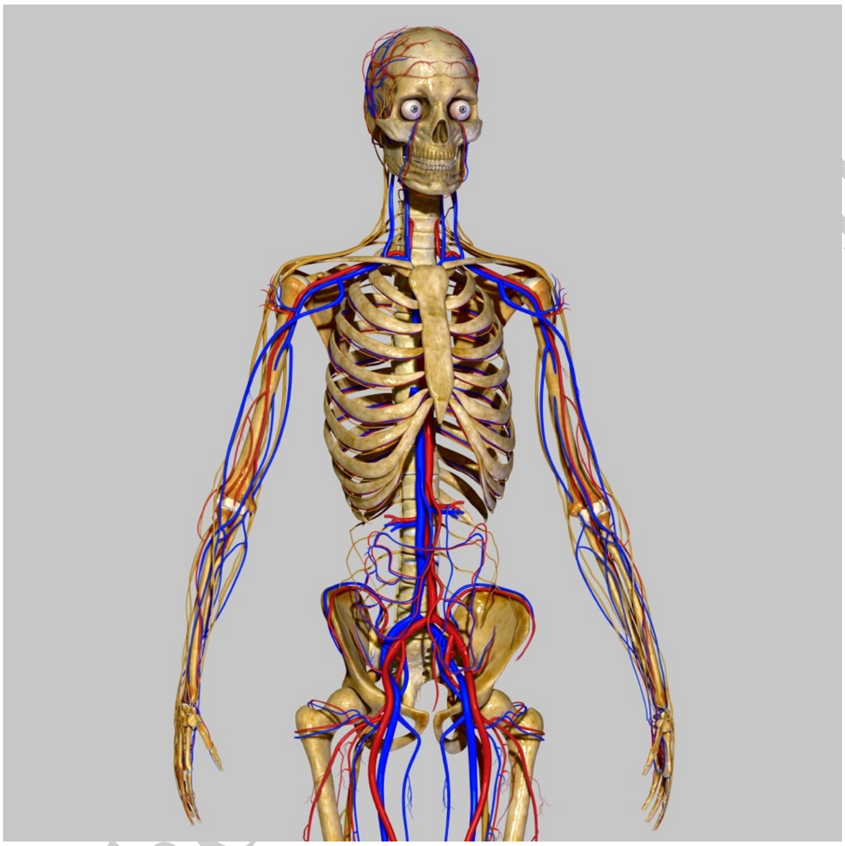
Anatomy & Physiology
For Yoga Teachers and Health Practitioners



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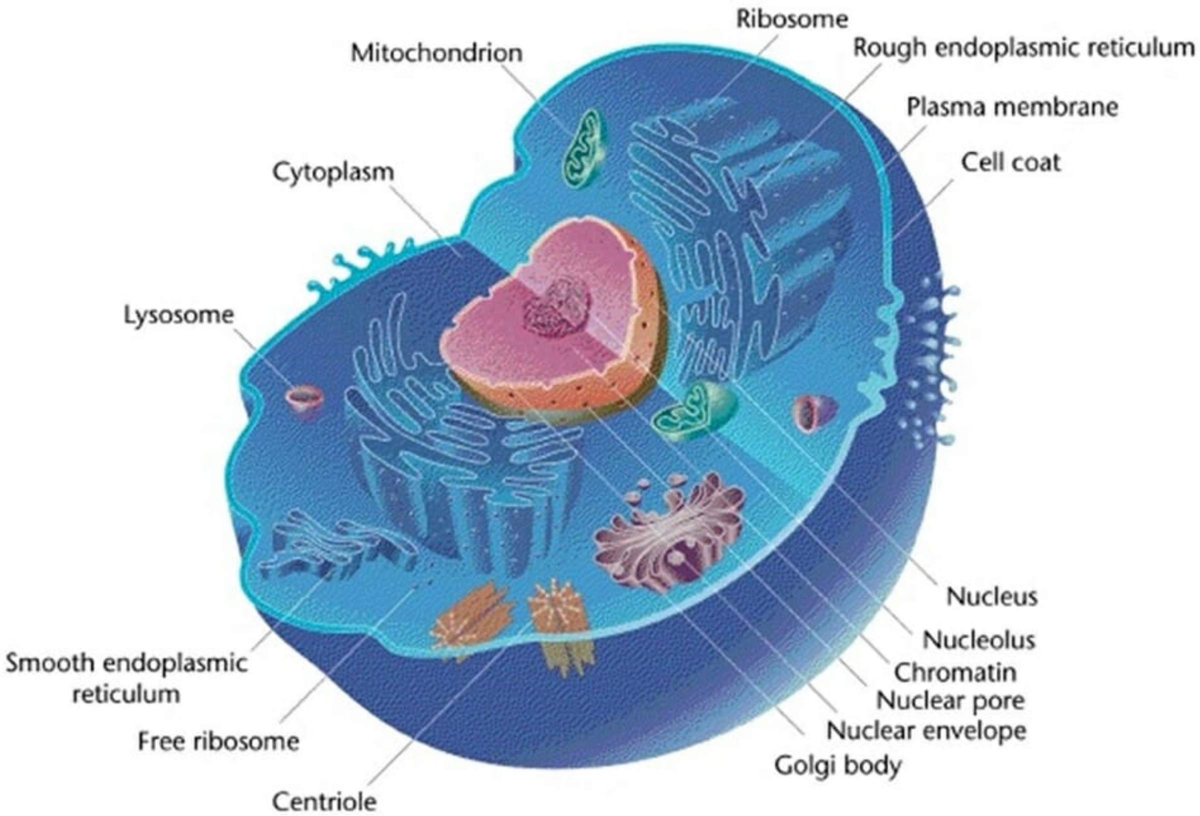
Cells & Tissues

The human body is a complex organism made up of many structures. Before we begin to look at the systems that allow us to function, we need to have a basic understanding of how it all works.

Our bodies are made up of small structures that all work together. The most basic, simplest unit in our body are cells, which are made from molecules.

Cells can be referred to as the basic building blocks of life (think of lego) and are the smallest structure able to carry out a living process. They contain information that determines what we look like, and some would say how we behave. There are many types of cells, such as red and white blood cells. A cell is surrounded by a cell membrane and the cell contains many components which are called organelles. The function of a cell is to allow for growth, respiration, irritability, movement, metabolism, excretion and reproduction.

A collection of cells of the same type makes a tissue. The cell is protected by the cell membrane, which also allows substances to travel in and out of the cell. The nucleus is in the centre of the cell, which carries out a unique function of storing the genes. It acts like the brain of the cell and controls many functions. The cytoplasm is the fluid that fills the cell and holds the organelles of the cell, such as the mitochondria and chloroplasts. Inside the cell is a dynamic structure called the matrix, which can change from solid to fluid and back again.

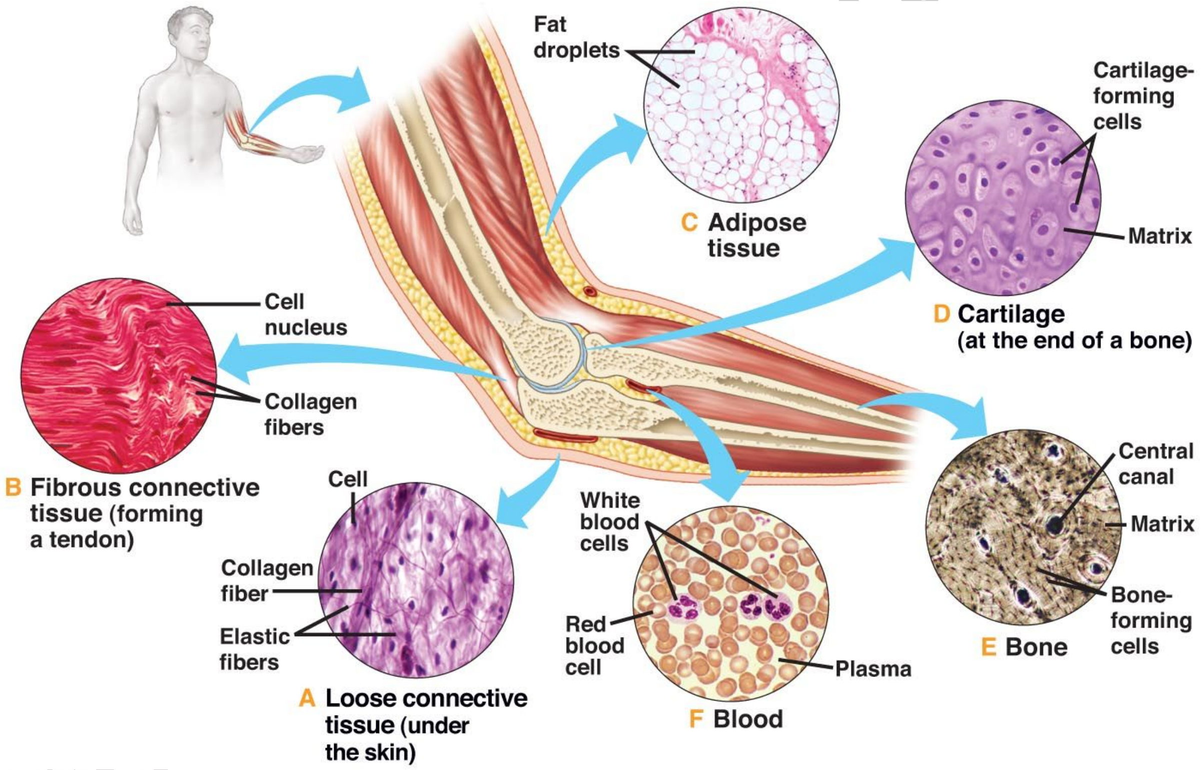


Tissues are made up of a collection of cells and are more complex in nature. There are four basic types of tissue; muscles, nervous, connective and epithelial tissue. Each type forms a different function. For example epithelial tissue provides a covering (skin), and blood is a major type of connective tissue. A collection of several different forms of tissue which carry out a special function, make up an organ.

Organs are even more complex than tissues and contain at least two different tissue types that carry out a function. For example; the skin is an organ as it contains epithelial tissue and connective tissue. There are many organs in the body such as the kidneys, lungs and stomach. A collection of organs, arranged to carry out a specific function will make a system.

Systems are by far the most complex component of the human body and are made up of varying organs, designed to carry out a function. For example; the circulatory system contains the heart and vessels and is organised to be able to pump oxygenated blood around the body. A collection of systems makes a human body, and it is now that we need to start to consider how one system will affect another, very much like a car being made up of several components.

Now we know how the body is made we can start looking at systems in more depth.



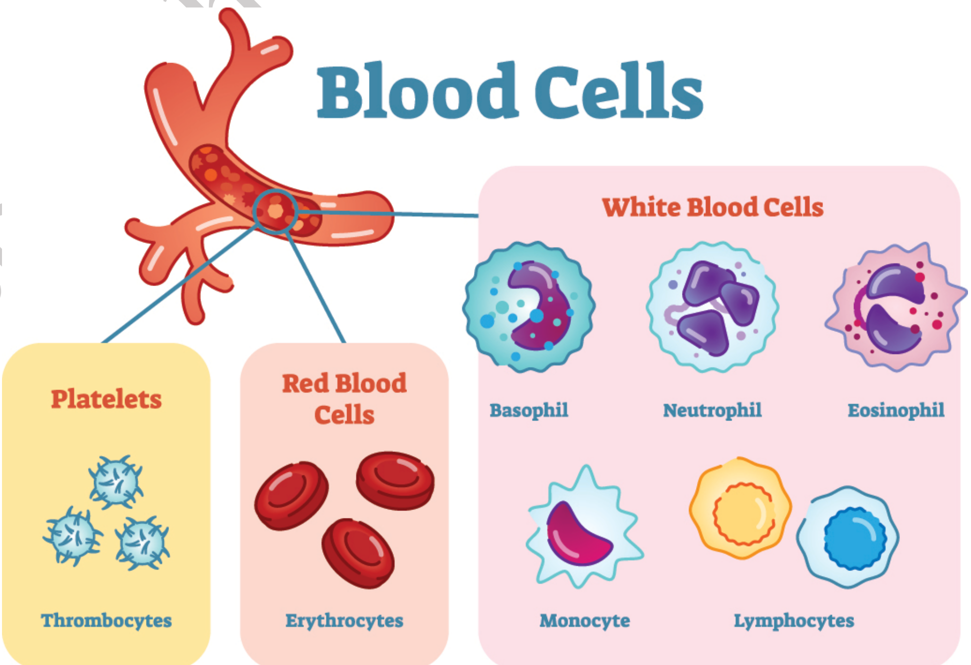
The Circulatory System

The main functions of this system are to supply oxygenated blood throughout the body, and to remove waste products, such as carbon dioxide. It is able to carry out this task by using three organs; the blood, vessels and the heart.

Blood

If we think of the circulatory system as a transportation service, then the blood would be the bus. Carrying and distributing oxygen, nutrients, antibodies, heat and hormones, it travels through the body, whilst also collecting waste products, such as carbon dioxide, which need to be removed. Its main functions are therefore protection, heat regulation, clotting and transportation. The blood is made up of 4 components, plasma, erythrocytes, leucocytes and thrombocytes, and an adult has 10.6 pints. It is one of the major types of connective tissue.

Plasma is a straw coloured fluid and accounts for about half of the total volume of blood. It is necessary for the suspension of blood cells and is made up of 90% water. The major protein in plasma is albumin which prevents fluid from leaking out of the blood vessels into tissues. Plasma also supplies water when additional liquids are needed in the tissues of the body, as well as play a crucial role in regulating the body temperature by carrying heat around the body. The Plasma contains dissolved substances, most of these are useful and are carried to places where they are to be stored or used. The products of digestion including glucose, amino acids, mineral salts and vitamins are carried from the small intestines (ileum) to other organs. Without plasma, the life-giving blood cells would be left without transportation.
Red blood cells (erythrocytes) carry oxygen, which is needed by the cells to produce energy, and are formed in the bone marrow of long bones. They are the most common type of blood cell and live for around 12o days and make up around 40% of the bloods volume. These blood cells contain protein chemical called haemoglobin which is bright red in colour. Haemoglobin allows the oxygen to be collected in the lungs by binding its molecules with the oxygen and then distributes it around the body. Carbon dioxide is then collected to allow it to be removed. If you have a lack of haemoglobin, you may develop a condition called anaemia.



White blood cells (leucocytes) are involved in the protection of the body and are on the continual look out for any sign of bacteria. There are five main types of white blood cells which all have a differing role. The white blood cells that are most numerous are Neutrophils which kill and ingest foreign material. Lymphocytes help protect against viral infections and produce antibodies. Monocytes ingest dead and damaged cells, Eosinophils protect by killing parasites and destroying some cancer cells as well as being involved in the allergic response, as well as the basophils.

White blood cells have a shorter life expectancy than red, only surviving for about 3 weeks. A drop of blood can contain anywhere from 7,000 to 25,000 white blood cells at a time. If an invading infection fights back and persists, that number will significantly increase.

Platelets, also called thrombocytes are necessary for the blood clotting process to take place. They are irregularly-shaped and colourless and have a sticky surface that lets them form clots to stop bleeding. When you cut yourself, platelets in the blood react to the air and calcium, vitamin K, and a protein called fibrinogen are released. This forms a blood clot, which seals or plug's the hole and later on becomes a scab. A scab is an external blood clot that we can easily see, but there are also internal blood clots. A bruise, or black-and-blue mark, is the result of a blood clot. Clotting is necessary, but sometimes it can be very dangerous as if a blood clot forms inside of a blood vessel, it can block the flow of blood, cutting off the supply of oxygen.

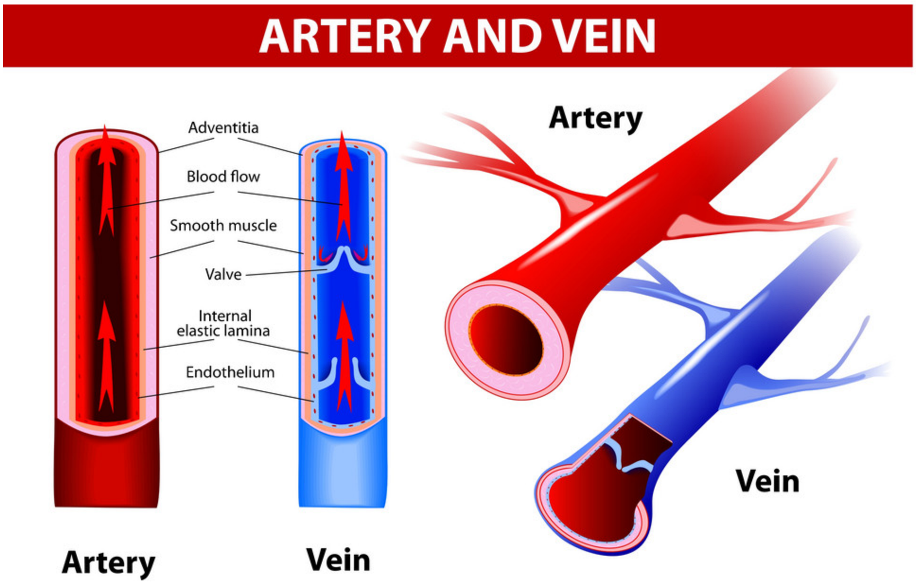
Blood Vessels

If the blood acts as a bus, then the blood vessels are road networks that it travels along. There are three main vessels, and the blood follows two pathways known as pulmonary and systemic.

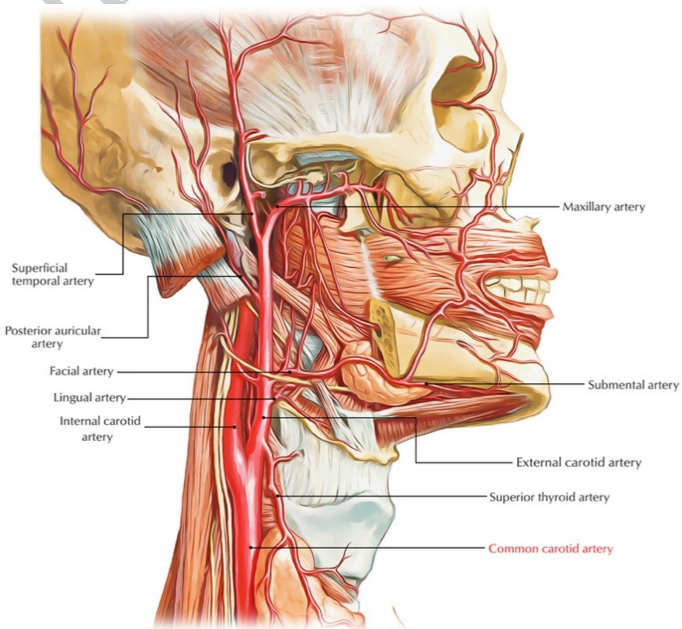
Arteries always carry blood away from the heart, with the exception of the pulmonary artery (we will look at that later). They are the biggest of the vessels and carry oxygenated blood. The walls of the artery are muscular and elastic which helps allow the blood to travel the body. The largest artery of the body is the aorta which originates from the heart, and branches out into smaller arteries. The smallest arteries are called arterioles which branch into capillaries. An artery has three layers. An outer layers of tissue a muscular middle and an inner layer of epithelial cells. There are two types of arteries. Pulmonary arteries carry blood from the heart to the lungs and systemic arteries carry blood to the rest of the body. The smallest arteries are called arterioles and deal with delivering blood from the arteries to the capillaries. Sometimes, pulmonary circulation is referred to. This means blood is circulated from the heart to the lungs and back to the heart. Arteries are found deep in the tissues to prevent damage.
Veins carry deoxygenated blood to the heart, under low pressure, in order for it to get sent to the lungs. Veins contain valves, which act like doors - preventing the blood from flowing in the wrong direction. The largest vein is the vena cava which leads to the right atrium of the heart. Veins also have three layers: an outer layer of tissue, muscle in the middle, and a smooth inner layer of epithelial cells, but the layers are thinner and contain less tissue. Because it lacks oxygen, the blood that flows through the veins has a deep red colour. The walls of the veins are rather thin which makes the blood visible through the skin on some parts of the body, such as the hands, wrists and ankles. As the skin refracts light, the deep red colour actually appears a little blue from outside the skin. Veins can be classified into four different types. Pulmonary veins carry blood from the lungs to the left atrium of the heart. Systemic veins carry deoxygenated blood from the remainder of the body to the right atrium of the heart. Superficial veins are to be found close to the surface of the skin and deep veins are located deep within muscle tissues.

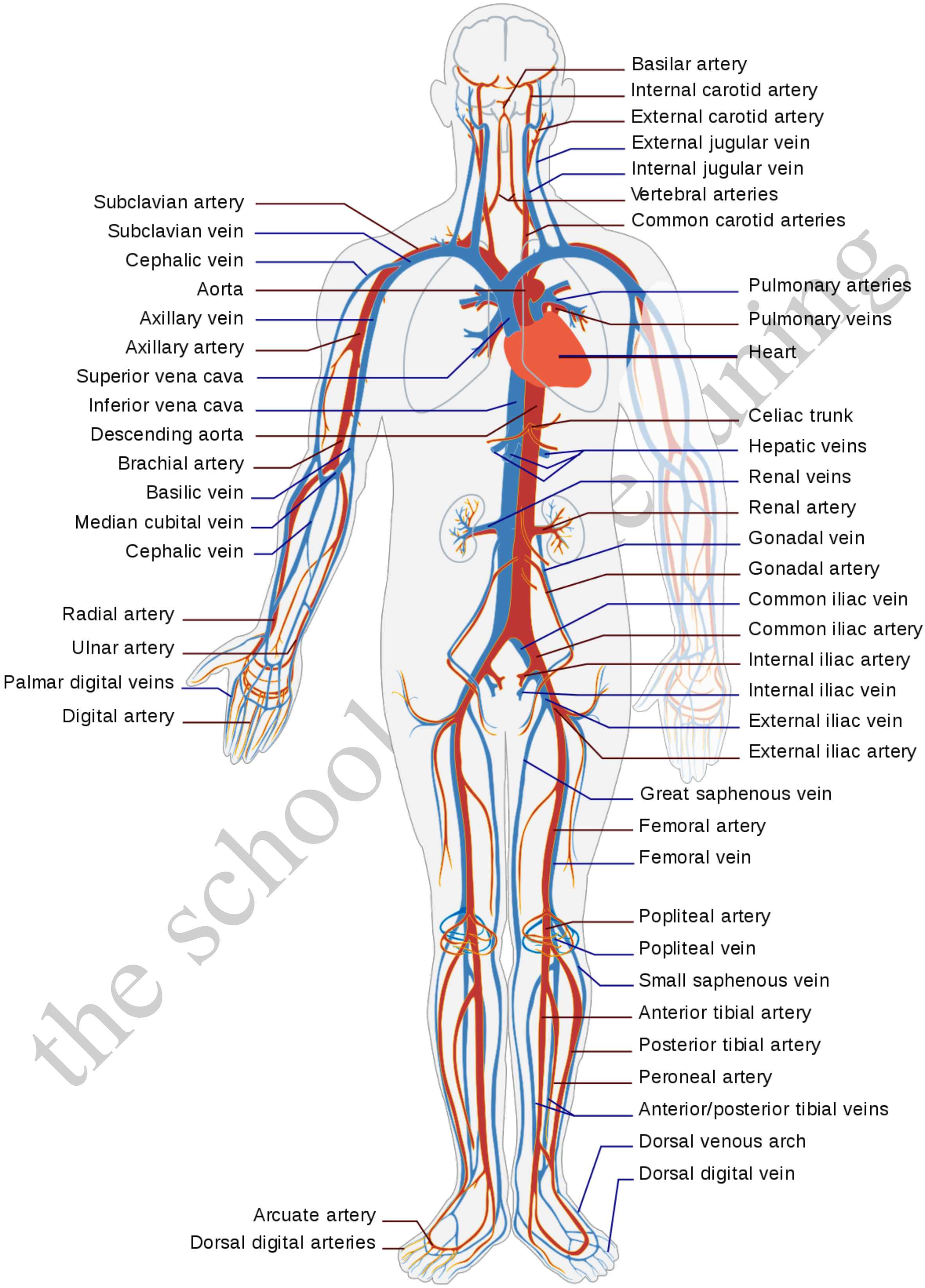
Capillaries are very small vessels that transport blood from the arteries to the veins. They have thin walls, made up of endothelium (single layer of overlapping flat cells) that allows substances such as nutrients to exchange. The capillaries are so small that red blood cells have to travel through them in single file. The flow of blood through the capillaries is controlled by structures called precapillary sphincters, which are located between arterioles and capillaries. They contain muscle fibres that allow them to contract. Blood flows freely to the capillary beds of body tissue when the sphincters are open, but when the sphincters are closed blood is not allowed to flow. Plasma moves out of the capillaries and becomes tissue fluid. This fluid bathes the cells in nutrients and oxygen, some waste and excess fluids move into the lymphatic vessels, with the carbon dioxide and waste returning to the capillaries.

