowed, making it hard to breathe.

Smoking-related emphysema.

Chronic obstructive pulmonary disease (COPD) is long-term lung disease that prevents a person from breathing properly due to excess mucus or the degeneration of the lungs. Chronic bronchitis and emphysema are considered COPD diseases.

Lung cancer is cancer that originates in the lungs. Symptoms of cancer include coughing up blood, a cough that doesn't go away, shortness of breath, wheezing, chest pain, headaches, hoarseness, weight loss and bone pain.

The Musculo-Skeletal System

The human musculoskeletal system (also known as the locomotor system) gives humans the ability to move using their muscular and skeletal systems.

Function

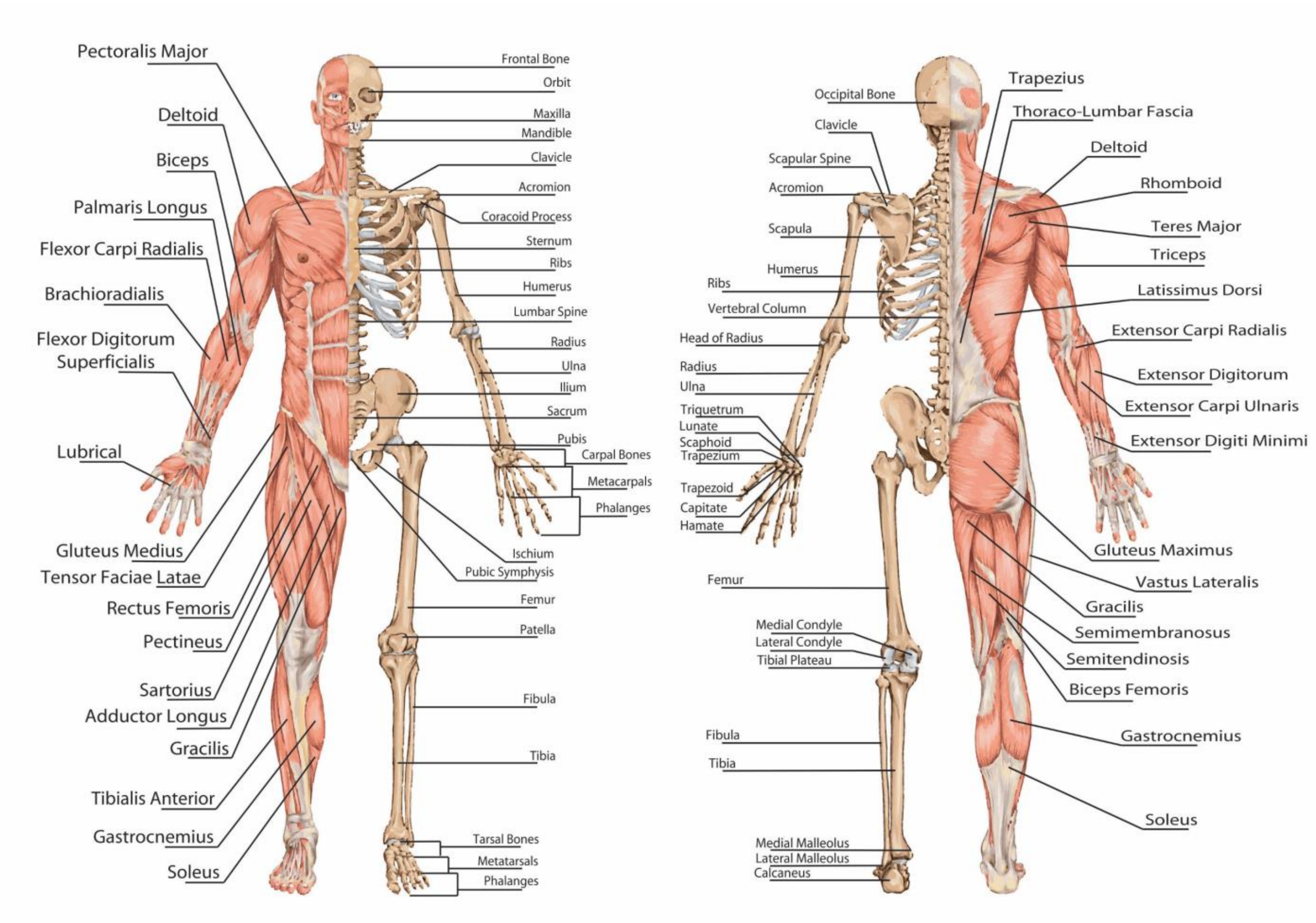
The skeletal portion of the system serves as the main storage system for calcium and phosphorus and contains critical components of the hematopoietic system. The primary function of the musculoskeletal system is to:

- Protect and support the internal structures and organs of the body
- Allow movement
- Give shape to the body
- Produce blood cells
- Store calcium and phosphorus
- Produce heat

Structure

It is made up of the bones of the skeleton, muscles, cartilage, tendons, ligaments, joints, and other connective tissue that supports and binds tissues and organs together.

The bones provide stability to the body. Muscles keep bones in place and also play a role in the movement of bones. To allow motion, different bones are connected by joints. Cartilage prevents the bone ends from rubbing directly onto each other. Muscles contract to move the bone attached at the joint.



Joints

Articulations

An articulation, or joint, is where two bones come together. In terms of the amount of movement they allow, there are three types of joints: *immovable, slightly movable and freely movable.*

With the exception of the hyoid bone, every bone in the body connects to at least one other bone by a joint.

The 3 major classifications of joints are fibrous, cartilaginous and synovial (or diarthrosis).

1. Fibrous joints consist of 2 bones united by fibrous tissue and have little or no movement. Fibrous joints are either **synarthrotic** or **amphiarthrotic**. In these joints, the bones come in very close contact and are separated only by a thin layer of fibrous connective tissue. The sutures in the skull are examples of immovable joints.

2. Cartilaginous joints unite 2 bones by means of hyaline cartilage or fibrocartilage. Slightly movable joints are called *amphiarthroses.* Cartilaginous joints allows only slight movement at the joint. These joints are slightly movable due to the flexible nature of the cartilage. A common example of this type of joint is the cartilage rod between most of the ribs and the sternum. The symphysis pubis is a slightly movable joint in which there is a fibrocartilage pad between the two bones. The joints between the vertebrae and the intervertebral disks are also of this type.

3. Synovial joints or Diarthrosis – freely movable. All diarthrosis joints are synovial joints (e.g., shoulder, hip, elbow, knee, etc.), and the terms "diarthrosis" and "synovial joint" are considered equivalent. These joints contain synovial fluid. This fluid is a thin lubricating film that allows considerable movement between articulating bones. The articular surfaces of bones within synovial joints are covered with a thin layer of hyaline cartilage. This cartilage provides a smooth surface where the bones meet. The joint is enclosed by a joint capsule.

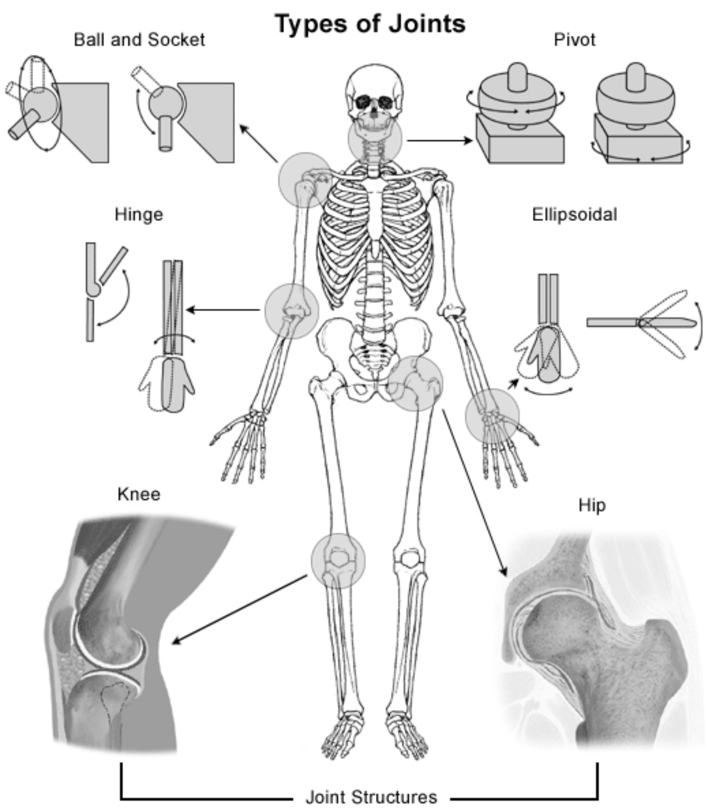
Synovial joints are classified into six divisions according to their shape.

1. **Plane or gliding joints** consist of two opposed flat surfaces that are about equal in size. Examples of these joints are the moving processes between vertebrae.

2. **Saddle joints** consist of two saddle-shaped moving surfaces oriented at right angles to each other. Movement in these joints can occur in two planes. An example is the joint of the thumb.

3. **Hinge joints** consist of a convex cylinder in one bone applied to a corresponding concavity in another bone. These joints permit movement in one plane only. Examples are the elbow and knee.

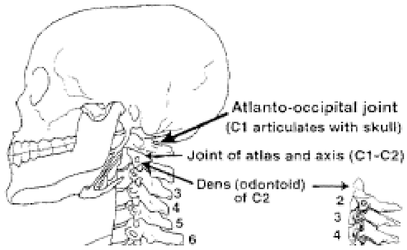
4. **Pivot joints** consist of a relatively cylindrical bony process. This process rotates within a ring composed partly of bone and partly of ligament. An example is where the two bones of the arm meet.

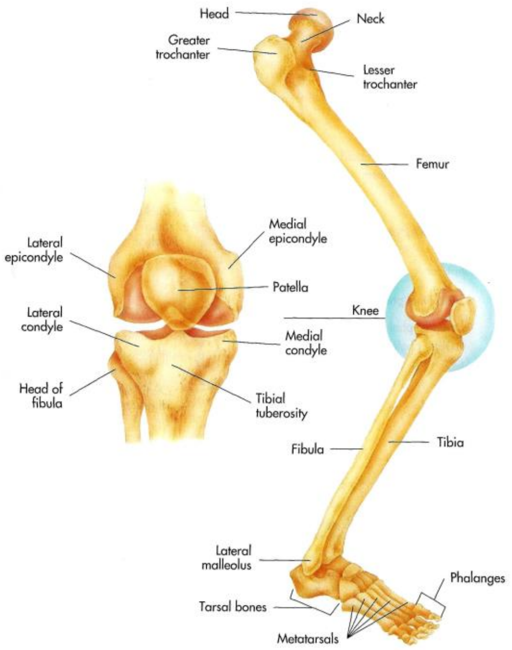


5. **Ball-and-socket joints** consist of a ball (head) at the end of one bone and a socket into an adjacent bone into which a portion of the ball fits. These joints allow wide ranges of movement in almost any direction. Examples are the shoulder and hip joints.

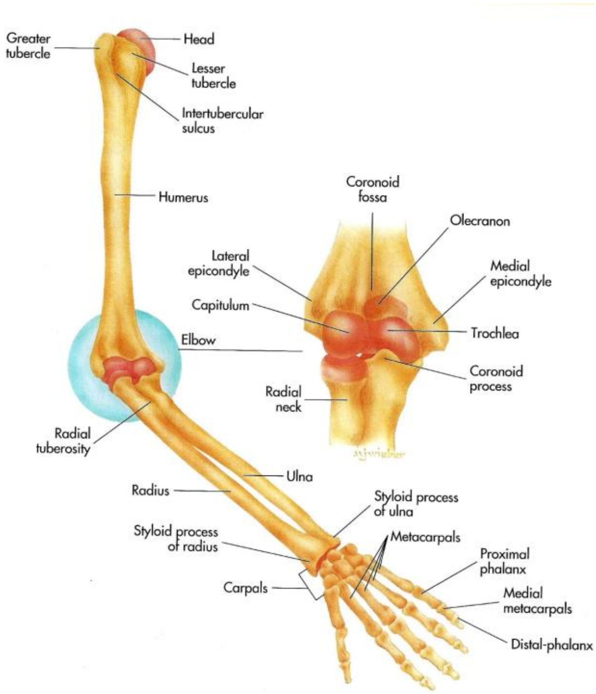
6. **Ellipsoid joints** are modified ball-and-socket joints. The articular surfaces are like an ellipse rather than a sphere. The shape of the joint limits movement, making it similar to a hinge motion, but the motion occurs in two planes.

   The Atlanto-occipital joint at the base of the skull is an ellipsoid joint.





Leg, ankle foot and knee joint



Arm, wrist, hand and elbow joint

The spine

The spine is a complex structure of bones, muscles, joints, ligaments, tendon, and discs. Extending from the skull to the pelvis, in a side view of the spinal cord you will see a natural 'S' curve. The spine can be divided into five sections — the first three sections (Cervical, Thoracic and Lumbar) are flexible and allow movement, twisting and bending of the spine.

The spine is made up of vertebrae, the main aim being to support the body and protect the nerves of the spinal cord. Each vertebra is separated by a tough, pliable disc which absorbs the force produced by movement — walking, running, twisting. The vertebrae and discs are held together by ligaments. Discs are soft and pliable and act like shock absorbers between each pair of vertebrae. The back, stomach and side muscles provide support to the spine and are an integral part of the back structure.

Health issues

There are diseases and disorders that may adversely affect the function and overall effectiveness of the system. Because many other body systems, including the vascular, nervous, and integumentary systems, are interrelated, disorders of one of these systems may also affect the musculoskeletal system and complicate the diagnosis of the disorder's origin.

Diseases of the musculoskeletal system mostly encompass functional disorders or motion discrepancies; the level of impairment depends specifically on the problem and its severity.

Articular (of or pertaining to the joints) disorders are the most common. However, also among the diagnoses are: primary muscular diseases, neurologic (related to the medical science that deals with the nervous system and disorders affecting it) deficits, toxins, endocrine abnormalities, metabolic disorders, infectious diseases, blood and vascular disorders, and nutritional imbalances.

Disorders of muscles from another body system can bring about irregularities such as: impairment of ocular motion and control, respiratory dysfunction, and bladder malfunction. Complete paralysis, paresis, or ataxia may be caused by primary muscular dysfunctions of infectious or toxic origin; however, the primary disorder is usually related to the nervous system, with the muscular system acting as the effector organ, an organ capable of responding to a stimulus, especially a nerve impulse.

A disorder begins during pregnancy is Pelvic girdle pain, it is complex and multi-factorial and likely to be also represented by a series of sub-groups driven by pain varying from peripheral or central nervous system, altered laxity/stiffness of muscles, laxity to injury of tendinous/ligamentous structures to 'mal-adaptive' body mechanics.

Arthritis is a group of more than 100 inflammatory diseases that damage joints and their surrounding structures. Arthritis can attack joints, joint capsules, the surrounding tissue, or throughout the body. It usually affects the joints of the neck, shoulders, hands, lower back, hips, or knees.

Bursitis is a disorder that most commonly affects the shoulder and hip joints. It is caused by an inflammation of the bursa, small fluid-filled bags that act as lubricating surfaces for muscles to move over bones.

Scoliosis, a side-to-side curve in the back or spine, often creating a pronounced "C" or "S" shape when viewed on an x-ray of the spine. This condition is typically becomes evident during adolescence.

The Skeletal System

Humans are vertebrates, which rely on a sturdy internal frame that is cantered on a prominent spine. The muscular system and how the skeletal and muscular systems work together to allow a wide range of movements and physical capabilities in humans.

Structure

The skeletal system consists of 206 bones and associated connective tissues. These tissues include cartilage, tendons, and ligaments and accounts for about 20 percent of the body weight. Bones provide a rigid framework, known as the skeleton. These bones and other connective tissues are organised into a skeletal system to give the body its form and protect vital organs. The fused bones of the cranium surround the brain to make it less vulnerable to injury. Vertebrae surround and protect the spinal cord and bones of the rib cage help protect the heart and lungs of the thorax.

Function

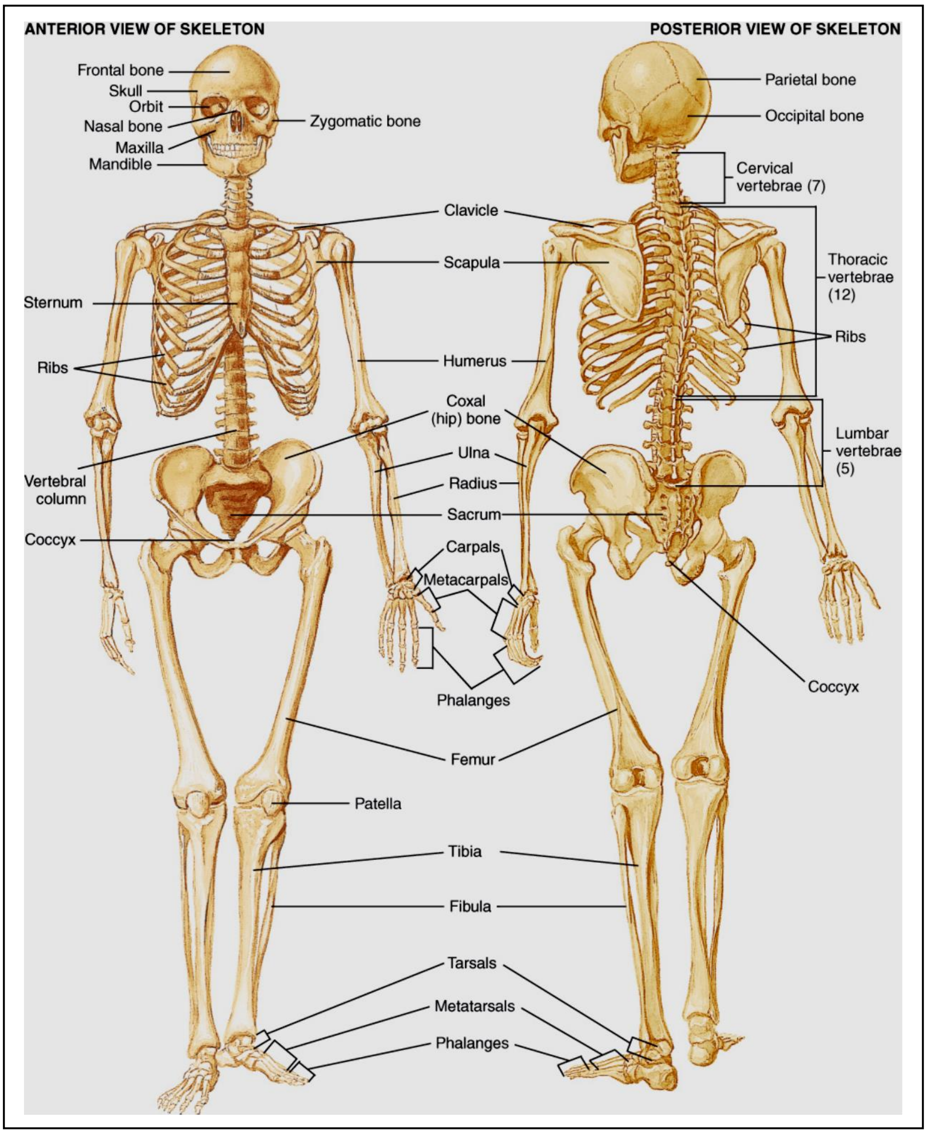
The skeletal system offers a rigid framework for support and protect the soft organs of the body. The skeleton supports the body against the pull of gravity. The large bones of the lower limbs support the trunk when standing. The living bones in our bodies use oxygen and give off waste products in metabolism. They contain active tissues that consume nutrients, require a blood supply and change shape or remodel in response to variations in mechanical stress. It also provides a system of levers on which muscles act to produce body movements.

Location

Skeletal bones are divided into two groups: the axial skeleton (front of the body) and the appendicular skeleton (back of the body).

The skeleton

The adult human skeleton usually consists of 206 named bones. These bones can be grouped in two divisions: axial skeleton and appendicular skeleton. The 80 bones of the axial skeleton form the vertical axis of the body. They include the bones of the head, vertebral column, ribs and breastbone or sternum. The appendicular skeleton consists of 126 bones and includes the free appendages and their attachments to the axial skeleton. The free appendages are the upper and lower extremities, or limbs, and their attachments, which are called girdles.



Divisions of the skeleton

The named bones of the body are listed below:

Axial Skeleton (80 bones)

Skull (28)

Cranial Bones

Parietal (2)

Temporal (2)

Frontal (1)

Occipital (1)

Ethmoid (1)

Sphenoid (1)

Facial Bones

Maxilla (2)

Zygomatic (2)

Mandible (1)

Nasal (2)

Platine (2)

Inferior nasal concha (2)

Lacrimal (2)

Vomer (1)

Auditory Ossicles

Malleus (2)

Incus (2)

Stapes (2)

Hyoid (1)

Vertebral Column (33)

Cervical vertebrae (7)

Thoracic vertebrae (12)

Lumbar vertebrae (5)

Sacrum (1)

Coccyx (1)

Thoracic Cage

Sternum (1)

Ribs (24)

Appendicular Skeleton (126 bones)

Pectoral girdles

Clavicle (2)

Scapula (2)

Upper Extremity

Humerus (2)

Radius (2)

Ulna (2)

Carpals (16)

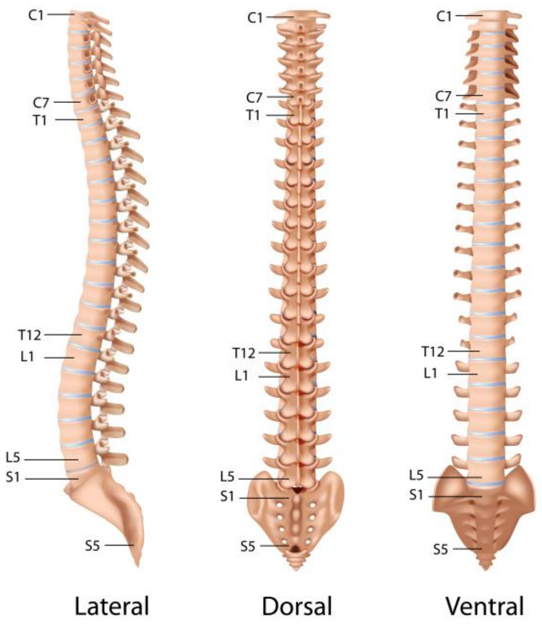
Metacarpals (10)

Phalanges (28)

Pelvic Girdle

Coxal, innominate, or hip bones (2)

Views of the spine, or vertebral column



Lower Extremity

Femur (2)

Tibia (2)

Fibula (2)

Patella (2)

Tarsals (14)

Metatarsals (10)

Phalanges (28)

Bones

Bones work together with muscles as simple mechanical lever systems to produce body movement.

Bones contain more calcium than any other organ. The intercellular matrix of bone contains large amounts of calcium salts, the most important being calcium phosphate.

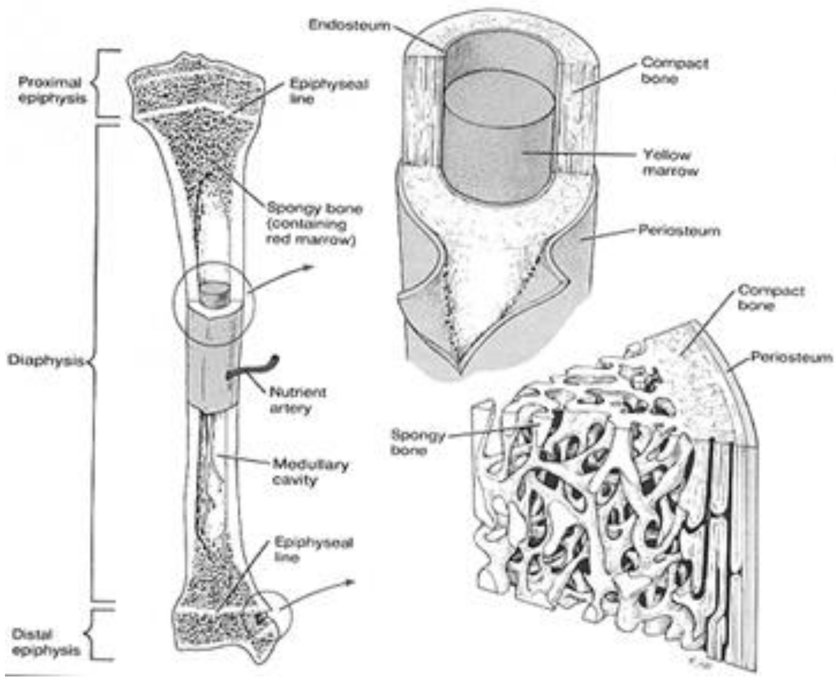
When blood calcium levels decrease below normal, calcium is released from the bones so that there will be an adequate supply for metabolic needs. When blood calcium levels are increased, the excess calcium is stored in the bone matrix. The dynamic process of releasing and storing calcium goes on almost continuously.

Haematopoiesis, the formation of blood cells, mostly takes place in the red marrow of the bones.

In infants, red marrow is found in the bone cavities. With age, it is largely replaced by yellow marrow for fat storage. In adults, red marrow is limited to the spongy bone in the skull, ribs, sternum, clavicles, vertebrae and pelvis. Red marrow functions in the formation of red blood cells, white blood cells and blood platelets.

Structure of bone tissue

There are two types of bone tissue: **compact and spongy.** The names imply that the two types of differ in density, or how tightly the tissue is packed together. There are three types of cells that contribute to bone homeostasis. Osteoblasts are bone-forming cell, osteoclasts resorb or break down bone, and osteocytes are mature bone cells. An equilibrium between osteoblasts and osteoclasts maintains bone tissue.