Diagram of a vein and an artery



Arteries of the neck





Basilar artery
Internal carotid artery
External carotid artery
External jugular vein
Internal jugular vein
Vertebral arteries
Common carotid arteries
Subclavian artery
Subclavian vein
Cephalic vein
Aorta
Axillary vein
Axillary artery
Superior vena cava
Inferior vena cava
Descending aorta
Brachial artery
Basilic vein
Median cubital vein
Cephalic vein
Pulmonary arteries
Pulmonary veins
Heart
Celiac trunk
Hepatic veins
Renal veins
Renal artery
Gonadal vein
Gonadal artery
Common iliac vein
Common iliac artery
Internal iliac artery
Internal iliac vein
External iliac vein
External iliac artery
Radial artery
Ulnar artery
Palmar digital veins
Digital artery
Great saphenous vein
Femoral artery
Femoral vein
Popliteal artery
Popliteal vein
Small saphenous vein
Anterior tibial artery
Posterior tibial artery
Peroneal artery
Anterior/posterior tibial veins
Dorsal venous arch
Dorsal digital vein
Arcuate artery
Dorsal digital arteries

The Heart

The heart is a muscular organ that is primarily a shell containing 4 chambers, which are the right and left atrium and the right and left ventricle. Its main function is to act as a pump and maintain a constant circulation of blood around the body.

The Right Atrium
This chamber receives de-oxygenated blood from the body through the superior vena cava (head and upper body) and inferior vena cava (legs and lower torso). An impulse is sent via the sinoatrial node, which causes the cardiac muscle tissue of the atrium to contract, allowing the tricuspid valve, which separates the right atrium from the right ventricle to open. This allows the de-oxygenated blood which has collected in the right atrium to flow into the right ventricle.

The Right Ventricle
This chamber receives de-oxygenated blood from the atrium as it contracts. The pulmonary valve leading into the pulmonary artery is closed which allows the ventricle to fill with blood, then to contract. As this contraction occurs, the tricuspid valve closes and the pulmonary valve opens. The closure of the tricuspid valve prevents blood from backing into the right atrium and the opening of the pulmonary valve allows the blood to flow into the pulmonary artery toward the lungs.

The Left Atrium
This chamber receives the newly oxygenated blood from the lungs through the pulmonary vein. A contraction triggered by the sinoatrial node progresses through the atrium and the blood passes through the mitral valve into the left ventricle.

The Left Ventricle
This chamber receives the oxygenated blood as the left atrium contracts, and the blood passes through the mitral valve into the left ventricle. The ventricle is able to fill with blood as the aortic valve leading into the aorta is closed. Once the ventricle is full it contracts, the mitral valve closes and the aortic valve opens. The closure of the mitral valve prevents blood from backing into the left atrium and the opening of the aortic valve allows the blood to flow into the aorta and flow throughout the body.

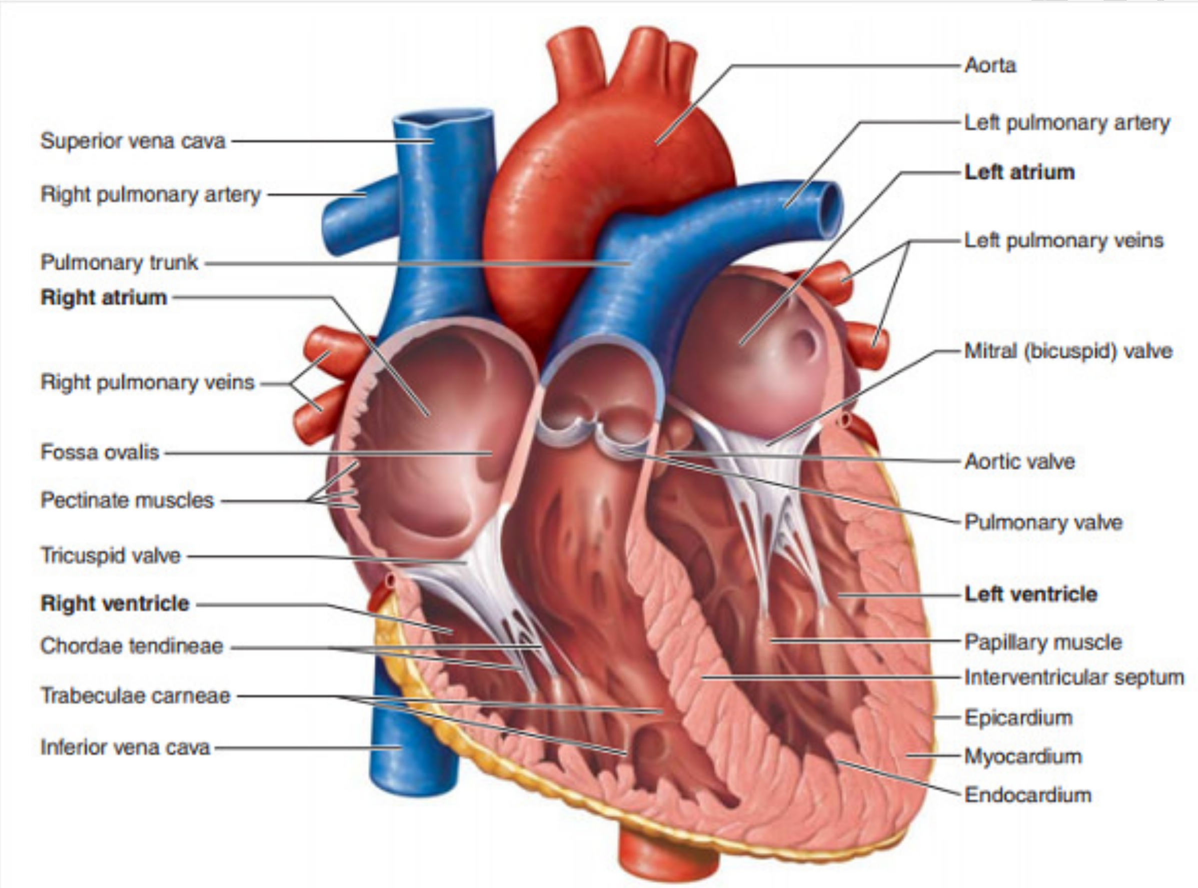
The right side of the heart is completely separate from the left side by the septum to prevent blood flowing into the opposite side.

The function of the heart is to pump blood around the body and is approximately the size of a fist. The heart walls are made up of a special type of muscle called cardiac muscle which allows it to contract and relax. The heart is centrally located but is tilted so that most of the heart muscle is to the left. The left ventricle contracts most forcefully, so you can feel your heart beating stronger on the left side of your chest.

- Deoxygenated blood enters the right side of the heart via the inferior and superior vena cava into the right atrium.
- From here it travels through the tricuspid valve, which shuts off once the blood fills the right ventricle.

- The blood then passes through the pulmonary valve into the pulmonary artery to the lungs to allow the carbon dioxide to be removed and to collect oxygen.
- Oxygenated blood then enters the left side of the heart via the pulmonary vein and enters the left atrium.
- It passes through the mitral valve that closes once the left ventricle is full.
- The ventricle now contracts and forces the blood through the aortic valve into the aorta so that blood is pumped to the head and rest of the body.

The function of the valves is to prevent the blood from flowing back the wrong way. The bodies' blood is circulated through the heart more than 1,000 times per day, and beats an average of 70 to 80 times per minute. Many factors can affect the pulse, such as exercise, age, gender, emotion and drugs.



Coronary Arteries
The heart tissue must have a constant supply of oxygen to allow the heart to contract and relax, so there is a network of vessels that deliver oxygenated blood to the tissues.

The aorta is supplied with the left and right coronary arteries, which gradually branch off into smaller vessels. The larger vessels are situated on the surface of the heart, with the smaller vessels penetrating the heart muscle. Over time, and in a diet that is rich in cholesterol, plaques can build up and eventually block the flow of blood through the coronary artery. When this happens, the heart tissue becomes starved of oxygen and stops functioning as it should. This results in a heart attack.

Blood Pressure

Blood pressure is the force applied against the walls of the arteries as the heart pumps blood through the body. The pressure is determined by the force and amount of blood pumped and the size and flexibility of the arteries.

Each time the heart beats (about 60–70 times a minute at rest); it pumps out blood into the arteries.

- our blood pressure is at its highest when the heart beats, pumping the blood. This is called systolic pressure.
- When the heart is at rest, between beats, your blood pressure falls. This is the diastolic pressure

If the blood pressure is too high, the heart may get larger, which could lead to heart failure. Small bulges (aneurysms) form in blood vessels. Common locations are the main artery from the heart (aorta); arteries in the brain, legs, and intestines; and the artery leading to the spleen.

Blood vessels in the kidney narrow, which may cause kidney failure. Arteries throughout the body "harden" faster, especially those in the heart, brain, kidneys, and legs. This can cause a heart attack, stroke, kidney failure, or amputation of part of the leg. Blood vessels in the eyes can burst or bleed which may cause vision changes and can result in blindness

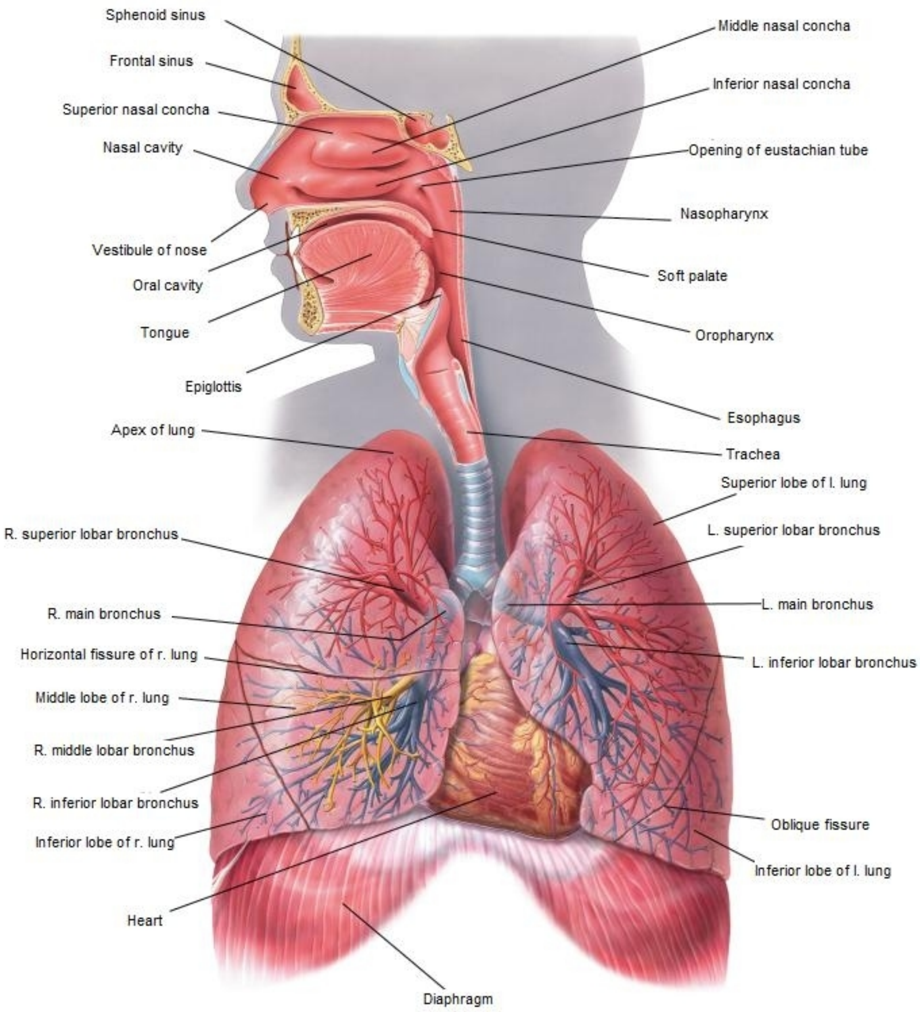
In 90 to 95% of high blood pressure cases, the cause is unknown. In fact, you can have high blood pressure for years without knowing it. When the cause is unknown, you have what's called essential or primary hypertension. Factors that may lead to high blood pressure in the remaining 5–10 percent of cases, which are known as secondary hypertension, include:

Kidney abnormality, a structural abnormality of the aorta (large blood vessel leaving the heart) existing since birth, narrowing of certain arteries, lifestyle factors such as diet and smoking.

Pathologies of the Circulatory System

Disease	Meaning
Aneurysm	A bulge in a blood vessel, which can split open.
Gangrene	Body’s tissues begin to decay due to an interruption of blood flow.
Arteriosclerosis	Where the arteries lose their elasticity and is a form of atherosclerosis’
Atherosclerosis	Hardening of the arteries, usually caused by cholesterol.
Palpitations	Noticeable heartbeat, often felt in the throat or neck.
Deep Vein Thrombosis	Blood clot within a blood vessel.
Stroke	A blockage of the blood supply to the brain due to a bleed of a blood clot.
Phlebitis	Inflammation of a vein usually caused by local trauma.
Varicose Veins	Swollen or enlarged veins, caused when valves within the veins become weakened.

The Respiratory System



We have already learnt how the circulatory system is responsible for supplying oxygenated blood to all parts of the body. We are now going to look at the respiratory system, which works hand in hand with the circulatory system.

The main function of the respiratory system is to allow oxygen to enter the body and for carbon dioxide to leave. This is called “gas exchange” and takes place on an internal level into tissues and an external level into the lungs. It is vital that it takes place for life to continue.

The circulatory system is constructed to allow this gas exchange to take place. Below are the organs within the system.

The Mouth allows an intake of air if there is a high demand or if the nasal passage is blocked in any way. It is an oval shaped cavity which is lined with a mucous membrane. The mouth contains the soft and hard palate, forming the roof of the mouth, as well as the gums in which the teeth sit. It is not ideal to continually breathe through the mouth as the air is not as well filtered and it can cause other medical problems.

The nasal cavity traps particles that enter the passages by containing shelf-like structures called turbinate's. Any material that is deposited in the nose is transported by ciliary action to the back of the throat in around 10-15 minutes. The vascular mucus membranes of the nose will also warm and moisten the air as it is inhaled. The mucus which is produced will also be moved to the back of the pharynx for either swallowing or expectoration. The nose is formed by the two nasal bones and by cartilage and is divided by a septum. The nose also acts as a sounding chamber for the voice as some of the bones surrounding the nasal cavity are hollow. These hollows are called paranasal sinuses and allow the voice to become resonant, lighter and to secrete mucus to help with air filtration. The olfactory receptors are found in the nasal cavity, where the nerves connect directly with the brain and have a powerful and immediate effect on emotions.

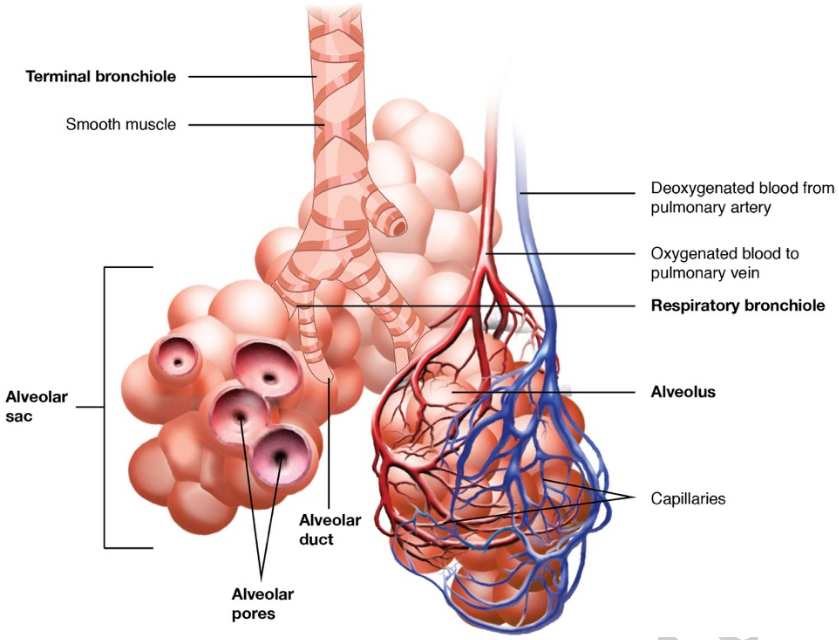
The pharynx (throat) is a muscular cavity that begins from behind the nose to the beginning of the voice box and the oesophagus. The pharynx is divided into three sections. The nasopharynx lies behind the nose and can be seen when the mouth is wide open, the oropharynx which lies behind the mouth, and the laryngopharynx which lies behind the larynx. The upper part of the pharynx lets air pass through, whilst the lower parts permit air, foods and fluids to pass. When it is necessary to swallow, breathing will stop as the oropharynx becomes blocked off from the nasopharynx as the soft palate is raised, as it is impossible to be able to breathe whilst swallowing.

The larynx, also known as the voice box, is a 2" tube shaped structure which is located at the entrance of the trachea. The larynx contains two vocal cords, which will vibrate together when air passes between them. This gives us the sound of the voice. The larynx is made up of several irregular cartilages and the lobes of the thyroid gland are on either side. The oesophagus, which is the tube that carries food from the mouth to the stomach, is just behind the trachea and the larynx. Both openings of the oesophagus and the larynx are close together in the throat, so when the act of swallowing occurs, a flap called the epiglottis keeps the food out of the windpipe by moving down over the larynx.

The trachea, also known as the windpipe, is a tube like structure consisting of between 16 – 20 rings of cartilage that joins the nose and mouth to the lungs. It measures approximately 10-12" in length and runs from the lower part of the larynx to the lungs by dividing into the bronchi. The trachea contains an epithelial lining that secretes mucus, which traps any dust. It is then swept upwards by the cilia towards the larynx away from the lungs.

The bronchi are supported by cartilage and are formed when the trachea forks into two branches, making up the left and right bronchi. These branches then divide again, with the right Bronchus being wider and shorter than the left. The right bronchi then divide into two branches for the middle and lower lobes. The left bronchi is nearly double in length, being 5cm long and divides again, one for each broncho-pulmonary segment. Within the lungs, the bronchi divide again into smaller bronchi, called bronchioles. There are numerous glands in the wall of the bronchi which secrete slimy mucus, which helps to trap dust and any other particles, which are then propelled upwards to the mouth by cilia.

The bronchioles are the first divisions of the bronchi that no longer contain cartilage, but are made up of a single layer of epithelial cells. The bronchioles are smaller than one millimetre in diameter and control the air distribution into the lungs. The bronchiole end in the alveoli.

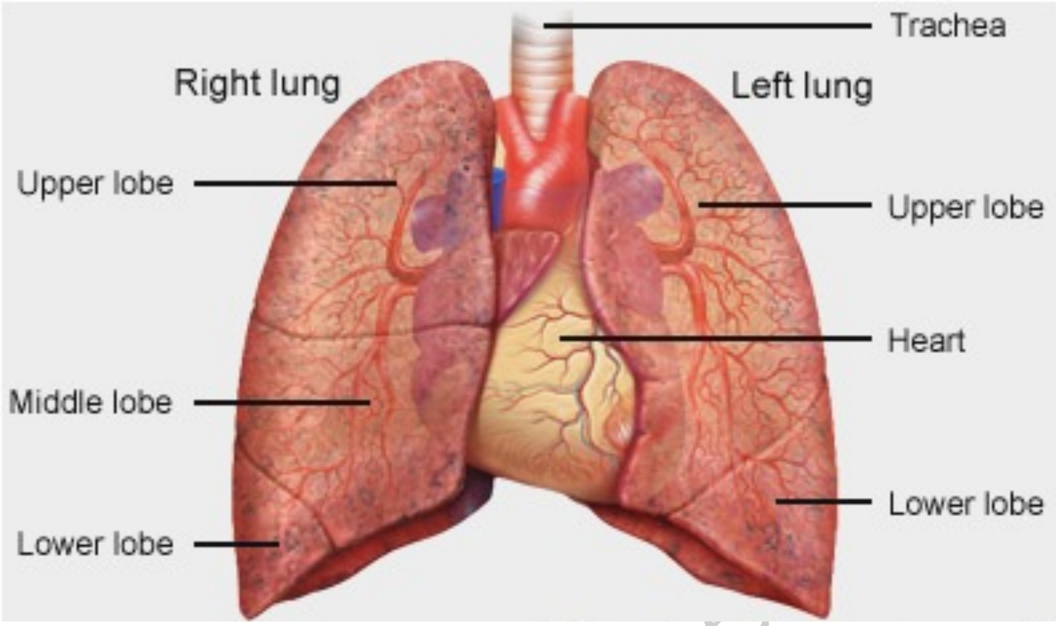


The alveolar sac contains around 300 million alveoli, which are arranged in grape like clusters to increase the surface area, which can become reduced due to irritants such as dust. It is here that gas exchange takes place. To allow this to happen, the alveoli are constantly moist and are surrounded by a network of capillaries. Oxygen is in a higher concentration in the alveoli than in the blood and so therefore it is able to diffuse into the blood through a thin layer of cells. The reverse happens with carbon dioxide, which is a higher concentration in the blood than the alveoli and so it diffuses into the alveoli through the thin layer of cells.

The lungs are located in the thorax and are cone shaped. They make up one of the largest organs of the body with a huge surface area. The main role of the lungs is to exchange gas; oxygen for carbon dioxide and on average a person breathes 25,000 times a day, moving 10,000 litres of air a day.

Mucus is produced in the lungs that traps any inhaled particles, which can be removed by coughing. The lungs are situated in a space, known as the pleural cavity. Each lung is covered in two thin layers of a single celled membrane called pleura which slide back and forth over each other every time a breath is taken to allow the lungs to expand and contract. There is a small amount of fluid here to prevent friction. The pleura, which are connected to the chest wall, are called the parietal pleura, and the pleura that are attached to the lung are called visceral pleura.

The front and back of the lungs are protected by the ribs, and the intercostals muscles help allow the chest wall to move. The front of the ribs contains costal cartilage which connects the sternum and the ends of the ribs. The back of the lungs contains the transverse processes of the thoracic vertebrae. The lungs differ on either side with the right lung having 3 lobes; the superior, middle and inferior lobe and the left lung only having the superior and inferior lobe.



The Diaphragm is a dome shaped muscular sheet that extends along the bottom of the rib cage and inserts into the lower ribs. The diaphragm relaxes during inhalation to allow more room in the thoracic cavity, which in turn creates a suction to allow air to be drawn into the lungs. When you exhale, the diaphragm expands which reduces the amount of space in the cavity for the lungs, which forces the air out.

The Intercostal Muscles occupy the space in-between the ribs and are made up of two types. The internal muscles are on the inside of the rib cage and extend from the front of the ribs and go around the back, and the external muscles are on the outside of the ribs and cover the back of the rib, around to the bony part at the front. They receive messages from the brain to control breathing, and are responsible for working alongside the diaphragm.

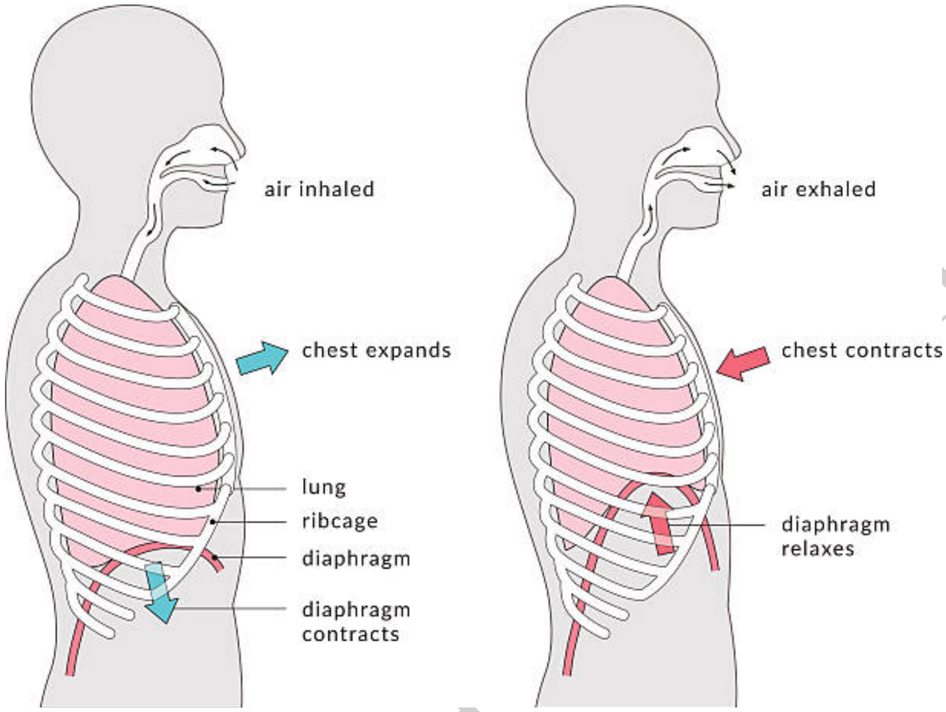
Breathing Mechanism
To be able to take in oxygen and allow carbon dioxide to be expelled, a complex procedure needs to take place.

Inhalation:

- The diaphragm contracts and moves downwards
- This forces the rib cage muscles to contract
- The ribs then move up and out
- There is decreased pressure in the chest
- The air is sucked down into the lungs through:
- Nose, pharynx, larynx, trachea, bronchus, bronchiole and to the alveoli.
- Once the oxygen is in the alveoli, gas exchange takes place so that the carbon dioxide is ready to be exhaled. The reverse then happens.

Exhalation:

- The muscles of the diagram and intercostals relax
- The size of the thorax reduces
- Air is forced out of the lungs



Gas Exchange

- Once the air that we have inhaled reaches the lungs, the 21% of dissolved oxygen then diffuses through the alveolar lining cells of the alveolar and the walls of the capillaries and enters the plasma of the blood.
- From the plasma, the oxygen then diffuses into the red blood cells (erythrocytes) and combines with the haemoglobin to form oxyhaemoglobin.
- The newly oxygenated blood then leaves the capillary network and enters the pulmonary veins to be transported back to the heart to be pumped around the body for its use.
- Once the oxygen has travelled the body, the deoxygenated blood leaves via the capillary network from the pulmonary artery back into the alveoli.
- The exhaled breath still contains 16% oxygen and 4 ½% carbon dioxide.

Breathing Patterns

Shallow Breathing

When we take short intakes of breath, the Intercostal muscles around the ribs tend to work harder than the diaphragm, which in turn can cause the diaphragm to become weak. Stress and tension can be the cause of shallow breathing and it can lead to a lack of oxygen entering the body, as well as constricting the chest and lung tissue.

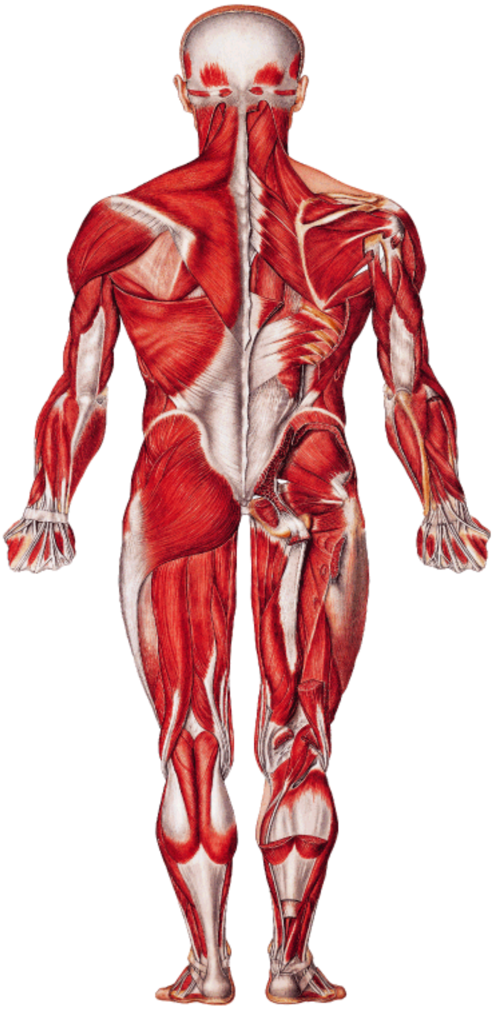
Deep Breathing

By using the diaphragm muscle, we are able to fully fill our lungs with air and therefore take in the largest amount possible. The abdominal muscles also play an important role in deep breathing.

Pathologies of the Circulatory System

Disease	Signs & Symptoms	Cause
Emphysema	Shortness of breath due to obstruction.	Permanent damage of the lungs due to smoking or working in an environment with chemicals.
Bronchitis	Burning sensation during breathing, cough, sore throat.	An infection of the airways caused by virus or bacteria.
Pneumonia	Cold feeling, difficulty breathing, cough, fever.	Inflammation of the tissue within the lungs.
Tuberculosis	Persistent cough, weight loss, night fevers.	Bacterial infection, usually affecting the lungs but can affect other body systems.
Rhinitis	Itching and sneezing and irritation of the nose.	Inflammation inside the nose, usually due to an allergy.
Laryngitis	Sore throat, pain in the voice box, mild fever.	Inflammation of the larynx (voice box) due to infection or damage.
Pharyngitis	Sore throat.	Bacterial or viral infection.

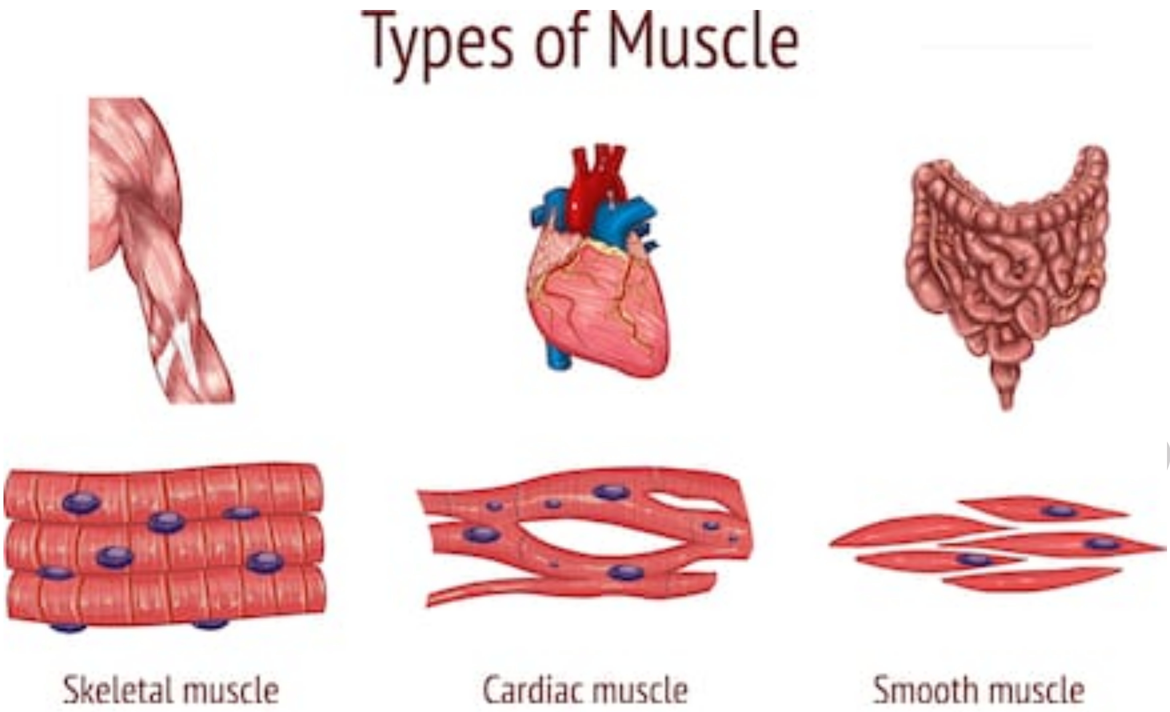
The Musculoskeletal System



This system gives individuals the ability to move, using muscles and the skeleton. It consists of the body's bones, muscles, tendons, ligaments, joints, cartilage, and other connective tissue.

Muscles
Muscles are classified into three different types, which are skeletal, smooth and cardiac.

Skeletal muscles, also known as striated due to its appearance, or voluntary due to its action, are attached to bones and deal with movement. These muscles are made up of fine, thread like fibres of muscles, containing light and dark bands. Skeletal muscles can be made to contract and relax by voluntary will. They have striations due to the actin and myosin fibres and create movement when contracted.



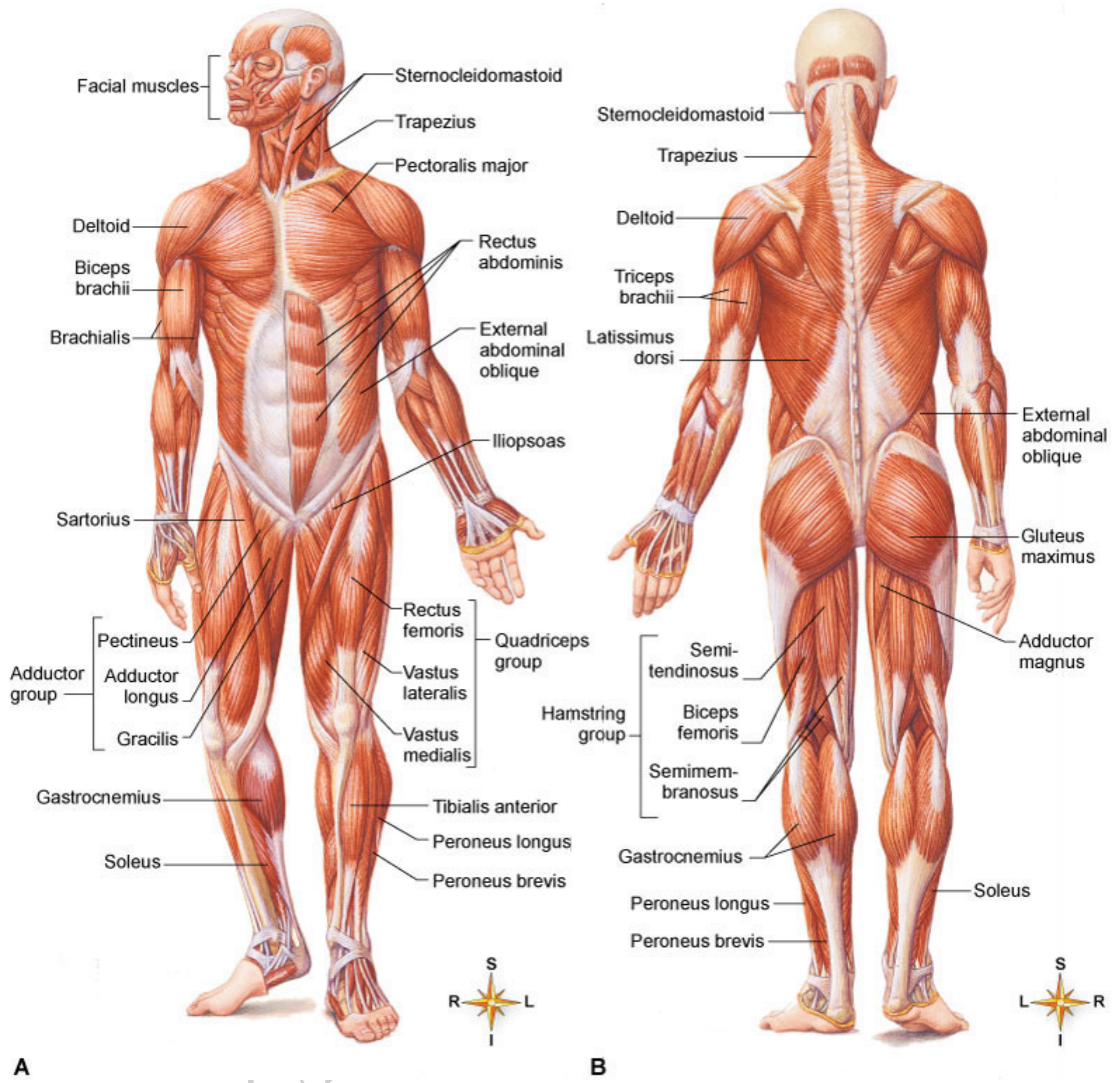
Smooth muscles also called unstriated or involuntary, tend to be found within hollow organs such as blood vessels, the intestines and the respiratory tract. This muscle works automatically with no participant control. This type of muscle does not tire easily and the contractions are slow, rhythmic and automatic.

Cardiac muscle is what the heart is made up of and only exists in your heart. It is similar in appearance to skeletal muscle, in that it is striated. This type of muscle never tires and contracts and relaxes with no participant control. It is made up of short, cylindrical fibres and is purely controlled by the nervous system.

There are over 650 different types of muscles in the human body, making up nearly half of the body weight. The main function is to move joints, to which they are joined, by shortening and pulling one end of the muscle closer to the other end. Each muscle is made up of muscle fibres that are controlled by the brain sending impulse to the fibres via the nerves.

When a muscle is damaged, fibres become torn and the connective tissue around the muscle is also damaged. The fibres are damaged and fluid seeps out of torn fibres, which causes localised swelling. This fluid tends to stick the fibres together which causes pain as the muscle is irritated by the slightest contraction. Stretching exercises will increase the length, flexibility and tone of muscles which allows the joint to move further than before.

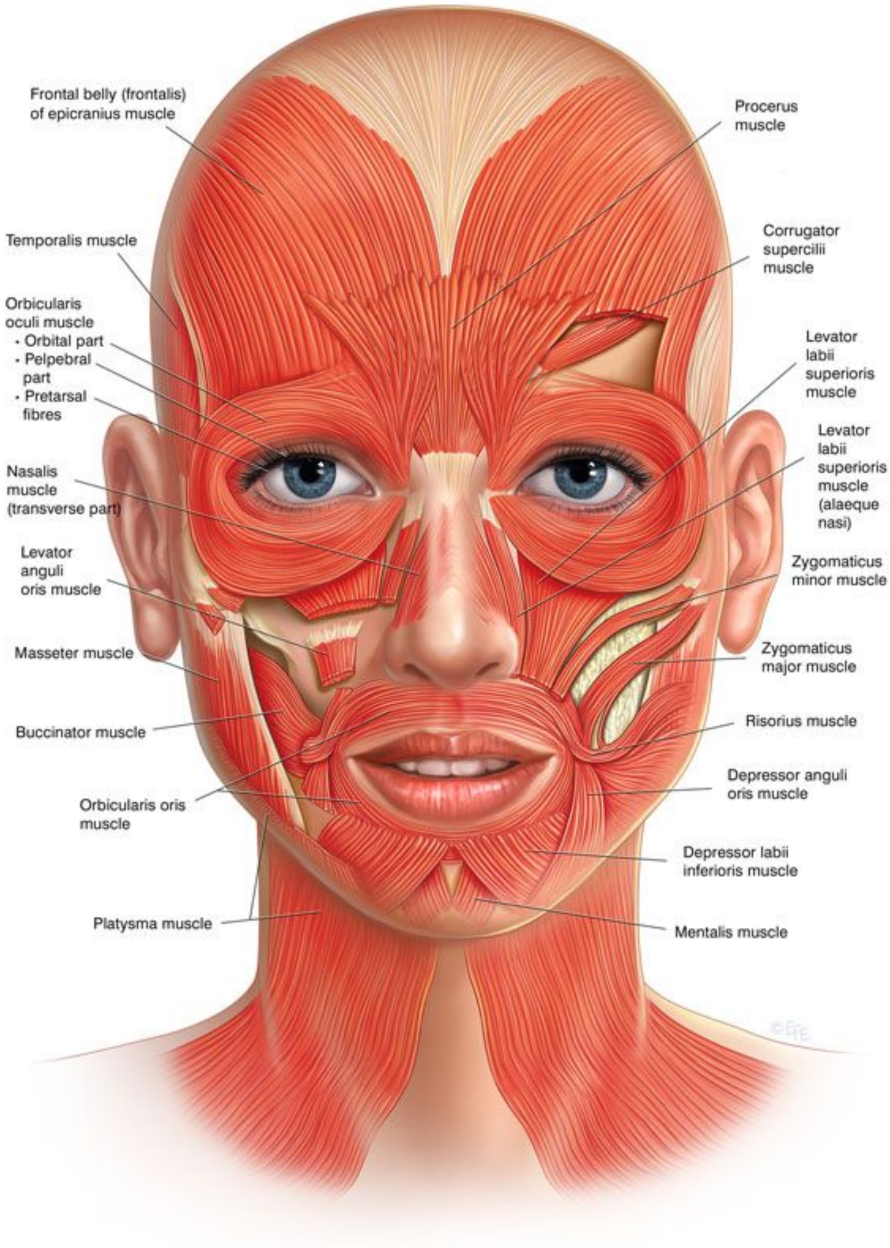
Muscles of the body



Muscles have many functions in the body, not just for movement. They also provide the body with its shape and contours as well as providing a supporting cover for the skeleton. Muscle tone can be improved by increasing your exercise.

Muscles of the Face, Neck, Shoulder, Back and Arms

The face has several relevant muscles.