Bone structure

Compact bone

Compact bone consists of closely packed osteons or haversian systems. The osteon consists of a central canal called the osteonic (haversian) canal, which is surrounded by concentric rings (lamellae) of matrix. Between the rings of matrix, the bone cells (osteocytes) are located in spaces called lacunae. Small channels (canaliculi) radiate from the lacunae to the osteonic (haversian) canal to provide passageways through the hard matrix. In compact bone, the haversian systems are packed tightly together to form what appears to be a solid mass. The osteonic canals contain blood vessels that are parallel to the long axis of the bone. These blood vessels interconnect, by way of perforating canals, with vessels on the surface of the bone.

Spongy (Cancellous) bone

Spongy (cancellous) bone is lighter and less dense than compact bone. Spongy bone consists of plates (trabeculae) and bars of bone adjacent to small, irregular cavities that contain red bone marrow. The canaliculi connect to the adjacent cavities, instead of a central haversian canal, to receive their blood supply. It may appear that the trabeculae are arranged in a haphazard manner, but they are organised to provide maximum strength similar to braces that are used to support a building. The trabeculae of spongy bone follow the lines of stress and can realign if the direction of stress changes.

Bone development and growth

The terms osteogenesis and ossification are often used synonymously to indicate the process of bone formation. Parts of the skeleton form during the first few weeks after conception. By the end of the eighth week after conception, the skeletal pattern is formed in cartilage and connective tissue membranes and ossification begins.

Bone development continues throughout adulthood. Even after adult stature is attained, bone development continues for repair of fractures and for remodelling to meet changing lifestyles. Osteoblasts, osteocytes and osteoclasts are the three cell types involved in the development, growth and remodelling of bones. Osteoblasts are bone-forming cells, osteocytes are mature bone cells and osteoclasts break down and reabsorb bone.

There are two types of ossification: intramembranous and endochondral.

Intramembranous ossification

Intramembranous ossification involves the replacement of sheet-like connective tissue membranes with bony tissue. Bones formed in this manner are called intramembranous bones. They include certain flat bones of the skull and some of the irregular bones. The future bones are first formed as connective tissue membranes. Osteoblasts migrate to the membranes and deposit bony matrix around themselves. When the osteoblasts are surrounded by matrix they are called osteocytes.

Endochondral ossification

Endochondral ossification involves the replacement of hyaline cartilage with bony tissue. Most of the bones of the skeleton are formed in this manner. These bones are called endochondral bones. In this process, the future bones are first formed as hyaline cartilage models. During the third month after conception, the perichondrium that surrounds the hyaline cartilage "models" becomes infiltrated with blood vessels and osteoblasts and changes into a periosteum.

The osteoblasts form a collar of compact bone around the diaphysis. At the same time, the cartilage in the centre of the diaphysis begins to disintegrate. Osteoblasts penetrate the disintegrating cartilage and replace it with spongy bone. This forms a primary ossification centre. Ossification continues from this centre toward the ends of the bones. After spongy bone is formed in the diaphysis, osteoclasts break down the newly formed bone to open up the medullary cavity.

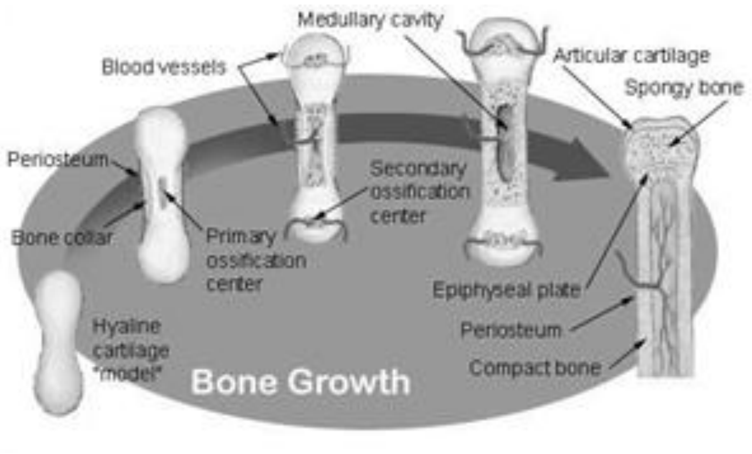
The cartilage in the epiphyses continues to grow so the developing bone increases in length. Later, usually after birth, secondary ossification centres form in the epiphyses. Ossification in the epiphyses is similar to that in the diaphysis except that the spongy bone is retained instead of being broken down to form a medullary cavity. When secondary ossification is complete, the hyaline cartilage is totally replaced by bone except in two areas. A region of hyaline cartilage remains over the surface of the epiphysis as the articular cartilage and another area of cartilage remains between the epiphysis and diaphysis. This is the epiphyseal plate or growth region.

Bone growth

Bones grow in length at the epiphyseal plate by a process that is similar to endochondral ossification. The cartilage in the region of the epiphyseal plate next to the epiphysis continues to grow by mitosis.

The chondrocytes, in the region next to the diaphysis, age and degenerate. Osteoblasts move in and ossify the matrix to form bone. This process continues throughout childhood and the adolescent years until the cartilage growth slows and finally stops.

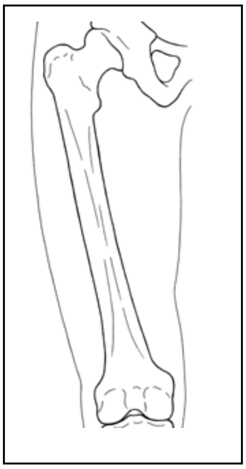
When cartilage growth ceases, usually in the early twenties, the epiphyseal plate completely ossifies so that only a thin epiphyseal line remains and the bones can no longer grow in length. Bone growth is under the influence of growth hormone from the anterior pituitary gland and sex hormones from the ovaries and testes.



Bone growth

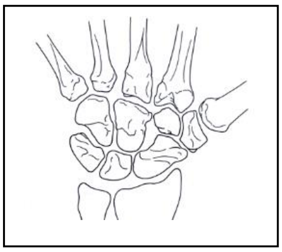
Even though bones stop growing in length in early adulthood, they can continue to increase in thickness or diameter throughout life in response to stress from increased muscle activity or to weight. The increase in diameter is called appositional growth. Osteoblasts in the periosteum form compact bone around the external bone surface. At the same time, osteoclasts in the endosteum break down bone on the internal bone surface, around the medullary cavity. These two processes together increase the diameter of the bone and, at the same time, keep the bone from becoming excessively heavy and bulky.

Classification of bones



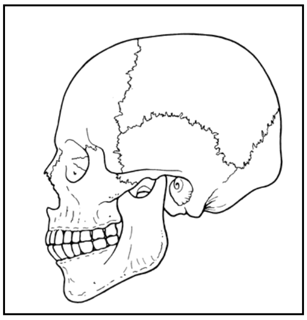
1. Long bones

The bones of the body come in a variety of sizes and shapes. The four principal types of bones are long, short, flat and irregular. Bones that are longer than they are wide are called long bones. They consist of a long shaft with two bulky ends or extremities. They are primarily compact bone but may have a large amount of spongy bone at the ends or extremities. Long bones include bones of the thigh, leg, arm, and forearm.



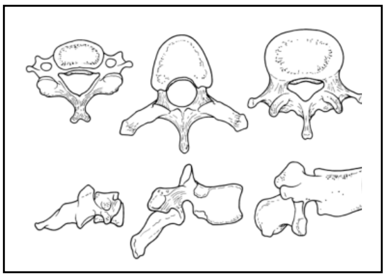
2. Short bones

Short bones are roughly cube shaped with vertical and horizontal dimensions approximately equal. They consist primarily of spongy bone, which is covered by a thin layer of compact bone. Short bones include the bones of the wrist and ankle.



3. Flat bones

Flat bones are thin, flattened, and usually curved. Most of the bones of the cranium are flat bones.



4. Irregular bones

Bones that are not in any of the above three categories are classified as irregular bones. They are primarily spongy bone that is covered with a thin layer of compact bone. The vertebrae and some of the bones in the skull are irregular bones.

All bones have surface markings and characteristics that make a specific bone unique. There are holes, depressions, smooth facets, lines, projections and other markings. These usually represent passageways for vessels and nerves, points of articulation with other bones or points of attachment for tendons and ligaments.

Health issues with the skeletal system

The primary skeletal conditions are metabolic bone diseases such as osteoporosis, osteomalacia.

Osteoporosis is a prevalent disease, particularly among the elderly, resulting in the loss of bone tissue. In osteoporosis, bone loses calcium, becomes thinner and may disappear completely.

Osteomalacia is a softening of the bones often caused by a vitamin D deficiency and results from a defect in the bone-building process.

Bone cancer - a malignancy arising in the bones and supporting structures such as cartilage.

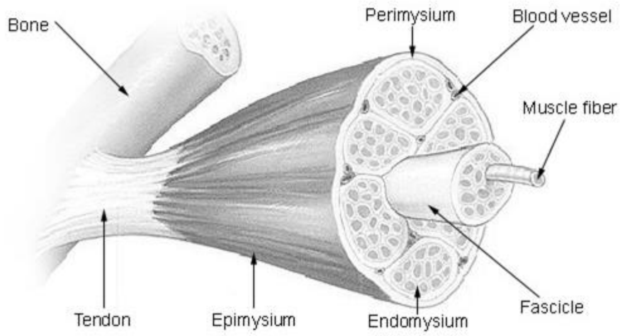
While leukaemia is a cancer that primarily affects the blood, the skeletal system is involved as the cancer starts in the marrow of the bone. With this type of cancer, abnormal white blood cells multiply uncontrollably, affecting the production of normal white blood cells and red blood cells.

The skeletal system is also susceptible to breaks, strains and fractures.

The Muscular System

Structure

The muscular system is composed of specialised cells called muscle fibres. There are more than 600 muscles in the body, which together account for about 40 percent of a person's weight.



Structure of muscle

Function

Their predominant function is contractibility. Muscles, where attached to bones or internal organs and blood vessels, are responsible for movement. Nearly all movement in the body is the result of muscle contraction. Exceptions to this are the action of cilia, the flagellum on sperm cells, and amoeboid movement of some white blood cells.

The integrated action of joints, bones, and skeletal muscles produces obvious movements such as walking and running. Skeletal muscles also produce more subtle movements that result in various facial expressions, eye movements, and respiration.

In addition to movement, muscle contraction also fulfils some other important functions in the body, such as posture, joint stability, and heat production. Posture, such as sitting and standing, is maintained as a result of muscle contraction. The skeletal muscles are continually making fine adjustments that hold the body in stationary positions.

The tendons of many muscles extend over joints and in this way contribute to joint stability. This is particularly evident in the knee and shoulder joints, where muscle tendons are a major factor in stabilising the joint.

Heat production, to maintain body temperature, is an important by-product of muscle metabolism. Nearly 85 percent of the heat produced in the body is the result of muscle contraction.

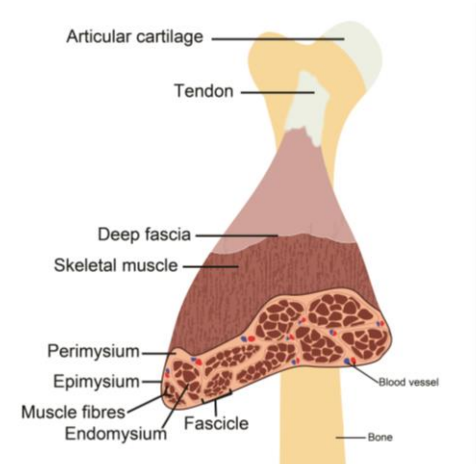
Location

The body is made up of 3 types of muscles:

1. **Skeletal** - help the body move, all over the body
2. **Smooth** - (or viscaral) involuntary muscles located inside organs, such as the stomach and intestines and blood vessels
3. **Cardiac** - found only in the heart. Its motion is involuntary

1. Skeletal muscle

Skeletal muscle, attached to bones, is responsible for skeletal movements. The peripheral portion of the central nervous system (CNS) controls the skeletal muscles. Thus, these muscles are under conscious, or voluntary, control. The basic unit is the muscle fibre with many nuclei. These muscle fibres are striated (having transverse streaks) and each acts independently of neighbouring muscle fibres.



Structure of a Skeletal Muscle

Skeletal muscle is further divided into two broad types:

- **Type I, slow twitch**, or "red" muscle, is dense with capillaries and is rich in mitochondria and myoglobin, giving the muscle tissue its characteristic red colour. It can carry more oxygen and sustain aerobic activity using fats or carbohydrates as fuel. Slow twitch fibres contract for long periods of time, but with little force.
- **Type II, fast twitch** muscle, has three major subtypes (IIa, IIx, and IIb) that vary in both contractile speed and force generated. Fast twitch fibres contract quickly and powerfully, but fatigue very rapidly, sustaining only short, anaerobic bursts of activity before muscle contraction becomes painful. They contribute most to muscle strength and have greater potential for increase in mass.

A whole skeletal muscle is considered an organ of the muscular system.

Each organ or muscle consists of skeletal muscle tissue, connective tissue, nerve tissue, and blood or vascular tissue.

Skeletal muscles vary considerably in size, shape, and arrangement of fibres. They range from extremely tiny strands such as the stapedium muscle of the middle ear to large masses such as the muscles of the thigh. Some skeletal muscles are broad in shape and some narrow. In some muscles the fibres are parallel to the long axis of the muscle, in some they converge to a narrow attachment, and in some they are oblique.

Each skeletal muscle fibre is a single cylindrical muscle cell. An individual skeletal muscle may be made up of hundreds, or even thousands, of muscle fibres bundled together and wrapped in a connective tissue covering. Each muscle is surrounded by a connective tissue sheath called the epimysium. Fascia, connective tissue outside the epimysium, surrounds and separates the muscles. Portions of the epimysium project inward to divide the muscle into compartments. Each compartment contains a bundle of muscle fibres. Each bundle of muscle fibre is called a fasciculus and is surrounded by a layer of connective tissue called the perimysium. Within the fasciculus, each individual muscle cell, called a muscle fibre, is surrounded by connective tissue called the endomysium.

Skeletal muscle cells (fibres), like other body cells, are *soft and fragile*. The connective tissue covering furnish support and protection for the delicate cells and allow them to withstand the forces of contraction. The coverings also provide pathways for the passage of blood vessels and nerves.

Commonly, the epimysium, perimysium, and endomysium extend beyond the fleshy part of the muscle, the belly or gaster, to form a thick rope like tendon or a broad, flat sheet-like aponeurosis. The tendon and aponeurosis form indirect attachments from muscles to the periosteum of bones or to the connective tissue of other muscles. Typically a muscle spans a joint and is attached to bones by tendons at both ends. One of the bones remains relatively fixed or stable while the other end moves as a result of muscle contraction.

Skeletal muscles have an *abundant supply of blood vessels and nerves.* This is directly related to the primary function of skeletal muscle, contraction. Before a skeletal muscle fibre can contract, it has to receive an impulse from a nerve cell. Generally, an artery and at least one vein accompany each nerve that penetrates the epimysium of a skeletal muscle. Branches of the nerve and blood vessels follow the connective tissue components of the muscle of a nerve cell and with one or more minute blood vessels called capillaries.

Muscle shapes

Muscles are further classified by their shape, size and direction.

Most skeletal muscles have names that describe some feature of the muscle. Often several criteria are combined into one name. Associating the muscle's characteristics with its name will help you learn and remember them.

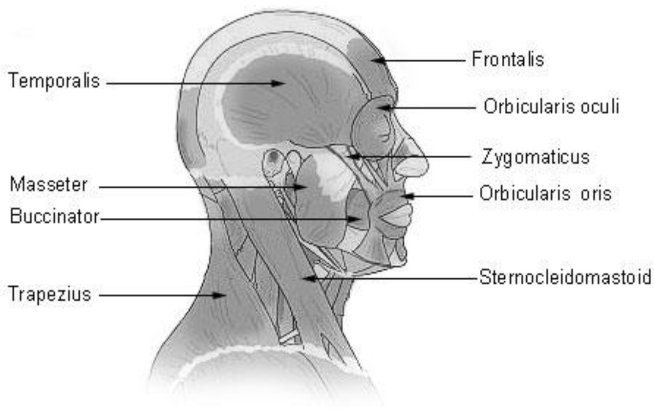
The following are some terms relating to muscle features that are used in naming muscles.

1. **Size**: vastus (huge); maximus (large); longus (long); minimus (small); brevis (short)
2. **Shape**: deltoid (triangular); rhomboid (like a rhombus with equal and parallel sides); latissimus (wide); teres (round); trapezius (like a trapezoid, a four-sided figure with two sides parallel)
3. **Direction of fibres**: rectus (straight); transverse (across); oblique (diagonally); orbicularis (circular)
4. **Location**: pectoralis (chest); gluteus (buttock or rump); brachii (arm); supra- (above); infra- (below); sub- (under or beneath); lateralis (lateral)
5. **Number of origins**: biceps (two heads); triceps (three heads); quadriceps (four heads)
6. **Origin and insertion**: sternocleidomastoideus (origin on the sternum and clavicle, insertion on the mastoid process); brachioradialis (origin on the brachium or arm, insertion on the radius)
7. **Action**: abductor (to abduct a structure); adductor (to adduct a structure); flexor (to flex a structure); extensor (to extend a structure); levator (to lift or elevate a structure); masseter (a chewer)

Muscles of the head and neck

Humans have well-developed muscles in the face that permit a large variety of facial expressions. Because the muscles are used to show surprise, disgust, anger, fear, and other emotions, they are an important means of nonverbal communication. Muscles of facial expression include frontalis, orbicularis oris, laris oculi, buccinator, and zygomaticus. These muscles of facial expressions are identified in the illustration below.

Muscles of the head and neck



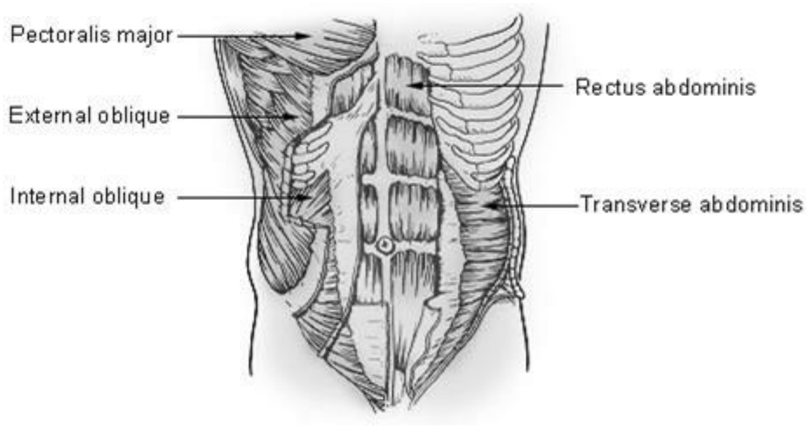
There are four pairs of muscles that are responsible for chewing movements or mastication. All of these muscles connect to the mandible and they are some of the strongest muscles in the body. Two of the muscles, temporalis and masseter are identified in the illustration above.

There are numerous muscles associated with the throat, the hyoid bone and the vertebral column, only two of the more obvious and superficial neck muscles are identified in the illustration. They are sternocleidomastoid and trapezius.

Muscles of the trunk

The muscles of the trunk include those that move the vertebral column, the muscles that form the thoracic and abdominal walls, and those that cover the pelvic outlet.

The erector spinae group of muscles on each side of the vertebral column is a large muscle mass that extends from the sacrum to the skull. These muscles are primarily responsible for extending the vertebral column to maintain erect posture. The deep back muscles occupy the space between the spinous and transverse processes of adjacent vertebrae.

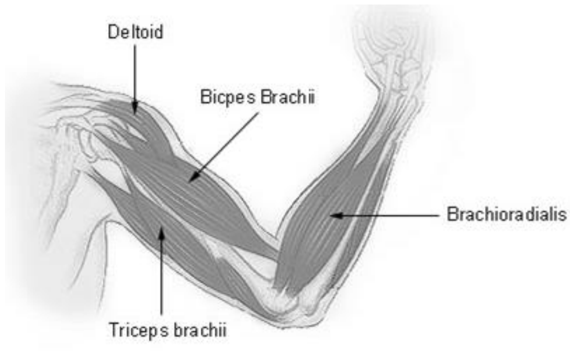


The muscles of the thoracic wall are involved primarily in the process of breathing. The intercostal muscles are located in spaces between the ribs. They contract during forced expiration. External intercostal muscles contract to elevate the ribs during the inspiration phase of breathing. The diaphragm is a dome-shaped muscle that forms a partition between the thorax and the abdomen. It has three openings in it for structures that have to pass from the thorax to the abdomen.

The abdomen, unlike the thorax and pelvis, has no bony reinforcements or protection. The wall consists entirely of four muscle pairs, arranged in layers, and the fascia that envelops them. The abdominal wall muscles are identified in the illustration below.

The pelvic outlet is formed by two muscular sheets and their associated fascia.

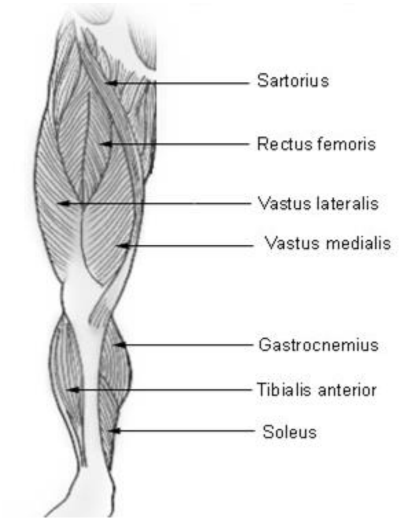
Muscles of the upper extremity



The muscles of the upper extremity include those that attach the scapula to the thorax and generally move the scapula, those that attach the humerus to the scapula and generally move the arm, and those that are located in the arm or forearm that move the forearm, wrist, and hand. The illustration below shows some of the muscles of the upper extremity.

Muscles that move the shoulder and arm include the trapezius and serratus anterior. The pectoralis major, latissimus dorsi, deltoid, and rotator cuff muscles connect to the humerus and move the arm. The muscles that move the forearm are located along the humerus, which include the triceps brachii, biceps brachii, brachialis, and brachioradialis. The 20 or more muscles that cause most wrist, hand, and finger movements are located along the forearm.

Muscles of the lower extremity



The muscles that move the thigh have their origins on some part of the pelvic girdle and their insertions on the femur. The largest muscle mass belongs to the posterior group, the gluteal muscles, which, as a group, abduct the thigh. The iliopsoas, an anterior muscle, flexes the thigh. The muscles in the medial compartment adduct the thigh. The illustration below shows some of the muscles of the lower extremity.

Muscles that move the leg are located in the thigh region. The quadriceps femoris muscle group straightens the leg at the knee. The hamstrings are antagonists to the quadriceps femoris muscle group, which are used to flex the leg at the knee.

The muscles located in the leg that move the ankle and foot are divided into anterior, posterior, and lateral compartments. The tibialis anterior, which dorsiflexes the foot, is antagonistic to the gastrocnemius and soleus muscles, which plantar flex the foot.

2. Smooth muscle

Smooth muscle, found in the walls of the hollow internal organs such as blood vessels, the gastrointestinal tract, bladder, and uterus, is under control of the autonomic nervous system. Smooth muscle cannot be controlled consciously and thus acts involuntarily. The non-striated (smooth) muscle cell is spindle-shaped and has one central nucleus. Smooth muscle contracts slowly and rhythmically.

3. Cardiac muscle

Cardiac muscle is found only in your heart, and its big features are endurance and consistency. It can stretch in a limited way, like smooth muscle and contract with the force of a skeletal muscle. It is a twitch muscle only and contracts involuntarily.

Cardiac muscle, is also under control of the autonomic nervous system. The cardiac muscle cell has one central nucleus, like smooth muscle, but it also is striated, like skeletal muscle. The cardiac muscle cell is rectangular in shape. The contraction of cardiac muscle is involuntary, strong, and rhythmical.

Health issues of the muscular system

Common primary muscle disorders include inflammatory myopathies, including polymyositis, which is characterised by inflammation and progressive weakening of the skeletal muscles; dermatomyositis, which is polymyositis accompanied by a skin rash; and inclusion body myositis, which is characterised by progressive muscle weakness and wasting.

Other common disorders are muscular dystrophies and metabolic muscle disorders. Muscular dystrophy affects muscle fibres. Metabolic muscle disorders interfere with chemical reactions involved in drawing energy from food. Neuromuscular junction disorders impair the transmission of nerve signals to muscles. The most common neuromuscular junction disorder is myasthenia gravis, which is characterised by varying degrees of weakness of the skeletal muscles. There are many types of peripheral neuropathies that can be secondary to other medical conditions, such as diabetes, or due to a variety of other causes, including toxins, inflammation and hereditary causes.

Motor neuron disorders affect the nerve cells that supply muscles. The most recognisable motor neuron disease is amyotrophic lateral sclerosis, or ALS, commonly known as Lou Gehrig's disease.

The Endocrine System

Function

The endocrine system, along with the nervous system, functions the regulation of body activities. The nervous system acts through electrical impulses and neurotransmitters to cause muscle contraction and glandular secretion. The effect is of short duration, measured in seconds, and localised. The endocrine system acts through chemical messengers called hormones that influence growth, development, and metabolic activities. The action of the endocrine system is measured in minutes, hours, or weeks and is more generalised than the action of the nervous system.

Structure

There are two major categories of glands in the body - exocrine and endocrine.

Exocrine glands

Exocrine glands have ducts that carry their secretory product to a surface. These glands include the sweat, sebaceous, and mammary glands and, the glands that secrete digestive enzymes.

Endocrine glands

The endocrine glands do not have ducts to carry their product to a surface. They are called ductless glands. The word endocrine is derived from the Greek terms "endo," meaning within, and "krine," meaning to separate or secrete. The secretory products of endocrine glands are called hormones and are secreted directly into the blood and then carried throughout the body where they influence only those cells that have receptor sites for that hormone.

Hormones

Hormones are essential for every activity of life, including the processes of digestion, metabolism, growth, reproduction, and mood control. Many hormones, such as neurotransmitters, are active in more than one physical process.

Definition - a regulatory chemical substance produced in the body that controls and regulates the activity of certain cells or organs. It is transported in tissue fluids such as blood to stimulate specific cells or tissues into action.

- a person's sex hormones as held to influence behaviour or mood.

Many hormones are secreted by special glands, such as thyroid hormone produced by the thyroid gland.

Chemically, hormones may be classified as either proteins or steroids. All of the hormones in the human body, except the sex hormones and those from the adrenal cortex, are proteins or protein derivatives.

Mechanism of hormones - *Action hormones* are carried by the blood throughout the entire body, yet they affect only certain cells. The specific cells that respond to a given hormone have receptor sites for that hormone. This is sort of a lock and key mechanism. If the key fits the lock, then the door will open. If a hormone fits the receptor site, then there will be an effect. If a hormone and a receptor site do not match, then there is no reaction. All the cells that have receptor sites for a given hormone make up the target tissue for that hormone. In some cases, the target tissue is localised in a single gland or organ. In other cases, the target tissue is diffuse and scattered throughout the body so that many areas are affected. Hormones bring about their characteristic effects on target cells by modifying cellular activity.

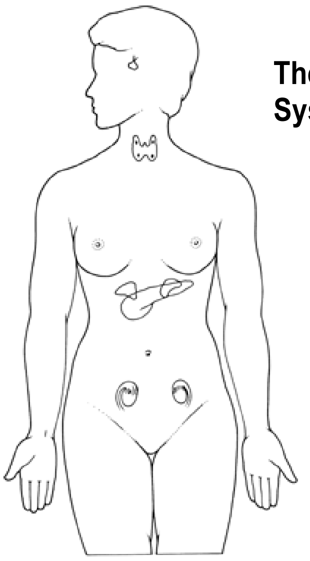
Protein hormones react with receptors on the surface of the cell, and the sequence of events that results in hormone action is relatively rapid. Steroid hormones typically react with receptor sites inside a cell. Because this method of action actually involves synthesis of proteins, it is relatively slow.

Control of hormone action - Hormones are a very potent substance which means that very small amounts of a hormone may have profound effects on metabolic processes. Because of their potency, hormone secretion must be regulated within very narrow limits in order to maintain homeostasis in the body.

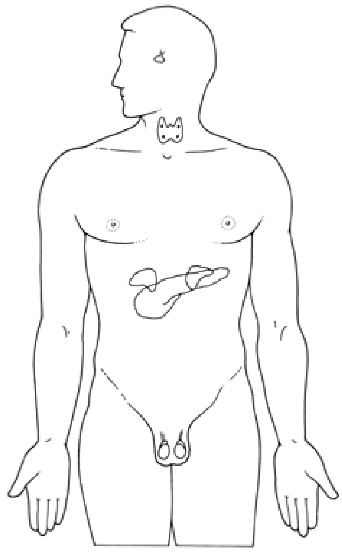
Some form of a negative feedback mechanism controls many hormones. In this type of system, a gland is sensitive to the concentration of a substance that it regulates. A negative feedback system causes a reversal of increases and decreases in body conditions in order to maintain a state of stability or homeostasis. Some endocrine glands secrete hormones in response to other hormones. The hormones that cause secretion of other hormones are called tropic hormones. A hormone from gland A causes gland B to secrete its hormone. A third method of regulating hormone secretion is by direct nervous stimulation. A nerve stimulus causes gland A to secrete its hormone.

The endocrine system is made up of the endocrine glands that secrete hormones. Although there are eight major endocrine glands scattered throughout the body, they are still considered to be one system because they have similar functions, similar mechanisms of influence, and many important interrelationships.

Some glands also have non-endocrine regions that have functions other than hormone secretion. For example, the pancreas has a major exocrine portion that secretes digestive enzymes and an endocrine portion that secretes hormones. The ovaries and testes secrete hormones and also produce the ova and sperm. Some organs, such as the stomach, intestines, and heart, produce hormones, but their primary function is not hormone secretion.



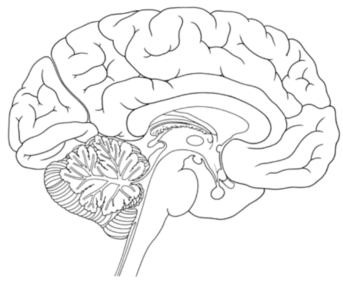
The Endocrine System



Pituitary gland

The pituitary gland or hypophysis is a small gland about 1 centimetre in diameter or the size of a pea. It is nearly surrounded by bone as it rests in the sella turcica, a depression in the sphenoid bone. The gland is connected to the hypothalamus of the brain by a slender stalk called the infundibulum.

There are two distinct regions in the gland: the anterior lobe (adenohypophysis) and the posterior lobe (neurohypophysis). Releasing hormones from the hypothalamus controls the activity of the adenohypophysis. The neurohypophysis is controlled by nerve stimulation.



Pituitary and pineal glands

Hormones of the anterior lobe (Adenohypophysis)

Growth hormone is a protein that stimulates the growth of bones, muscles, and other organs by promoting protein synthesis. This hormone drastically affects the appearance of an individual because it influences height. If there is too little growth hormone in a child, that person may become a pituitary dwarf of normal proportions but small stature. An excess of the hormone in a child results in an exaggerated bone growth, and the individual becomes exceptionally tall or a giant.

Thyroid-stimulating hormone, or thyrotropin, causes the glandular cells of the thyroid to secrete thyroid hormone. When there is a hypersecretion of thyroid-stimulating hormone, the thyroid gland enlarges and secretes too much thyroid hormone.

Adrenocorticotropic hormone reacts with receptor sites in the cortex of the adrenal gland to stimulate the secretion of cortical hormones, particularly cortisol.

Gonadotropic hormones react with receptor sites in the gonads, or ovaries and testes, to regulate the development, growth, and function of these organs.

Prolactin hormone promotes the development of glandular tissue in the female breast during pregnancy and stimulates milk production after the birth of the infant.

Hormones of the posterior lobe (Neurohypophysis)

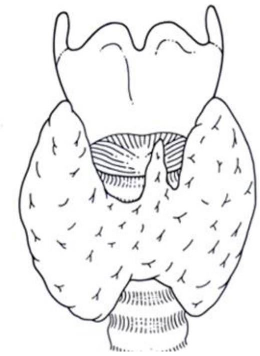
Antidiuretic hormone promotes the reabsorption of water by the kidney tubules, with the result that less water is lost as urine. This mechanism conserves water for the body. Insufficient amounts of antidiuretic hormone cause excessive water loss in the urine. Oxytocin causes contraction of the smooth muscle in the wall of the uterus. It also stimulates the ejection of milk from the lactating breast.

Pineal gland

The pineal gland, also called pineal body or epiphysis cerebri, is a small cone-shaped structure that extends posteriorly from the third ventricle of the brain. The pineal gland consists of portions of neurons, neuroglial cells, and specialised secretory cells called pinealocytes. The pinealocytes synthesize the hormone melatonin and secrete it directly into the cerebrospinal fluid, which takes it into the blood. Melatonin affects reproductive development and daily physiologic cycles.

Thyroid gland

Location and structure - The thyroid gland is a very vascular organ that is located in the neck. It consists of two lobes, one on each side of the trachea, just below the larynx or voice box. A narrow band of tissue called the isthmus connects the two lobes. Internally, the gland consists of follicles, which produce thyroxine and triiodothyronine hormones. These hormones contain iodine.



Thyroid gland

Function – To produce hormones. About 95 percent of the active thyroid hormone is thyroxine, and most of the remaining 5 percent is triiodothyronine. Both of these require iodine for their synthesis. Thyroid hormone secretion is regulated by a negative feedback mechanism that involves the amount of circulating hormone, hypothalamus, and adenohypophysis.

If there is an iodine deficiency, the thyroid cannot make sufficient hormone. This stimulates the anterior pituitary to secrete thyroid-stimulating hormone, which causes the thyroid gland to increase in size in a vain attempt to produce more hormones. But it cannot produce more hormones because it does not have the necessary raw material, iodine. This type of thyroid enlargement is called simple goiter or iodine deficiency goiter.

The parafollicular cells of the thyroid gland secrete calcitonin. This hormone opposes the action of the parathyroid glands by reducing the calcium level in the blood. If blood calcium becomes too high, calcitonin is secreted until calcium ion levels decrease to normal.

Parathyroid gland

Four small masses of epithelial tissue are embedded in the connective tissue capsule on the posterior surface of the thyroid glands. These are parathyroid glands, and they secrete parathyroid hormone or parathormone. Parathyroid hormone is the most important regulator of blood calcium levels. The hormone is secreted in response to low blood calcium levels, and its effect is to increase those levels.

Hypoparathyroidism, or insufficient secretion of parathyroid hormone, leads to increased nerve excitability. The low blood calcium levels trigger spontaneous and continuous nerve impulses, which then stimulate muscle contraction.

Adrenal gland

The adrenal, or suprarenal, gland is paired with one gland located near the upper into an outer cortex and an inner medulla. The cortex and medulla of the adrenal the pituitary, develop from different embryonic tissues and secrete different hormo the medulla may be removed with no life-threatening effects.

The hypothalamus of the brain influences both portions of the adrenal gland but b regulated by negative feedback involving the hypothalamus and adrenocorticotrop impulses from the hypothalamus.

Adrenal gland

Hormones of the adrenal cortex

The adrenal cortex consists of three different regions, with each region producing a different group or type of hormones. Chemically, all the cortical hormones are steroid. The outermost region of the adrenal cortex secretes mineralocorticoids. The principal mineralocorticoid is aldosterone, which acts to conserve sodium ions and water in the body. The middle region of the adrenal cortex secretes glucocorticoids. The principal glucocorticoid is cortisol, which increases blood glucose levels.

The third group of steroids secreted by the adrenal cortex is the gonadocorticoids, or sex hormones. The innermost region secretes these. Male hormones, androgens, and female hormones, estrogens, are secreted in minimal amounts in both sexes by the adrenal cortex, but their effect is usually masked by the hormones from the testes and ovaries. In females, the masculinisation effect of androgen secretion may become evident after menopause, when oestrogen levels from the ovaries decrease.

Gonads

The gonads, the primary reproductive organs, are the testes in the male and the ovaries in the female. These organs are responsible for producing the sperm and ova, but they also secrete hormones and are considered to be endocrine glands.

Testes

Male sex hormones, as a group, are called androgens. The principal androgen is testosterone, which is secreted by the testes. A small amount is also produced by the adrenal cortex. Production of testosterone begins during foetal development, continues for a short time after birth, nearly ceases during childhood, and then resumes at puberty.

This steroid hormone is responsible for:

- The growth and development of the male reproductive structures
- Increased skeletal and muscular growth
- Enlargement of the larynx accompanied by voice changes
- Growth and distribution of body hair
- Increased male sexual drive

Testes

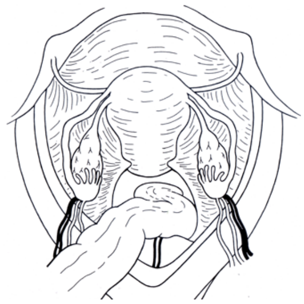
Testosterone secretion is regulated by a negative feedback system that involves releasing hormones from the hypothalamus and gonadotropins from the anterior pituitary.

Ovaries

Two groups of female sex hormones are produced in the ovaries, the estrogens and progesterone. These steroid hormones contribute to the development and function of the female reproductive organs and sex characteristics.

At the onset of puberty, estrogen promotes:

- The development of the breasts
- Distribution of fat evidenced in the hips, legs, and breast
- Maturation of reproductive organs such as the uterus and vagina



Ovaries

Progesterone causes the uterine lining to thicken in preparation for pregnancy. Together, progesterone and estrogens are responsible for the changes that occur in the uterus during the female menstrual cycle.

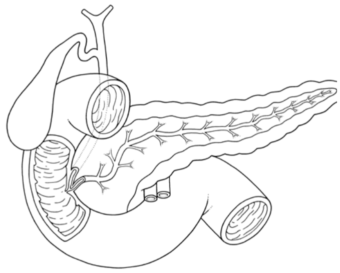
Hormones of the adrenal medulla

The adrenal medulla develops from neural tissue and secretes two hormones, epinephrine and norepinephrine. These two hormones are secreted in response to stimulation by sympathetic nerve, particularly during stressful situations. A lack of hormones from the adrenal medulla produces no significant effects. Hypersecretion, usually from a tumour, causes prolonged or continual sympathetic responses.

Pancreas - Islets of Langerhans

Description - The pancreas is a large gland behind the stomach which secretes digestive enzymes into the duodenum. Embedded in the pancreas are the islets of Langerhans, which secrete into the blood the hormones insulin and glucagon.

Location - It lies transversely along the posterior abdominal wall, posterior to the stomach, and extends from the region of the duodenum to the spleen.



Function - This gland has an exocrine portion that secretes digestive enzymes that are carried through a duct to the duodenum. The endocrine portion consists of the pancreatic islets, which secrete glucagons and insulin.

Alpha cells in the pancreatic islets secrete the hormone glucagons in response to a low concentration of glucose in the blood. Beta cells in the pancreatic islets secrete the hormone insulin in response to a high concentration of glucose in the blood.

Other endocrine glands

In addition to the major endocrine glands, other organs have some hormonal activity as part of their function. These include the thymus, stomach, small intestines, heart, and placenta.

Thymosin, produced by the thymus gland, plays an important role in the development of the body's immune system.

The lining of the stomach, the gastric mucosa, produces a hormone, called gastrin, in response to the presence of food in the stomach. This hormone stimulates the production of hydrochloric acid and the enzyme pepsin, which are used in the digestion of food.

The mucosa of the small intestine secretes the hormones secretin and cholecystokinin. Secreting stimulates the pancreas to produce a bicarbonate-rich fluid that neutralises the stomach acid. Cholecystokinin stimulates contraction of the gallbladder, which releases bile. It also stimulates the pancreas to secrete digestive enzyme.

The heart also acts as an endocrine organ in addition to its major role of pumping blood. Special cells in the wall of the upper chambers of the heart, called atria, produce a hormone called atrial natriiuretic hormone, or atriopeptin.

The placenta develops in the pregnant female as a source of nourishment and gas exchange for the developing foetus. It also serves as a temporary endocrine gland. One of the hormones it secretes is human chorionic gonadotropin, which signals the mother's ovaries to secrete hormones to maintain the uterine lining so that it does not degenerate and slough off in menstruation.

Health issues of the endocrine system

Hormone levels that are too high or too low indicate a problem with the endocrine system. Hormone diseases also occur if your body does not respond to hormones in the appropriate ways. Stress, infection, and changes in the blood's fluid and electrolyte balance can also influence hormone levels. Hormone imbalances can have a significant impact on the reproductive system.

Diabetes - the body does not properly process glucose. Hypoglycaemia, also called low blood glucose or low blood sugar, occurs when blood glucose drops below normal levels.

Hypothyroidism, occurs when the thyroid gland does not produce enough thyroid hormone to meet the body’s needs.

Thyroid cancer begins in the thyroid gland and starts when the cells in the thyroid begin to change, grow uncontrollably and eventually form a tumour.

The Digestive System

The digestive system is s essential to good health because if the digestive system shuts down, the body cannot be nourished or rid itself of waste.

Function

The digestive system includes the digestive tract and its accessory organs, which process food into molecules that can be absorbed and utilised by the cells of the body. Food is broken down, bit by bit, until the molecules are small enough to be absorbed and the waste products are eliminated.

Put simply - Food is broken down by the digestive system to give energy to every cell in the body.

The digestive tract, also called the alimentary canal or gastrointestinal (GI) tract, consists of a long continuous tube that extends from the mouth to the anus. It includes the mouth, pharynx, oesophagus, stomach, small intestine, and large intestine.

The tongue and teeth are accessory structures located in the mouth. The salivary glands, liver, gallbladder, and pancreas are major accessory organs that have a role in digestion. These organs secrete fluids into the digestive tract. Digestion and absorption occur in the digestive tract. After the nutrients are absorbed, they are available to all cells in the body and are utilised by the body cells in metabolism.

The primary function - The digestive system prepares nutrients for utilisation by body cells through six activities, or functions.

1. Ingestion

The first activity of the digestive system is to take in food through the mouth. This process, called ingestion has to take place before anything else can happen.

2. Mechanical digestion

The large pieces of food that are ingested have to be broken into smaller particles that can be acted upon by various enzymes. This is mechanical digestion, which begins in the mouth with chewing or mastication and continues with churning and mixing actions in the stomach.

3. Chemical digestion

The complex molecules of carbohydrates, proteins, and fats are transformed by chemical digestion into smaller molecules that can be absorbed and utilised by the cells. Chemical digestion, through a process called hydrolysis, uses water and digestive enzymes to break down the complex molecules. Digestive enzymes speed up the hydrolysis process, which is otherwise very slow.

4. Movements

After ingestion and mastication, the food particles move from the mouth into the pharynx, then into the oesophagus. This movement is deglutition, or swallowing. Mixing movements occur in the stomach as a result of smooth muscle contraction. These repetitive contractions usually occur in small segments of the digestive tract and mix the food particles with enzymes and other fluids. The movements that propel the food particles through the digestive tract are called peristalsis. These are rhythmic waves of contractions that move the food particles through the various regions in which mechanical and chemical digestion takes place.

5. Absorption

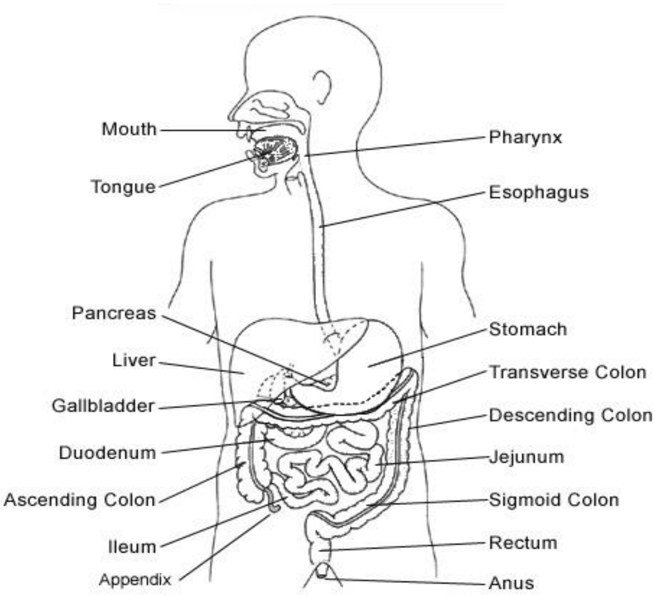
The simple molecules that result from chemical digestion pass through cell membranes of the lining in the small intestine into the blood or lymph capillaries. This process is called absorption.

6. Elimination

The food molecules that cannot be digested or absorbed need to be eliminated from the body. The removal of indigestible wastes through the anus, in the form of faeces, is defecation or elimination.

Location

Alimentary canal (digestive tract) - the passage through the body, starting at the mouth, through the oesophagus, stomach, intestines and ending at the anus.



Structure

The long continuous tube that is the digestive tract is about 9 meters in length. It opens to the outside at both ends, through the mouth at one end and through the anus at the other. Although there are variations in each region, the basic structure of the wall is the same throughout the entire length of the tube.

The wall of the digestive tract has four layers or tunics:

1. Mucosa
2. Submucosa
3. Muscular layer
4. Serous layer or serosa

The mucosa, or mucous membrane layer, is the innermost tunic of the wall. It lines the lumen of the digestive tract. The mucosa consists of epithelium, an underlying loose connective tissue layer called lamina propria, and a thin layer of smooth muscle called the muscularis mucosa. In certain regions, the mucosa develops folds that increase the surface area. Certain cells in the mucosa secrete mucus, digestive enzymes, and hormones. Ducts from other glands pass through the mucosa to the lumen. In the mouth and anus, where thickness for protection against abrasion is needed, the epithelium is stratified squamous tissue. The stomach and intestines have a thin simple columnar epithelial layer for secretion and absorption.

The submucosa is a thick layer of loose connective tissue that surrounds the mucosa. This layer also contains blood vessels, lymphatic vessels, and nerves. Glands may be embedded in this layer.

The smooth muscle responsible for movements of the digestive tract is arranged in two layers, an inner circular layer and an outer longitudinal layer. The myenteric plexus is between the two muscle layers.

Above the diaphragm, the outermost layer of the digestive tract is a connective tissue called adventitia. Below the diaphragm, it is called serosa.

Mouth

The mouth, or oral cavity, is the first part of the digestive tract. It is adapted to receive food by ingestion, break it into small particles by mastication, and mix it with saliva. The lips, cheeks, and palate form the boundaries. The oral cavity contains the teeth and tongue and receives the secretions from the salivary glands.

Lips and cheeks

The lips and cheeks help hold food in the mouth and keep it in place for chewing. They are also used in the formation of words for speech. The lips contain numerous sensory receptors that are useful for judging the temperature and texture of foods.

Palate

The palate is the roof of the oral cavity. It separates the oral cavity from the nasal cavity. The anterior portion, the hard palate, is supported by bone. The posterior portion, the soft palate, is skeletal muscle and connective tissue. Posteriorly, the soft palate ends in a projection called the uvula. During swallowing, the soft palate and uvula move upward to direct food away from the nasal cavity and into the oropharynx.

Tongue

The tongue manipulates food in the mouth and is used in speech. The surface is covered with papillae that provide friction and contain the taste buds.

Teeth

A complete set of deciduous (primary) teeth contains 20 teeth. There are 32 teeth in a complete permanent (secondary) set. The shape of each tooth type corresponds to the way it handles food.

Pharynx

The pharynx is a fibromuscular passageway that connects the nasal and oral cavities to the larynx and oesophagus. It serves both the respiratory and digestive systems as a channel for air and food. The upper region, the nasopharynx, is posterior to the nasal cavity. It contains the pharyngeal tonsils, or adenoids, functions as a passageway for air, and has no function in the digestive system. The middle region posterior to the oral cavity is the oropharynx. This is the first region food enters when it is swallowed. The opening from the oral cavity into the oropharynx is called the fauces. Masses of lymphoid tissue, the palatine tonsils, are near the fauces. The lower region, posterior to the larynx, is the laryngopharynx, or hypopharynx. The laryngopharynx opens into both the oesophagus and the larynx.

Food is forced into the pharynx by the tongue. When food reaches the opening, sensory receptors around the fauces respond and initiate an involuntary swallowing reflex. This reflex action has several parts. The uvula is elevated to prevent food from entering the nasopharynx. The epiglottis drops downward to prevent food from entering the larynx and trachea in order to direct the food into the oesophagus. Peristaltic movements propel the food from the pharynx into the oesophagus.

Oesophagus

The oesophagus is a collapsible muscular tube that serves as a passageway between the pharynx and stomach. As it descends, it is posterior to the trachea and anterior to the vertebral column. It passes through an opening in the diaphragm, called the oesophageal hiatus, and then empties into the stomach. The mucosa has glands that secrete mucus to keep the lining moist and well lubricated to ease the passage of food. Upper and lower oesophageal sphincters control the movement of food into and out of the oesophagus. The lower oesophageal sphincter is sometimes called the cardiac sphincter and resides at the oesophagogastric junction.

The stomach, which receives food from the oesophagus, is located in the upper left quadrant of the abdomen. The stomach is divided into the fundic, cardiac, body, and pyloric regions. The lesser and greater curvatures are on the right and left sides, respectively, of the stomach.

Gastric secretions

The mucosal lining of the stomach is simple columnar epithelium with numerous tubular gastric glands. The gastric glands open to the surface of the mucosa through tiny holes called gastric pits.

Four different types of cells make up the gastric glands:

1. Mucous cells
2. Parietal cells
3. Chief cells
4. Endocrine cells

The secretions of the exocrine gastric glands - composed of the mucous, parietal, and chief cells - make up the gastric juice. The products of the endocrine cells are secreted directly into the bloodstream and are not a part of the gastric juice. The endocrine cells secrete the hormone gastrin, which functions in the regulation of gastric activity.

The regulation of gastric secretion is accomplished through neural and hormonal mechanisms. Gastric juice is produced all the time but the amount varies subject to the regulatory factors. Regulation of gastric secretions may be divided into cephalic, gastric, and intestinal phases. Thoughts and smells of food start the cephalic phase of gastric secretion; the presence of food in the stomach initiates the gastric phase; and the presence of acid chyme in the small intestine begins the intestinal phase.

Stomach emptying

Relaxation of the pyloric sphincter allows chyme to pass from the stomach into the small intestine. The rate of which this occurs depends on the nature of the chyme and the receptivity of the small intestine.

Small intestine

The small intestine extends from the pyloric sphincter to the ileocecal valve, where it empties into the large intestine. The small intestine finishes the process of digestion, absorbs the nutrients, and passes the residue on to the large intestine. The liver, gallbladder, and pancreas are accessory organs of the digestive system that are closely associated with the small intestine.

The small intestine is divided into the duodenum, jejunum, and ileum. The small intestine follows the general structure of the digestive tract in that the wall has a mucosa with simple columnar epithelium, submucosa, smooth muscle with inner circular and outer longitudinal layers, and serosa. The absorptive surface area of the small intestine is increased by plicae circulares, villi, and microvilli.

Exocrine cells in the mucosa of the small intestine secrete mucus, peptidase, sucrase, maltase, lactase, lipase, and enterokinase. Endocrine cells secrete cholecystokinin and secretin.

The most important factor for regulating secretions in the small intestine is the presence of chyme. This is largely a local reflex action in response to chemical and mechanical irritation from the chyme and in response to distension of the intestinal wall. This is a direct reflex action, thus the greater the amount of chyme, the greater the secretion.

Large intestine

The large intestine is larger in diameter than the small intestine. It begins at the ileocecal junction, where the ileum enters the large intestine, and ends at the anus. The large intestine consists of the colon, rectum, and anal canal.