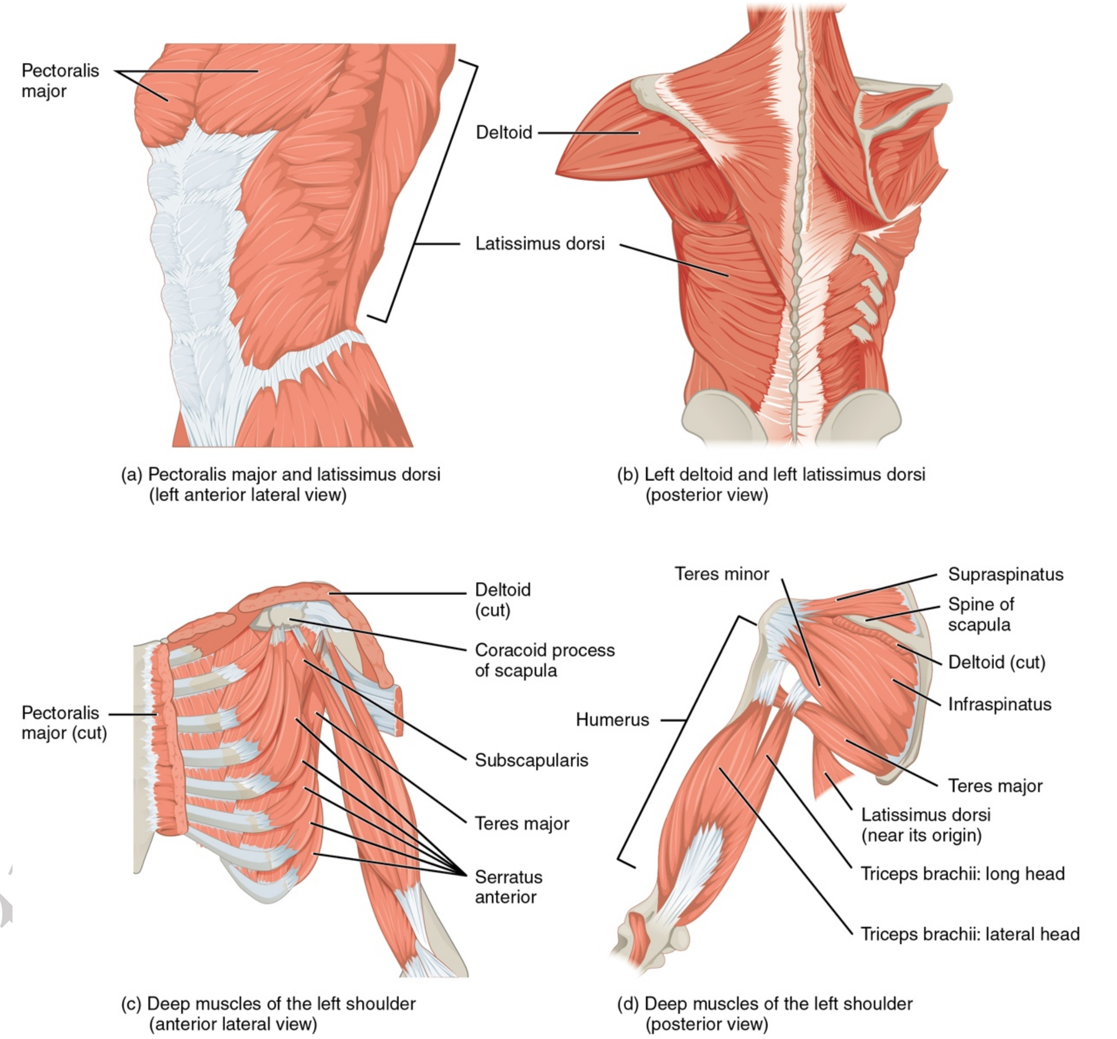


Names, position and function of facial muscles

Name	Position	Action
Frontalis	Upper part of the cranium	Elevates eyebrows Draws the scalp forwards
Corrugator	Inner corner of eyebrows	Forms vertical wrinkles between the eyebrows
Procerus	Top of nose between eyebrows	Depresses the eyebrows (forms wrinkles over bridge of nose)
Orbicularis Oculi	Surrounds the eye	Closes the eye (blinking) Remember Oculi rhymes with eye
Nasalis	Over the front of nose	Compresses nose (causing wrinkles)
Temporalis	Runs downs the side of face towards jaw	Aids chewing Closes mouth
Masseter	Runs down and back to the angle of the jaw	Retracts the jaw and aids chewing (remember Masseter - eater)
Buccinator	Forms most of the cheek and gives it shape	Puffs out cheeks when blowing Keeps food in mouth when chewing
Risorius	Lower cheek	Pulls back angles of the mouth(smiling)
Zygomaticus	Runs down the cheek towards the corner of the mouth	Pulls corner of the month upwards and sideways
Quadratus labii superiorus	Runs upward from the upper lip	Lifts the upper lip Helps open the mouth
Orbicularis Oris	Surrounds the lip and forms the mouth	Closes the mouth Pushes lips forwards
Mentalis	Forms the chin	Lifts the chin Moves the lower lip outwards
Triangularis	Corner of the lower lip, extends over the chin	Pulls the corner of the chin down
Platysma	Front of throat	Draws the lower lip and jaw down, and forms horizontal wrinkles in the neck
Sternocleido mastoid (SCM)	Either side of the neck	Allows neck to flex and rotate, and nod the head
Occipitalis	Back of the skull	Draws the head backwards

Muscles of the Upper Body

Name	Position	Action
Trapezuis	Upper back and sides of neck	Rotation of shoulders Draws back the scapula (retracts) Pulls head back Assists in rotation of head
Pectoralis	Front of chest, under breast	Pulls arms forward and assists rotation of the arm
Deltoids	Surrounds shoulders	Lifts arms sideways, forwards and backwards



(a) Pectoralis major and latissimus dorsi (left anterior lateral view)

(b) Left deltoid and left latissimus dorsi (posterior view)

(c) Deep muscles of the left shoulder (anterior lateral view)

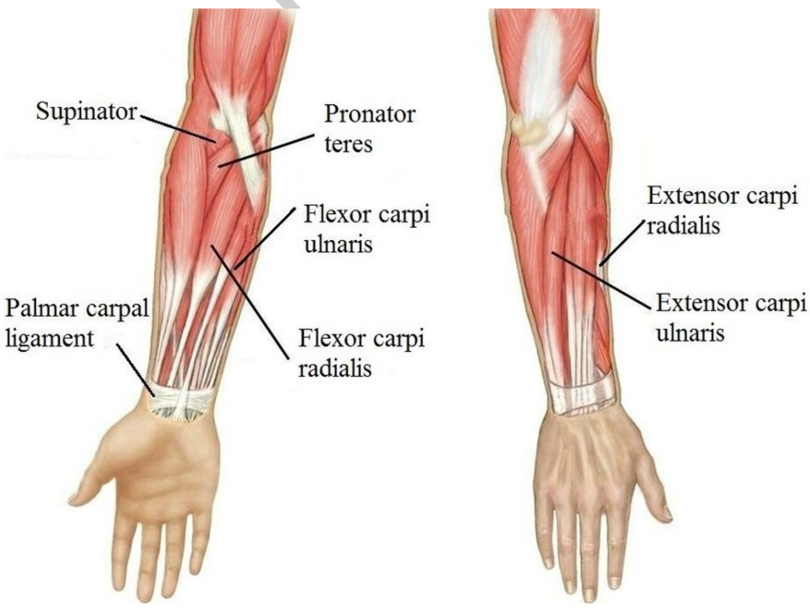
(d) Deep muscles of the left shoulder (posterior view)

Muscles of the Arm and Hand

Many of the muscles in the forearm are termed according to their action. They are grouped as flexors and extensors.

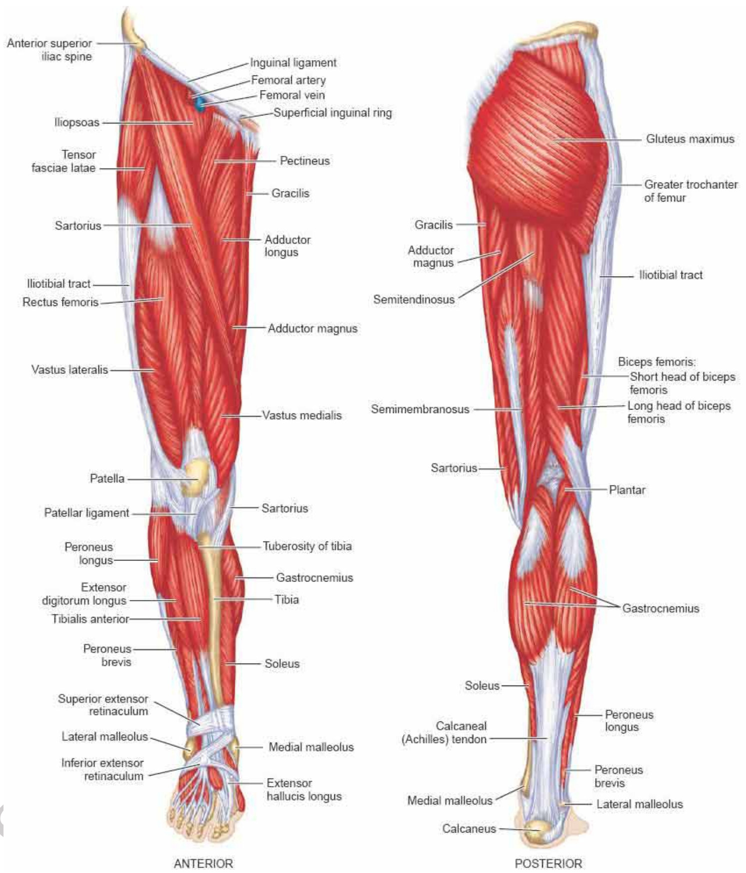
The muscles flex and extend, supinate and pronate the hand and arm and the fingers to spread apart and close together

Name	Position	Action
Deltoids	Surrounds shoulders	Lifts arms sideways, forwards and backwards
Biceps	Front of upper arm	Flexes elbow Supinates the forearm and hand
Triceps	Back of upper arm	Extends the elbow
Brachio radialis	On the thumb side of the forearm	Flexes the elbow
Flexors	Middle of the forearm	Flexes and bends the wrist drawing it towards the forearm
Extensors	Little finger side of the forearm	Extends and straightens the wrist and hand
Thenar muscle	Palm of the hand below the thumb	Flexes the thumb and moves it outwards and inwards
Hypothenar muscle	Palm of hand below little finger	Flexes little finger and moves it outwards and inwards



Muscles of the Chest, Abdomen, Hips, Legs and Feet

The pectoralis major is the main muscle that covers the front of the chest. It is a thick, fan shaped muscle which gives the chest its contour. It makes up most of the males chest shape and lies under the breasts on females. The latissimus dorsi covers the back of the chest and abdomen. It adducts, extends and medially rotates the shoulder joint. The serratus anterior runs around the side wall of the chest.



- The main muscles are at the front of the thigh and are called the quadriceps. They are responsible for extending the knee joint and flexing the hip
- The Adductors are the group of muscles on the inside of the thigh and moves the leg in towards the body
- The Abductors are on the outside of the thigh, and moves the hip outwards. (Remember that the term abduct means to take away)
- The hamstrings are located at the rear of the thigh and extends the thigh and flexes the leg
- The abdominal area consists of the two different types of muscles. The internal and external oblique. These muscles allow you to move your body from left to right.

- The transversus and rectus abdominus allow us to bend down and pick things up (flexion of the trunk)
- Dorsiflexion of the foot is performed by the tibialis anterior
- The glutes are the biggest muscle in the body and are the muscles that give your bottom its shape. They are known to be lazy muscles as they are only used to be sat on.

Name	**Position**	**Action**
Pectoralis major	Across upper chest	Used in throwing ad climbing Adducts and medially rotates the arm
Pectoralis minor	Underneath pectoralis major	Draws shoulders downwards and forwards
Gluteals	In the buttocks	Used in walking and running adduction and rotation of the thigh, and extending the hip
Hamstrings	Back of the thigh	Flexes and extends the knee
Gastrocnemius	Calf of the leg	Flexes the knee Plantar-flexes the foot
Soleus	Calf of leg, below the gastrocnemius	Plantar-flexes the foot
Quadriceps extensor	Front of the thigh Group of four muscles	Extends the knee, used in kicking
Sartorius	Crosses the front of the thigh	Flexes the knee and hip Abducts and rotates the femur
Adductors	Inner thigh	Adducts the hip Flexes and rotates the femur
Tibialis anterior	Front of the lower leg	Inverts the foot Dorsiflexes the foot Rotates the foot outwards

Muscles of the Back

Name	**Position**	**Action**
Trapezuis	The back of the neck and chest	Moves scapula up, down and back (retracts) Raises the clavicle
Latissimus dorsi	Across the back	Used in rowing. Adducts, extends and medially rotates the shoulder joint
Erector spinae	Three groups of muscle which lie either side of the spine form the neck to the pelvis	Extends the spine Keeps body in an upright position
Rhomboids	Between the shoulders	Braces the shoulders Rotates the scapula

Muscles of Respiration
As previously mentioned, the diaphragm is a vital muscle of the respiratory system. This sheet of muscle divides the chest from the abdomen and expands and contracts to allow inhalation and exhalation to occur. But along with the diagram are two other muscles that are important. These are the external and internal intercostal muscles. These muscles draw the ribs downwards and inwards.

Tendons and Ligaments
Tendons and ligaments are made up of collagenous tissue with ligaments attaching bone to bone and tendons attaching muscle to bone. The place where a muscle attaches to a bone but does not move, is known as the origin. To make movement occur, the muscles contract, which will pull on the tendons, this then pulls on the muscles.

Tendons are tough, yet flexible bands of fibrous tissue, which allows movement. Ligaments are stretchy connective tissue which helps to stabilise the joints. They control the range of movements of a joint to prevent them from bending the wrong way. Injuries to both tendons and ligaments are very common, caused mainly by sporting injuries. It is fairly common for tendons to be stretched or torn which can be extremely painful. If ligaments are stretched, either by injury or excess strain the joint will become weaker, as the ligaments are unable to support it.

Muscle Tone
Muscle tone refers to the amount of tension or resistance to movement in a muscle.

Muscle tone is what enables us to keep our bodies in a certain position or posture. A change in muscle tone is what enables us to move. For example, to bend your arm to brush your teeth, you must shorten (increase the tone of) the bicep muscles on the front of your arm at the same time you are lengthening (reducing the tone of) the tricep muscles on the back of your arm. To complete a movement smoothly, the tone in all muscle groups involved must be balanced. The brain must send messages to each muscle group to actively change its resistance.

Characteristics of a Muscle
Muscle tissue has four main properties which allow it to carry out its function. It is able to respond to stimuli (Excitability). It can contract (Contractibility). It can extend without tearing (Extensibility) and it can return to its normal shape (Elasticity)

Growth and Repair of the Muscles
Muscle hypertrophy is the term used for when a muscle cell grows in size, and the commonest reason for this is due to exercise, where there will be an increase in muscle fibre. When a muscle is damaged (torn) the body has to repair it and will do this by using satellite cells which fuse with the ends of the damaged fibre. If the damage is constant then the process will repeat itself so that more satellite cells are used which will create growth of the muscle.

Pathologies of the Muscular System

Disorder	Signs & Symptoms	Cause
Cramp	Sudden muscle pain, mostly commonly in the calf muscle	The muscle suddenly shortens, which can be due to exercise, nerves or tendons shortening due to age
Sprains	Pain, inflammation, lack of movement	A stretch, tear or twist of a ligament due to force
Strains	Pain, inflammation, lack of movement	A stretch, tear or twist of a muscle fibre due to force
Fibromyalgia	Pain and stiffness in the muscles, ligaments and tendons	No known cause
Muscular Dystrophy	Causes muscles weakness which slowly gets worse and loss of muscle tissue	inherited
Spasticity	An abnormal increase in muscle tone or stiffness in the muscles which will affect movement	May occur with spinal cord injury, MS, Cerebral palsy, brain damage

The Skeletal System

The Skeletal System serves many important functions; it provides the shape and form for our bodies in addition to supporting, protecting, allowing bodily movement, producing blood for the body, and storing minerals such as calcium.

Functions

Its 206 bones form a rigid framework to which the softer tissues and organs of the body are attached. Skeletal bones provide the body with a protective framework, and provides storage for calcium.

- Vital organs are protected by the skeletal system. The brain is protected by the surrounding skull as the heart and lungs are encased by the sternum and rib cage.
- Bodily movement is carried out by the interaction of the muscular and skeletal systems. For this reason, they are often grouped together as the muscular-skeletal system. Muscles are connected to bones by tendons. Bones are connected to each other by ligaments. Where bones meet one another is typically called a joint. Muscles which cause movement of a joint are connected to two different bones and contract to pull them together. An example would be the contraction of the biceps and a relaxation of the triceps. This produces a bend at the elbow. The contraction of the triceps and relaxation of the biceps produces the effect of straightening the arm.
- Blood cells are produced by the marrow located in some bones. An average of 2.6 million red blood cells is produced each second by the bone marrow to replace those worn out and destroyed by the liver.
- Bones serve as a storage area for minerals such as calcium and phosphorus. When an excess is present in the blood, build-up will occur within the bones. When the supply of these minerals within the blood is low, it will be withdrawn from the bones to replenish the supply.

The human skeleton is divided into two distinct parts:

The axial skeleton consists of bones that form the axis of the body and support and protect the organs of the head, neck, and trunk. These bones are:

The Skull, the Sternum, the Ribs and the Vertebral Column

The appendicular skeleton is composed of bones that anchor the appendages to the axial skeleton. These bones are:

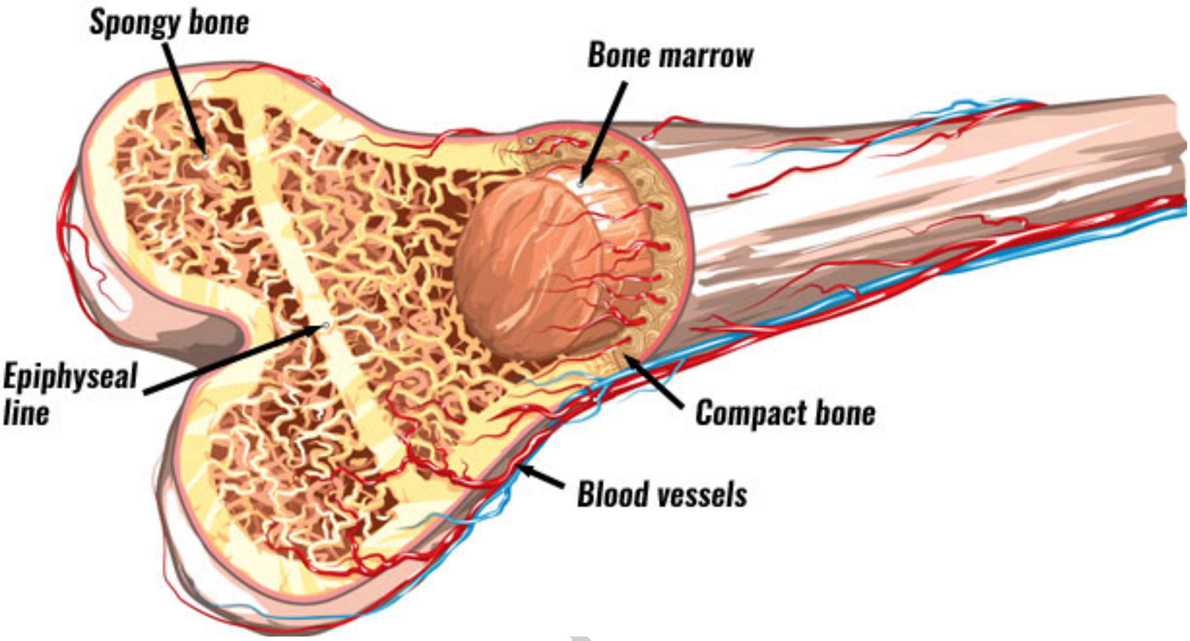
The Upper and Lower Extremities, the Shoulder and Pelvic Girdle (the sacrum and coccyx are considered part of the vertebral column)

Types of Bone

The bones of the body fall into four general categories: long bones, short bones, flat bones, and irregular bones.

- Long bones are longer than they are wide and work as levers. The bones of the upper and lowerextremities (ex. humerus, tibia, femur, ulna, metacarpals, etc.) are of this type.

- Short bones are short, cube-shaped, and found in the wrists and ankles.
- Flat bones have broad surfaces for protection of organs and attachment of muscles (ex. ribs, cranial bones, bones of shoulder girdle).
- Irregular bones are all others that do not fall into the previous categories. They have varied shapes, sizes, and surfaces features and include the bones of the vertebrae and a few in the skull.



Bone Composition
Bones are composed of tissue that may take one of two forms. Compact 0r dense bone, spongy or cancellous bone. Most bones contain both types.

- Compact bone is dense, hard, and forms the protective exterior portion of all bones.
- Spongy bone is inside the compact bone and is very porous (full of tiny holes like chocolate aero). Spongy bone occurs in most bones.

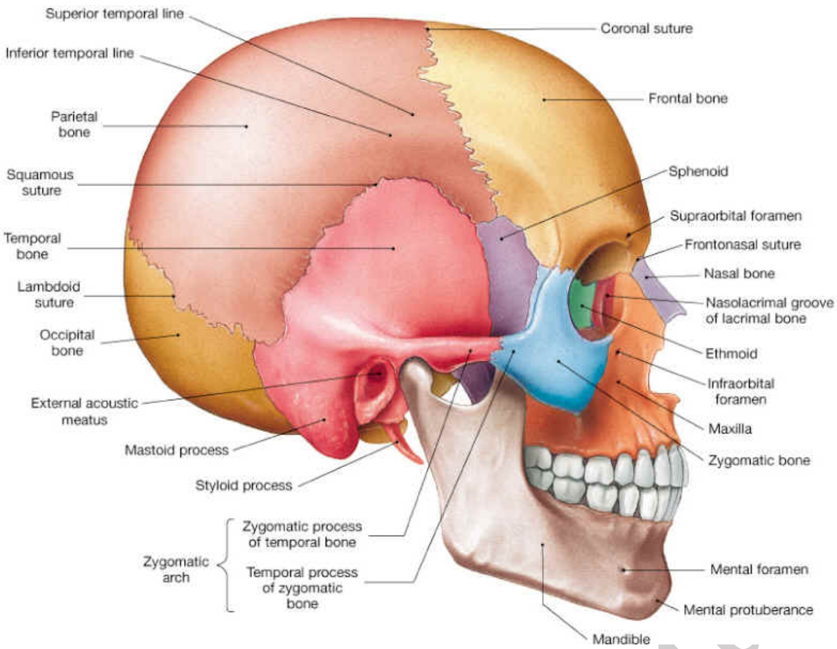
The following charts show the main bones that you will need to have a good knowledge of.

Bones of the Skull and Face

The adult skull is usually made up of 22 bones. You can find a fibrous joint in the sutures of the skull. Many of the 22 bones are small bones that make up larger ones. The most significant to you as a therapist are:-

Name	**Position**
Frontal	Makes up your forehead and also the roof of your eye sockets. It joins with the parietal and temporal bones
Parietal	Forms the roof and sides of the cranium
Occipital	Situated at the back of the cranium
Temporal	Situated on both sides of the cranium
Sphenoid	Located at the front of the temples and contains a sinus cavity and houses the pituitary gland
Ethmoid	Forms the roof of the nasal passage
Nasal	Forms the bridge of the nose
Lacrimal	The most fragile bone of the face and is part of the eye socket
Maxilla	Forms the upper jaw and is the largest facial bone
Mandible	Forms the lower jaw and is the strongest of the skull
Zygomatic	Form the angle of the cheeks

Within the skull, the sinuses aim to lighten and improve the voice tone, and to secrete mucus to help with air filtration. They are to be found at the frontal, ethmoid, maxilla and sphenoid bones.



Bones of the Neck, Chest, Shoulder and Spine

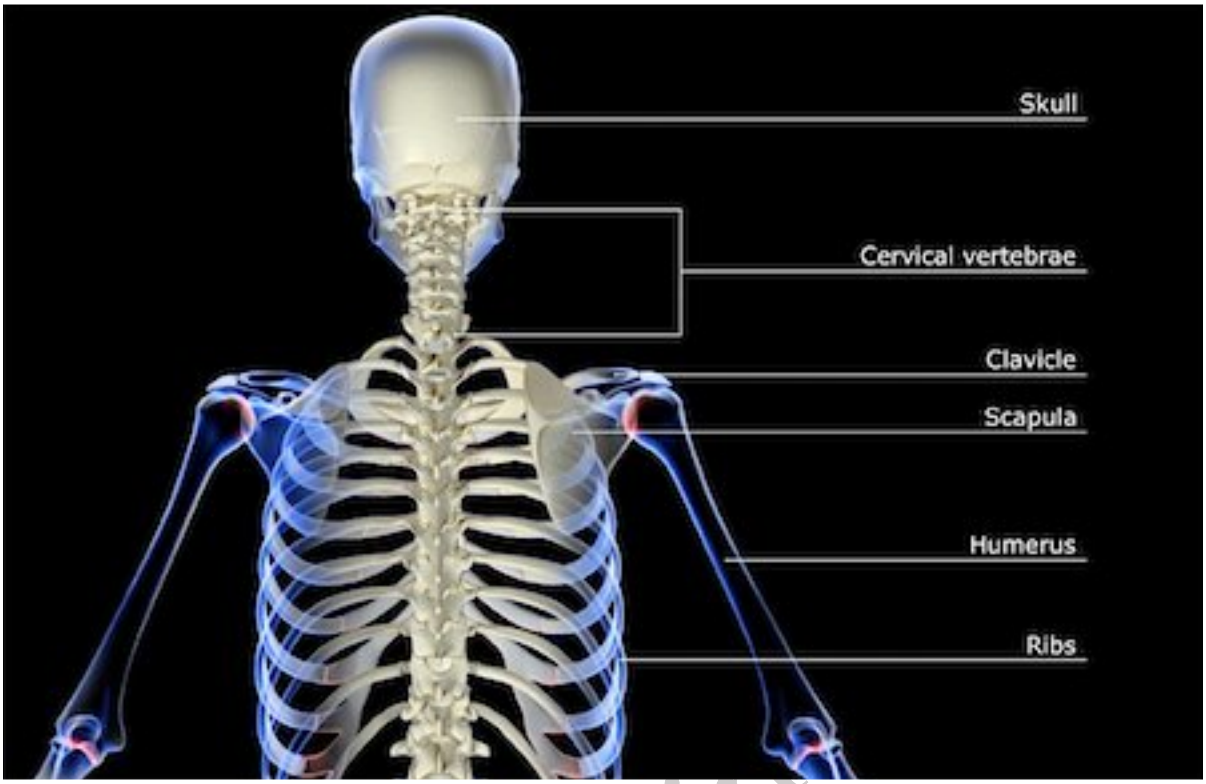
Name	**Position**
Cervical version	The neck
Hyoid	U-shaped bone at the front of the neck
Clavicle	Slender long bones at the base of neck
Scapula	Triangular bones in the upper back
Humerus	Upper arm
Sternum	Breast bone

We have 7 bones in the neck, which form the cervical vertebrae. Our shoulders have 4 bones. These are 2 clavicles (collar bones) and 2 scapulae (shoulder bones).