The wall of the large intestine has the same types of tissue that are found in other parts of the digestive tract but there are some distinguishing characteristics. The mucosa has a large number of goblet cells but does not have any villi. The longitudinal muscle layer, although present, is incomplete. The longitudinal muscle is limited to three distinct bands, called teniae coli that run the entire length of the colon. Contraction of the teniae coli exerts pressure on the wall and creates a series of pouches, called haustra, along the colon. Epiploic appendages, pieces of fat-filled connective tissue, are attached to the outer surface of the colon.

Unlike the small intestine, the large intestine produces no digestive enzymes. Chemical digestion is completed in the small intestine before the chyme reaches the large intestine. Functions of the large intestine include the absorption of water and electrolytes and the elimination of faeces.

Rectum and anus

The rectum continues from the sigmoid colon to the anal canal and has a thick muscular layer. It follows the curvature of the sacrum and is firmly attached to it by connective tissue. The rectum and ends about 5 cm below the tip of the coccyx, at the beginning of the anal canal.

The last 2 to 3 cm of the digestive tract is the anal canal, which continues from the rectum and opens to the outside at the anus. The mucosa of the rectum is folded to form longitudinal anal columns. The smooth muscle layer is thick and forms the internal anal sphincter at the superior end of the anal canal. This sphincter is under involuntary control. There is an external anal sphincter at the inferior end of the anal canal. This sphincter is composed of skeletal muscle and is under voluntary control.

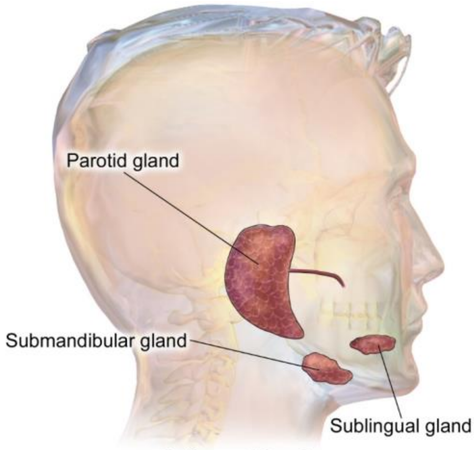
The salivary glands, liver, gallbladder, and pancreas are not part of the digestive tract, but they have a role in digestive activities and are considered accessory organs.

Salivary glands

Three pairs of major salivary glands (parotid, submandibular, and sublingual glands) and numerous smaller ones secrete saliva into the oral cavity, where it is mixed with food during mastication. Saliva contains water, mucus, and enzyme amylase.

Functions of saliva include the following:

- It has a cleansing action on the teeth
- It moistens and lubricates food during mastication and swallowing
- It dissolves certain molecules so that food can be tasted
- It begins the chemical digestion of starches through the action of amylase, which breaks down polysaccharides into disaccharides



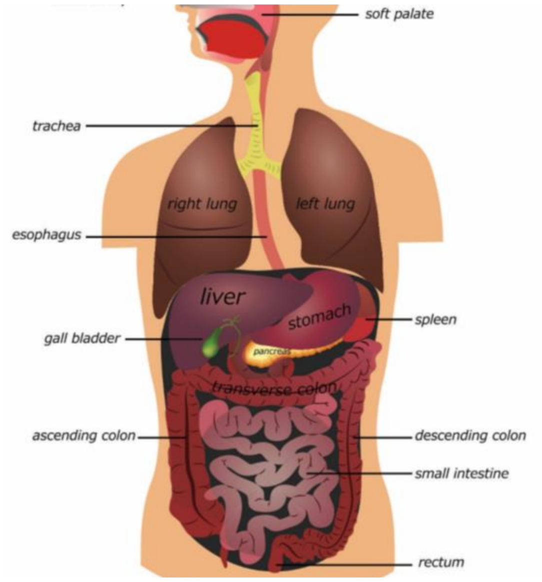
Salivary Glands

Liver

Location - The liver is located primarily in the right hypochondriac and epigastric regions of the abdomen, just beneath the diaphragm.

Structure - It is the largest gland in the body. On the surface, the liver is divided into two major lobes and two smaller lobes. The functional units of the liver are lobules with sinusoids that carry blood from the periphery to the central vein of the lobule.

Function - The liver receives blood from two sources. Freshly oxygenated blood is brought to the liver by the common hepatic artery, a branch of the celiac trunk from the abdominal aorta. Blood that is rich in nutrients from the digestive tract is carried to the liver by the hepatic portal vein.



The liver has a wide variety of functions and many of these are vital to life. Hepatocytes perform most of the functions attributed to the liver, but the phagocytic Kupffer cells that line the sinusoids are responsible for cleansing the blood.

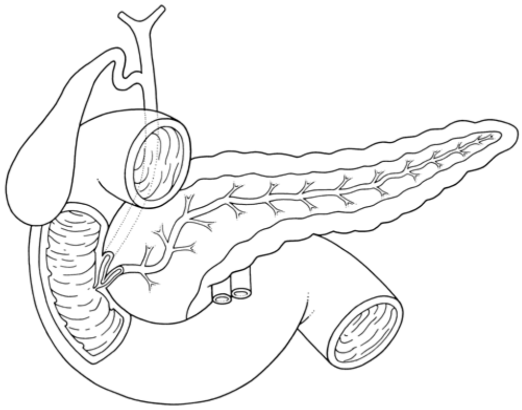
Basic liver functions include the following:

- Secretion
- Synthesis of bile salts
- Synthesis of plasma protein
- Storage
- Detoxification
- Excretion
- Carbohydrate metabolism
- Lipid metabolism
- Protein metabolism
- Filtering

Gallbladder

Structure and location - The gallbladder is a pear-shaped sac that is attached to the visceral surface of the liver by the cystic duct.

Function - The principal function of the gallbladder is to serve as a storage reservoir for bile. Bile is a yellowish-green fluid produced by liver cells. The main components of bile are water, bile salts, bile pigments, and cholesterol. Bile salts act as emulsifying agents in the digestion and absorption of fats. Cholesterol and bile pigments from the breakdown of haemoglobin are excreted from the body in the bile.



Gallbladder and Pancreas

Pancreas

The pancreas has both endocrine and exocrine functions. The endocrine portion consists of the scattered islets of Langerhans, which secrete the hormones insulin and glucagon into the blood. The exocrine portion is the major part of the gland. It consists of pancreatic acinar cells that secrete digestive enzymes into tiny ducts interwoven between the cells. Pancreatic enzymes include amylase, trypsin, peptidase, and lipase. Pancreatic secretions are controlled by the hormones secretin and cholecystokinin.

Health issues of the digestive system

Many symptoms can signal problems with the GI tract, including: abdominal pain, blood in the stool, bloating, constipation, diarrhoea, heartburn, incontinence, nausea and vomiting and difficulty swallowing etc.

The most widely known diseases of the digestive system is colon cancer. Polyp growth and irregular cells, which may or may not be cancerous, are the most common development paths for colorectal cancers.

Other diseases and conditions of the digestive system include irritable bowel syndrome, diverticulitis, GERD (acid reflux) and Crohn's disease.

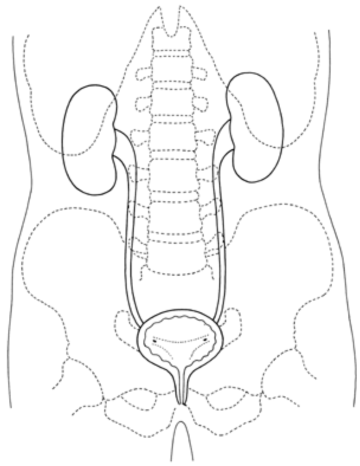
The Urinary System

Also known as the renal system.

Structure

The urinary system consists of two kidneys, a urinary bladder, two ureters and a single urethra. It is responsible for regulating blood pressure and volume, maintaining PH levels, excreting waste and foreign matter and producing hormones.

Location



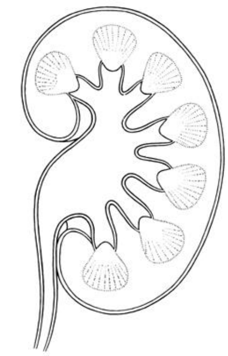
- The *kidneys* are small organs located between the peritoneum and the posterior wall of the abdomen. The right kidney is slightly lower than the left. They are protected and held within the ribcage (between the 11th and 12th pair of ribs). The kidneys form the urine and account for the other functions attributed to the urinary system.
- The *ureters* are a pair of tubes leading from each kidney to the bladder. The walls of the ureters are thick and narrow and at the end they open into the bladder. The ureters carry the urine away from kidneys to the urinary bladder, which is a temporary reservoir for the urine.
- The *bladder* is a muscular hollow organ that is situated in the pelvic cavity. In a male it is anterior to the rectum and in females, it is anterior to the vagina and inferior to the uterus. It is smaller in females, because of the location of the uterus.
- The *urethra* is a tube that leads from the bladder to an exterior part of the body and enables urine to pass out of the body.

Function

- **The principal function of the urinary system is to maintain the volume and composition of body fluids within normal limits by regulating the amount of water that is excreted in the urine.**
- One aspect of this function is to rid the body of waste products that accumulate as a result of cellular metabolism and because of this, it is sometimes referred to as the excretory system.
- Another aspect of its function include regulating the concentrations of various electrolytes in the body fluids and maintaining normal pH of the blood.
- In addition to maintaining fluid homeostasis in the body, the urinary system controls red blood cell production by secreting the hormone erythropoietin. The urinary system also plays a role in maintaining normal blood pressure by secreting the enzyme renin.

Although the urinary system has a major role in excretion, other organs contribute to the excretory function. The lungs in the respiratory system excrete some waste products, such as carbon dioxide and water. The skin is another excretory organ that rids the body of wastes through the sweat glands. The liver and intestines excrete bile pigments that result from the destruction of haemoglobin. The major task of excretion still belongs to the urinary system. If it fails the other organs cannot take over and compensate adequately.

Kidneys



The Kidney

The kidneys are the primary organs of the urinary system. The kidneys are the organs that filter the blood, remove the wastes, and excrete the wastes in the urine. **They are the organs that perform the functions of the urinary system**. The other components are accessory structures to eliminate the urine from the body.

The paired kidneys are located between the twelfth thoracic and third lumbar vertebrae, one on each side of the vertebral column, along the posterior wall of the abdominal cavity. The right kidney usually is slightly lower than the left because the liver displaces it downward. The kidneys protected by the lower ribs, lie in shallow depressions against the posterior abdominal wall and behind the parietal peritoneum. This means they are retroperitoneal. Each kidney is held in place by connective tissue, called renal fascia, and is surrounded by a thick layer of adipose tissue, called perirenal fat, which helps to protect it. A tough, fibrous, connective tissue renal capsule closely envelopes each kidney and provides support for the soft tissue that is inside.

In the adult, each kidney is approximately 3 cm thick, 6 cm wide and 12 cm long. It is roughly bean-shaped with an indentation, called the hilum, on the medial side. The hilum leads to a large cavity, called the renal sinus, within the kidney. The ureter and renal vein leave the kidney, and the renal artery enters the kidney at the hilum.

The outer, reddish region, next to the capsule, is the renal cortex. This surrounds a darker reddish-brown region called the renal medulla. The renal medulla consists of a series of renal pyramids, which appear striated because they contain straight tubular structures and blood vessels. The wide bases of the pyramids are adjacent to the cortex and the pointed ends, called renal papillae, are directed toward the centre of the kidney. Portions of the renal cortex extend into the spaces between adjacent pyramids to form renal columns. The cortex and medulla make up the parenchyma, or functional tissue, of the kidney.

The central region of the kidney contains the renal pelvis, which is located in the renal sinus and is continuous with the ureter. The renal pelvis is a large cavity that collects the urine as it is produced. The periphery of the renal pelvis is interrupted by cuplike projections called calyces. A minor calyx surrounds the renal papillae of each pyramid and collects urine from that pyramid. Several minor calyces converge to form a major calyx. From the major calyces the urine flows into the renal pelvis and from there into the ureter.

Each kidney contains over a million functional units, called nephrons, in the parenchyma (cortex and medulla). A nephron has two parts: a renal corpuscle and a renal tubule. The renal corpuscle consists of a cluster of capillaries, called the glomerulus, surrounded by a double-layered epithelial cup, called the glomerular capsule. An afferent arteriole leads into the renal corpuscle and an efferent arteriole leaves the renal corpuscle. Urine passes from the nephrons into collecting ducts then into the minor calyces. The juxtaglomerular apparatus, which monitors blood pressure and secretes renin, is formed from modified cells in the afferent arteriole and the ascending limb of the nephron loop.

Ureters

Each ureter is a small tube, about 25 cm long that carries urine from the renal pelvis to the urinary bladder. It descends from the renal pelvis, along the posterior abdominal wall, behind the parietal peritoneum, and enters the urinary bladder on the posterior inferior surface. The wall of the ureter consists of three layers. The outer layer, the fibrous coat, is a supporting layer of fibrous connective tissue. The middle layer, the muscular coat, consists of inner circular and outer longitudinal smooth muscle. The main function of this layer is peristalsis to propel the urine. The inner layer, the mucosa, is transitional epithelium that is continuous with the lining of the renal pelvis and the urinary bladder. This layer secretes mucus, which coats and protects the surface of the cells.

Urinary bladder

The urinary bladder is a temporary storage reservoir for urine. It is located in the pelvic cavity, posterior to the symphysis pubis, and below the parietal peritoneum. The size and shape of the urinary bladder varies with the amount of urine it contains and with pressure it receives from surrounding organs.

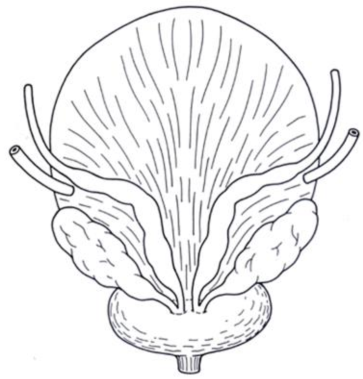
The inner lining of the urinary bladder is a mucous membrane of transitional epithelium that is continuous with that in the ureters. When the bladder is empty, the mucosa has numerous folds called rugae. The rugae and transitional epithelium allow the bladder to expand as it fills.

The second layer in the walls is the submucosa that supports the mucous membrane. It is composed of connective tissue with elastic fibres.

The next layer is the muscularis, which is composed of smooth muscle. The smooth muscle fibres are interwoven in all directions and collectively these are called the detrusor muscle. Contraction of this muscle expels urine from the bladder. On the superior surface, the outer layer of the bladder wall is parietal peritoneum. In all other regions, the outer layer is fibrous connective tissue. There is a triangular area, called the trigone, formed by three openings in the floor of the urinary bladder.

Two of the openings are from the ureters and form the base of the trigone. Small flaps of mucosa cover these openings and act as valves that allow urine to enter the bladder but prevent it from backing up from the bladder into the ureters. The third opening, at the apex of the trigone, is the opening into the urethra. A band of the detrusor muscle encircles this opening to form the internal urethral sphincter.

Urethra



Bladder and Urethra

The final passageway for the flow of urine is the urethra, a thin-walled tube that conveys urine from the floor of the urinary bladder to the outside. The opening to the outside is the external urethral orifice. The mucosal lining of the urethra is transitional epithelium. The wall also contains smooth muscle fibres and is supported by connective tissue.

The internal urethral sphincter surrounds the beginning of the urethra, where it leaves the urinary bladder. This sphincter is smooth (involuntary) muscle. Another sphincter, the external urethral sphincter, is skeletal (voluntary) muscle and encircles the urethra where it goes through the pelvic floor. These two sphincters control the flow of urine through the urethra.

In females, the urethra is short, only 3 to 4 cm (about 1.5 inches) long. The external urethral orifice opens to the outside just anterior to the opening for the vagina.

In males, the urethra is much longer, about 20 cm (7 to 8 inches) in length, and transports both urine and semen. The first part, next to the urinary bladder, passes through the prostate gland and is called the prostatic urethra. The second part, a short region that penetrates the pelvic floor and enters the penis, is called the membranous urethra. The third part, the spongy urethra, is the longest region. This portion of the urethra extends the entire length of the penis, and the external urethral orifice opens to the outside at the tip of the penis.

Health issues of the urinary system

Urinary tract infections (UTIs) occur when bacteria enters the urinary tract and can affect the urethra, bladder or even the kidneys.

Incontinence is another common disease of the urinary system.

Kidney disease. Kidney failure, also called renal failure and chronic kidney disease. Other conditions, such as diabetes and hypertension, can cause chronic kidney disease.

Interstitial cystitis (IC), also called painful bladder syndrome, is a chronic bladder condition.

Prostatitis is a swelling of the prostate gland and, therefore, can only occur in men.

Kidney stones are clumps of calcium oxalate that can be found anywhere in the urinary tract.

Bladder cancer - the symptoms, including back or pelvic pain, difficulty urinating and urgent/and or frequent urination, mimic other diseases or disorders of the urinary system.

The Reproductive System

The major function of the reproductive system is to ensure survival of the species. Other systems in the body, such as the endocrine and urinary systems, work continuously to maintain homeostasis for survival of the individual. An individual may live a long, healthy, and happy life without producing offspring, but if the species is to continue, at least some individuals must produce offspring.

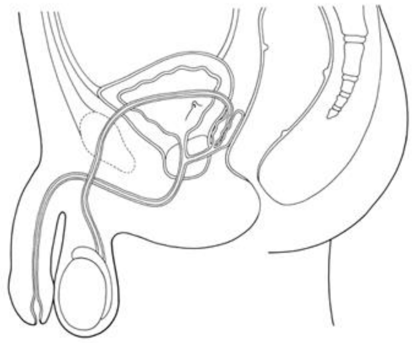
Within the context of producing offspring, the reproductive system has 4 functions:

1. To produce egg and sperm cells
2. To transport and sustain these cells
3. To nurture the developing offspring
4. To produce hormones

These functions are divided between the primary and secondary, or accessory, reproductive organs. The primary reproductive organs, or gonads, consist of the ovaries and testes. These organs are responsible for producing the egg and sperm cells, (gametes), and for producing hormones. These hormones function in the maturation of the reproductive system, the development of sexual characteristics, and have important roles in regulating the normal physiology of the reproductive system. All other organs, ducts, and glands in the reproductive system are considered secondary, or accessory, reproductive organs. These structures transport and sustain the gametes and nurture the developing offspring.

Male reproductive system

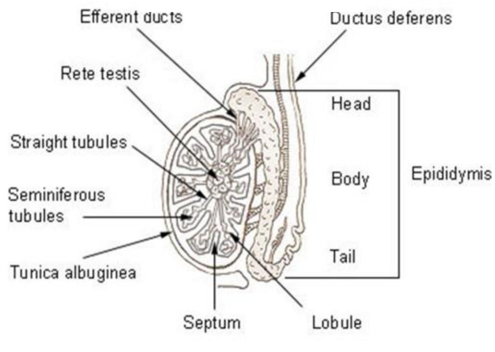
The male reproductive system, like that of the female, consists of those organs whose function is to produce a new individual, i.e., to accomplish reproduction. This system consists of a pair of testes and a network of excretory ducts (epididymis, ductus deferens (vas deferens), and ejaculatory ducts), seminal vesicles, the prostate, the bulbourethral glands, and the penis.



Testes

The male gonads, testes, or testicles, begin their development high in the abdominal cavity, near the kidneys. During the last two months before birth, or shortly after birth, they descend through the inguinal canal into the scrotum, a pouch that extends below the abdomen, posterior to the penis. Although this location of the testes, outside the abdominal cavity, may seem to make them vulnerable to injury, it provides a temperature about 3° C below normal body temperature. This lower temperature is necessary for the production of viable sperm. The scrotum consists of skin and subcutaneous tissue. A vertical septum, or partition, of subcutaneous tissue in the centre divides it into two parts, each containing one testis.

The Testicle



Smooth muscle fibres, called the dartos muscle, in the subcutaneous tissue contract to give the scrotum its wrinkled appearance. When these fibres are relaxed, the scrotum is smooth. Another muscle, the cremaster muscle, consists of skeletal muscle fibres and controls the position of the scrotum and testes. When it is cold or a man is sexually aroused, this muscle contracts to pull the testes closer to the body for warmth.

Structure

Each testis is an oval structure about 5 cm long and 3 cm in diameter. A tough, white fibrous connective tissue capsule, the tunica albuginea, surrounds each testis and extends inward to form septa that partition the organ into lobules. There are about 250 lobules in each testis. Each lobule contains 1 to 4 highly coiled seminiferous tubules that converge to form a single straight tubule, which leads into the rete testis.

Short efferent ducts exit the testes. Interstitial cells (cells of Leydig), which produce male sex hormones, are located between the seminiferous tubules within a lobule.

Spermatogenesis

Sperm are produced by spermatogenesis within the seminiferous tubules. A transverse section of a seminiferous tubule shows that it is packed with cells in various stages of development. Interspersed with these cells, there are large cells that extend from the periphery of the tubule to the lumen. These large cells are the supporting, or sustentacular cells (Sertoli's cells), which support and nourish the other cells.

Early in embryonic development, primordial germ cells enter the testes and differentiate into spermatogonia, immature cells that remain dormant until puberty. Spermatogonia are diploid cells, each with 46 chromosomes (23 pairs) located around the periphery of the seminiferous tubules. At puberty, hormones stimulate these cells to begin dividing by mitosis. Some of the daughter cells produced by mitosis remain at the periphery as spermatogonia. Others are pushed toward the lumen, undergo some changes, and become primary spermatocytes. Because they are produced by mitosis, primary spermatocytes, like spermatogonia, are diploid and have 46 chromosomes.

Each primary spermatocyte goes through the first meiotic division, meiosis I, to produce two secondary spermatocytes, each with 23 chromosomes (haploid). Just prior to this division, the genetic material is replicated so that each chromosome consists of two strands, called chromatids, which are joined by a centromere. During meiosis I, one chromosome, consisting of two chromatids, goes to each secondary spermatocyte. In the second meiotic division, meiosis II, each secondary spermatocyte divides to produce two spermatids.

There is no replication of genetic material in this division, but the centromere divides so that a single-stranded chromatid goes to each cell. As a result of the two meiotic divisions, each primary spermatocyte produces four spermatids. During spermatogenesis there are two cellular divisions, but only one replication of DNA so that each spermatid has 23 chromosomes (haploid), one from each pair in the original primary spermatocyte. Each successive stage in spermatogenesis is pushed toward the centre of the tubule so that the more immature cells are at the periphery and the more differentiated cells are nearer the centre.

Spermatogenesis (and oogenesis in the female) differs from mitosis because the resulting cells have only half the number of chromosomes as the original cell. When the sperm cell nucleus unites with an egg cell nucleus, the full number of chromosomes is restored. If sperm and egg cells were produced by mitosis, then each successive generation would have twice the number of chromosomes as the preceding one.

The final step in the development of sperm is called spermiogenesis. In this process, the spermatids formed from spermatogenesis become mature spermatozoa, or sperm. The mature sperm cell has a head, midpiece, and tail. The head, also called the nuclear region, contains the 23 chromosomes surrounded by a nuclear membrane. The tip of the head is covered by an acrosome, which contains enzymes that help the sperm penetrate the female gamete. The midpiece, metabolic region contains mitochondria that provide adenosine triphosphate (ATP). The tail, locomotor region, uses a typical flagellum for locomotion. The sperm are released into the lumen of the seminiferous tubule and leave the testes. They then enter the epididymis where they undergo their final maturation and become capable of fertilising a female gamete.

Sperm production begins at puberty and continues throughout the life of a male. The entire process, beginning with a primary spermatocyte, takes about 74 days. After ejaculation, the sperm can live for about 48 hours in the female reproductive tract.

Duct system

Sperm cells pass through a series of ducts to reach the outside of the body. After they leave the testes, the sperm passes through the epididymis, ductus deferens, ejaculatory duct, and urethra.

Epididymis

Sperm leave the testes through a series of efferent ducts that enter the epididymis. Each epididymis is a long (about 6 meters) tube that is tightly coiled to form a comma-shaped organ located along the superior and posterior margins of the testes. When the sperm leave the testes, they are immature and incapable of fertilising ova. They complete their maturation process and become fertile as they move through the epididymis. Mature sperm are stored in the lower portion, or tail, of the epididymis.

Ductus deferens

The ductus deferens, also called vas deferens, is a fibromuscular tube that is continuous with the epididymis. It begins at the bottom (tail) of the epididymis then turns sharply upward along the posterior margin of the testes. The ductus deferens enters the abdominopelvic cavity through the inguinal canal and passes along the lateral pelvic wall. It crosses over the ureter and posterior portion of the urinary bladder, and then descends along the posterior wall of the bladder toward the prostate gland. Just before it reaches the prostate gland, each ductus deferens enlarges to form an ampulla. Sperm are stored in the proximal portion of the ductus deferens, near the epididymis, and peristaltic movements propel the sperm through the tube.

The proximal portion of the ductus deferens is a component of the spermatic cord, which contains vascular and neural structures that supply the testes. The spermatic cord contains the ductus deferens, testicular artery and veins, lymph vessels, testicular nerve, cremaster muscle that elevates the testes for warmth and at times of sexual stimulation, and a connective tissue covering.

Ejaculatory duct

Each ductus deferens, at the ampulla, joins the duct from the adjacent seminal vesicle (one of the accessory glands) to form a short ejaculatory duct. Each ejaculatory duct passes through the prostate gland and empties into the urethra.

Urethra

The urethra extends from the urinary bladder to the external urethral orifice at the tip of the penis. It is a passageway for sperm and fluids from the reproductive system and urine from the urinary system. While reproductive fluids are passing through the urethra, sphincters contract tightly to keep urine from entering the urethra.