The sternum is a dagger shaped bone located in the centre of the chest. It helps protect the heart, along with the ribs, which are thin, flat curved bones. There are 24 bones which make up the ribs, and these are arranged in 12 pairs. The function of the ribcage is to allow for inspiration and expiration.

The spine, technically called the vertebral column, consists of 33 irregular shaped bones, called vertebrae. Its main function is to house and protect the spinal cord. Arranged within 5 sections, these bones make up the 7 vertebrae of the cervical (neck) , the 12 vertebrae of the thoracic (chest), 5 lumbar (lower back), 5 that are fused to form the sacrum (back wall of pelvic girdle) and 4 coccygeal bones that form the coccyx (tail bone).

In between these vertebrae are vertebral discs which are made up of fibrous cartilage which acts as a shock absorber. Sometimes a disc may collapse. This is called a “slipped disc” and can cause intense pain as the disc presses on a nerve root. Massage may be of a great benefit if this happens.

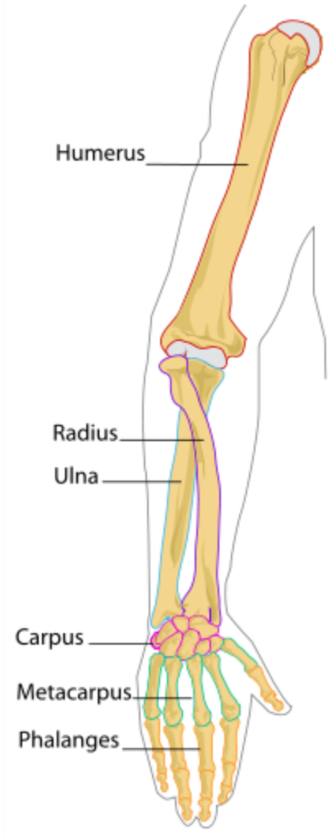


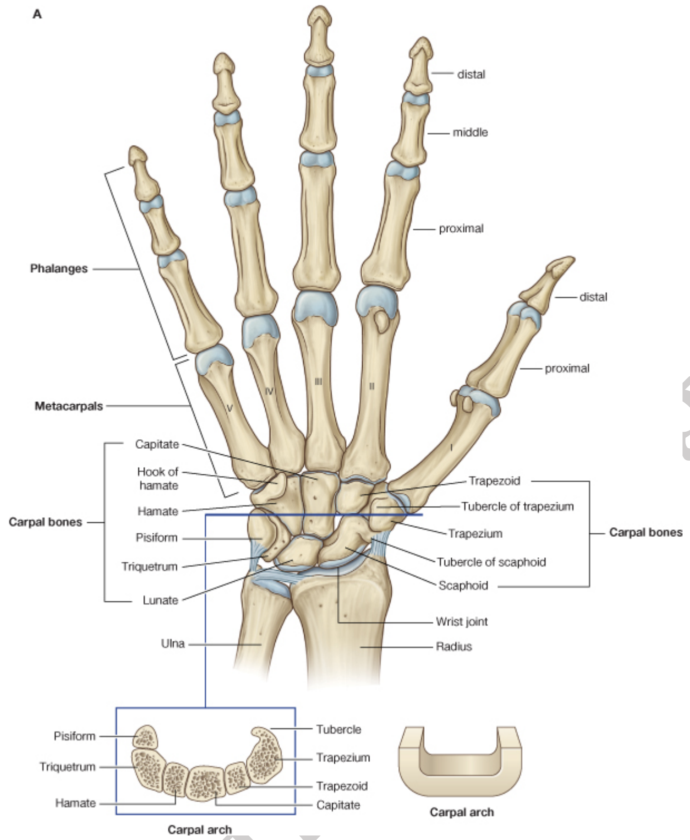
Bones of the Arm and Hand

The forearm is made up of two bones called the Radius and Ulna, with the ulna being the larger of these two bones. The radius and ulna on the forearm form a hinge with the upper arm bone called the Humerus and this enables the arm to flex and extend.

The wrist is made up of eight individual bones called the Carpals.

The palm of the hand is made up of bones called the Metacarpals and the finger bones are called the Phalanges. The fingers are made up of three bones except for the thumb which has two.

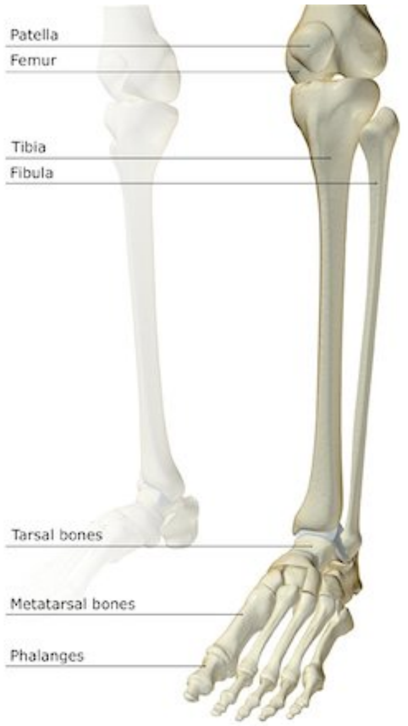




Bones of the Leg and Foot
The tibia and the fibula are the bones that make up the lower leg. (The tibia is normally called the shinbone) the fibula forms part of the ankle joint.

Seven bones all with individual names make up the tarsals they are named Calcaneum, Talus, Cuboid, Outer Cuneiform, Middle Cuneiform, Inner cuneiform and Navicular and five Meta tarsals together support the major arches of the foot.

The toes are made of phalanges like the fingers. Big toes have two phalanges and the others have three.



(a) Superior view

Joints

A joint is formed where two or more bones meet and join each other. A joint will allow movement, for example the elbow and wrist. As we discovered earlier, the bones are joined to each other by ligaments.

There are three types of joints. They are fibrous (immoveable), cartilaginous (partially moveable) and synovial (freely moveable).

Fibrous joints are held together by only a ligament, for example the teeth are held to their bony sockets. These joints are immovable and an example would be the sutures of the skull.

Cartilaginous joints occur where the connection between the bones is made up of cartilage. An example would be between the vertebrae in the spine, which allows for some movement.

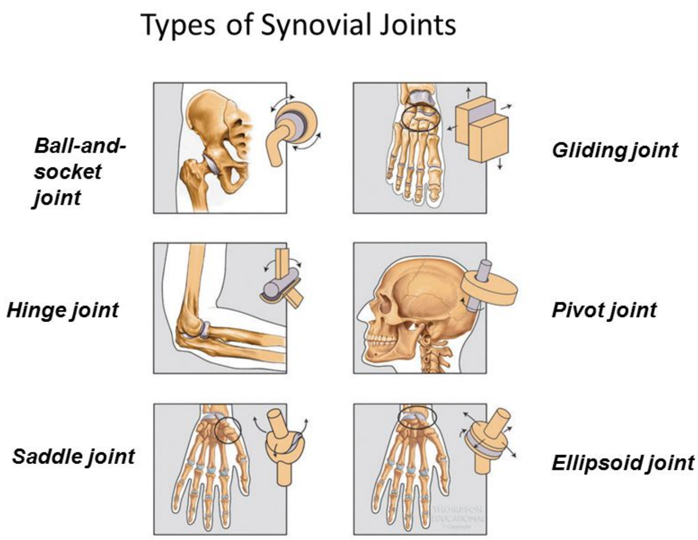
Synovial joints are the commonest and are highly moveable. They consist of two or more bones held together by a synovial capsule which surrounds the entire joint. They also have a synovial membrane which secretes synovial fluid, which acts as a lubricant. There are five types of synovial joints which are classified by the shape of the joint and the movement available. They are the ball and socket, such as the hip and shoulder, the hinge, such as the knee, the double hinge, such as the wrist, the gliding joint where bones glide on each other and the pivot joint, where one bone turns on another.

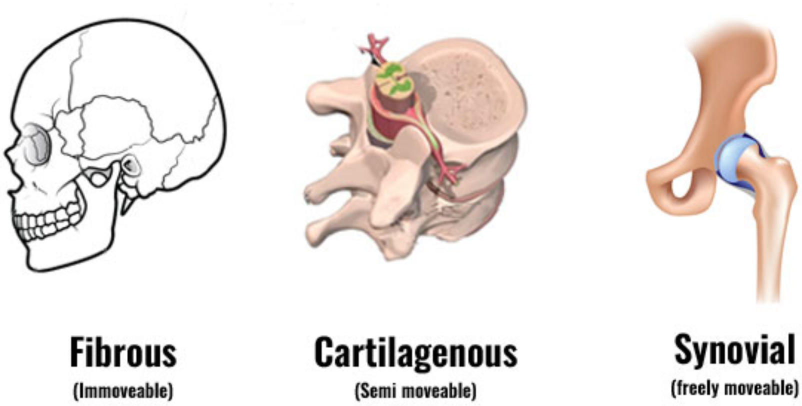
Cartilage

Cartilage is a form of dense connective tissue that covers the surface of joints and acts as a shock absorber. It is found in many areas of the body, including the knees, ribs, the nose, ear and bronchial tubes.

Growth and Repair of Bones

Bone is continually going through a system of growth and repair called ossification. There are two stages of ossification, with the first stage consisting of the cartilage being covered with a layer of Osteoblasts, which are cells that are constantly forming new bone, using calcium and other minerals. Further cells called osteoclasts then break down the calcium to prevent the bones becoming too dense whilst the bones get larger. There are also old bone cells called osteocytes which are mature cells that store the calcium of the body.





Pathologies of the Skeletal System

Postural Defects	Meaning
Kyphosis	Excessive curvature at the top of the spine.
Scoliosis	Curvature of the spine to one side.
Lordosis	Inward curve of the lower back.
Cervical Spondylitis	Arthritis of the spine in the neck.

Fractures	Meaning
Simple	Fracture causing little damage to the surrounding tissue. The skin remains intact.
Compound	The bone is sticking through the skin.
Comminuted	The bone breaks into several pieces.
Greenstick	The bone is bent and broken on only one side.
Impacted	One broken fragment is impacted into the end of another.
Complicated	When the broken bone causes damage to other organs.

Skeletal Disease	Meaning
Gout	Type of arthritis in one or more joints, usually the big toe.
Paget's	Normal cycle of bone renewal and repair is disrupted.
Osteoarthritis	Arthritis where bony spurs grow.
Osteoporosis	Weak and fragile bones.
Rheumatoid arthritis	Arthritis that attacks the cells that line the joints.
Rickets	Softening and weakening of bones that can cause bow legs.
Scleroderma	Targets the connective tissue of skin, muscles and organs.
Synovitis	Inflammation of the synovial membrane.
Ankylosing Spondilitis	A form of inflammatory arthritis, affecting the joints of the lower back.
Systemic Lupus Erythematosus	An autoimmune disorder that can affect many parts of the body including the joints

The Integumentary System

This system protects the body from damage from the outside world and the harmful substances. It consists of the skin, hair, nails and sweat glands. The word integument comes from the Latin word integumentum, meaning "cover" or "enclosure. It is the most visible organ system and one of the most complex.

The Skin

The Skin Structure
Skin makes up around 12% of an adult's body weight and is the largest organ in the body. It's very adaptable and able to mould into different shapes, covering bones and muscles to perform various functions of the body's make up.

The functions of skin (remember the word Shapes) are:

- Sensation - Main sensory organ for temperature, pressure, touch and pain. Pain and pressure receptors in the skin send messages to the brain to help prevent potential damage or injury.
- Heat Regulation – Controls the body temperature by sweating to cool the body down when it overheats, allowing the sweat onto the surface of the skin where it evaporates, and shivering when the body is cold. Shivering occurs due to the arrector pili muscle contracting.
- Absorption – Some creams, fatty substances, essential oils and some medication can be absorbed through the hair follicles.
- Protection – Too much UV light may harm the skin, so the skin protects itself by producing a pigment, seen in a tan, called Melanin. Bacteria and germs (invading antigens) are prevented from entering the skin by a protective barrier called the Acid Mantle. This barrier also helps protect against moisture loss.
- Excretion – Waste products and toxins are eliminated from the body through the sweat glands onto the skins surface.
- Secretion – Sebum, a waxy substance and sweat are secreted onto the skins surface. The sebum keeps the skin lubricated and soft and the sweat combines with the sebum to form the acid mantle.

Another function of the skin:

- Vitamin D production - Absorption of UV rays from the sun helps formation of vitamin D, which the body needs for the formation of strong bones and good eyesight.

There are 3 major layers of the skin, the Epidermis, Dermis and the Subcutaneous (adipose):

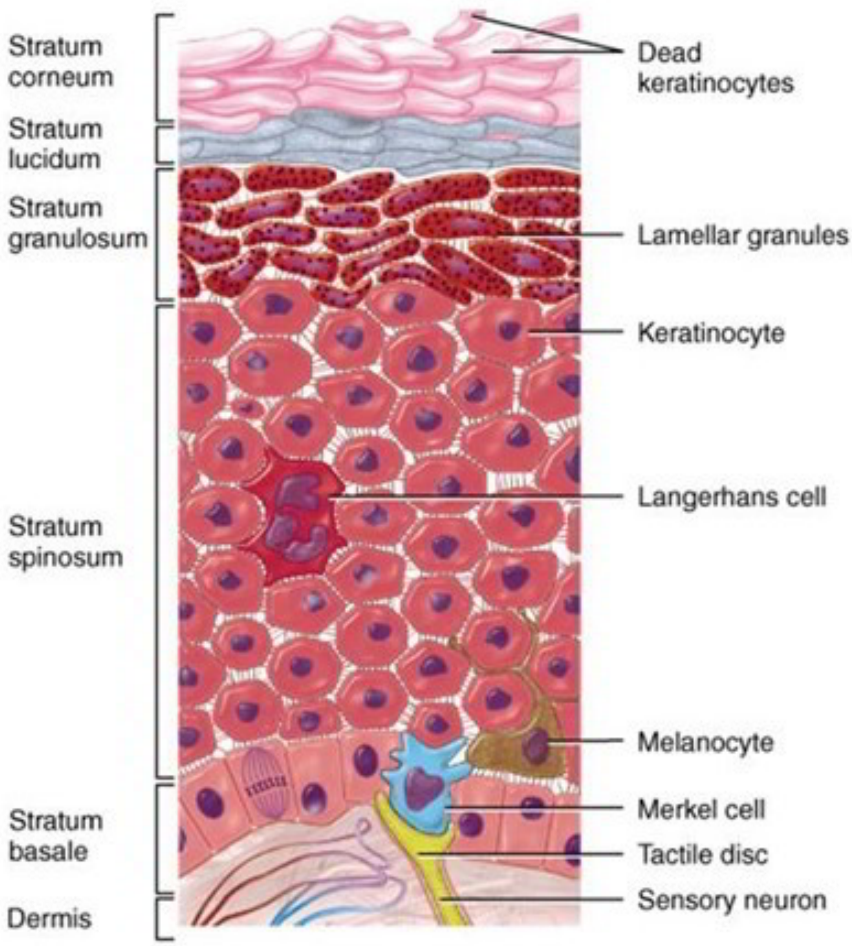
The Epidermis Layer
The outermost layer of the skin is called the epidermis layer. There are no blood vessels in the epidermis but it's the deepest layer and is supplied with lymph fluid. It is at its thickest in the palms of the hands and on the bottom of the feet.

There are various layers of cells within the epidermis, the outermost of which is called the stratum corneum (or horny layer). The layers may be clearly seen in the diagram of the skin. The surface layer is composed of twenty-five to thirty sub-layers of flattened scale-like cells, which are continually being cast off by friction and replaced by the cells of the deeper epidermal layers. The surface layer is considered the real protective layer of the skin. The cells are commonly called keratinised cells

because the living matter within the cell is changed to a protein (keratin) which helps to give the skin its protective properties.
New skin cells are formed in the deepest layer within the epidermis. This area is called the stratum germinative. The new cells will gradually move towards the outer layers of the skin as the stratum corneum is shed. The new cells gradually change in form as they move upward to the outer layers, becoming keratinized in the process.

Names of the Layers of the Epidermis

English Name	**Latin Name**
Horny Layer	Stratum Corneum
Clear Layer	Stratum Lucidum
Granular Layer	Stratum Granulosum
Prickle Cell Layer	Stratum Spinosum
Basal/Germinative Layer	Stratum Basale



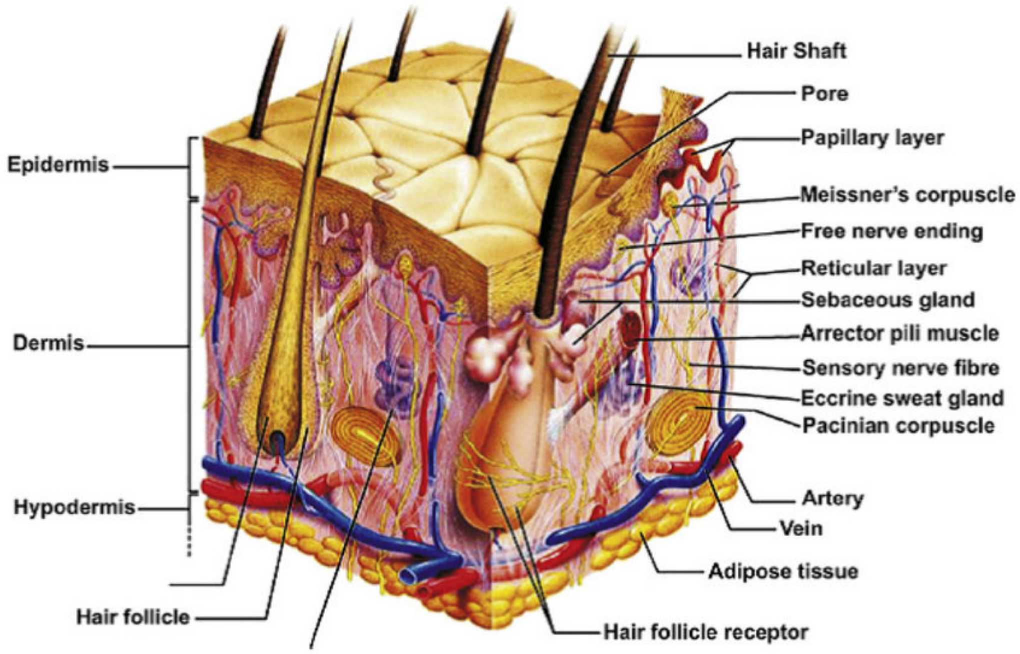
The Dermis Layer
The dermis is a tough and elastic layer containing white fibrous tissue interlaced with yellow elastic fibres and is found beneath the epidermis. Many structures are embedded in the dermis including: · Blood vessels – form a fine network with capillary branches · Lymphatic capillaries and vessels – form a network throughout the dermis · Sweat glands and their ducts – eccrine and aprocine glands ·

Sebaceous glands – secrete sebum (oil) · Sensory nerve endings - send messages via the nervous system · The arrector pilli muscle - involuntary muscle sometimes activated in cold weather to give 'goose bumps' · Hair follicles, hair bulbs and hair roots

The Subcutaneous Layer (Adipose)
This is the deepest of the layers of skin and is located on the bottom of the skin diagram. It lies below the dermis and above the muscle layer and connects the dermis above it to the underlying organs. The subcutaneous layer is mainly composed of loose fibrous connective tissue made up of fat cells, interlaced with blood vessels. The hypodermis is generally about 8% thicker in females than in males. The main functions of the hypodermis are insulation, storage of lipids, cushioning of the body and temperature regulation.

Below the dermis and above the muscle layer

Diagram of the Skin



Diseases and Disorders of the skin

There are some common diseases and disorders of the skin that affect many people. They can be troublesome and some of them can even be dangerous. They are broken down into different categories; bacterial, viral, fungal, infestations, sebaceous gland disorders, sweat gland disorders, pigmentation disorders, malignant tumours and allergies.

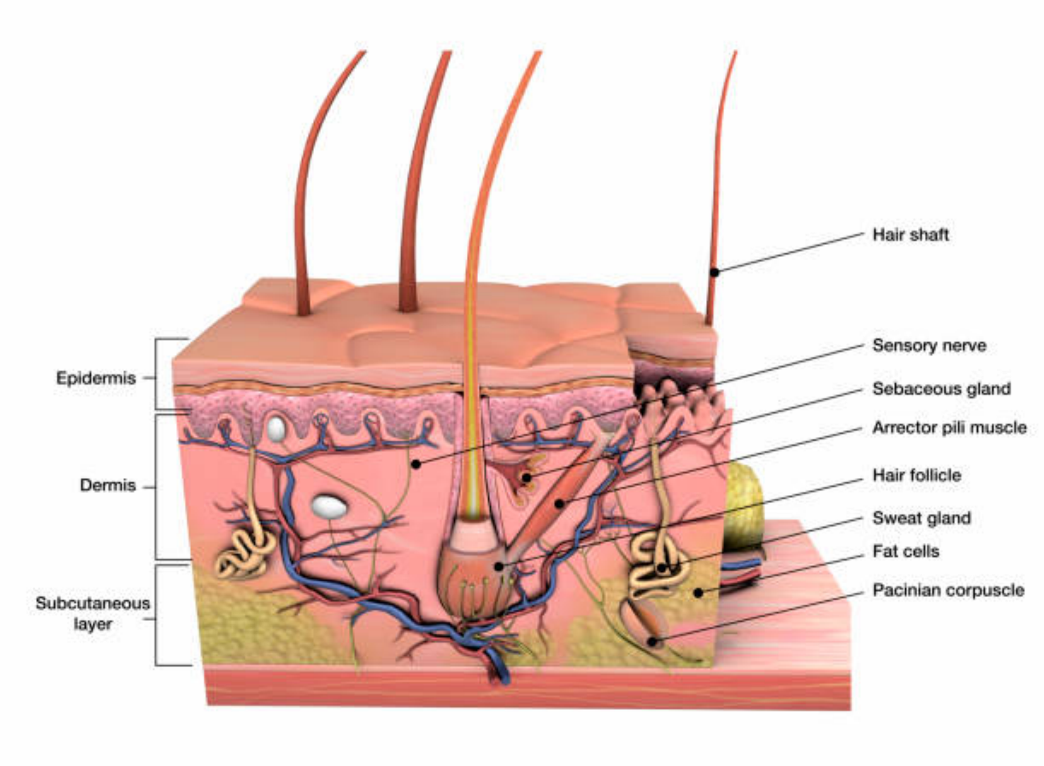
Name	Appearance	Cause	Categories i. e fungal, bacterial etc
Contact Dermatitis	Inflammation of the skin, swelling & redness	Allergic reaction to contact with allergen (always wear protective clothing)	Allergy
Seborrheic Warts	Flat top/warty looking lesion	Ageing	Fungal
Herpes simplex	Red sore/scab usually on side of the mouth also none as a cold sore	Viral infection transmitted by contact with another infected area. Highly contagious	Viral
Warts	Small solid growth	Same as Herpes simplex	Viral
Scabies	Itchy white spots	Mite transmitted by direct skin to skin contact typically from itchy infected area and transporting mite to someone else under fingernails.	Infestation by a mite, fungal
Psoriasis	Red itchy scaly patches erupting on skin	The immune system sends out a faulty signal that speeds up the growth cycle of skin cells	Chronic recurring skin disease which can be pustular or non pustular
Acne Rosacea	Redness on nose and cheeks	Dilation of minute capillaries in the skin	Skin disorder
Impetigo	Red spot which blisters then discharges developing a yellow crust	Highly contagious. Spread through direct contact and itching	Bacterial
Milia	Small harmless pinhead cysts also called milk spots	Manifestation of immature sebaceous glands and become blocked with keratin	Benign cyst

Eczema	Same as dermatitis: Redness is due to dilated blood vessels and as fluid accumulates itching, and swelling occurs. Weeping skin can then become infected	Allergic reaction Stress	Allergy

The Hair

There are roughly 5 million hairs that cover the body and with the exception of the palms, soles, the lips, the sides of the fingers and toes and some parts of the genitals, the whole body is covered in hair.