The male urethra is divided into three regions. The prostatic urethra is the proximal portion that passes through the prostate gland. It receives the ejaculatory duct, which contains sperm and secretions from the seminal vesicles, and numerous ducts from the prostate glands. The next portion, the membranous urethra, is a short region that passes through the pelvic floor. The longest portion is the penile urethra (also called spongy urethra or cavernous urethra), which extends the length of the penis and opens to the outside at the external urethral orifice. The ducts from the bulbourethral glands open into the penile urethra.

Accessory glands

The accessory glands of the male reproductive system are the seminal vesicles, prostate gland, and the bulbourethral glands. These glands secrete fluids that enter the urethra.

Seminal vesicles

The paired seminal vesicles are saccular glands posterior to the urinary bladder. Each gland has a short duct that joins with the ductus deferens at the ampulla to form an ejaculatory duct, which then empties into the urethra. The fluid from the seminal vesicles is viscous and contains fructose, which provides an energy source for the sperm; prostaglandins, which contribute to the mobility and viability of the sperm; and proteins that cause slight coagulation reactions in the semen after ejaculation.

Prostate

The prostate gland is a firm, dense structure that is located just inferior to the urinary bladder. It is about the size of a walnut and encircles the urethra as it leaves the urinary bladder. Numerous short ducts from the substance of the prostate gland empty into the prostatic urethra. The secretions of the prostate are thin, milky coloured, and alkaline. They function to enhance the motility of the sperm.

Bulbourethral glands

The paired bulbourethral (Cowper's) glands are small, about the size of a pea, and located near the base of the penis. A short duct from each gland enters the proximal end of the penile urethra. In response to sexual stimulation, the bulbourethral glands secrete an alkaline mucus-like fluid. This fluid neutralises the acidity of the urine residue in the urethra, helps to neutralise the acidity of the vagina, and provides some lubrication for the tip of the penis during intercourse.

Seminal fluid

Seminal fluid, or semen, is a slightly alkaline mixture of sperm cells and secretions from the accessory glands. Secretions from the seminal vesicles make up about 60 percent of the volume of the semen, with most of the remainder coming from the prostate gland. The sperm and secretions from the bulbourethral gland contribute only a small volume.

The volume of semen in a single ejaculation may vary from 1.5 to 6.0 ml. There are usually between 50 to 150 million sperm per millilitre of semen. Sperm counts below 10 to 20 million per millilitre usually present fertility problems. Although only one sperm actually penetrates and fertilises the ovum, it takes several million sperm in an ejaculation to ensure that fertilisation will take place.

Penis

The penis, the male copulatory organ, is a cylindrical pendant organ located anterior to the scrotum and functions to transfer sperm to the vagina. The penis consists of three columns of erectile tissue that are wrapped in connective tissue and covered with skin. The two dorsal columns are the corpora cavernosa. The single, midline ventral column surrounds the urethra and is called the corpus spongiosum. The penis has a root, body (shaft), and glans penis. The root of the penis attaches it to the pubic arch and the body is the visible, pendant portion. The corpus spongiosum expands at the distal end to form the glans penis. The urethra, which extends throughout the length of the corpus spongiosum, opens through the external urethral orifice at the tip of the glans penis. A loose fold of skin, called the prepuce, or foreskin, covers the glans penis.

Male sexual response

The male sexual response includes erection and orgasm accompanied by ejaculation of semen. Orgasm is followed by a variable time period during which it is not possible to achieve another erection.

Three hormones are the principle regulators of the male reproductive system. Follicle-stimulating hormone (FSH) stimulates spermatogenesis; luteinising hormone (LH) stimulates the production of testosterone; and testosterone stimulates the development of male secondary sex characteristics and spermatogenesis.

Female reproductive system

The organs of the female reproductive system produce and sustain the female sex cells (egg cells or ova), transport these cells to a site where they may be fertilised by sperm, provide a favourable environment for the developing foetus, move the fetus to the outside at the end of the development period, and produce the female sex hormones. The female reproductive system includes the ovaries, Fallopian tubes, uterus, vagina, accessory glands, and external genital organs.

Ovaries

The primary female reproductive organs, or gonads, are the two ovaries. Each ovary is a solid, ovoid structure about the size and shape of an almond, about 3.5 cm in length, 2 cm wide, and 1 cm thick. The ovaries are located in shallow depressions, called ovarian fossae, one on each side of the uterus, in the lateral walls of the pelvic cavity. They are held loosely in place by peritoneal ligaments.

Structure

The ovaries are covered on the outside by a layer of simple cuboidal epithelium called germinal (ovarian) epithelium. This is actually the visceral peritoneum that envelops the ovaries. Underneath this layer there is a dense connective tissue capsule, the tunica albuginea. The substance of the ovaries is distinctly divided into an outer cortex and an inner medulla. The cortex appears more dense and granular due to the presence of numerous ovarian follicles in various stages of development. Each of the follicles contains an oocyte, a female germ cell. The medulla is loose connective tissue with abundant blood vessels, lymphatic vessels, and nerve fibres.

Oogenesis

Female sex cells, or gametes, develop in the ovaries by a form of meiosis called oogenesis. The sequence of events in oogenesis is similar to the sequence in spermatogenesis, but the timing and final results are different. Early in foetal development, primitive germ cells in the ovaries differentiate into oogonia. These divide rapidly to form thousands of cells, still called oogonia, which have a full complement of 46 (23 pairs) chromosomes. Oogonia then enter a growth phase, enlarge, and become primary oocytes. The diploid (46 chromosomes) primary oocytes replicate their DNA and begin the first meiotic division, but the process stops in prophase and the cells remain in this suspended state until puberty. Many of the primary oocytes degenerate before birth, but even with this decline, the two ovaries together contain approximately 700,000 oocytes at birth. This is the lifetime supply, and no more will develop. This is quite different than the male in which spermatogonia and primary spermatocytes continue to be produced throughout the reproductive lifetime. By puberty the number of primary oocytes has further declined to about 400,000.

Beginning at puberty, under the influence of follicle-stimulating hormone, several primary oocytes start to grow again each month. One of the primary oocytes seems to outgrow the others and it resumes meiosis I. The other cells degenerate. The large cell undergoes an unequal division so that nearly all the cytoplasm, organelles, and half the chromosomes go to one cell, which becomes a secondary oocyte. The remaining half of the chromosomes go to a smaller cell called the first polar body. The secondary oocyte begins the second meiotic division, but the process stops in metaphase. At this point ovulation occurs. If fertilisation occurs, meiosis II continues. Again this is an unequal division with all of the cytoplasm going to the ovum, which has 23 single-stranded chromosomes. The smaller cell from this division is a second polar body. The first polar body also usually divides in meiosis to produce two even smaller polar bodies. If fertilisation does not occur, the second meiotic division is never completed and the secondary oocyte degenerates. Here again there are obvious differences between the male and female. In spermatogenesis, four functional sperm develop from each primary spermatocyte. In oogenesis, only one functional fertilisable cell develops from a primary oocyte. The other three cells are polar bodies and they degenerate.

Ovarian follicle development

An ovarian follicle consists of a developing oocyte surrounded by one or more layers of cells called follicular cells. At the same time that the oocyte is progressing through meiosis, corresponding changes are taking place in the follicular cells. Primordial follicles, which consist of a primary oocyte surrounded by a single layer of flattened cells, develop in the foetus and are the stage that is present in the ovaries at birth and throughout childhood.

Beginning at puberty follicle-stimulating hormone stimulates changes in the primordial follicles. The follicular cells become cuboidal, the primary oocyte enlarges, and it is now a primary follicle. The follicles continue to grow under the influence of follicle-stimulating hormone, and the follicular cells proliferate to form several layers of granulose cells around the primary oocyte. Most of these primary follicles degenerate along with the primary oocytes within them, but usually one continues to develop each month. The granulosa cells start secreting oestrogen and a cavity, or antrum, forms within the follicle. When the antrum starts to develop, the follicle becomes a secondary follicle. The granulose cells also secrete a glycoprotein substance that forms a clear membrane, the zona pellucida, around the oocyte. After about 10 days of growth the follicle is a mature vesicular (graafian) follicle, which forms a "blister" on the surface of the ovary and contains a secondary oocyte ready for ovulation.

Ovulation

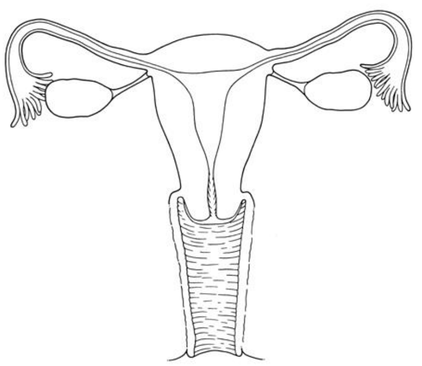
Ovulation, prompted by luteinising hormone from the anterior pituitary, occurs when the mature follicle at the surface of the ovary ruptures and releases the secondary oocyte into the peritoneal cavity. The ovulated secondary oocyte, ready for fertilisation, is still surrounded by the zona pellucida and a few layers of cells called the corona radiata. If it is not fertilised, the secondary oocyte degenerates in a couple of days. If a sperm passes through the corona radiata and zona pellucida and enters the cytoplasm of the secondary oocyte, the second meiotic division resumes to form a polar body and a mature ovum.

After ovulation and in response to luteinising hormone, the portion of the follicle that remains in the ovary enlarges and is transformed into a corpus luteum. The corpus luteum is a glandular structure that secretes progesterone and some estrogens. Its fate depends on whether fertilisation occurs. If fertilisation does not take place, the corpus luteum remains functional for about 10 days then it begins to degenerate into a corpus albicans, which is primarily scar tissue, and its hormone output ceases. If fertilisation occurs, the corpus luteum persists and continues its hormone functions until the placenta develops sufficiently to secrete the necessary hormones. Again, the corpus luteum ultimately degenerates into corpus albicans, but it remains functional for a longer period of time.

Fallopian tubes

There are two uterine tubes, also called Fallopian tubes or oviducts. There is one tube associated with each ovary. The end of the tube near the ovary expands to form a funnel-shaped infundibulum, which is surrounded by finger like extensions called fimbriae. Because there is no direct connection between the infundibulum and the ovary, the oocyte enters the peritoneal cavity before it enters the Fallopian tube. At the time of ovulation, the fimbriae increase their activity and create currents in the peritoneal fluid that help propel the oocyte into the Fallopian tube. Once inside the Fallopian tube, the oocyte is moved along by the rhythmic beating of cilia on the epithelial lining and by peristaltic action of the smooth muscle in the wall of the tube. The journey through the Fallopian tube takes about 7 days. Because the oocyte is fertile for only 24 to 48 hours, fertilisation usually occurs in the Fallopian tube.

Female reproductive organs



Uterus

The uterus is a muscular organ that receives the fertilised oocyte and provides an appropriate environment for the developing foetus. Before the first pregnancy, the uterus is about the size and shape of a pear, with the narrow portion directed inferiorly. After childbirth, the uterus is usually larger, and then regresses after menopause. The uterus is lined with the endometrium. The stratum functional of the endometrium sloughs off during menstruation. The deeper stratum basale provides the foundation for rebuilding the stratum functional.

Vagina

The vagina is a fibromuscular tube, about 10 cm long that extends from the cervix of the uterus to the outside. It is located between the rectum and the urinary bladder. Because the vagina is tilted posteriorly as it ascends and the cervix is tilted anteriorly, the cervix projects into the vagina at nearly a right angle. The vagina serves as a passageway for menstrual flow, receives the erect penis during intercourse, and is the birth canal during childbirth.

External genitalia

The external genitalia are the accessory structures of the female reproductive system that are external to the vagina. They are also referred to as the vulva or pudendum. The external genitalia include the labia majora, mons pubis, labia minora, clitoris, and glands within the vestibule.

The clitoris is an erectile organ, similar to the male penis, which responds to sexual stimulation. Posterior to the clitoris, the urethra, vagina, paraurethral glands and greater vestibular glands open into the vestibule.

Female sexual response & hormone control

The female sexual response includes arousal and orgasm, but there is no ejaculation. A woman may become pregnant without having an orgasm.

Follicle-stimulating hormone, luteinising hormone, oestrogen, and progesterone have major roles in regulating the functions of the female reproductive system.

At puberty, when the ovaries and uterus are mature enough to respond to hormonal stimulation, certain stimuli cause the hypothalamus to start secreting gonadotropin-releasing hormone. This hormone enters the blood and goes to the anterior pituitary gland where it stimulates the secretion of follicle-stimulating hormone and luteinising hormone. These hormones, in turn, affect the ovaries and uterus and the monthly cycles begin.

A woman's reproductive cycles last from menarche to menopause. The monthly ovarian cycle begins with the follicle development during the follicular phase, continues with ovulation during the ovulatory phase, and concludes with the development and regression of the corpus luteum during the luteal phase.

The uterine cycle takes place simultaneously with the ovarian cycle. The uterine cycle begins with menstruation during the menstrual phase, continues with repair of the endometrium during the proliferative phase, and ends with the growth of glands and blood vessels during the secretory phase.

Menopause occurs when a woman's reproductive cycles stop. Decreased levels of ovarian hormones and increased levels of pituitary follicle-stimulating hormone and luteinising hormone mark this period. The changing hormone levels are responsible for the symptoms associated with menopause.

Mammary glands

Functionally, the mammary glands produce milk; structurally, they are modified sweat glands. Mammary glands, which are located in the breast overlying the pectoralis major muscles, are present in both sexes, but usually are functional only in the female.

Externally, each breast has a raised nipple, which is surrounded by a circular pigmented area called the areola. The nipples are sensitive to touch, due to the fact that they contain smooth muscle that contracts and causes them to become erect in response to stimulation.

Internally, the adult female breast contains 15 to 20 lobes of glandular tissue that radiate around the nipple. The lobes are separated by connective tissue and adipose. The connective tissue helps support the breast. Some bands of connective tissue, called suspensory (Cooper's) ligaments extend through the breast from the skin to the underlying muscles.

The amount and distribution of the adipose tissue determines the size and shape of the breast. Each lobe consists of lobules that contain the glandular units. A lactiferous duct collects the milk from the lobules within each lobe and carries it to the nipple.

Just before the nipple the lactiferous duct enlarges to form a lactiferous sinus (ampulla), which serves as a reservoir for milk. After the sinus, the duct again narrows and each duct opens independently on the surface of the nipple.

Hormones regulate mammary gland function. At puberty, increasing levels of oestrogen stimulate the development of glandular tissue in the female breast. Oestrogen also causes the breast to increase in size through the accumulation of adipose tissue. Progesterone stimulates the development of the duct system.

During pregnancy these hormones enhance further development of the mammary glands. Prolactin from the anterior pituitary stimulates the production of milk within the glandular tissue, and oxytocin causes the ejection of milk from the glands.

Health issues of the reproductive system

Both genders can develop sexually transmitted diseases, including genital herpes, gonorrhoea and syphilis.

Male:

Erectile dysfunction.

Prostatitis typically involves swelling or inflammation of the prostate gland - can cause painful or difficult urination and ejaculation.

Prostate testicular and penile cancer.

Female:

Severe menstrual cramping, or dysmenorrhea, is the most common disease of the reproductive system occurs with a woman's monthly menstrual period.

Cancer can attack the uterus, ovaries, breast and cervix, among other organs.

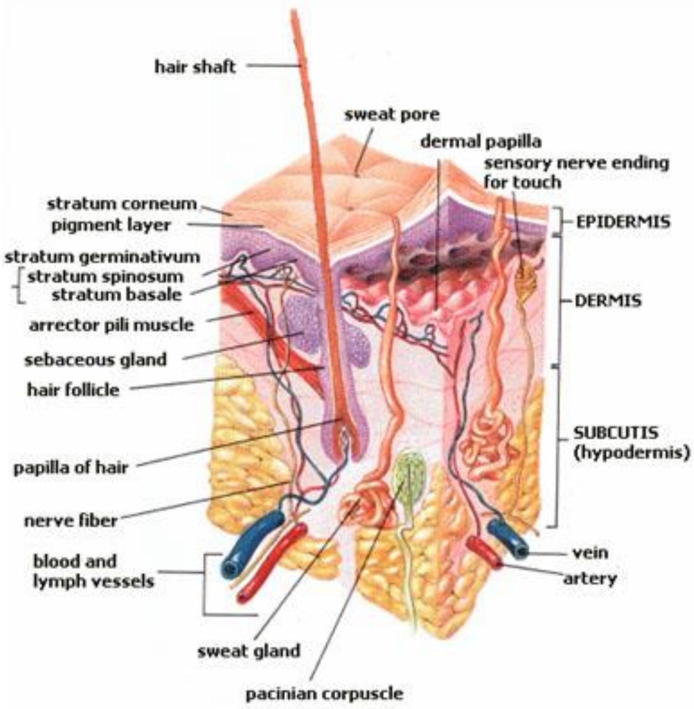
Vaginal yeast infection, which is caused by a yeast fungus in the vagina.

Endometriosis is a condition where that normally lines the inside of your uterus — the endometrium — ends up outside of uterus, most commonly in the ovaries, bowel or the tissue lining your pelvis.

Pelvic inflammatory disease can involve an infection of any of the female reproductive organs, including the uterus and ovaries. Sexually transmitted diseases, such as gonorrhoea and chlamydia, are typical causes of pelvic inflammatory disease.

The Integumentary System

Structure



The Integumentary System is the bodily system composed of the skin (integument is the Latin word for covering) and the other things that cover the outside of the body, hair, nails, sweat glands, and sebaceous glands.

The skin itself has three main layers.

The **dermis** (or corium or cutis, "the true skin") is the middle layer, which contains hair follicles, sweat and sebaceous glands, blood and lymph vessels, and nerves and nerve endings.

On top of the dermis is an avascular layer that has no blood supply, which is called, appropriately, the **epidermis**. Constantly cells of the epidermis are pushed up from the basal layer of the epidermis to the outer layer, where they harden and slough off.

Melanocytes in the basal layer produce melanin, the dark skin pigment that protects against ultraviolet light. Albinism (a white condition) results from a lack of melanin.

The **subcutaneous** layer under the dermis contains blood vessels and fatty tissues, lipocytes, and it protects the inner tissues of the body, and acts as an insulator for heat and cold. The hair likewise protects the head from heat and cold, while the nails provided protection – prior to man's development of other weapons of self-defence!

Location

It is a waterproof covering of the body, which protects the blood vessels from damage, excess of temperatures and infection.

The integumentary system is often considered to be a single organ system and as such it has the largest surface area of all the organ systems. In human beings, it amounts to about 16 percent of the body weight.

Function

The skin in the largest organ in the body, and can weigh up to 20 pounds. In the skin are the nerves or sensory receptors that relay to the brain information about temperature, pain, touch and pressure, and the brain in response through its motor nerves can direct appropriate commands, such as an increase or decrease in the activity of the sweat glands or sebaceous glands.

Being the first line of defence in the immune system, it also protects the body from bacteria, chemicals, and injury; and it also keeps things in the body that otherwise would escape. The sweat, or sudoriferous, glands regulate body temperature, and also secrete some metabolic wastes. The sebaceous glands produce sebum, an oil that lubricates the skin and prevents it from drying out, or the growth of bacteria. An overproduction in adolescents leads to acne, pimples and pustules, whereas in later life a reduced production creates wrinkles and dry skin.

It is composed of many types of tissue, including epithelial, connective, neural, and muscular. This organ system, composed of many diverse cells and tissues, provides a wall of defense between the body and the environment. These integumentary cells are the most vulnerable of all the bodily cells to death and destruction. The epidermal epithelial cells are replaced every ten to 30 days. The wound healing system of the human skin is a remarkable feat of intercellular cooperation that continues to mystify medical researchers.

Sweat or perspiration is a watery fluid excreted by the sweat (sudoriparous) glands of the skin of mammals. Sweat contains primarily water, but also salts and metabolic waste products—primarily sodium chloride, urea, lactic acid, and potassium ions (Blood et al. 2007).

Sweat serves an excretory function for releasing excess water and waste products. In some animals, and in particularly humans, it also plays a role in regulating body temperature through evaporative cooling when the water in the sweat evaporates. The urocanic acid in sweat also may offer protection for the skin against ultraviolet radiation (Kent 2006).

Sweating (as well as perspiration) refers to the production, secretion, and evaporation of sweat. The importance of sweating varies between species.

Sweating is part of the intricate complexity of animals. In humans, it is part of a carefully coordinated process, controlled by the hypothalamus, to regulate body temperature. Furlow (2004) also summarises some recent scientific evidence that molecules in the sweat from apocrine glands may be involved in a women's selection of a potential mate, guiding them toward those with genetically different MHC (major histocompatibility complex) profiles and ones potentially better for having healthy offspring.

Hair, a filamentous, often pigmented, outgrowth from the skin, is found only on mammals and often in a high-density of filaments per unit area. These threadlike fibres protrude from the outer layer of the skin, the epidermis, and grow from hair follicles in the inner portion of the skin, the dermis. Each fibre comprises nonliving cells whose primary component is long chains (polymers) of amino acids forming the protein keratin. The keratinised cells arise from cell division in the hair matrix at the base of a hair follicle and are tightly packed together. Keratins also are a principle part of the cells in the nails, feathers, hooves, horny tissues, and tooth enamel of mammals.

In humans, hair, with its variety of colours, textures, shape, length, density, and other qualities, adds to individual uniqueness and provides an aesthetic quality for others to see and appreciate.

Health issues with the integumentary system

Common conditions such as acne, moles and warts; chronic skin conditions such as vitiligo, eczema and psoriasis; and more serious diseases like skin cancer.

Warts are rough bumps caused by a viral infection.

Eczema looks like red, itchy, flaky skin.

Acne, a disorder of the hair and oil glands, is among the most common conditions treated by dermatologists. Acne presents itself as red bumps and pimples on the face, chest and back.

Vitiligo is a condition in which the cells that produce skin colour — melanocytes — no longer function properly. Some are attacked by the immune system. Sometimes, the cells mysteriously die or stop working. When this happens, the person with vitiligo can get multiple patches of white skin. One of the best treatments for vitiligo is specialised light treatment from a doctor.

Psoriasis is an inflammatory skin condition in which red, itchy plaques commonly occur on the knees and elbows.

Moles are normal parts of the skin. Moles can be flat or raised, and they can be red, brown, black or skin-coloured. If a mole start changing — in size, colour or shape, or if it bleeds and doesn't heal on its own in three weeks — it should be evaluated by a doctor to make sure it is not turning into a skin cancer.

There are three main types of skin cancer, the most common of which is basal cell carcinoma. This type of cancer is skin coloured or has a slight pearl colour to it. Can be very problematic if it's not treated and can destroy skin tissue and bone.

The second most common skin cancer is squamous cell carcinoma. This is a rough-surfaced skin-coloured lesion. Squamous cell skin cancer causes death in about 10 percent of affected patients.

The most serious skin cancer is melanoma, which looks like a dark, changing, bleeding skin spot, which is fatal in as many as 35 percent of patients diagnosed.

The Lymphatic System

Function

The lymphatic system is a network of tissues and organs that help rid the body of toxins, waste and other unwanted materials. The primary function of the lymphatic system is to transport lymph, a fluid containing infection-fighting white blood cells, throughout the body.

First of all, it returns excess interstitial fluid to the blood. Of the fluid that leaves the capillary, about 90 percent is returned. The 10 percent that does not return becomes part of the interstitial fluid that surrounds the tissue cells. Small protein molecules may "leak" through the capillary wall and increase the osmotic pressure of the interstitial fluid. This further inhibits the return of fluid into the capillaries, and fluid tends to accumulate in the tissue spaces. If this continues, blood volume and blood pressure decrease significantly and the volume of tissue fluid increases, which results in oedema (swelling). Lymph capillaries pick up the excess interstitial fluid and proteins and return them to the venous blood. After the fluid enters the lymph capillaries, it is called lymph.

The second function of the lymphatic system is the absorption of fats and fat-soluble vitamins from the digestive system and the subsequent transport of these substances to the venous circulation. The mucosa that lines the small intestine is covered with finger like projections called villi. There are blood capillaries and special lymph capillaries, called lacteals, in the centre of each villus. The blood capillaries absorb most nutrients, but the fats and fat-soluble vitamins are absorbed by the lacteals. The lymph in the lacteals has a milky appearance due to its high fat content and is called chyle. The third and probably most well-known function of the lymphatic system is defence against invading micro-organisms and disease. Lymph nodes and other lymphatic organs filter the lymph to remove micro-organisms and other foreign particles. Lymphatic organs contain lymphocytes that destroy invading organisms.

Structure

The lymphatic system consists of a fluid (lymph), vessels that transport the lymph and organs that contain lymphoid tissue.

The lymphatic system primarily consists of lymphatic vessels, which are similar to the circulatory system's veins and capillaries. The vessels are connected to lymph nodes, where the lymph is filtered. The tonsils, adenoids, spleen and thymus are all part of the lymphatic system.

The lymphatic system is a network of tubes throughout the body that drains fluid (called lymph) from tissues and empties it back into the bloodstream. The main roles of the lymphatic system include managing the fluid levels in the body, filtering out bacteria, and housing types of white blood cells. Lymph is filtered through the spleen, thymus and lymph nodes before being emptied into the blood.

Location

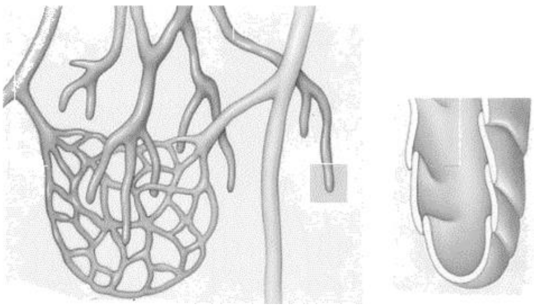
A network of tubes throughout the body. Hundreds of lymph nodes located deep inside the body, such as around the lungs and heart, or closer to the surface, such as under the arm or groin

What is lymph?

Lymph is a fluid similar in composition to blood plasma. It is derived from blood plasma as fluids pass through capillary walls at the arterial end. As the interstitial fluid begins to accumulate, it is picked up and removed by tiny lymphatic vessels and returned to the blood. As soon as the interstitial fluid enters the lymph capillaries, it is called lymph. Returning the fluid to the blood prevents oedema and helps to maintain normal blood volume and pressure.

Lymphatic vessels

Lymphatic vessels, unlike blood vessels, only carry fluid away from the tissues. The smallest lymphatic vessels are the lymph capillaries, which begin in the tissue spaces as blind-ended sacs. Lymph capillaries are found in all regions of the body except the bone marrow, central nervous system, and tissues, such as the epidermis, that lack blood vessels. The wall of the lymph capillary is composed of endothelium in which the simple squamous cells overlap to form a simple one-way valve. This arrangement permits fluid to enter the capillary but prevents lymph from leaving the vessel. The microscopic lymph capillaries merge to form lymphatic vessels.



Lymphatic vessels

Small lymphatic vessels join to form larger tributaries, called lymphatic trunks, which drain large regions. Lymphatic trunks merge until the lymph enters the two lymphatic ducts. The right lymphatic duct drains lymph from the upper right quadrant of the body. The thoracic duct drains all the rest.

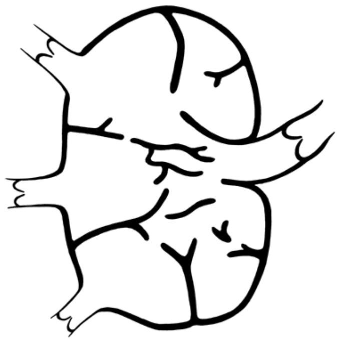
Like veins, the lymphatic tributaries have thin walls and have valves to prevent backflow of blood. There is no pump in the lymphatic system like the heart in the cardiovascular system. The pressure gradients to move lymph through the vessels come from the skeletal muscle action, respiratory movement, and contraction of smooth muscle in vessel walls.

Lymphatic organs

Lymphatic organs are characterised by clusters of lymphocytes and other cells, such as macrophages, enmeshed in a framework of short, branching connective tissue fibres. The lymphocytes originate in the red bone marrow with other types of blood cells and are carried in the blood from the bone marrow to the lymphatic organs. When the body is exposed to micro-organisms and other foreign substances, the lymphocytes proliferate within the lymphatic organs and are sent in the blood to the site of the invasion. This is part of the immune response that attempts to destroy the invading agent.

Lymph nodes

Lymph nodes are small bean-shaped structures that are usually less than 2.5 cm in length. They are widely distributed throughout the body along the lymphatic pathways where they filter the lymph before it is returned to the blood. Lymph nodes are not present in the central nervous system. There are three superficial regions on each side of the body where lymph nodes tend to cluster. These areas are the inguinal nodes in the groin, the axillary nodes in the armpit, and the cervical nodes in the neck.



Lymph node

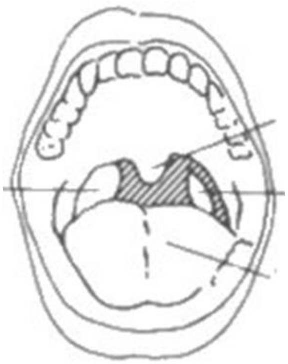
The typical lymph node is surrounded by a connective tissue capsule and divided into compartments called lymph nodules. The lymph nodules are dense masses of lymphocytes and macrophages and are separated by spaces called lymph sinuses. Several afferent lymphatic vessels, which carry lymph into the node, enter the node on the convex side. The lymph moves through the lymph sinuses and enters an efferent lymphatic vessel, which carries the lymph away from the node. Because there are more afferent vessels than efferent vessels, the passage of lymph through the sinuses is slowed down, which allow time for the cleansing process. The efferent vessel leaves the node at an indented region called the hilum.

Tonsils

Structure - Tonsils are clusters of lymphatic tissue just under the mucous membranes that line the nose, mouth, and throat (pharynx). There are three groups of tonsils.

Location - The pharyngeal tonsils are located near the opening of the nasal cavity into the pharynx. When these tonsils become enlarged they may interfere with breathing and are called adenoids. The palatine tonsils are the ones that are located near the opening of the oral cavity into the pharynx. Lingual tonsils are located on the posterior surface of the tongue, which also places them near the opening of the oral cavity into the pharynx.

Function - Lymphocytes and macrophages in the tonsils provide protection against harmful substances and pathogens that may enter the body through the nose or mouth.



Spleen

The spleen plays multiple supporting roles in the body. It acts as a filter for blood as part of the immune system. Old red blood cells are recycled in the spleen, and platelets and white blood cells are stored there. The spleen also helps fight certain kinds of bacteria that cause pneumonia and meningitis.

Since the spleen is involved in so many bodily functions, it is vulnerable to a wide range of disorders. However, the human body adapts well to life without this organ, so surgically removing a diseased or damaged spleen is possible without causing any serious harm to the person.

Location - The spleen is located in the upper left abdominal cavity, just beneath the diaphragm, and posterior to the stomach.

Structure - It is similar to a lymph node in shape and structure but it is much larger. The spleen is the largest lymphatic organ in the body. Surrounded by a connective tissue capsule, which extends inward to divide the organ into lobules, the spleen consists of two types of tissue called white pulp and red pulp. The white pulp is lymphatic tissue consisting mainly of lymphocytes around arteries. The red pulp consists of venous sinuses filled with blood and cords of lymphatic cells, such as lymphocytes and macrophages.

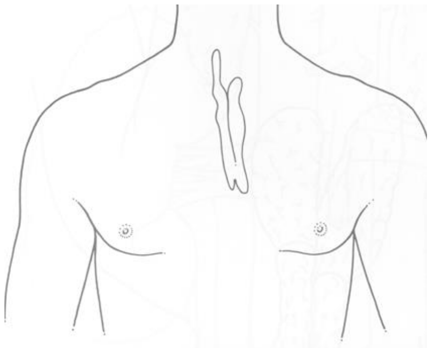
Function - The spleen, along with the liver, removes old and damaged erythrocytes from the circulating blood. The spleen filters the blood and removes abnormal cells (such as old and defective red blood cells), and it makes disease-fighting components of the immune system (including antibodies and lymphocytes).

Blood enters the spleen through the splenic artery, moves through the sinuses where it is filtered, then leaves through the splenic vein. Lymphocytes in the spleen react to pathogens in the blood and attempt to destroy them. Macrophages then engulf the resulting debris, the damaged cells, and the other large particles.

Like other lymphatic tissue, it produces lymphocytes, especially in response to invading pathogens. The sinuses in the spleen are a reservoir for blood. In emergencies such as hemorrhage, smooth muscle in the vessel walls and in the capsule of the spleen contracts. This squeezes the blood out of the spleen into the general circulation.

Thymus

The thymus is a soft organ with two lobes that is located anterior to the ascending aorta and posterior to the sternum. It is relatively large in infants and children but after puberty it begins to decrease in size so that in older adults it is quite small.



The primary function of the thymus is the processing and maturation of special lymphocytes called T-lymphocytes or T-cells. While in the thymus, the lymphocytes do not respond to pathogens and foreign agents. After the lymphocytes have matured, they enter the blood and go to other lymphatic organs where they help provide defence against disease. The thymus also produces a hormone, thymosin, which stimulates the maturation of lymphocytes in other lymphatic organs.

Health issues of the lymphatic system

The most common diseases of the lymphatic system are enlargement of the lymph nodes (also known as lymphadenopathy), swelling due to lymph node blockage (also known as lymphedema) and cancers.

When bacteria are recognised in the lymph fluid, the lymph nodes make more infection-fighting white blood cells, which can cause swelling. The swollen nodes can sometimes be felt in the neck, underarms and groin.

Lymphadenopathy is usually caused by infection, inflammation, or cancer. Infections that cause lymphadenopathy include bacterial infections such as strep throat, locally infected skin wounds, or viral infections such as mononucleosis or HIV infection.

The enlargement of the lymph nodes may be localised to the area of infection, as in strep throat, or more generalised as in HIV infection. In some areas of the body the enlarged lymph nodes are palpable, while others are too deep to feel and can be seen on CT scan or MRI.

Inflammatory or autoimmune conditions occur when a person's immune system is active, and can result in enlargement of lymph nodes. This can happen in lupus.

Lymphoma is cancer of the lymph nodes. It occurs when lymphocytes grow and multiply uncontrollably.

Castleman disease is a group of inflammatory disorders that cause lymph node enlargement and can result in multiple-organ dysfunction. While not specifically a cancer, it is a similar to a lymphoma and is often treated with chemotherapy. It can be unicentric (one lymph node) or multicentric, involving multiple lymph nodes.

Lymphangiomatosis is a disease involving multiple cysts or lesions formed from lymphatic vessels thought to be the result of a genetic mutation.

The Nervous System

Function

The nervous system is the major controlling, regulatory, and communicating system located throughout the body. It is the centre of all mental activity including thought, learning, and memory. **Together with the endocrine system, the nervous system is responsible for regulating and maintaining homeostasis.**

Through its receptors, the nervous system keeps us in touch with our environment, both external and internal.

Structure

Like other systems in the body, the nervous system is composed of organs, principally the brain, spinal cord, nerves and ganglia. These, in turn, consist of various tissues, including nerve, blood, and connective tissue. Together these carry out the complex activities of the nervous system.

The various activities of the nervous system can be grouped together as three general, overlapping functions:

1. Sensory
2. Integrative
3. Motor

Millions of sensory receptors detect changes, called stimuli, which occur inside and outside the body. They monitor such things as temperature, light, and sound from the external environment. Inside the body, the internal environment, receptors detect variations in pressure, pH, carbon dioxide concentration, and the levels of various electrolytes. All of this gathered information is called sensory input.

Sensory input is converted into electrical signals called nerve impulses that are transmitted to the brain. There the signals are brought together to create sensations, to produce thoughts, or to add to memory; Decisions are made each moment based on the sensory input. This is integration.

Based on the sensory input and integration, the nervous system responds by sending signals to muscles, causing them to contract, or to glands, causing them to produce secretions. Muscles and glands are called effectors because they cause an effect in response to directions from the nervous system. This is the motor output or motor function.

Although the nervous system is very complex, there are only two main types of cells in nerve tissue. The actual nerve cell is the neuron. It is the "conducting" cell that transmits impulses and the structural unit of the nervous system. The other type of cell is neuroglia, or glial, cell. The word "neuroglia" means "nerve glue." These cells are nonconductive and provide a support system for the neurons. They are a special type of "connective tissue" for the nervous system.

Neurons

Neurons, or nerve cells, carry out the functions of the nervous system by conducting nerve impulses. They are highly specialised and amitotic. This means that if a neuron is destroyed, it cannot be replaced because neurons do not go through mitosis. The image following illustrates the structure of a typical neuron.

Nerve cell

Each neuron has three basic parts: cell body (soma), one or more dendrites, and a single axon.

Cell body

In many ways, the cell body is similar to other types of cells. It has a nucleus with at least one nucleolus and contains many of the typical cytoplasmic organelles. It lacks centrioles, however. Because centrioles function in cell division, the fact that neurons lack these organelles is consistent with the amitotic nature of the cell.

Dendrites

Dendrites and axons are cytoplasmic extensions, or processes, that project from the cell body. They are sometimes referred to as fibres. Dendrites are usually, but not always, short and branching, which increases their surface area to receive signals from other neurons. The number of dendrites on a neuron varies. They are called afferent processes because they transmit impulses to the neuron cell body. There is only one axon that projects from each cell body. It is usually elongated and because it carries impulses away from the cell body, it is called an efferent process.

Axon

An axon may have infrequent branches called axon collaterals. Axons and axon collaterals terminate in many short branches or telodendria. The distal ends of the telodendria are slightly enlarged to form synaptic bulbs. Many axons are surrounded by a segmented, white, fatty substance called myelin or the myelin sheath. Myelinated fibres make up the white matter in the CNS, while cell bodies and unmyelinated fibres make the grey matter. The unmyelinated regions between the myelin segments are called the nodes of Ranvier.

In the peripheral nervous system, the myelin is produced by Schwann cells. The cytoplasm, nucleus, and outer cell membrane of the Schwann cell form a tight covering around the myelin and around the axon itself at the nodes of Ranvier. This covering is the neurilemma, which plays an important role in the regeneration of nerve fibres. In the CNS, oligodendrocytes produce myelin, but there is no neurilemma, which is why fibres within the CNS do not regenerate.

Functionally, neurons are classified as afferent, efferent, or interneurons (association neurons) according to the direction in which they transmit impulses relative to the central nervous system. Afferent, or sensory, neurons carry impulses from peripheral sense receptors to the CNS. They usually have long dendrites and relatively short axons. Efferent, or motor, neurons transmit impulses from the CNS to effector organs such as muscles and glands. Efferent neurons usually have short dendrites and long axons. Interneurons, or association neurons, are located entirely within the CNS in which they form the connecting link between the afferent and efferent neurons. They have short dendrites and may have either a short or long axon.

Neuroglia

Neuroglia cells do not conduct nerve impulses, but instead, they support, nourish, and protect the neurons. They are far more numerous than neurons and, unlike neurons, are capable of mitosis.

Organisation of the nervous system

Although terminology seems to indicate otherwise, there is really only one nervous system in the body. Although each subdivision of the system is also called a "nervous system," all of these smaller systems belong to the single, highly integrated nervous system. Each subdivision has structural and functional characteristics that distinguish it from the others. The nervous system as a whole is divided into two subdivisions: the central nervous system (CNS) and the peripheral nervous system (PNS).

The Central Nervous System (CNS)

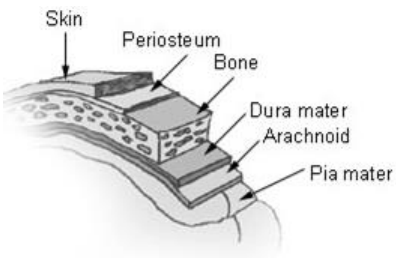
The brain and spinal cord are the organs of the central nervous system. Because they are so vitally important, the brain and spinal cord, located in the dorsal body cavity, are encased in bone for protection. The cranium surrounds the brain, and the vertebrae protect the spinal cord. The brain is in the cranial vault, and the spinal cord is in the vertebral canal of the vertebral column. Although considered to be two separate organs, the brain and spinal cord are continuous at the foramen magnum.

The brain is continuous with the spinal cord at the foramen magnum. In addition to bone, the CNS is surrounded by connective tissue membranes, called meninges, and by cerebrospinal fluid.

Meninges

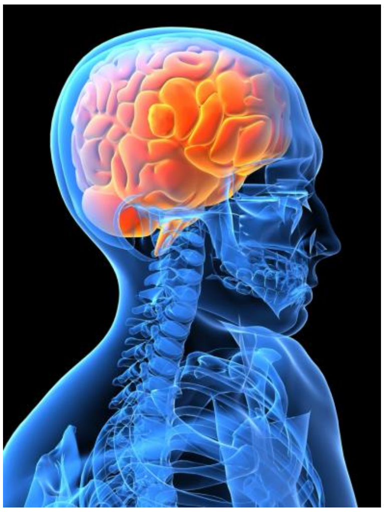
There are three layers of meninges around the brain and spinal cord. The outer layer, the dura mater, is tough white fibrous connective tissue. The middle layer of meninges is arachnoid, which resembles a cobweb in appearance, is a thin layer with numerous threadlike strands that attach it to the innermost layer. The space under the arachnoid, the subarachnoid space, is filled with cerebrospinal fluid and contains blood vessels. The pia mater is the innermost layer of meninges. This thin, delicate membrane is tightly bound to the surface of the brain and spinal cord and cannot be dissected away without damaging the surface.

Layers of the meninges



Brain

The brain is divided into 4 parts - the cerebrum, diencephalons, brain stem, and cerebellum.



1. Cerebrum

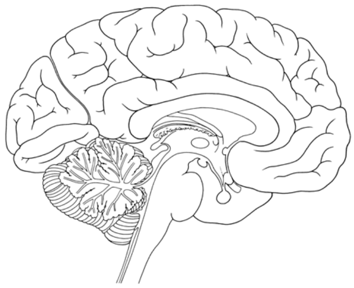
The largest and most obvious portion of the brain is the cerebrum, which is divided by a deep longitudinal fissure into two cerebral hemispheres. The two hemispheres are two separate entities but are connected by an arching band of white fibres, called the corpus callosum that provides a communication pathway between the two halves. Each cerebral hemisphere is divided into five lobes, four of which have the same name as the bone over them: the frontal lobe, the parietal lobe, the occipital lobe, and the temporal lobe. A fifth lobe, the insula or Island of Reil, lies deep within the lateral sulcus.

2. Diencephalon

The diencephalon is centrally located and is nearly surrounded by the cerebral hemispheres. It includes the thalamus, hypothalamus, and epithalamus. The thalamus, about 80 percent of the diencephalons, consists of two oval masses of grey matter that serve as relay stations for sensory impulses, except for the sense of smell, going to the cerebral cortex. The hypothalamus is a small region below the thalamus, which plays a key role in maintaining homeostasis because it regulates many visceral activities. The epithalamus is the most dorsal portion of the diencephalons. This small gland is involved with the onset of puberty and rhythmic cycles in the body. It is like a biological clock.

3. Brain stem

The brain stem is the region between the diencephalons and the spinal cord. It consists of three parts: midbrain, pons, and medulla oblongata. The midbrain is the most superior portion of the brain stem. The pons is the bulging middle fibres that form conduction tracts between the higher brain centres and spinal cord. The medulla oblongata, or simply medulla, extends inferiorly from the pons. It is continuous with the spinal cord at the foramen magnum. All the ascending (sensory) and descending (motor) nerve fibres connecting the brain and spinal cord pass through the medulla portion of the brain stem. This region primarily consists of nerve



4. Cerebellum

The cerebellum, the second largest portion of the brain, is located below the occipital lobes of the cerebrum. Three paired bundles of myelinated nerve fibres, called cerebellar peduncles, form communication pathways between the cerebellum and other parts of the central nervous system.

Ventricles and cerebrospinal fluid

A series of interconnected, fluid-filled cavities are found within the brain. These cavities are the ventricles of the brain, and the fluid is cerebrospinal fluid (CSF).

Spinal cord

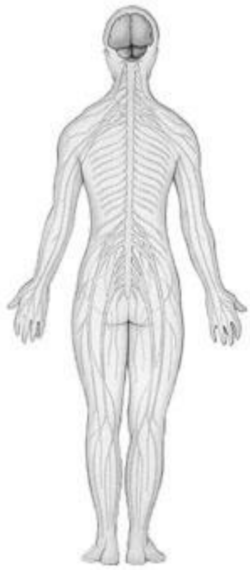
The spinal cord extends from the foramen magnum at the base of the skull to the level of the first lumbar vertebra. The cord is continuous with the medulla oblongata at the foramen magnum. Like the brain, the spinal cord is surrounded by bone, meninges, and cerebrospinal fluid.

The spinal cord is divided into 31 segments with each segment-giving rise to a pair of spinal nerves. At the distal end of the cord, many spinal nerves extend beyond the conus medullaris to form a collection that resembles a horse's tail. This is the cauda equina. In cross section, the spinal cord appears oval in shape.

The spinal cord has two main functions:

1) Serving as a conduction pathway for impulses going to and from the brain. Sensory impulses travel to the brain on ascending tracts in the cord. Motor impulses travel on descending tracts.
2) Serving as a reflex centre. The reflex arc is the functional unit of the nervous system. Reflexes are responses to stimuli that do not require conscious thought and consequently, they occur more quickly than reactions that require thought processes. For example, with the withdrawal reflex, the reflex action withdraws the affected part before you are aware of the pain. Many reflexes are mediated in the spinal cord without going to the higher brain centres.

The Peripheral Nervous System



Components - The organs of the peripheral nervous system are the *nerves and ganglia*. Nerves are bundles of nerve fibres, much like muscles are bundles of muscle fibres. The peripheral nervous system consists of the nerves that branch out from the brain and spinal cord. These nerves form the communication network between the CNS and the body parts.

Cranial nerves and spinal nerves extend from the CNS to peripheral organs such as *muscles and glands.* Ganglia are collections, or small knots, of nerve cell bodies outside the CNS.

Structure - The peripheral nervous system is subdivided into an *afferent (sensory) division and an efferent (motor) division.* The afferent or sensory division transmits impulses from peripheral organs to the CNS. The efferent or motor division transmits impulses from the CNS out to the peripheral organs to cause an effect or action.

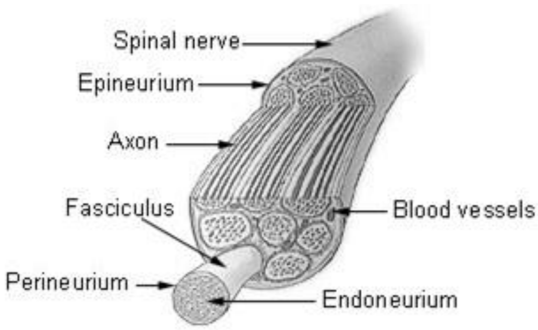
Finally, the efferent or motor division is again subdivided into the *somatic nervous system* and the *autonomic nervous system*.

The somatic nervous system, also called the somatomotor or somatic efferent nervous system, supplies motor impulses to the skeletal muscles. The somatic nervous system consists of nerves that go to the skin and muscles and is involved in conscious activities. Because these nerves permit conscious control of the skeletal muscles, it is sometimes called the voluntary nervous system.

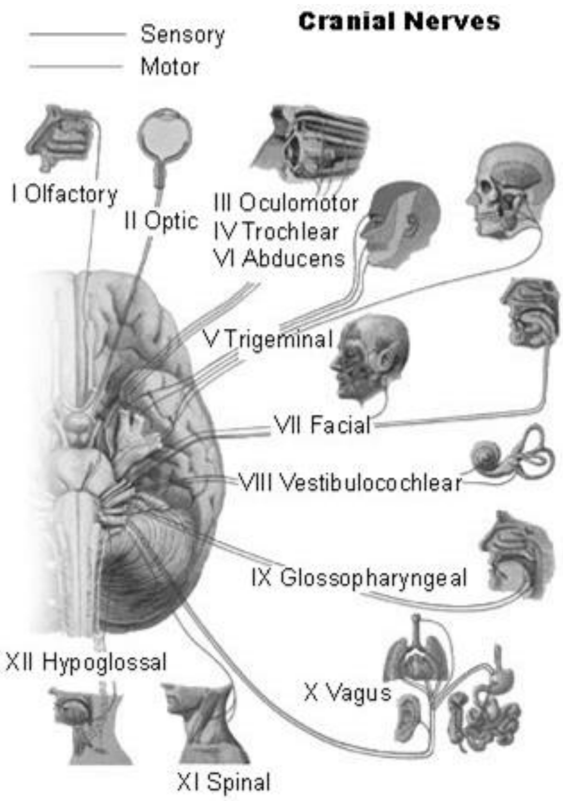
The autonomic nervous system, also called the visceral efferent nervous system, supplies motor impulses to cardiac muscle, to smooth muscle, and to glandular epithelium. The autonomic nervous system consists of nerves that connect the CNS to the visceral organs such as the heart, stomach, and intestines. It mediates unconscious activities. It is further subdivided into sympathetic and parasympathetic divisions. Because the autonomic nervous system regulates involuntary or automatic functions, it is called the involuntary nervous system.

Structure of a nerve

A nerve contains bundles of nerve fibres, either axons or dendrites, surrounded by connective tissue. Sensory nerves contain only afferent fibres, long dendrites of sensory neurons. Motor nerves have only efferent fibres, long axons of motor neurons. Mixed nerves contain both types of fibres. A connective tissue sheath called the epineurium surrounds each nerve. Each bundle of nerve fibres is called a fasciculus and is surrounded by a layer of connective tissue called the perineurium. Within the fasciculus, each individual nerve fibre, with its myelin and neurilemma, is surrounded by connective tissue called the endoneurium. A nerve may also have blood vessels enclosed in its connective tissue wrappings.



Cranial nerves



Twelve pairs of cranial nerves emerge from the inferior surface of the brain. All of these nerves, except the vagus nerve, pass through foramina of the skull to innervate structures in the head, neck, and facial region.

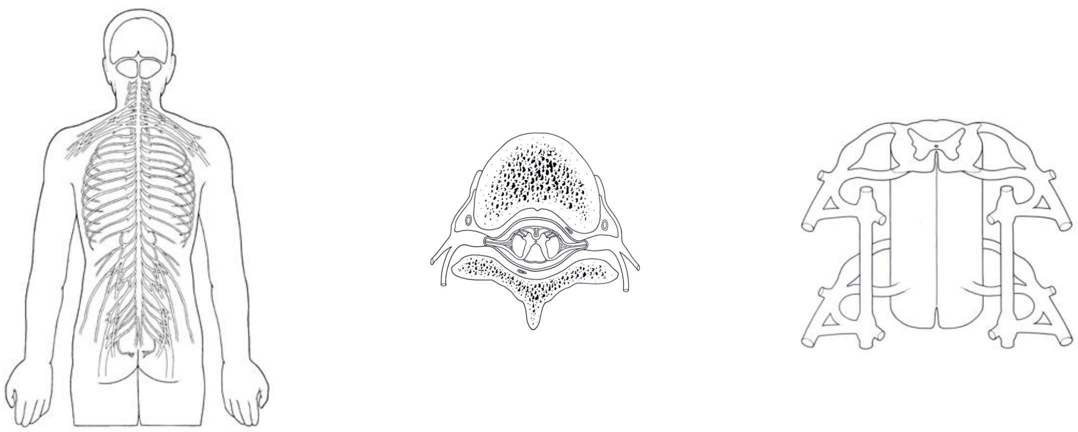
The cranial nerves are designated both by name and by Roman numerals, according to the order in which they appear on the inferior surface of the brain. Most of the nerves have both sensory and motor components. Three of the nerves are associated with the special senses of smell, vision, hearing, and equilibrium and have only sensory fibres. Five other nerves are primarily motor in function but do have some sensory fibres for proprioception. The remaining four nerves consist of significant amounts of both sensory and motor fibres.