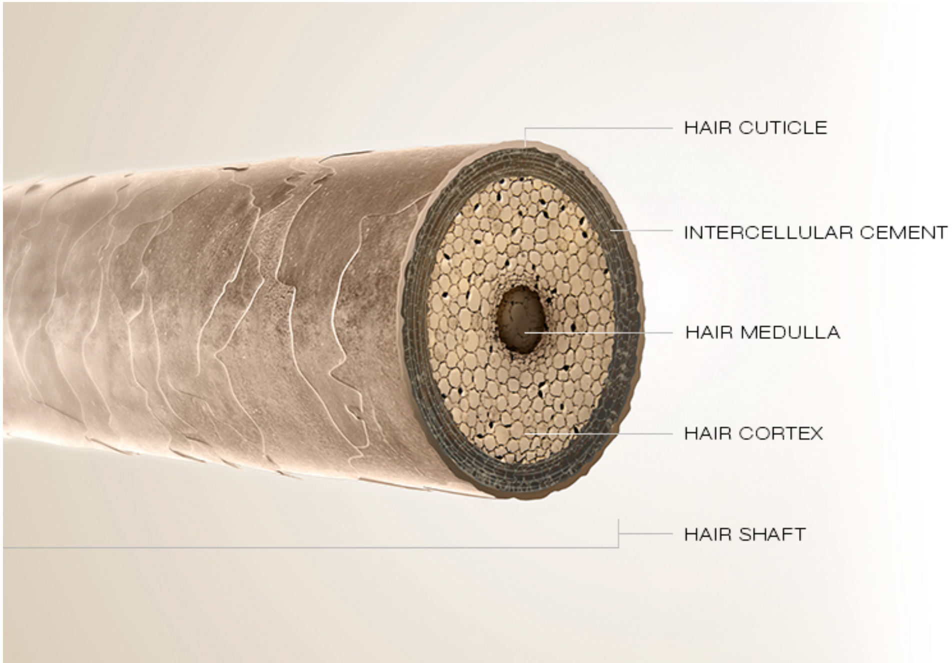
- Hair originates from a structure called a hair follicle. This tube like structure extends into the dermis layer and is fed by capillaries and nerves which are attached to it.
- Epithelial cells grow and divide inside the base of the follicle, which forms the hair bulb.
- Keratin, a protein which is found in the epithelial cells coats the hair which causes it to stiffen as it grows up through the follicles. Whilst the hair is in the follicle, it is called the root, but once exposed from the scalp it is called the hair shaft.



Structure of the Hair Root
Below the surface of the skin is the hair root, which is enclosed within a hair follicle. At the base of the hair follicle is the dermal papilla. The dermal papilla is feed by the bloodstream, which carries nourishment to produce new hair. The dermal papilla is a structure very important to hair growth because it contains receptors for male hormones and androgens. Androgens regulate hair growth and in scalp hair, Androgens may cause the hair follicle to get progressively smaller and the hairs to become finer in individuals who are genetically predisposed to this type of hair loss.

Each strand of hair consists of three layers.

1. An innermost layer or medulla, which is a core of loosely arranged cells and air spaces and only present in large thick hairs.
2. The middle layer known as the cortex. The cortex provides strength and both the colour and the texture of hair, and is made up of densely packed keratinized cells.
3. The outermost layer is known as the cuticle, made up of a single layer of scaly cells that overlap. The cuticle is thin and colourless and serves as a protector of the cortex.



As the newly formed cells grow and push up from the follicle base, the older epithelial cells die. The colour of the hair is determined by pigmented cells called melanocytes, which contain melanin. The amount of melanin will determine the colour of hair.

Hair Types and Textures

Straight Hair

With this type of hair, there is absolutely no curl pattern, and it is completely straight and sleek. The hair tends to be shiny because of the lack of curl pattern which allows the light to reflect off of the hair, giving it a shiny finish.

If straight hair appears dull is may be because it has become damaged. It is essential to care for the hair carefully to maintain its shine.

Wavy Hair

Wavy Hair can either be fine, or medium textured which looks coarser and thicker. It is possible to style and straighten the hair for a sleek look, but tighter curls can also be added.

Medium Curly Hair

This hair has a tighter curl pattern, and can either be loose curl or a tighter curl pattern. There is a lot of body in this hair which gives it versatility and it can be styled in many different styles, although it may be hard to straighten. The hair easily absorbs water when wet, but then it shrinks.

Kinky, Coily Hair

Tightly coiled hair has a lot more kink and appears thicker than other curly hair but it can be fairly fine. This type of hair is found in Afro styles and should not be brushed when dry as it can cause damage and breakage.

Texture

Hair texture is the measure of the circumference of the hair strand and is classified as either being "coarse", "fine", or "medium".

- Coarse hair has the largest circumference and is strong as it has more substance. It can be resistant to colouring and perming.
- Medium texture indicates a middle-range size circumference of the hair shaft, it's considered normal and poses no special considerations regarding processing and chemical services.
- Fine hair, has the smallest circumference, and is often very easy to process. It is easily damaged from chemicals and heat.

Hair texture varies from individual to individual, and the same head of hair can have different textures in different places.

Hair Density

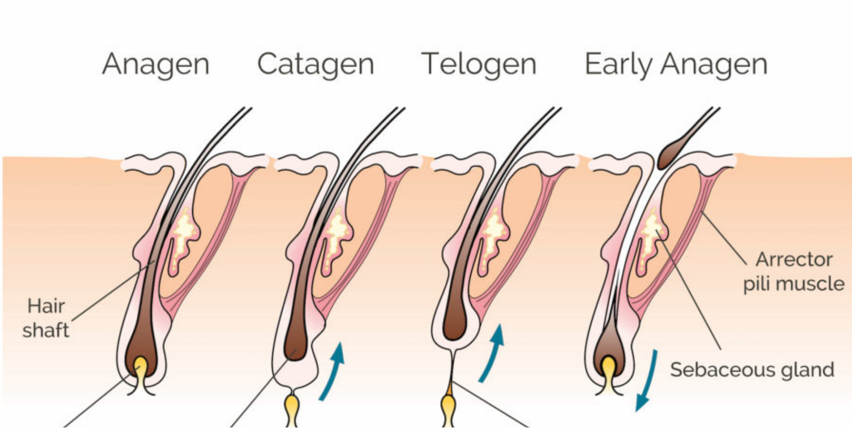
Hair density is the amount of hair strands on the head, and is measured by counting the number of hair strands found in one square inch (2.5cm) of scalp. Generally, the classifications of hair density are thick, medium, and thin, and are unrelated to the texture of the hair. The average head has approximately 2,200 strands of hair per square inch, and a total of approximately 100,000 hairs.

Hair Growth Cycle

Hair follicles grow in repeated cycles. One cycle can be broken down into three phases.

1. Anagen - Growth Phase
2. Catagen - Transitional phase
3. Telogen - Resting Phase

Each hair passes through the phases independent of the neighbouring hairs.



We are constantly losing around 30,000 to 40,000 dead skin cells form the surface of the skin every day, with the epidermis constantly replacing old skin cells and shedding them. The germinativum layer (basale) has cells that are shaped liked columns that divide and push new cells into the layer above. This process continues through each layer with the final layer – the corneum being made up of dead, flat cells that shed around every 2 weeks.

Nails

Nails provide some protection to our sensitive fingers and toes as well as allowing us to grasp small objects

The nail is made up from the following:-

Nail Wall: This is the folds of skin that overlap the sides of the nail. It holds the nail in place and protects the nail plate edges.

Matrix: The only living reproducing part of the nail, this is situated directly below the cuticle. New cells form here and continually push towards to produce the nail plate. It also contains blood vessels and nerves. Blood supply provides the cells with nourishment. If the matrix is damaged the nail will grow deformed.

Lunula: (Halfmoon) This is the meeting point for the matrix and nail bed and is pearly coloured and crescent shaped due to the cells being pushed closely together. The blood capillaries cannot be seen through the lunula because of this.

Nail Plate: Visible nail that rests on the nail bed up to the free edge. This is made up from dead cells (that have been pushed up from the matrix) and are held together with a minimum amount of moisture. The nail is semi-transparent – allowing the colour of blood supply of the dermis to show through (pink colour).

Nail Bed: Part of the nail that the nail plate rests on, also a continuation of the matrix. It is abundantly supplied with blood vessels and nerves, having numerous parallel ridges which dovetail exactly with the ridges on the under surface of the nail plate.

Free Edge: Is an extension of the nail plate. It overlaps the hyponichium. This part of the nail can be filed and shaped.

Cuticle: This is the overlapping epidermis surrounding the nail. It protects the matrix from invading bacterial and physical damage.
Eponychium – Base of the nail.
Peronychium – Sides of the nail.
Hyponichium -The portion of the skin at the end of the finger which is underneath the free edge.
Nail Grooves (Or furrows): Side of the nails upon which the nail moves on and acts as a guideline for the nail to follow.

Mantle: Is the skin over the matrix which protects it.

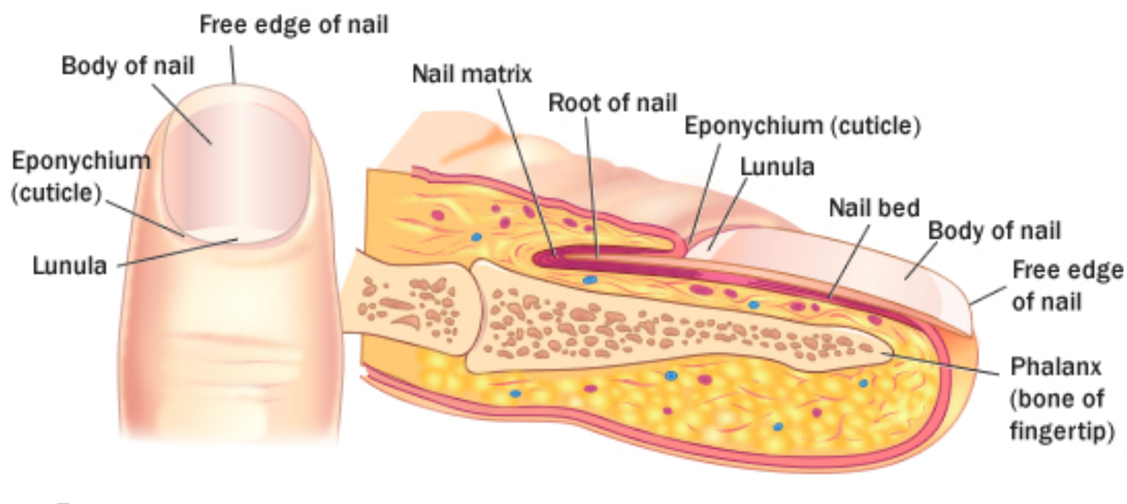
Disease or Disorders of the Nail

There are a variety of diseases that can affect the nail, ranging from anonychia, which is a congenital abnormality in which there is an absence of a nail, koilonychias, where the nail becomes spoon shaped, onycholysis, which is where the nail becomes separated from the nail bed and paronychia, in which there is a bacterial infection of the cuticle. Nails can also become curved, shed or ingrown.

Nail Pathologies

Name	Appearance	Cause
Leukonychia	White flecks within the nail plate.	Trauma to the nail or signs of a disease.
Hang nail	A small piece of torn skin next to the nail	Usually picking or biting the nails
Paronychia	Skin infection around the nails, causing red swelling	From biting or injury
Vertical ridges	Lines running the length of the nail	Unknown but more common as you get older. Nothing to worry about
Onycholysis	Separation of the nail from the bed	Usually trauma but can be a sign of disease

Diagram of the Structure of the Nail



Glands

There are two types of glands that are associated with the Integumentary system. They are sweat and sebaceous glands and both have their own different roles. There are around 2.5 million sweat glands covering the majority of the body and these consist of eccrine and aprocine sweat glands. The eccrine sweat glands produce a clear secretion with is made up of 99% water. The other 1% consists of salts and traces of waste. These glands are found all over the body but have a large supply on the forehead, upper lip and palms. The aprocine sweat glands are larger and do not function until puberty. They are found in the armpits and groin and secrete a cloudy substance which contains proteins and fatty acids. If the secretions remain on the skin for too long an odour can occur as the bacteria living on the skin break down the proteins and fatty acids.

All over the body, with the exception of the soles and palms, sebaceous glands lie in the dermis. The function of these glands is to secrete a substance called sebum which acts as a lubricant to prevent the skin and hair from drying out. The sebum consists of a mixture of fats, proteins the debris of dead fat-producing cells and is deposited onto the hair inside the follicles. If there is no hair on a particular surface, the sebum is deposited through ducts.

Homeostasis

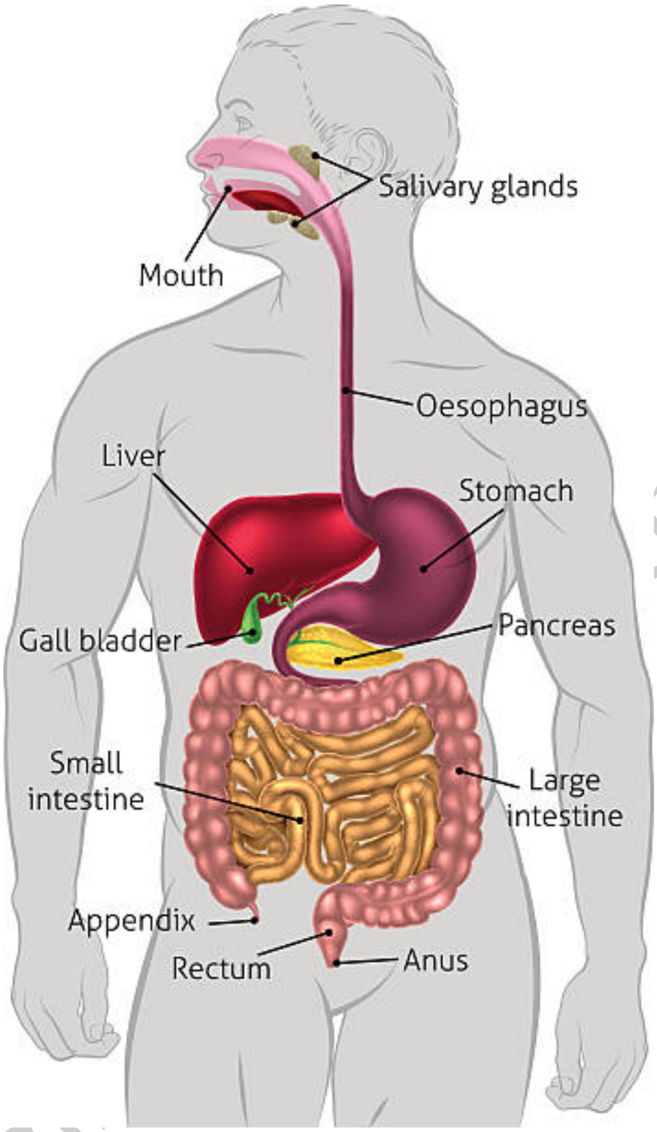
Homeostasis involves maintaining a constant internal environment in order for the body to function, regardless of the external conditions. The skin plays an important role in this as it contains heat and cold receptors in the skin which regulates the body temperature, keeping it at around 37°C.

The glands that we have discussed also reduce the growth of fungi by producing acidic secretions, as well as responding to signals from the hypothalamus in the brain. These nerve signals send messages to the glands which stimulates the production of sweat to cool the body down.

The blood vessels within the skin also respond to the hypothalamus and dilate to allow blood to flow closer to the skin and allow heat to be lost, as well as constrict to retain heat within the body when the temperature drops.

The pigmented cells, melanocytes also play a part in homeostasis as they act as a barrier from the damaging effects of ultraviolet light.

The Digestive System



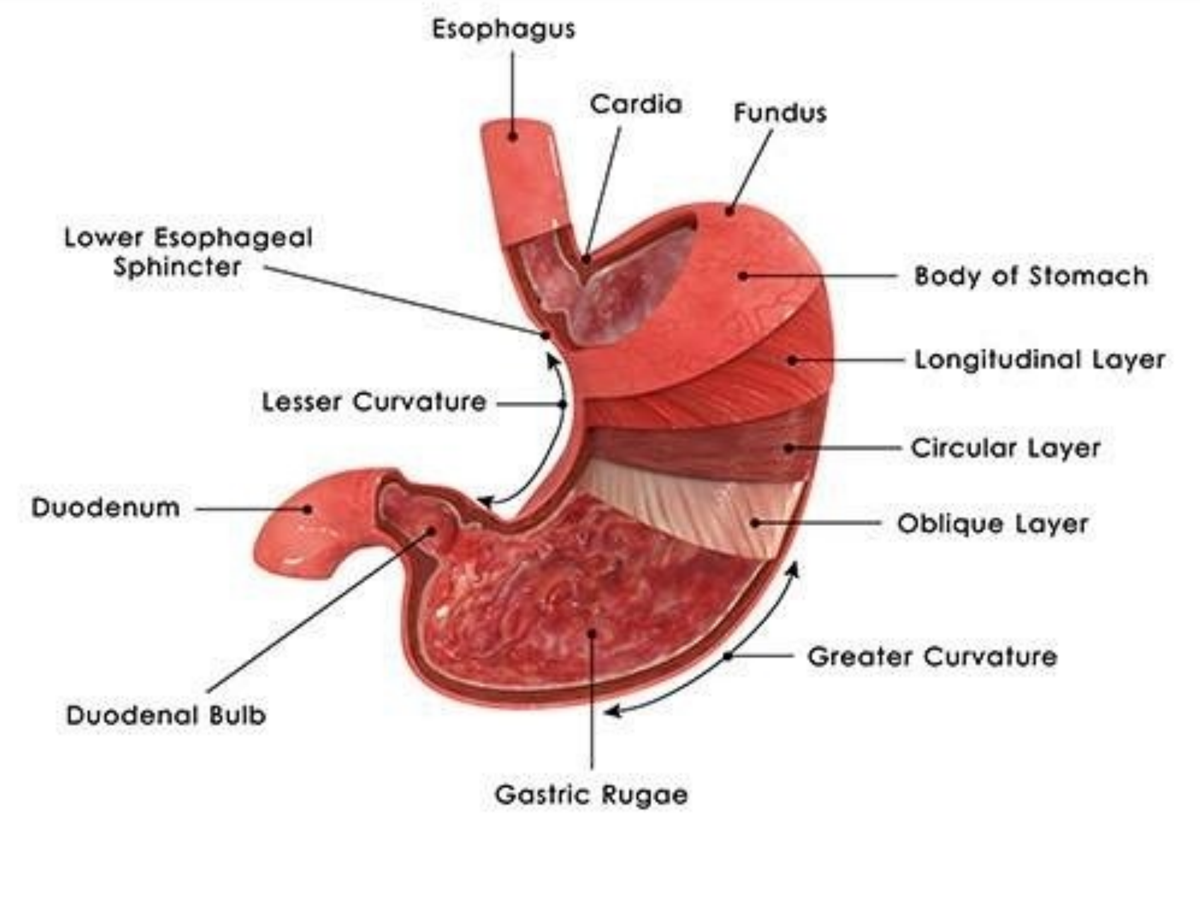
The digestive system allows for the breaking down of chemicals in the body that can be absorbed and contains a number of hollow organs which runs from the mouth to the anus. There are a number of stages to digestion as it follows its route through the digestive tract, which takes from 20 – 30 hours, and we are going to look at them in turn as we follow that journey. The digestive systems main aim is to allow for mastication, digestion, absorption and then elimination of food.

The Mouth
When we think of food or before it even enters the mouth, saliva is released from the salivary glands which are passed around the mouth by the tongue. The saliva, which is secreted at around 1 – ½ litres a day, contains an enzyme called amylase that assists with chemically breaking down some carbohydrates. The saliva also moistens the food, making it easier to swallow. Our teeth break down food into smaller manageable pieces by tearing and shredding.

Movements by the tongue and the jaw push the food to the back of the pharynx (throat), where a tiny flap of skin called the epiglottis closes over the entrance of the trachea to prevent choking. This swallowed food, now called a bolus, is pushed down into the oesophagus, where wave like contractions, called peristalsis push the food further down to the stomach. The food passes through a muscular ring, called the cardiac sphincter into the stomach, which then quickly shuts to prevent food travelling back up the oesophagus.

The Stomach
Once in the muscular J shaped sac, the food and liquids are stored and mixed with strong digestive juices that are secreted by the lining of the stomach. The bolus is churned and squeezed by the powerful muscular contractions of the stomach wall. Hydrochloric acid breaks down the bolus into chyme, which is a liquid. The acid does not damage the stomach walls due to a thick layer of protective mucus, but if this mucus becomes limited, then an ulcer may form. With the exception of water, alcohol and certain drugs, very little of the chyme is absorbed into the blood from the stomach.