Spinal nerves

Thirty-one pairs of spinal nerves emerge laterally from the spinal cord. Each pair of nerves corresponds to a segment of the cord and they are named accordingly. This means there are 8 cervical nerves, 12 thoracic nerves, 5 lumbar nerves, 5 sacral nerves, and 1 coccygeal nerve.

Each spinal nerve is connected to the spinal cord by a dorsal root and a ventral root. The cell bodies of the sensory neurons are in the dorsal root ganglion, but the motor neuron cell bodies are in the grey matter. The two roots join to form the spinal nerve just before the nerve leaves the vertebral column. Because all spinal nerves have both sensory and motor components, they are all mixed nerves.

Spinal nerves



Autonomic nervous system

The autonomic nervous system is a visceral efferent system, which means it sends motor impulses to the visceral organs. It functions automatically and continuously, without conscious effort, to innervate smooth muscle, cardiac muscle, and glands. It is concerned with heart rate, breathing rate, blood pressure, body temperature, and other visceral activities that work together to maintain homeostasis.

The autonomic nervous system has two parts, the sympathetic division and the parasympathetic division. Many visceral organs are supplied with fibres from both divisions. In this case, one stimulates and the other inhibits. This antagonistic functional relationship serves as a balance to help maintain homeostasis.

Health issues of the nervous system

Nerve related pain.

Epilepsy, in which abnormal electrical discharges from brain cells cause seizures

Parkinson's disease, which is a progressive nerve disease that affects movement

Multiple sclerosis (MS), in which the protective lining of the nerves is attacked by the body's immune system

Amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig's disease, is a motor neuron disease which weakens the muscles and progressively hampers physical function

Huntington's disease, which is an inherited condition that cause the nerve cells in the brain to degenerate

Alzheimer's disease, which covers a wide range of disorders that impacts mental functions, particularly memory.

The nervous system can also be affected by vascular disorders such as:

Stroke, which occurs when there is bleeding on the brain or the blow flow to the brain is obstructed;

Transient ischemic attack (TIA), which are mini-type strokes that last a shorter period of time but mimic stroke symptoms; and

Subarachnoid haemorrhage, which is specifically bleeding in the space between your brain and the surrounding membrane that can be the result of a trauma or rupturing of a weak blood vessel.

Infections such as meningitis, encephalitis, polio, and epidural abscess can also affect the nervous system.

The Immune System

Function

A complex system that is responsible for distinguishing us from everything foreign to us, and for protecting us against infections and foreign substances.

The immune system works to seek and kill invaders. A key part of the immune system's role is to differentiate between invaders and the body's own cells - when it fails to make this distinction, a reaction against 'self' cells and molecules causes autoimmune disease.

The inflammatory response (inflammation) is part of innate immunity. It occurs when tissues are injured by bacteria, trauma, toxins, heat or any other cause.

The immune system protects the body from potentially harmful substances by recognising and responding to antigens. Antigens are molecules (usually proteins) on the surface of cells, viruses, fungi, or bacteria. Nonliving substances such as toxins, chemicals, drugs, and foreign particles (such as a splinter) can be antigens. The immune system recognises and destroys substances that contain these antigens.

Even your own body cells have proteins that are antigens. These include a group of antigens called HLA antigens. Your immune system learns to see these antigens as normal and does not usually react against them.

Innate immunity

Innate, or non-specific, immunity is a defense system that you are born with. It protects you against all antigens. Innate immunity involves barriers that keep harmful materials from entering your body. These barriers form the first line of defense in the immune response.

Examples of anatomical innate immunity include:

- Cough reflex
- Enzymes in tears and skin oils
- Mucus, which traps bacteria and small particles
- Skin
- Stomach acid

Innate immunity also comes in a protein chemical form, called innate humoral immunity. Examples include: the body's complement system and substances called interferon and interleukin-1 (which causes fever).

If an antigen gets past these barriers, it is attacked and destroyed by other parts of the immune system.

Acquired immunity

Acquired immunity is immunity that develops with exposure to various antigens. Your immune system builds a defense that is specific to that antigen.

Passive immunity

Passive immunity involves antibodies that are produced in a body other than your own. Infants have passive immunity because they are born with antibodies that are transferred through the placenta from the mother. These antibodies disappear between 6 and 12 months of age.

Passive immunisation involves injection of antiserum, which contains antibodies that are formed by another person or animal. It provides immediate protection against an antigen, but does not provide long-lasting protection. Gamma globulin (given for hepatitis exposure) and tetanus antitoxin are examples of passive immunisation.

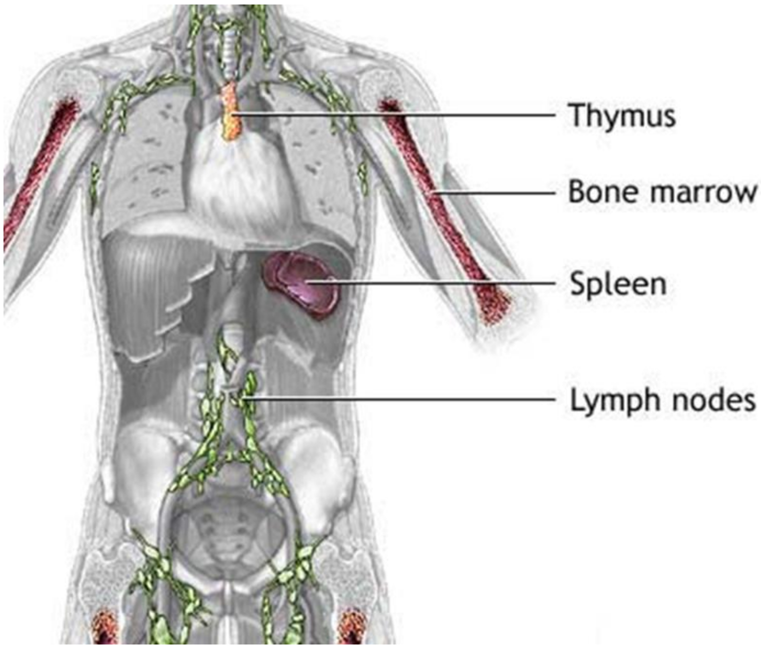
Inflammation

The inflammatory response (inflammation) occurs when tissues are injured by bacteria, trauma, toxins, heat, or any other cause. The damaged tissue releases chemicals including histamine, bradykinin, and serotonin. These chemicals cause blood vessels to leak fluid into the tissues, causing swelling. This helps isolate the foreign substance from further contact with body tissues.

The chemicals also attract white blood cells called phagocytes that "eat" micro-organisms and dead or damaged cells. This process is called phagocytosis. Phagocytes eventually die. Puss is formed from a collection of dead tissue, dead bacteria, and live and dead phagocytes.

Structure

Blood components



The immune system includes certain types of white blood cells. It also includes chemicals and proteins in the blood, such as antibodies, complement proteins, and interferon. Some of these directly attack foreign substances in the body, and others work together to help the immune system cells.

Lymphocytes are white blood cells, which includes B cells and T cells.

- B cells produce antibodies. Antibodies attach to a specific antigen and make it easier for the immune cells to destroy the antigen
- T cells attack antigens directly and help control of the immune response. They also release chemicals, known as interleukins, which control the entire immune response

As lymphocytes develop, they normally learn to tell the difference between your own body tissues and substances that are not normally found in your body. Once B cells and T cells are formed, a few of those cells will multiply and provide "memory" for the immune system. This allows the immune system to respond faster and more efficiently the next time you are exposed to the same antigen, and in many cases will prevent you from getting sick. For example, an individual who has had chickenpox or has been immunised against chickenpox is immune from getting chickenpox again.

Lymph nodes: Small, bean-shaped structures that produce and store cells that fight infection and disease and are part of the lymphatic system — which consists of bone marrow, spleen, thymus and lymph nodes. Lymph nodes also contain lymph, the clear fluid that carries those cells to different parts of the body. When the body is fighting infection, lymph nodes can become enlarged and feel sore.

Spleen: The largest lymphatic organ in the body, which is on your left side, under your ribs and above your stomach, contains white blood cells that fight infection or disease. The spleen also helps control the amount of blood in the body and disposes of old or damaged blood cells.

Health issues of the immune system

Disorders of the immune system can result in autoimmune diseases, inflammatory diseases and cancer.

Allergic diseases such as allergic rhinitis, asthma and eczema. Asthma and allergies also involve the immune system.

Other dysregulation of the immune system includes autoimmune diseases such as lupus and rheumatoid arthritis.

Common autoimmune diseases include Hashimoto's thyroiditis, rheumatoid arthritis, diabetes mellitus type 1 and systemic lupus erythematosus. Another disease considered to be an autoimmune disorder is myasthenia gravis (pronounced my-us-THEE-nee-uh GRAY-vis).

Immunodeficiency occurs when the immune system is not as strong as normal, resulting in recurring and life-threatening infections. In humans, immunodeficiency can either be the result of a genetic disease such as severe combined immunodeficiency, acquired conditions such as HIV/AIDS, or through the use of immunosuppressive medication.

The Special Senses

Smell

Smell is a chemical sense that is the result of molecules interacting with smell receptors located in the nasal cavity. The formal word for smell is olfaction and it refers to our ability to detect and identify odours that we come into contact with. The smell or olfactory receptors are covered by nasal mucosa, which continuously produce mucus secretions to wash the olfactory area surface in the nose. This prevents the same molecules constantly stimulating the olfactory cilia (the small hairs protruding from the olfactory receptors).

The cilia are the first stage of the olfactory or smell pathway. When stimulated they produce a nerve impulse that eventually travels to the brain. They travel along the olfactory tracts before diverging into two pathways.

The first pathway goes to the limbic system. This area of the brain allows us to remember and feel emotions. It is believed this is why we sometimes associate smells with emotions and memories.

The second pathway travels to the higher cortical areas of the frontal lobes. This connection to the cortex allows us to differentiate smells on a more logical or factual basis.

Taste

Taste is a sensory function of the central nervous system. It is a chemical sense caused by the interaction of food/drink molecules with taste receptors. The formal word for taste is gustation and it refers to the ability to detect the flavours of food and drink (or other objects) being dissolved in our mouths with the help of saliva.

As food is dissolved it comes into contact with our taste buds (specialised receptors on the surface of our tongue), soft palate, pharynx and epiglottis. Our taste buds are constantly renewed as the basal cells constantly produce new supporting cells which eventually develop into the gustatory or taste receptor cells.

The taste buds, once activated, stimulate the afferent neurone and pass the sensation of the taste through several cranial nerves into the brain. These impulses pass through the cranial nerve to: - medulla oblongata - limbic system - hypothalamus - thalamus - primary gustatory area.

The primary gustatory area allows conscious awareness of the taste, e.g. sweet, salty, sour or bitter.

How do taste and smell interact?

The four basic taste sensations are sweet, sour, bitter, and salty. When these tastes, along with texture, temperature, and information from the common chemical sense, combine with odours, the perception of flavour occurs. Flavour defines the food that is eaten, and is recognised mainly through the sense of smell.

Source: National Institute on Deafness and Other Communication Disorders

Vision and the eye

The eye provides us with sight. Our sense of sight is one of our most precious senses. Just think of the things you can see that bring you so much joy – the smiles of your children, the place you live, the places you have travelled to and watching your favourite football team. As we well know, life revolves around our eyes. Eye injuries do happen and can be very painful and serious. Accurate and immediate treatment can minimise pain and may help to prevent damage to the eye.

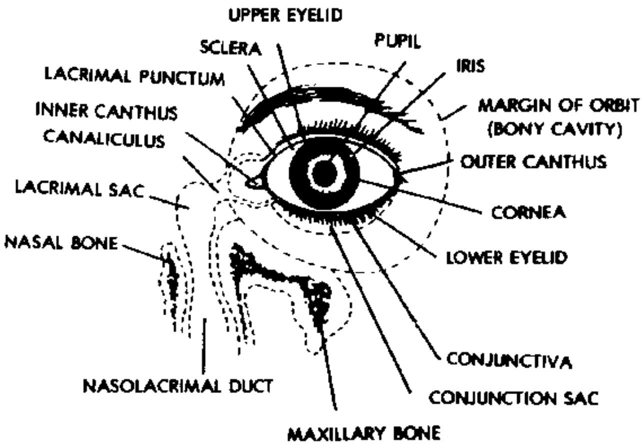
The eye

Each eyeball is positioned in a bony depression of the skull called the orbit. The orbit supports and protects the eye. The eye is also called oculus. The eye is approximately 1-inch in diameter, spherical in shape and is suspended within the bony orbit of the skull. The shape of the eye is maintained by a jelly-like mass called vitreous humour.

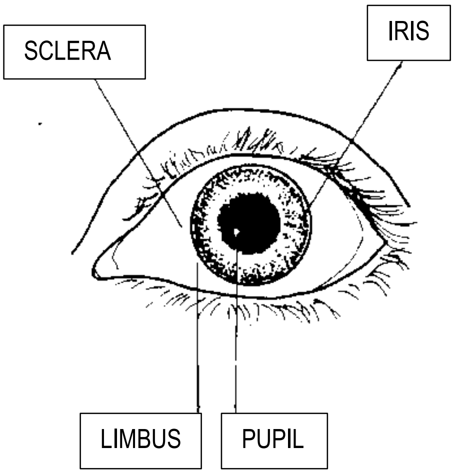
Abbreviations associated with the eye are:

- O.D. (oculus dexter) -- right eye
- O.S. (oculus sinister) -- left eye
- O.U. (oculus uterque) -- both eyes

External and accessory structures of the eye include the eyebrow, eyelid, eyelashes, lacrimal ducts and the conjunctiva.

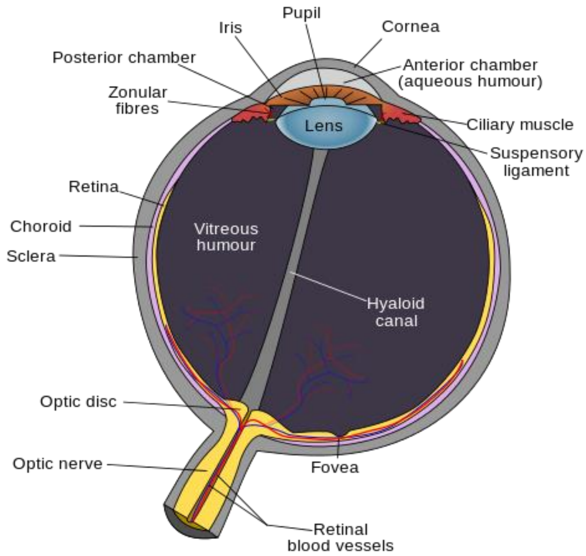


- The eyebrow protects the eyeball from:
  - falling objects
  - perspiration (sweat)
  - the direct rays of the sun
- The eyelid:
  - shades the eye during sleep
  - protects the eye from excessive light
  - protects the eye from foreign objects
  - spreads lubrication secretion over the eyeball
  - supports a row of eyelashes
- The eyelashes:
  - protect the eye from airborne particles (the upper eyelashes turn upwards and are long. The lower lid eyelashes turn downward and are short)
- The lacrimal ducts:
  - clean, lubricate and moisten the eyeball (the fluid is spread over the surface of the eye by blinking the eyelids)
- The conjunctiva, which is:
  - a delicate membrane that lines the eyelids and covers the outer surface of the eyeball



You should also know their location.

- Iris--the colour portion of the eye
- Pupil--the opening in the centre of the iris where light is permitted to enter
- Cornea--the normally transparent anterior surface of the eye
- Sclera-- the "white coat" of the eye
- Limbus-- the edge of the cornea where the cornea joins the sclera
- Inner/outer canthus--the angle formed by lids at either end of the eyelids
- Nasolacrimal duct--the channel where tears flow from the eye (lacrimal punctum) through the nose
- Conjunctiva--the thin, mucous, transparent membrane covering the front surface of the eye
- Conjunctival sac--the "bag" under the eye, beneath the eyelid
- Top/bottom eyelid--the movable fold of the skin forming the protective curtain over the eyeball
- Orbit--the bony cavity containing the eyeball



By Rhcastilhos – Schematic diagram of the human eye

Health issues of the eye

The most common problems with vision are near-sightedness (myopia), farsightedness, (hyperopia), a defect in the eye caused by nonspherical curvature (astigmatism) and age-related farsightedness (presbyopia).

Causes of blindness include cataracts (clouding of the lens), age-related macular degeneration (deterioration of the central retina), glaucoma (damage to the optic nerve), and diabetic retinopathy (damage to retinal blood vessels).

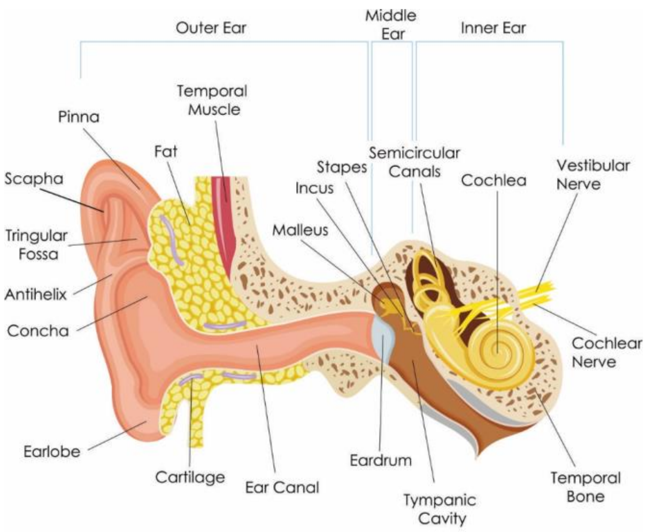
Other common disorders include amblyopia (lazy eye) and strabismus (crossed eyes).

The ear

The ear isn't just the hearing organ. It is a complex system of parts that not only allows humans to hear, but also makes it possible for humans to walk. The ear is often regarded as two important organs housed in one anatomical structure. **Hearing** is one of the organs in which sound waves are converted into nerve impulses. **Sense of balance** is the other organ that maintains the proper relationship between head positioning and motion.

Structure

Let's review the structure of the ear. The ear is divided into three parts: the external ear, the middle ear and the inner ear.



External ear: The external ear includes the outer ear (pinna), the auditory canal, and the eardrum. The pinna is the most prominent structure of the external ear. Its shape is maintained by cartilage. The auditory canal is the opening and the canal that runs from the pinna into the skull. This canal ends at the eardrum. The eardrum separates the inner end of the canal from the middle ear. The principal function of the external ear is the collection and conduction of sound waves to the middle and inner ear.

Middle ear: The middle ear (tympanic cavity) is an irregular space in the temporal bone filled with air and containing the three ossicles of the ear: malleus (hammer), incus (anvil), and stapes (stirrup). These bones conduct vibrations from the eardrum to the internal ear. The Eustachian tube connects the middle ear with the nasopharynx. Its principal function is to keep the air pressure equal on either side of the eardrum. It is also the avenue of infection by which disease spreads from the throat to the middle ear.

Inner ear: The inner ear contains receptors for hearing and equilibrium. The receptor for hearing lies within the cochlea. The cochlea is coiled and resembles a snail shell. Sound waves, which pass through the external auditory canal, vibrate the eardrum and ossicles, and are transmitted through the fluid of the inner ear. The inner ear also contains three circular canals that control equilibrium.

Eustachian tube

The Eustachian tube equalises the pressure between the middle ear and outer ear, that is, across both sides of the eardrum. If pressure on either side of the eardrum is unequal the membranes cannot vibrate and hearing is impaired. Abrupt pressure changes between the external and internal air can cause rupture of the eardrum. This can happen during the take-off or landing of an aeroplane.

The Eustachian tube opens when we swallow or yawn and allows atmospheric air to enter or leave the middle ear until the internal pressure equals the external pressure. Blowing your nose properly helps to equalise middle ear pressure.

Hearing and the ear

Sound waves result from alternate compression and decompression of air. They originate from a vibrating object, and travel through the air in much the same way as waves travel in water. Sound waves reach the ear and are trapped and directed by the pinna into the external auditory canal. When the waves hit the eardrum the alternate compression and decompression causes the membrane to vibrate.

The vibrations are picked up by the malleus and transmitted to the incus and then the stapes. As the stapes vibrates (moves back and forth) it pushes the oval window in and out. The movement of the oval window then sets up waves in the perilymph. The waves increase pressure and cause the hair cells of the organ of corti to move.

In some way (that we don't properly understand yet) the movement of the hairs stimulates the conversion of sound waves to nerve impulses. These impulses are then passed to the cochlear branch of the vestibulocochlear nerve in the brain.

Equilibrium

Equilibrium refers to balance and stability, and this sense relies on the structures of the inner ear.

There are two types of equilibrium that play different roles in maintaining homeostasis:

1. Static equilibrium
2. Dynamic equilibrium

Static equilibrium maintains posture against gravity when we are not moving. When the head moves against gravity the otolithic membrane shifts and the mechanoreceptors (hair cells) in the macula detect this movement and send messages along the vestibular nerve to the brain for interpretation. The brain is concerned with interpreting which way is up.

Dynamic equilibrium maintains posture when in motion e.g. riding in a car, or during bodily Movements e.g. playing tennis. The receptors for dynamic equilibrium are located in the semicircular canals. Each semicircular canal is a complex mechanoreceptor called a crista ampullaris which contains the mechanoreceptors (hair cells) for dynamic equilibrium; when the perilymph in one of the semicircular canals moves, the hair cells in the crista ampullaris are stimulated to send nerve impulses to the brain.

Health issues of the ear

Ears are delicate organs that can often have problems due to damage, bacteria or even changes in the environment.

Ear infections - Common symptoms of ear infections are drainage from the ear, hearing loss, earache, fever, headaches, pain in the ear and a feeling of fullness in the ear.

Meniere's disease a disease of the inner ear that may be the result of fluid problems inside the ear. Symptoms include hearing loss, pressure or pain, dizziness and tinnitus.

Tinnitus is a roaring in the ears. It can also be caused by loud noises, medicines or a variety of other causes.

Ear barotrauma is an injury to the ear due to changes in barometric or water pressure. It typically occurs during flights in an airplane, traveling to places at high altitudes or diving into deep waters. Symptoms include pain, stuffy ears, hearing loss and dizziness. Barotrauma can usually be fixed by “popping” the ears by yawning, chewing gum or trying to blow outward while keeping the nose pinched and mouth closed.

Ear wax, also called cerumen, has antibacterial properties and also lubricates and protects the ear. Normal amounts shouldn't bother most people, though sometimes, wax can build up and should be removed.

Hearing typically declines with age naturally, though damage to the ear can cause hearing loss at a very young age.

MAINTAINING A HEALTHY BODY

Body functions

Body functions are the physiological or psychological functions of body systems. The body's functions are ultimately its cells' functions. Survival is the body's most important business. Survival depends on the body's maintaining or restoring homeostasis, a state of relative constancy, of its internal environment.

Homeostasis depends on the body's ceaselessly carrying on many activities. Its major activities or functions are responding to changes in the body's environment, exchanging materials between the environment and cells, metabolising foods, and integrating all of the body's diverse activities. The body's ability to perform many of its functions changes gradually over the years. In general, the body performs its functions least well at both ends of life - in infancy and in old age. During childhood, body functions gradually become more and more efficient and effective. During late maturity and old age the opposite is true. They gradually become less and less efficient and effective. During young adulthood, they normally operate with maximum efficiency and effectiveness.

Life process

All living organisms have certain characteristics that distinguish them from non-living forms. The basic processes of life include organisation, metabolism, responsiveness, movements, and reproduction. In humans, who represent the most complex from of life, there are additional requirements such as growth, differentiation, respiration, digestion, and excretion. All of these processes are interrelated. No part of the body, from the smallest cell to a complete body system, works in isolation. All function together, in fine-tuned balance, for the wellbeing of the individual and to maintain life. Disease such as cancer and death represent a disruption of the balance in these processes.

The following is a brief description of the life process:

Organisation

At all levels of the organisational scheme, there is a division of labour. Each component has its own job to perform in cooperation with others. Even a single cell, if it loses its integrity or organisation, will die.

Metabolism

Metabolism is a broad term that includes all the chemical reactions that occur in the body. One phase of metabolism is catabolism in which complex substances are broken down into simpler building blocks and energy is released.

Responsiveness

Responsiveness or irritability is concerned with detecting changes in the internal or external environments and reacting to that change. It is the act of sensing a stimulus and responding to it.

Movement

There are many types of movement within the body. On the cellular level, molecules move from one place to another. Blood moves from one part of the body to another. The diaphragm moves with every breath. The ability of muscle fibres to shorten and thus to produce movement is called contractility.

Reproduction

For most people, reproduction refers to the formation of a new person, the birth of a baby. In this way, life is transmitted from one generation to the next through reproduction of the organism. In a broader sense, reproduction also refers to the formation of new cells for the replacement and repair of old cells as well as for growth. This is cellular reproduction. Both are essential to the survival of the human race.

Growth

Growth refers to an increase in size either through an increase in the number of cells or through an increase in the size of each individual cell. In order for growth to occur, anabolic processes must occur at a faster rate than catabolic processes.

Differentiation

Differentiation is a developmental process by which unspecialised cells change into specialised cells with distinctive structural and functional characteristics. Through differentiation, cells develop into tissues and organs.

Respiration

Respiration refers to all the processes involved in the exchange of oxygen and carbon dioxide between the cells and the external environment. It includes ventilation, the diffusion of oxygen and carbon dioxide, and the transport of the gases in the blood. Cellular respiration deals with the cell's utilisation of oxygen and release of carbon dioxide in its metabolism.

Digestion

Digestion is the process of breaking down complex ingested foods into simple molecules that can be absorbed into the blood and utilised by the body.