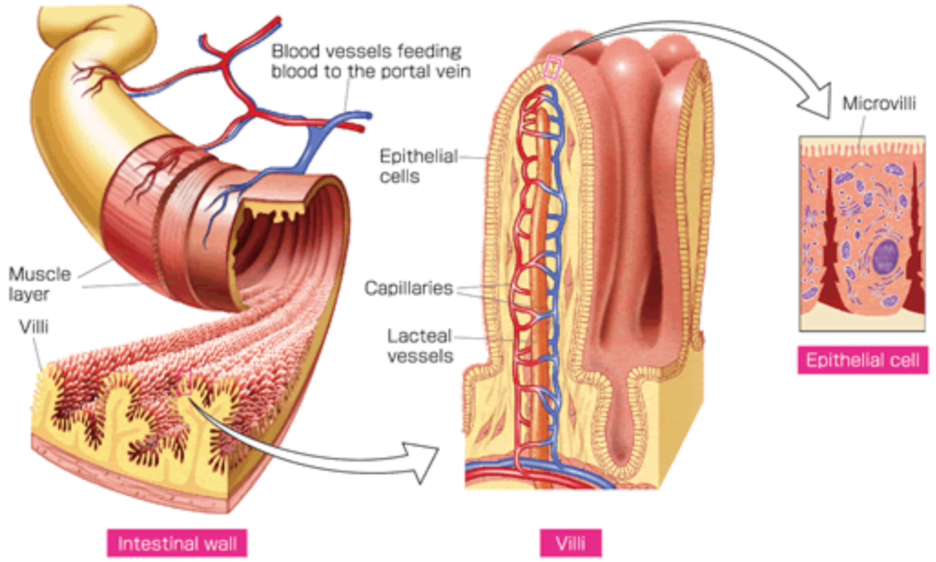
The stomach walls contain three layers of smooth muscle arranged in longitudinal, circular, and diagonal rows, which allows the stomach to squeeze and churn the food during mechanical digestion. Whilst this digestive process in the stomach is occurring, which can take several hours, a stomach enzyme called pepsin is breaking down proteins. The chyme is then transported a little at a time through the pylorus into the small intestine, via the pyloric sphincter.



The Small Intestine
Sometimes called the small bowel, the small intestine is the longest portion of the digestive tract and is approximately 20 feet long is made up of the duodenum, the jejunum and the ileum and is a narrow tubed structure that fills most of the lower abdomen. Once the chyme is in the duodenum, bile from the gallbladder and enzymes from the pancreas all combine to complete the final stages of digestion. The acid from the stomach is neutralised in the duodenums alkaline environment.

Gland cells in the small intestine secrete digestive enzymes that chemically break down complex food molecules into simpler ones.

The chyme leaves the duodenum and it enters the jejunum and ileum. Here the nutrients are absorbed through the lining of the small intestine and transferred to the bloodstream and liver by tiny villi which cover the walls of the small intestine.



These finger like projections allow for a greater surface area, allowing the chyme to be absorbed. Such products as fibre and water, that have not been digested in the small intestine travel to the large intestine. The ileum is the final portion of the small intestine, which leads into the large intestine.

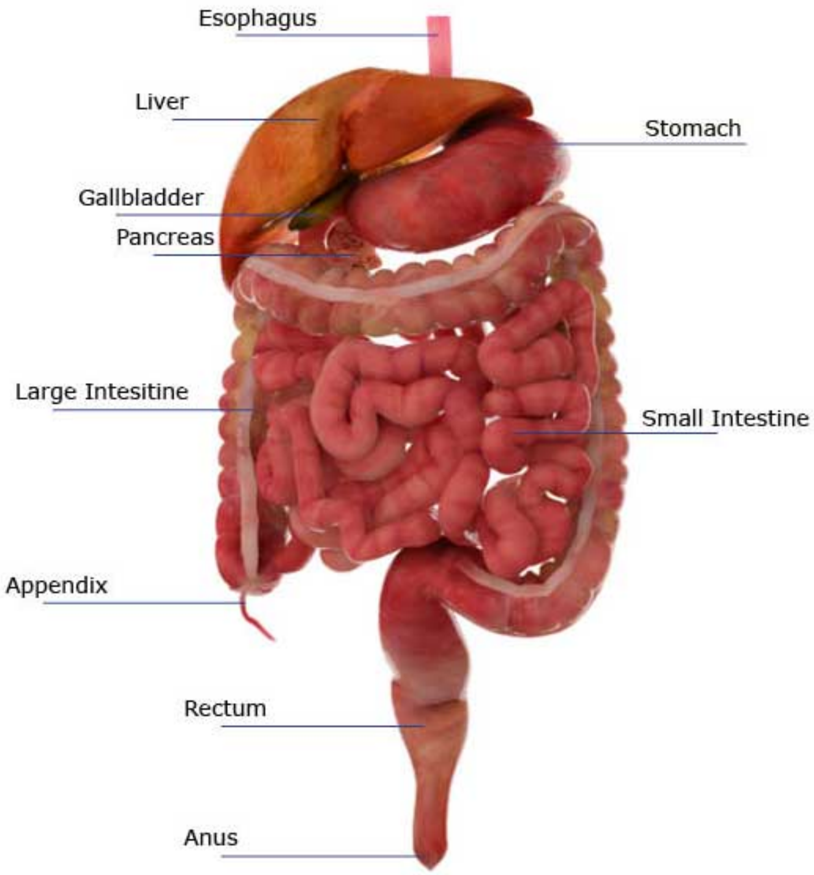
The large Intestine

Sometimes called the large bowel, the large intestine collects and stores all waste products before processing them into faeces to be removed from the body. This part of the intestines is around 5 feet long and is made up of the caecum, appendix, colon and rectum.

The caecum is shaped like a pouch and is found in the right lower abdomen and stores all the material; fibre, water salts and some vitamins from the small intestines before moving it along to the colon. The material enters the expanded caecum through a valve that separates the small intestines from the large intestine. A small projection, the appendix, emerges from the caecum, and although it has no known function it can become troublesome if it becomes infected.

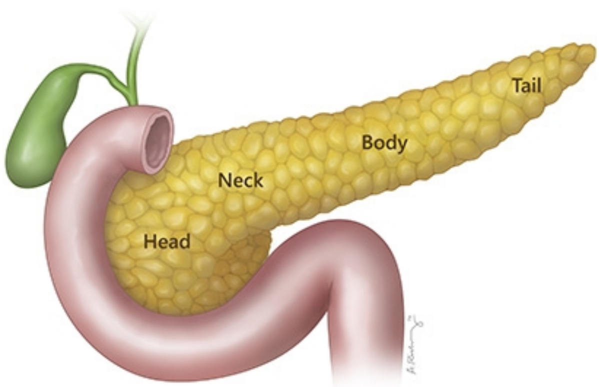
Starting at the caecum, the ascending colon travels up the abdomen towards the liver. The colon then becomes transverse as it travels across the abdomen, and then descends down the left side of the abdomen to the sigmoid colon. This S shaped organ is the largest part of the intestine and joins onto the rectum. All the time that the processed mixture is in the colon, mucus and bacteria from within the large intestine mix and starts to form faeces. This water and some vitamins and minerals from the faeces are then absorbed into the colon.

The faeces are pushed along to the sigmoid colon and finally the rectum by muscular action, where they are stored until being passed as a bowel motion.



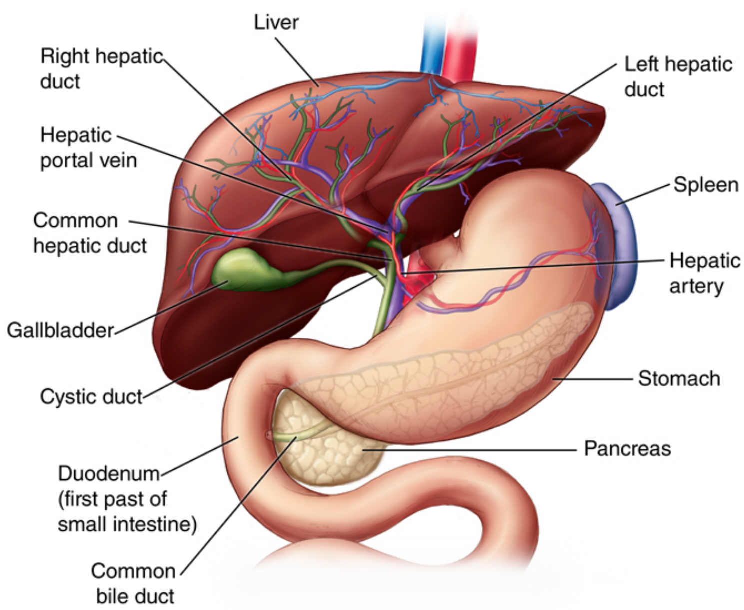
The Pancreas

This 12-15cm organ is located just below the stomach, and slightly behind it. Around 99% of the pancreas is made up of small clusters of glandular epithelial cells called acini, which is responsible for producing the clear pancreatic juice which has many functions. These enzymes enter the duodenum via two pancreatic ducts, which classifies it as an exocrine gland. Pancreatic amylase is secreted for digesting carbohydrates, trypsin to digest proteins and lipase to digest fats. The remaining 1% of the pancreas contains cells which are arranged into clusters called Islets of Langerhans. These cells directly secrete the hormones Insulin and glucogen, needed to control the blood sugar level into the bloody which also means the pancreas is an endocrine gland.



The Liver

Found in the upper abdominal cavity towards the right and above the diaphragm, the liver is the heaviest gland in the body. The livers cells or hepatocytes process chemical changes and its main function is to regulate the composition of blood, so is therefore highly vascular, receiving oxygenated blood via the hepatic artery and deoxygenated blood from the stomach and intestines via the hepatic portal vein. Here, excess glucose from the blood is removed and stored in the form of glycogen, until all the glucose in the body has been used up and blood sugar levels fall. The liver then re-converts the glycogen back into glucose. Filtering the blood of any harmful substances is crucial and this is done by the liver extracting it from the blood. Blood is transported back to the heart via the inferior vena cava. As well as the mentioned functions, the liver also secretes bile, which consists of cholesterol, pigments, salts and traces of other substances. Bile is removed from the liver to the gall bladder for storage via the canaliculi.



The Gall Bladder

Acting as a storage vessel for bile produced in the liver, this small 4 inch sac is located behind the liver and has an important function of adding mucus to the bile which increases its concentration. As the body requires bile to emulsifier fats, the gall bladder contracts and releases bile into the bile duct. Along with the pancreatic duct, bile enters the duodenum.

Enzymes

Enzymes are biological catalysts, made up of proteins, which speed up chemical reactions in all living things. They are needed to digest food and only work for one specific reaction. Human saliva contains an enzyme called amylase which breaks down starch into a sugar called maltose. The pancreas is the main digestive gland in the body

In the stomach the gastric enzymes pepsin, gelatinase, gastric amylase and gastric lipase are secreted. All of these enzymes have a different role, from breaking down proteins to degrading starch

Digestive Hormones

As well as releasing enzymes, at least four digestive hormones are released which help aid and regulate the digestive system. These consist of gastrin found in the stomach, secretin, cholecystokinin and gastric inhibitory peptide also found in the duodenum.

Absorption and Transportation of Nutrients

The human body is made up of two-thirds water and it is an essential nutrient that is involved in every function of the body. Water helps transport nutrients and waste products in and out of cells and is necessary for all digestive, absorption, circulatory, and excretory functions. Maintenance of the proper body temperature is determined by water and it is recommended that you drink at least eight 8-ounce glasses of water each day.

Carbohydrates, such as starch and sugars need to be broken down into simpler molecules by enzymes in the saliva and pancreatic enzymes. Starches are digested by the enzyme in saliva and pancreatic juices and sugars are digested by an enzyme found in the lining of the small intestine.

Fibre is indigestible and does not get broken down at all by enzymes. Soluble fibre can be dissolved in water, whereas insoluble fibre passes through the intestines unchanged.

Fats need to be broken down by being dissolved in the intestine and then by the bile acids produced by the liver, so they form tiny droplets. These droplets are then carried into the cells of the mucosa before changing back into large molecules. They then pass into the lymphatic’s to be carried to the veins of the chest, and by blood vessels to the fat deposits in the body where they are laid down as storage.

Proteins must start to be digested by an enzyme in the stomach before they can be used to help build and repair the bodies cells and tissues. Once in the small intestine, pancreatic enzymes complete the breakdown of larger protein molecules into smaller ones called amino acids. Once absorbed, they can be carried to all parts of the body for growth and repair

Vitamins are classified by being either water-soluble vitamins (the B vitamins and vitamin C) or fat-soluble vitamins (vitamins A, D, E, and K). It is difficult to store water-soluble vitamins, and any excess are flushed out in the urine. Fat-soluble vitamins can be stored in the liver and the fatty tissue of the body.

Minerals are needed in small amounts. Minerals are classified into essential minerals and trace minerals, with the body only needing very small amounts of trace minerals. Those classified as essential are magnesium, sulphur, sodium, potassium, phosphorus, iron and calcium. The main function of minerals is to control body fluids, build strong bones and teeth and to assist with converting food into energy that can be used.

Water is an essential nutrient which makes up around 50-75% of our body weight. It removes toxins in the body, regulates temperature and is essential for growth of the body.

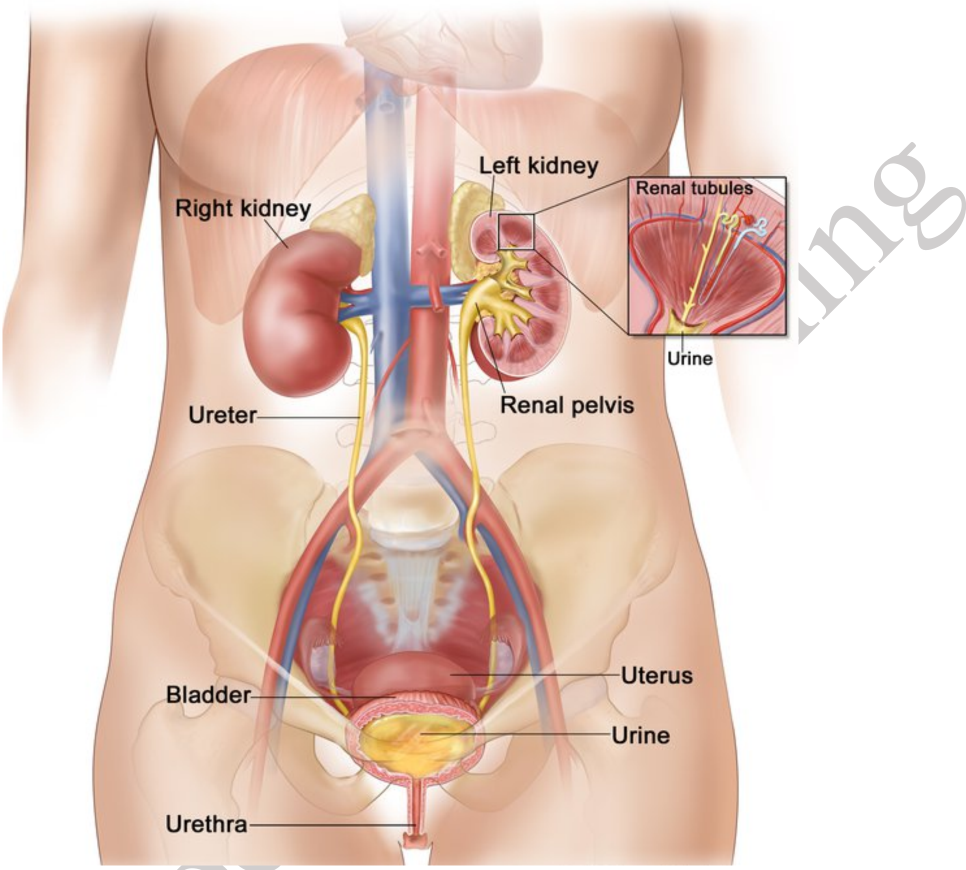
Recommended Daily Allowance (RDA)

The RDA was originally set in 1979 by the Government of Health to state what the minimum amount of nutrients needed by the body but the term Dietary Reference Value (DRV) can also be used. The rates are different for adults, children, male and females. The law now ensures that food is labelled to state what percentage it is providing against the RDA, and also many foods now contain the “traffic light” symbols.

Pathologies of the Digestive System

Disease	Meaning
Crohn's Disease	Inflammation in the gut, a long term disease, affecting any part of the digestive system.
Coeliac's Disease	An intolerance to gluten which causes indigestion, bloating, weight loss
Gall stones	Pebble like deposits, usually made of cholesterol, that form inside the gall bladder.
Irritable bowel syndrome	Bouts of stomach cramps, bloating and a change in bowel motion.
Hepatitis	Inflammation of the liver, usually caused by a virus.
Hernia	The lining of the abdominal cavity weakens and protrudes through a weak area of the abdominal wall.

The Urinary/Excretory System



The urinary/excretory system is made up of the kidneys, ureters, bladder and urethra and is responsible for controlling the amount of water and salts that are absorbed and filtered into the blood, and will regulate the chemical composition of body fluids by removing water and salts (metabolic waste).

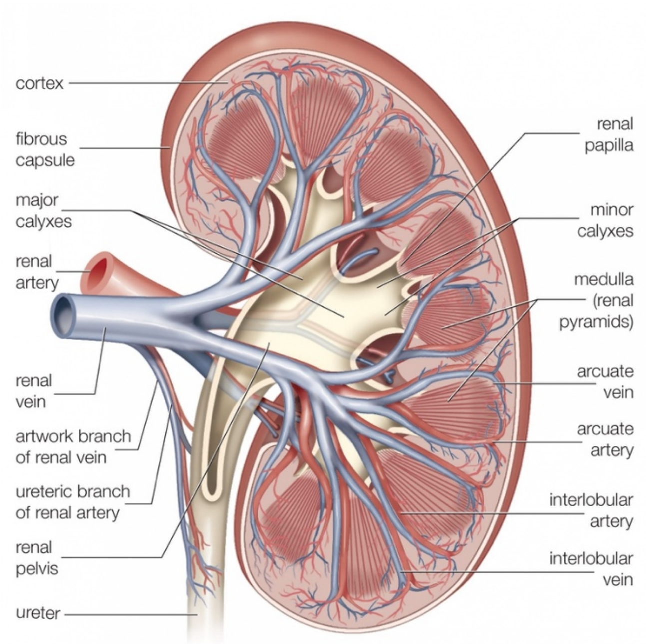
The Kidneys
These are two bean shaped kidneys in the body, one on either side, located near the middle of the back behind the 13th rib. These 5 – 6 inch long organs are responsible for processing waste products and filtering the blood to ensure that the body is in a state of balance. The waste comes from the normal breakdown from the food that is eaten.

It is essential that this waste is removed as it could damage the body. Each kidney is joined to the aorta, which is the largest artery in the body by a short renal artery, as they receive a huge blood supply.

Each kidney contains around a million nephrons, a tube which is closed at one end, and open at the other. Inside the nephron is a tiny blood vessel called a glomerulus. This vessel intertwines with a tiny tubule where waste materials and water leave the blood and enters the urinary system where it is turned into urine, to continue the journey to the urethra. The main filtered substances consist of water, nitrogen containing compounds, acids, salts and alkalis.

The renal artery supplies blood, containing glucose and oxygen to the kidney from the left hand side of the heart. Blood in the renal artery must have sufficient pressure or the kidney will not be able to filter the blood. The blood in this vessel contains a toxic product called urea which must be removed, as it may have too much salt and water. It is the kidneys function to remove these excess materials.

The renal vein has a large diameter and a thin wall, and carries blood away from the kidney and back to the right hand side of the heart. Blood in the kidney has had all its urea removed. The renal vein contains blood that has exactly the right amount of water and salts, as the kidneys remove excess water and salts. The kidney is controlled by the brain, and a hormone in the blood called Anti-Diuretic Hormone (ADH) is used to control exactly how much water is excreted.



Any products that can be re-used enter the blood and travels throughout the body. About 150 litres of blood pass through the kidneys every day, but of this only about 1% is excreted as the rest is cleaned and re-used.

The cortex is the outer part of the kidney and is where the blood is filtered. This process is called ultra-filtration or high pressure filtration because it only works if the blood entering the kidney in the renal artery is at high pressure.

The medulla is the inside part of the kidney and is where the amount of salt and water in your urine is controlled. It is dark red in colour and contains billions of loops of Henle' which pumps sodium ions. ADH stimulates the loops to work harder to pump more sodium ions, which results in very concentrated urine, is produced.

Nephron

A nephron is the functional unit of the kidney which is responsible for purifying and filtering the blood. It is around 2-4cm in length and each cortex contains around one million nephrons, and each one consists of a renal corpuscle and a renal tubule which carry out the functions of the nephron.

The Glomerulus

The glomerulus is the main filter of the nephron and is found within the Bowman's capsule. It looks like a twisted mass of tiny tubes through which the blood passes. The glomerulus is semi permeable which allows water and soluble wastes to pass through and be excreted out of the Bowman's capsule as urine. Once filtered, the blood passes out of the glomerulus into the efferent arteriole to be returned through the medullary plexus to the intralobular vein.

Bowman's Capsule

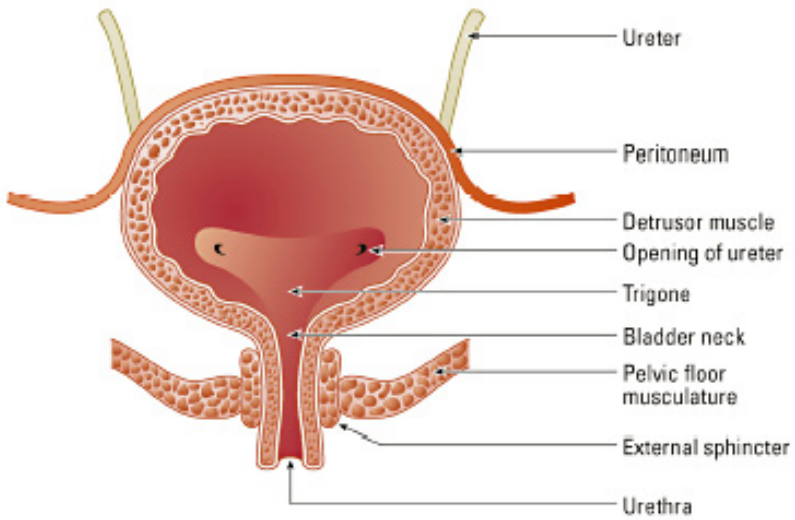
This is where the glomerulus is contained. Blood is transported into the Bowman's capsule from the afferent arteriole and within the capsule; the blood is filtered through the glomerulus and then passes out via the efferent arteriole.

Ureter

Leading from each of the kidneys to the bladder is a 25cm long tube called the ureters. The walls of the ureters are hollow and contain smooth muscles which contracts and allows the movement of urine out of the kidneys. Each Ureter is lined with a membrane coated with mucus. This lining is impermeable to the normal soluble substances of the urine.

The Bladder

The bladder is a hollow, elastic muscular organ in which urine is stored until it is passed out of the body via the urethra. The bladder is found in the pelvis behind the pelvic bone and can expand and hold around 400 – 600ml of urine at a time, for up to five hours.
The more fluid that is drunk, the more urine is produced. When the body becomes hot, and sweat is produced, less urine will be made.



Of the urine produced, around 96% of it is water, but it also contains waste salts and a substance called urea, which is made during the breakdown of proteins in the liver. It is a transparent solution but is amber in colour. The sweat that the body produces may also contain urea and it is essential that this does not build up in the body as it can be an indicator that the kidneys are not working satisfactorily.