Excretion

Excretion is the process that removes the waste products of digestion and metabolism from the body. It gets rid of by-products that the body is unable to use, many of which are toxic and incompatible with life.

The ten life processes described above are not enough to ensure the survival of the individual. In addition to these processes, life depends on certain physical factors from the environment. These include water, oxygen, nutrients, heat, and pressure.

It is important to apply the knowledge you have gained about the major body systems and understand that they do not work in isolation. Know the components of each body system and their location in relation to the other major body systems.

Healthy body functions

Factors that support healthy functioning of the body

Work with a basic understanding of how to maintain the whole body in an overall state of health. A basic understanding of the relationships between body systems is required to support healthy functioning.

Processes, conditions and resources (factors) the body needs to support healthy functioning may include but are not limited to:

1. Body regulation including:
   - maintenance of body temperature
   - body fluids (including e.g. absorption of water from digestive system, loss of water through skin, distribution of water by cardiovascular system)
   - elimination of wastes from the body
   - maintenance of blood pressure
2. Protection from infection
3. Physical activity (exercise) - active and passive

Homeostasis

The *Macquarie Dictionary* defines homeostasis as the 'physiological equilibrium within living creatures involving a balance of functions and chemical composition'. In other words, it occurs when the internal environment of the body remains in a state of balance.

In order for homeostasis to be maintained the body is required to:

1. Maintain optimal levels of nutrients, fluid, gases and ions
2. Maintain optimal temperature
3. Maintain optimal pressure for cell function
4. Have sufficient sleep

If homeostasis equates to the body's good health it is understandable that when it can't be maintained the body is at risk of illness or even death. However, homeostasis is constantly being challenged within the body. The body's internal environment, and subsequently homeostasis, is constantly being disturbed. These disturbances or imbalances are caused by stressors. These stressors might be mild or severe, short term or long term, known or unknown and their impact will vary amongst individuals.

Feedback

When confronted by stressors the body uses mechanisms to cope with the disruption and restore balance. These are called feedback systems and they can either be negative or positive.

Negative feedback systems

This system reverses the effect of the stressor. For example, if the body temperature lowers, the body will attempt to reverse the drop in temperature by shivering as a means of raising the temperature to normal again.

Positive feedback systems

Positive feedback systems usually reinforce conditions that do not happen very often, for example, childbirth. The stressor or stimuli would begin with the contractions which push the baby into the cervix. This causes internal stretching which sends nerve impulses to the brain asking it to release oxytocins. The uterus contracts more forcefully and the baby's body stretches the cervix more, which in turn releases more oxytocins and the cycle continues. Positive feedback systems usually continue until there is a break in the cycle e.g. the birth of the baby or medicine.

Vital signs

Vital signs are used to measure the body's basic functions. The normal ranges for a person's vital signs vary with age, weight, gender, and overall health. There are four primary vital signs: pulse (heart rate); breathing rate (respiratory rate); blood pressure and body temperature (not shown in the table below, a separate table is on the next page).

VITAL SIGNS AT REST	AGE	PULSE (per minute)		RESPIRATIONS (breathing rate per minute)		BLOOD PRESSURE (MM HG)
		Range	Average	Range	Average	Average
	1 month -1 year	90 - 140	120	25 - 40	30	80 / 60
	1 year – 5 years	80 - 120	100	20 - 30	25	95 / 65
	5 - 13 years	70 - 110	90	15 - 25	20	100 / 65
	13 - 18 years	60 - 105	80	12 - 20	16	115 / 75
	Adult	60 - 100	70	12 - 15	14	110 / 60

Blood pressure

Blood flows through the body to service the body tissues constantly, which is vital for our survival. How much blood flows and the force of the flow depends on the pressure. Blood pressure increases and decreases depending on the location in the body. It is highest at the aorta and decreases as it gets further away.

Blood pressure is also dependant on the amount or volume of blood in the body. The body can sustain small losses of blood. However, if the body experiences a decrease in blood volume by 10% or more then blood pressure will drop. Conversely, if the body retains fluid, blood volume can increase and so too will blood pressure.

Blood pressure (BP), skin colour, blood loss and shock:

There are several indicators or signs to help assess a casualty's blood pressure. A simple test is to press and release pressure on a fingernail or skin.

- **Normal or adequate blood pressure** - A person is said to have an adequate blood pressure if the colour immediately returns when you press and release;
- **Inadequate blood pressure** - If the area is still pale after 2 seconds, this indicates their blood pressure is low, which may be a cause for concern.

Inadequate blood pressure could indicate **blood loss**. When a person loses blood, the blood pressure falls and the casualty will have pale, cold, clammy skin. The pulse is usually faster than normal and they may become thirsty. Another good indicator of blood loss is the colour of the tongue. If it's pale, it means blood loss. These are also signs and symptoms of **shock.**

- **Pale skin colour** - A person who has suffered significant blood loss will be pale (so will their tongue).
- **Blue skin colour** - If the oxygen levels are reduced, they could have a blue colour to the ear lobes, lips and fingers.

Low blood pressure can result in insufficient blood flow to vital organs and therefore inadequate oxygen and nutrients reaching vital organs and cells. This could result in organ damage.

Low blood pressure might result in:

- Unconsciousness
- Light-headedness, when standing from a sitting or lying position
- Unsteadiness
- Dizziness
- Weakness
- Blurred vision
- Fatigue
- Fainting

Chronic (ongoing, long-term) high blood pressure can result in:

- Heart attack
- Heart failure
- Stroke or 'mini stroke' – Transient Ischemic Attack (TIA)
- Kidney failure
- Eye damage with loss of vision
- Peripheral arterial disease
- Outpouchings of the aorta, called aneurysms

High blood pressure can cause:

- Headache
- Dizziness
- Blurred vision
- Nausea

Optimal body temperature

Humans are warm-blooded and maintain a near-constant body temperature (36.2° C – 37.6°C). Maintaining temperature (thermoregulation) is an important aspect of human homeostasis. In the human body, heat is mainly produced by the liver and when muscles contract.

High temperatures pose great danger for humans as it puts serious stress on the body and can result in injury or death. If body temperature reaches extremes of 45°C it can cause an individual's metabolism to stop and could ultimately result in death. Increased temperatures cause the body to perspire/sweat in an attempt to cool the body. This also results in a loss of fluids which is why it is important to keep fluids up when presented with increased temperature.

Similarly abnormally low temperatures can be dangerous and even life threatening. Shivering is the body's way of dealing with low temperatures as muscles involuntarily contract in order to produce heat and increase temperature.

When temperatures are low blood vessels contract sending less blood to the skin in an effort to preserve heat for more vital areas. In extreme cases (hypothermia) the subject will need to be hospitalised. In less extreme cases the subject can be warmed with blankets and hot fluids e.g. soup.

- **Normal human body temperature** is 36.2 – 37.6 °C, with **37°C** being stated as the **average normal temperature**.
- **Fever** - The body attempts to maintain a normal temperature. When that set-point is raised, the result is a fever. Fevers are not to be confused with heat stroke. Note: The difference between fever and hyperthermia is the underlying mechanism. A fever is usually a response to infection and can be lowered with medications.

	Average body temperatures		Common signs and symptoms
COLD	Medical emergency	<32°C	Hallucinations, delirium, complete confusion, extreme sleepiness, progressively becoming comatose. Shivering is absent (may even think they are hot). Reflex absent or very slight.
	Hypothermia	<35°C	Intense shivering, numbness, bluish/grey skin. *Seek medical help.*
	Normal Average	**37 °C**	**Varies, depending on time of day, activity and mode of measurement.**
	Fever	>37°C	Feeling hot, sweating, feeling thirsty, chills. *Seek medical help.*
	Hyperthermia	>38°C	Severe sweating, may be flushed and red or pallor with dry skin. Fast heart rate, breathlessness. Possible convulsions. *Seek medical help.*
HOT	Medical emergency	>41°C	Fainting, vomiting, severe headache, dizziness, confusion, hallucinations, delirium, drowsiness. May become comatose, convulsions, brain damage, cardiac arrest.

Optimal levels of fluid and pressure

Maintaining the volume and composition of bodily fluids is essential for homeostasis. Bodily fluids are the dilute, watery solutions found in 2 types of fluid compartments – 1. Inside cells (**intracellular fluid**) and 2. Surrounding them (**extracellular fluid**).

Cells rely on intracellular fluid containing oxygen, nutrients, proteins and a variety of ions to maintain life.

The extracellular fluid that surrounds all cells (interstitial fluid) is constantly changing as it provides the cells of the body with nutrients and offers a means of waste disposal as well. Approximately 2/3 body water is intracellular. Extracellular water divided mostly between plasma and interstitial fluid.

Body fluids are composed of solutes. There are 2 types of solutes – 1. Electrolytes and 2. Non-electrolytes.

The movement of fluids between compartments is dependent upon - 1. Osmotic pressure (related to the amount of electrolytes) and 2.Hydrostatic pressure (related to the volume of fluids)

Osmoregulation refers to the regulation of the osmotic pressure of bodily fluids to maintain the body's water content and thus homeostasis. Osmoregulation keeps the body's fluids from becoming too dilute or too concentrated.

Osmotic pressure is a measure of the tendency of water to move into one solution from another by osmosis. The higher the osmotic pressure of a solution the more water wants to go into the solution.

The kidneys are essential for regulating the volume and composition of bodily fluids. The kidneys are the organ responsible for removing excess ions from the blood, thus affecting the osmotic pressure. These are then expelled as urine.

Body water varies based on of age, gender, mass (body fat) and body composition.

For example - Water decreases with age and leaner people have a higher proportion of water.

BODY WATER	AGE	WATER PERCENTAGE (approximate)
		% OF BODY WEIGHT
	Baby - child	73% (Low body fat. Low bone mass)
	Adult - male	60%
	Adult - female	50%
	Elderly	45%

Correct body water balance - Water and sodium regulation are integrated to defend the body against all possible disturbances in the volume and Osmotic concentration (osmolarity) of bodily fluids. Examples of such disturbances - dehydration, blood loss, salt ingestion and plain water ingestion.

Osmotic concentration (osmolarity) - the measure of solute concentration, defined as the number of osmoles (Osm) of solute per litre (L) of solution (osmol/L or Osm/L). (The concentration of a solution expressed as the total number of solute particles per litre).

Water balance is achieved by ensuring that the amount of water consumed in food and drink (and generated by metabolism) equals the amount of water excreted i.e. what is going in, should be equal to what is going out.

The consumption side is regulated by behavioural mechanisms, including thirst and salt cravings. While almost a litre of water per day is lost through the skin, lungs, and faeces, the kidneys are the major site of regulated excretion of water.

Sources of water intake – Liquids (60%); Food (30%) and Metabolic water (10%).

Sources of water loss – Urine (60%); Skin/Lungs (28%); Sweat (8%) and Faeces (4%).

The kidneys can directly control the volume of bodily fluids by the amount of water excreted in the urine. The kidneys either conserve water by producing urine that is concentrated relative to plasma, or they rid the body of excess water by producing urine that is dilute relative to plasma.

Direct control of water excretion in the kidneys is exercised by vasopressin, or anti-diuretic hormone (ADH), a peptide hormone secreted by the hypothalamus. ADH causes the insertion of water channels into the membranes of cells lining the collecting ducts, allowing water reabsorption to occur. Without ADH, little water is reabsorbed in the collecting ducts and dilute urine is excreted.

ADH secretion is influenced by several factors (note that anything that stimulates ADH secretion also stimulates thirst):

1. By special receptors in the hypothalamus that are sensitive to increasing plasma osmolarity (when the plasma gets too concentrated). These stimulate ADH secretion.
2. By stretch receptors in the atria of the heart, which are activated by a larger than normal volume of blood returning to the heart from the veins. These inhibit ADH secretion, because the body wants to rid itself of the excess fluid volume.
3. By stretch receptors in the aorta and carotid arteries, which are stimulated when blood pressure falls. These stimulate ADH secretion, because the body wants to maintain enough volume to generate the blood pressure necessary to deliver blood to the tissues.

Sodium balance - In addition to regulating total volume, the osmotic concentration (the amount of solute per unit volume) of bodily fluids is also tightly regulated. Extreme variation in osmotic concentration causes cells to shrink or swell, damaging or destroying cellular structure and disrupting normal cellular function.

Regulation of osmotic concentration is achieved by balancing the intake and excretion of sodium with that of water. The regulation of osmotic concentration must be integrated with regulation of volume, because changes in water volume alone have diluting or concentrating effects on the bodily fluids. For example, when dehydrated, proportionately more water is lost than solute (sodium), so the osmotic concentration of bodily fluids increases. In this situation the body must conserve water but not sodium, thus stemming the rise in osmotic concentration. If a large amount of blood is lost due to trauma or surgery, the loss of sodium and water are proportionate to the composition of bodily fluids. In this situation the body should conserve both water and sodium.

As noted, ADH plays a role in lowering osmotic concentration (reducing sodium concentration) by increasing water reabsorption in the kidneys, thus helping to dilute bodily fluids. To prevent osmotic concentration from decreasing below normal, the kidneys also have a regulated mechanism for reabsorbing sodium in the distal nephron. This mechanism is controlled by aldosterone**,** a steroid hormone produced by the adrenal cortex.

Electrolytes

Any fluid that conducts electricity, such as a saltwater solution, is known as an electrolyte solution: the salt ions of which it's composed are then commonly referred to as electrolytes.

There are several common electrolytes found in the body, each serving a specific and important role, but most are in some part responsible for maintaining the balance of fluids between the intracellular (inside the cell) and extracellular (outside the cell) environments. **This balance is vitally important for things like hydration, nerve impulses, muscle function and pH level.**

An electrolyte imbalance, (too much or too little), can be detrimental to health. Muscle contraction, for example, requires calcium, potassium and sodium; deficiency may result in muscle weakness or severe cramping. Too much sodium, on the other hand, can cause high blood pressure and significantly increase your risk of heart disease. Luckily, electrolyte levels are mostly determined by food and water consumption so keeping the right balance simply comes down to proper nutrition.

There are 8 major electrolytes in 2 groups:

Anions:

1. Bicarbonate (HCO_3^-)
2. Chloride (Cl^-)
3. Phosphate (HPO_4^{-}–)
4. Sulphate

Cations:

5. Sodium (Na^+)
6. Potassium (K^+)
7. Calcium (Ca^{++})
8. Magnesium (Mg^{++})

Each plays a critical role in keeping the body running well, but the key thing to note is that they function in a very specific balance. The reason it is so important to know just what electrolytes do is because most people don't realise that it's all in the balance. Disrupting the equilibrium to either toxic or deficient levels can have disastrous effects. Increasing incidence of hypertension and heart disease all over the world can be attributed to the rising occurrences of sodium imbalances.

The solution is simple – eat a healthy, natural diet.

PH balance

The body maintains a delicate acid-alkaline balance. pH stands for *potential hydrogen*, or *power of hydrogen* - a measurement of the hydrogen ion concentration in the body. **The total pH scale ranges from 1 to 14, with 7 considered to be neutral**. A pH less than 7 is said to be acidic and solutions with a pH greater than 7 are basic or alkaline.

Proper pH varies throughout the body for many reasons. For example, the bowels, skin and vagina should be slightly acidic– this helps keep unfriendly bacteria away. Saliva is more alkaline, while urine is normally more acidic, especially in the morning. In addition, the body regularly deals with naturally occurring acids that are the by-products of respiration, metabolism, cellular breakdown and exercise. So clearly the goal is not to think of acid as "bad" and alkaline "good."

By far the most important measurement is your blood. **For optimal cellular health, blood pH must be slightly alkaline with a pH between 7.365 and 7.45.** Our bodies are programmed to maintain this range no matter what, since even the slightest dip or rise in pH can have seriously dangerous consequences.

pH levels can be tested by using a piece of litmus paper in saliva or urine first thing in the morning before eating or drinking anything.

Acidic substances and foods include meat, dairy, highly processed food products and refined sugar. Environmental toxins can be acidic, which are hard to avoid.

Tips on maintaining general health

Maintain pH levels

Some research claims our bodies can self-correct in the presence of acidic materials with no negative health impact—however other studies suggests our bodies have to work harder to neutralise the acidic load, resulting in a gradual decline in health. Further research is needed, but we do know that high acid diets are associated with gout and kidney stones, so it seems likely there's something to the whole pH and food connection.

Protection from infection

This is not always possible as you are always going to be exposed to germs and other molecules that could make you ill. However, you can increase your strength of defence by following the general health tips.

Some ways your body tries to protect itself from infection:

1. The lymphatic system has infection fighting white cells
2. The integumentary system – skin covers the whole body and is the first line of defence for the immune system
3. The Immune system - A complex system that is responsible for protecting us from everything foreign

You can also reduce your risk of infection by:

1. Maintaining good personal hygiene e.g. wash your hands regularly and or use anti-bacterial hand washes.
2. Use personal protective equipment such as gloves and or face masks for situations that pose risks in both professional and personal situations.
3. Avoid contact with those that have infectious diseases.

Eat well

We have discussed the nutrients that the body needs to support and maintain cell function. We obtain these nutrients through our food so a balanced diet provides you with a variety of vitamins and minerals and other nutrients needed for the healthy functioning of your body.

Active and passive physical activity

Passive physical activity – There is no substitution for getting your body up and moving daily via such activity as walking, swimming, biking, jogging, hiking, tennis, basketball or even lifting weights or walking a treadmill in a gym. However, due to physical challenges, illness, age limitations, time restrictions and weather factors, many people simply cannot or do not get their body moving every day. Many people spend their day commuting, working, raising a family, sitting in front of a computer or TV, or sleeping.

Passive physical activity is where movement applied to the body or a body part, by another person or persons (physiotherapy), or via a motion machine. When a passive range of motion is applied, the body or body part (arm, leg, head, ankle, wrist, knee), of the individual receiving the passive exercise is completely relaxed, while the outside force moves the body part throughout the available range of motion.

Exercise (active physical activity) - Regular exercise, for example, 30 minutes 3 times a week, will help to:

- Increase your endurance
- Maintain healthier muscles, joints and bones
- Increase cardiovascular fitness
- Prevent disease
- Increase your metabolism
- Provide increased energy
- Increase overall well being
- Increaser ability to cope with stress
- Improve quality of and ability to sleep

Aerobic exercise - Physical activity long in duration, low in intensity - rhythmic and repetitive for the purpose of conditioning or strengthening any part of the body. Aerobic means "with air", emphasis placed on the oxygen in the air. Muscles need oxygen to function. Aerobic activity continually supplies enough oxygen to the exercising muscles for the duration of the activity.

Benefits - Aerobic exercise conditions the heart, blood vessels and cardiovascular system (lungs), by increasing the oxygen available to the body and by enabling the heart to use oxygen more efficiently. Regular aerobic exercise releases endorphins, the body's natural painkillers.

Activities include bicycling, brisk walking, dancing, swimming, rowing, soccer, skating and cross country skiing.

Anaerobic Exercise - Physical activity short in duration, high in intensity - general level of intensity too great to allow enough oxygen into the body to burn fat for energy. The body then switches to burning stored fuels such as glycogen and small amounts of carbohydrate stored in muscles. Since we only store about 2 minutes worth of anaerobic energy, anaerobic activity usually lasts a short time or becomes stop and go as we tire faster.

Benefits - Anaerobic benefits determine how well a workout strengthens and develops muscles.

Anaerobic activities includes weight lifting, racquetball, downhill skiing, tennis, martial arts and sprinting.

Keep the mind active - Research suggests memory loss can be improved by 30 to 50 per cent simply by doing mental exercises. The brain is like a muscle - if you don't give it regular workouts, its functions will decline. Suggestions include:

- Keep up your social life and engage in plenty of stimulating conversations.
- Read newspapers, magazines and books.
- Play 'thinking' games like Scrabble, cards and Trivial Pursuit.
- Take a course on a subject that interests you.
- Cultivate a new hobby.
- Learn a language.
- Do crossword puzzles and word games.
- Play games that challenge the intellect and memory, such as chess.
- Watch 'question and answer' game shows on television, and play along with the contestants.
- Hobbies such as woodwork can improve the brain's spatial awareness.
- Keep stress under control with meditation and regular relaxation, since an excess of stress hormones like cortisol can be harmful to neurones.
- Stay curious and involved — commit to lifelong learning.
- Attend lectures and plays.
- Enroll in courses at your local adult education center, community college or other community group.
- Garden.
- Try memory exercises.

Get enough sleep (passive activity)

Sleep allows the body to repair itself physically and psychologically. It allows for new information to be integrated with previously learned information. The optimal amount of sleep for most people is about eight hours per twenty four hours.

Reduce stress and exposure to stressors

Stressors are any stimuli that disturb homeostasis. These might be:

- Physical e.g. hunger, thirst fatigue
- Psychological e.g. work pressure, relationship problems
- Sociological e.g. poor living conditions

Too much stress can suppress the body's immune system and threaten homeostasis. Too much stress makes you prone to illness and disease. Stress can be reduced by eliminating the stressor or reducing exposure to it. It can also be reduced by undertaking some relaxing pastimes such as meditation, going to a movie or gentle exercise to suggest a few.

Just as too much stress can be hard on the body so can too little. Too little stress can also lead to disease so it is important to keep active and stimulated without becoming over stressed.

Protect your body - Principles of good biomechanics

To protect your back:

- Have a wide base of support: your feet well-spaced, keep your centre of gravity low and between your feet
- Know what you're lifting, how much it weighs and get a good grip before you lift
- Maintain the back in a neutral posture i.e. avoid twisting, bending forwards or bending backwards
- Keep the load close to the body so your body isn't acting like a lever, increasing the force and stress on the body
- Use the stronger larger muscles of your legs to create force where possible – they are better equipped to cope with the load. For example, when pushing – start the movement from your legs, not from your back
- Smooth movements are less likely to result in injury than jerky, fast or sharp movements
- Your back is more stable if you engage your stomach muscles and back muscles to support the back before moving

To protect shoulders and wrists:

- The shoulder is at its strongest and safest when the upper arm is close to the side of the body. When reaching above shoulder height, below knee height, forwards or backwards, there is increased risk of injury to the shoulder
- Avoid twisting through the shoulder, forearm or wrist
- Avoid holding one position for long periods of time. This creates static loading on the muscles and increases risk of injury
- Avoid repetitive movement
- Avoid long distance carrying

Body postures

Posture is more than just sitting or standing up straight.

While posture includes positions when the body is still, it also refers to moving positions, such as reaching to grasp something or bending or picking up something.

Since backs are not straight, but have 3 curves, it is better to think of alignment of the back and the maintenance of these normal curves.

A good posture involves working with the spine with the following curves:

- A slight inward curve at the neck
- An outward curve between the shoulder blades and
- An inward curve in the lower back

Appropriate posture and handling techniques are used to reduce muscle load on exertion and reduce the possibility of injury.

What does good posture do?

Good posture allows the pressure to be distributed over the areas that are able to tolerate it most effectively. Key to safe lifting is to keep the back 'S' curve in its natural position. Poor posture usually results in your spine taking on a 'C' shape.

Nerve roots branch out through the spaces between each vertebra and when the spine bends these nerves become more exposed and vulnerable. When you flex the discs are compressed. The outer layer of a disc is not designed for heavy load bearing. As discs have minimal nerves supply they can be damaged over time and not provide any warning that damage is occurring. Damage to discs can cause them to bulge or tear. This increases pressure on ligaments and nerves which causes back pain.

Trunk (spine) positions

Trunk side flexion & rotation

The trunk or back is in a neutral position when you are standing in a straight posture with your shoulders aligned over your hips and feet, with your head level and facing straight ahead. Trunk or back flexion is when you are bending forwards. Trunk or back extension is when you are bending backwards.

The human body prefers to be in a neutral posture where possible. It is when the body is in postures away from neutral postures that the risk of injury increases.

Trunk side flexion & rotation

- Neutral posture (shoulders aligned over hips and toes) = decreased risk of injury
- Awkward postures (bending sideways or twisting) = increased risk of injury

Trunk flexion & extension

Trunk flexion and extension

- Neutral posture (standing straight) = decreased risk of injury
- Awkward postures (bending forwards/backwards) = increased risk of injury
- Sideways flexion occurs when you are bending sideways (i.e. one shoulder is lower than the other)
- Rotation is when you are twisting through your spine. An easy way to spot this is when your shoulders or head is facing a different direction than your hips or feet

Wrist positions

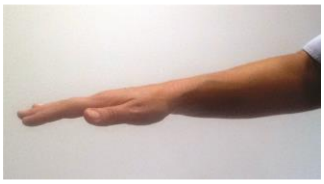
Your wrist is in a neutral position when the hand and forearm are aligned.

- Extension occurs when your hand moves upwards = increased risk of injury
- Flexion is when your hand moves downwards = increased risk of injury
- Neutral posture (hand in line with forearm) = decreased risk of injury

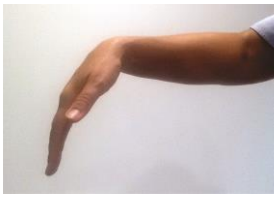
The wrist is in its strongest position when it is in a neutral posture. If a work task requires the wrist to be in extension or flexion, the risk of injury increases.

WRIST

Extension



Neutral



Flexion

Hand & forearm positions

The **neutral** posture for the forearm is the *handshake* position, when your arm is at the midpoint between the palm facing up and palm facing down. This neutral posture is also called the power position, as when in this posture, the forearm is at its strongest.

Pronation is the term for when your palm faces down.

Supination is the term for when your palm faces up.

When in the extremes of pronation or supination, the muscles of the forearm and hand are not able to work in their ideal position and thus are at increased risk of injury, as they do not have the same strength compared to being in the neutral posture.

- Pronation - when your palm faces down = increased risk of injury
- Neutral posture - hand at mid-range/handshake position = decreased risk of injury
- Supination - palm faces up = increased risk of injury

HAND AND FOREARM

Pronation

Neutral

Supination

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