The Urethra

This tube runs from the bottom of the bladder to the outside of the body. In males the urethra is approximately 8 inches long and leaves the bladder, passing downward through the prostate gland, through the length of the penis until it ends at the urethral orifice or opening at the tip of the glans penis. In females, the tube is around 4 – 5 cm in length and exits the body just in front of the vagina.

A ring like band of muscle, called the internal urethral sphincter helps control the process of urination. This sphincter is an involuntary muscle and therefore requires no participant control. The external sphincter, lying below the internal sphincter is made up of smooth and striated muscle and is under the control of the pudendal nerve.

The striated muscle allows it to be under voluntary action and its function is to keep urine in the bladder. As the bladder fills, the internal pressure inside the bladder activates stretch receptions in the bladder wall and a message gets sent to the nervous system. This produces small waves in the muscle attached to the internal sphincter which relaxes and becomes funnel shaped. This action causes the conscious effort of tightening the external sphincter until the person is able to urinate and relax the external sphincter.

As well as the organs mentioned, other organs also have an important role in excreting waste substances. The lungs excrete carbon dioxide and water, the liver excretes bile and the skin secretes waste in the form of sweat.

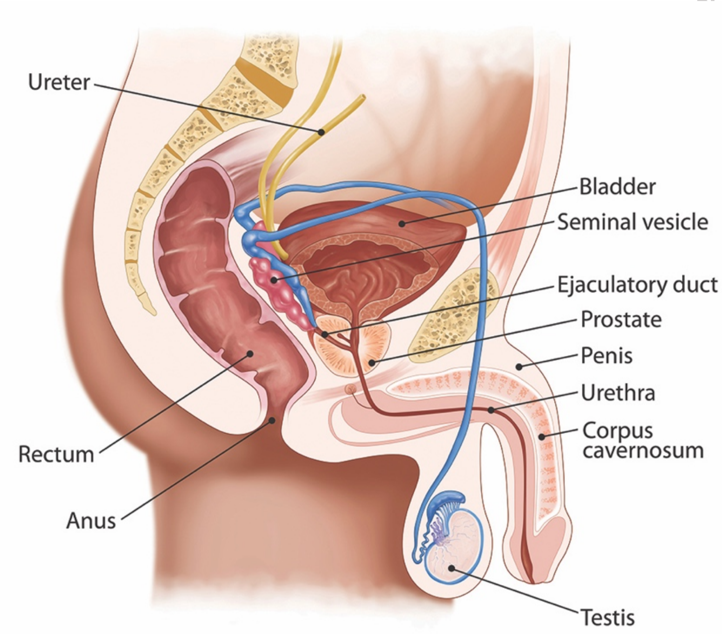
In addition to removing waste products from the body, the urinary system also secretes an enzyme called renin which maintains normal blood pressure and a hormone called erythropoietin which controls red blood cell production.

Pathologies of the Urinary System

Disease	Meaning
Urinary Tract Infection	An infection that can happen anywhere along the urinary tract.
Cystitis	Inflammation of the bladder, usually caused by an infection.
Nephritis	Inflammation of a kidney.
Kidney Stones	Stone that are made in the kidneys, usually out of tiny crystals. Pain occurs if the stones move into the ureters.
Bladder Stones	Small stones that form inside the bladder, which can disrupt the flow of urine.
Renal Failure	A deterioration of kidney function which can be caused by other conditions such as diabetes.
Renal Colic	Abdominal pain, usually caused by kidney stones.

The Reproductive System

The primary function of the reproductive system is to ensure that the human species survives. All living things reproduce and it is one of the functions that sets living things apart from nonliving things. The continuation of the species will happen by producing an egg and sperm cell and allowing for the transportation of these cells. Another role is to nurture and develop the offspring and to produce hormones.



The Male Reproductive System
This system consists of organs which allows for the production of a new individual. The organs involved are the testes, excretory ducts made up of the epididymis and the vas deferens, glands such as seminal vesicles and the prostate gland and the penis.

Testes
The testes are the principal structure of the male reproductive system. The two egg shaped organs, approximately 2 inches in length are suspended from the body by the scrotal sac, a pouch of skin that allows the testes to remain at an optimum temperature for the development of sperm. The scrotum changes size to be able to maintain the right temperature. The testicles produce and store million of sperm cells. Around 850 feet of tubules are packed into each testis and is where sperm are produced by meiosis. The testes also produce testosterone, the primary hormone which is involved in puberty. During ejaculation, the muscular movements of the vas deferens and the ejaculatory duct aid the ejection of the sperm.

Excretory Ducts

The epididymis and the vas deferens make up the duct system of the male reproductive system. The epididymis is a c shaped set of coiled tubes that is connected to the vas deferens. They are found at the back of the testes and are where sperm are matured and stored. The vas deferens is a muscular tube that passes up along the side of the testicles and transports the semen.

Glands

The function of the glands in the male reproductive system is to secrete fluids during ejaculation.

- The seminal vessels have a short duct that joins with the ductus deferens to form an ejaculatory duct that empties into the urethra.
- The fluid produced assists with the mobility and viability of the sperm, as well as neutralising the acidity in the female reproductive tract.
- The prostate is a firm, walnut size gland that encircles the urethra as it leaves the urinary bladder. It secretes a thin, milky coloured liquid that enhances the mobility of the sperm. It is of an alkaline substance that counteracts the acidity of the urethra.
- The paired bulbourethral glands, or sometimes called the Cowper's glands are about the size of a pea and are found near the base of the penis. During sexual stimulation, theses glands secrete mucus like fluid which neutralises the acidity of the urine residue in the urethra. It also provides some lubrication for the tip of the penis during intercourse.

The Penis

The penis is the sex organ that allows for the passage of both urine and sperm. Apart from the muscles on the tip of the penis, it does not contain bone or muscles.

The penis is made up of three columns of erectile tissue that are wrapped in connective tissue and covered with skin. It has a root, shaft and glans penis, with the root attached to the pubic arch. The shaft is the visible part.

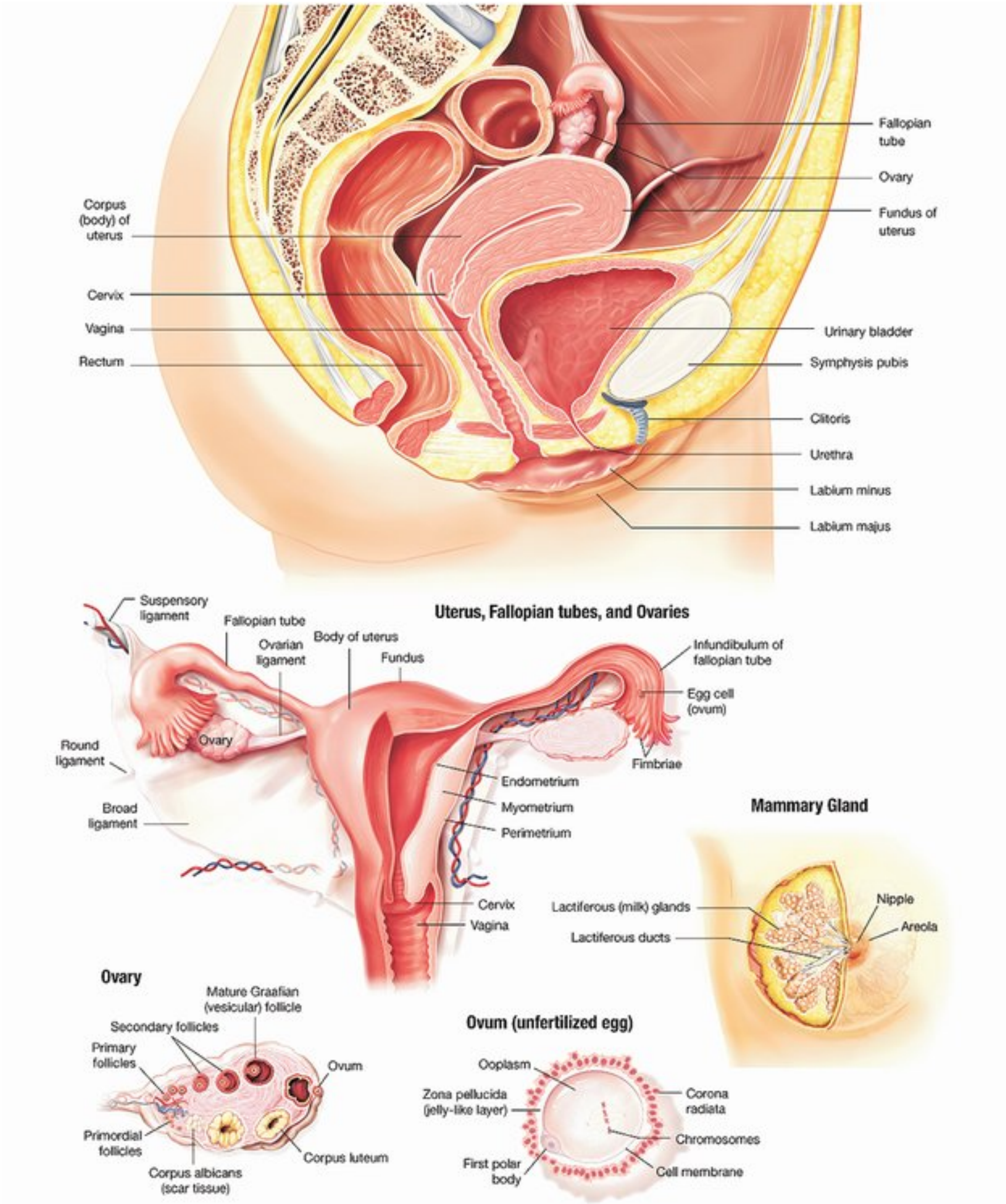
The glans penis is formed at the end and the urethra extends throughout the length of the penis and opens through the external urethral orifice at the tip of the glans penis. The foreskin, a loose folding of skin covers the glans penis.

Seminal Fluid

Seminal fluid contains a mixture of sperm cells and secretions from the accessory glands. In fact around 60% of semen is made up of the secretions from the seminal vesicles, with the prostate gland providing the remainder. Only a small amount comes from the bulbourethral gland and sperm.

In one single ejaculation, the volume of semen can vary from 1.5 to 6.0ml with usually anything between 50 to 150 million sperm per millilitre of semen.

The Female Reproductive System



Again, this system consists of organs which allows for the production of a new individual. The organs involved are the ovaries, fallopian tube, uterus, cervix and vagina.

The Ovaries

- The ovaries are the primary female reproductive organs, with each one being a solid oval structure around the size and shape of an almond.
- They are approximately 3.5 cm in length and 2 cm wide and are located one on each side of the uterus, in the lateral walls of the pelvic cavity.
- They are suspended by the ligaments in the upper pelvic cavity, one being on either side of the uterus. At the birth of a female, each ovary contains over 200,000 immature ova, with each ova being encased in a sac called a follicle. In response to various sex hormones, each follicle develops until they become primary follicles, which is when ovulation occurs.
- The ovum breaks free of the follicle and enters the fallopian tube. The ovaries are also responsible for producing oestrogen and progesterone, which are vital for proper reproductive function
- There are two fallopian tubes, each about 4 inches in length and a narrow as a piece of string, attached to a side of the uterus. Each tube resembles a funnel, which is wider at the ovary and becomes narrower at the uterus.
- Once in the fallopian tubes, Epithelial tissue that has tall, oblong-shaped cells with hair-like projections, known as ciliated columnar, move ova in one direction, down the narrow passageway towards the uterus.
- If fertilization takes place, it will usually occur in the wider part of the fallopian tube. Once the ovum has become fertilized it is called a zygote and travels to the uterus over the next 7 days.

The Uterus

The uterus is suspended by broad ligaments and is situated between the bladder and the rectum. It is shaped like an upside-down pear, with a thick lining, muscular walls and a rich blood supply. It is made up of three layers, being the peritoneum (outer layer), myometrium (middle layer) and endometrium (inner lining). The uterus serves as a pathway for sperm to reach the fallopian tubes as well as to be able to expand and contract to accommodate a growing foetus and push the baby out during labour. If fertilisation occurs, the uterus will provide a source of attachment and nourishment for the growing zygote, which embeds into the endometrium. When a woman isn't pregnant, the uterus is only about 3 inches long and 2 inches wide and the lining of the uterus (endometrium) breaks down during menstruation.

The Cervix

The uterus ends at the cervix which is the lower portion or neck of the uterus. The cervix is lined with mucus and joins the top end of the vagina. It is a thick tube of smooth muscle that acts as a channel for sperm to reach the waiting ovum. During late pregnancy the walls of the narrowed channel thin out to allow for the babies head to descent. The opening of the cervix is very small and during childbirth, the cervix can expand to allow a baby to pass.

The Vagina

The vagina is the female's sex organ and extends about 3 – 5 inches inside, up to the cervix. It is a muscular, ridged sheath connecting the external genitals to the uterus. The vagina acts as a pathway for the penis to enter during intercourse to allow sperm to be deposited. It also acts as a passageway for the birth of a baby. During sexual arousal, droplets of fluid appear along the vaginal walls and eventually cover the sides of the vagina completely. The tissues are rich in blood vessels which when engorged with blood as a result of sexual arousal, press against the tissue, forcing natural tissue fluids through the walls of the vagina

Menstruation, Conception and Pregnancy

Menstruation is controlled by hormones and the cycle is usually a 28 day process, although this can vary greatly.

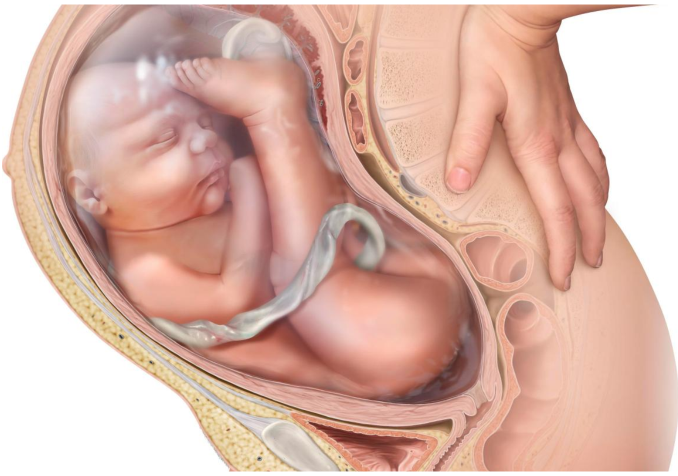
- During day 1 – 5 the hormones oestrogen and progesterone reduce which causes a breakdown of the endometrium. This results in the discharge of blood, tissue fluid and mucus, but also in the preparation of a mature follicle.
- During days 6 – 13, two more hormones, Follicle Stimulating Hormone (FSH) and luteinizing hormone stimulate the ovaries to produce more oestrogen. This in turn allows for the endometrium to re-build.
- By now a mature follicle is ready to be released on day 14.
- Between days 15 – 28, progesterone is stimulated by luteinizing hormone to prepare the uterus to receive the fertilised ovum, if there is one.
- If fertilisation does not occur then the hormone changes will start the cycle over again and initiate the breakdown of the lining.

The process of conception is nothing short of a miracle. Once the ovum has been released, it travels along the fallopian tubes, producing an enzyme that attracts any sperm. One sperm will break through the tough coating of the ovum to fertilise it, which will then continue to the uterus. Once the zygote has arrived in the uterus it will implant itself into the endometrial lining and become an embryo.

Pregnancy

The first four weeks after fertilisation will show a rapid amount of development as all of the major organs and body systems start to develop. The placenta and umbilical cord, which sustains pregnancy, are also being formed.

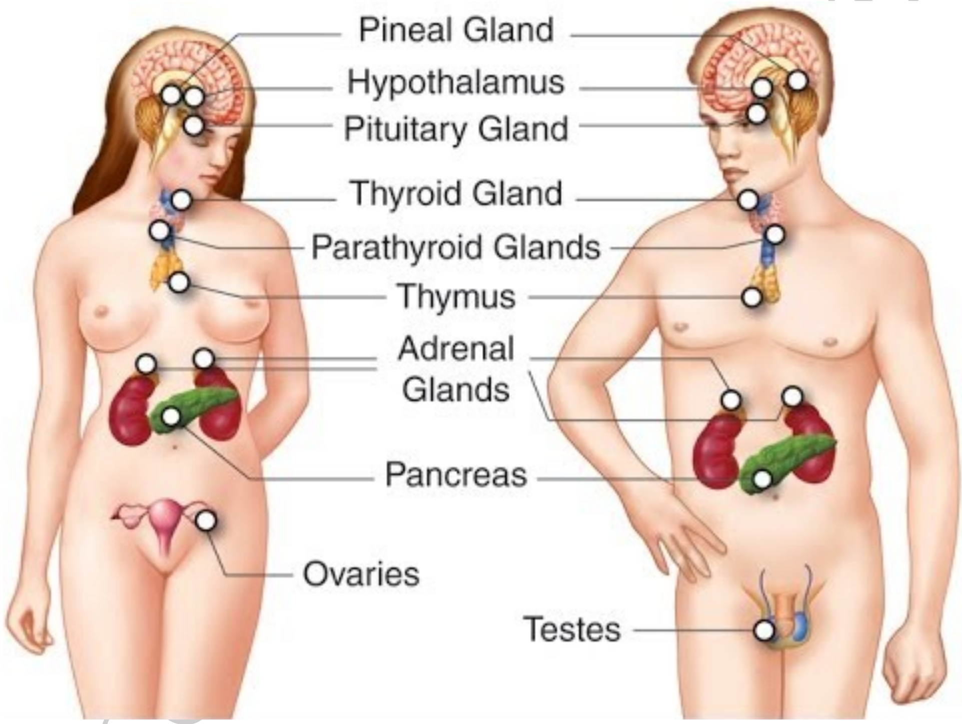
- During weeks 5 – 8, the embryo starts to become recognisably human in form as the limbs begin to grow and the torso straightens out.
- By weeks 9 – 12, the first trimester is closing and the foetus is almost double in length with all organs formed. The eyelids are fused with the eyes remaining closed.
- Weeks 13 – 16 see the foetus rapidly increasing in size, with movements alerting the pregnant women of its presence. The foetal circulation is now established with the blood being pumped around its body.
- By the fifth month, the skin of the foetus has become more mature and a network of blood capillaries and nerve endings has become established.
- The sixth month marks the end of the second trimester and the facial features are beginning to resemble those of a full term baby. The growth rate is slow but weight is being gained rapidly.
- The last trimester up until 40 weeks is a period where the foetus continues to develop, but in a much smaller space.
- By week 33, the foetus is still putting on weight at just over 5lb, but still lacks adequate fat stores under the skin.
- The last few weeks of pregnancy can be a time of great discomfort for many women. For the foetus the fingernails have reached the ends of the digits and its body is covered in a coating called vernix. The average pregnancy lasts from 38 weeks from fertilisation or 40 weeks when calculated from the last day of the menstrual cycle.



Pathologies of the Reproductive System

Disease	Meaning
Mastitis	Inflammation of the breast tissue, which can be caused by infection, engorgement or blocked ducts.
Amenorrhoea	The absence of menstruation in a women who is still of a reproductive age.
Dysmenorrhoea	Pain during menstruation
Endometriosis	Small pieces of uterus lining are found outside of the uterus which causes pain.
Pelvic Inflammatory Disease	Inflammation of the uterus, fallopian tubes and ovaries.

The Endocrine System



The endocrine system is a collection of glands that release hormones which have an influence on almost every cell, organ, and function of the body. Hormones are chemicals that carry messages from one cell to another through the bloodstream. The endocrine system regulates our mood, growth and development, the function of tissues, as well as metabolism and sexual function.

The endocrine system is in charge of body processes such as breathing and cell growth, which are controlled by hormones that transfer information and instructions from one set of cells to another. Many different hormones circulate throughout the bloodstream, and each one has a specific role. The levels of hormones circulating can be influenced by factors such as stress, infection, and changes in the balance of fluid and minerals in blood. In summary, the endocrine system produce's chemicals called hormones, which are secreted directly into the blood stream, where they are then carried to their target organ.

The major glands that make up the human endocrine system include the:

- Hypothalamus
- Pituitary gland
- Thyroid
- Parathyroid's
- Thymus
- Adrenal glands
- Pineal body
- Reproductive glands
- Pancreas

A gland has more than one function. It produces and secretes chemicals but it also selects and removes materials from the blood, processes them, and then secretes the finished chemical product to be used in a specific area in the body.

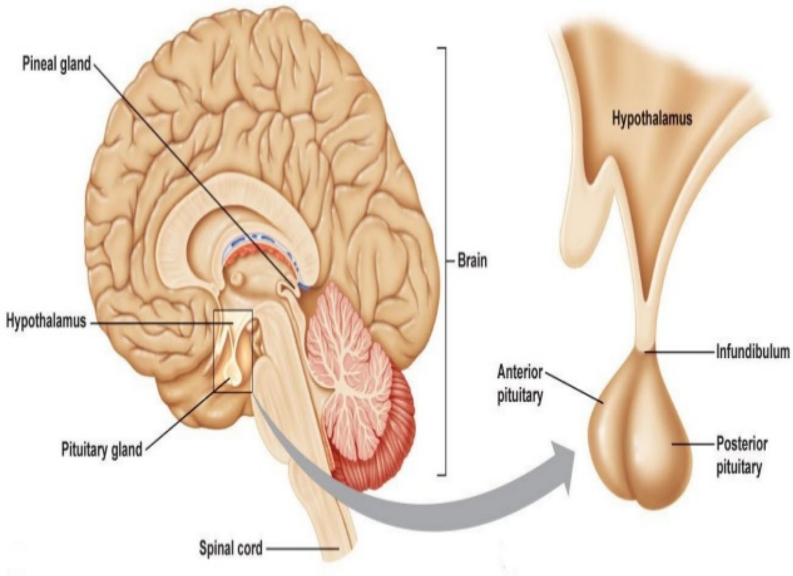
There are two different types of glands. Exocrine glands have ducts that carry their secretory product to a surface. Such glands include the sweat, sebaceous, and mammary glands. Endocrine glands release hormones directly into the blood stream for transportation around the body. Some other organs in the body, but not part of the endocrine system, also release hormones, such as the brain and heart.
We are going to look at each one in turn:

The hypothalamus
The hypothalamus is a small cone shaped structure of specialized cells that is located in the lower central part of the brain just above the brain stem. It acts as the primary link between the endocrine and nervous systems through the pituitary gland. The hypothalamus has to respond to many different signals and has the following functions:

- Controls the autonomic functions
- Controls emotions
- Plays a significant role in homeostasis
- Controls motor functions
- Regulates food and water intake
- Regulates the sleep and wake cycle

The hypothalamus controls the pituitary gland, which is sometimes referred to as the master gland, and sends hormones down to the pituitary gland.

The Pituitary Gland
Around the size of a pea and located just below the hypothalamus, this tiny gland has a powerful effect on the body. This master gland makes hormones that control other endocrine glands, such as the thyroid and adrenals, and receives its information from the hypothalamus, for example a change in temperature.



The pituitary is divided into two parts:

- The anterior lobe regulates the thyroid, adrenals and reproductive glands.

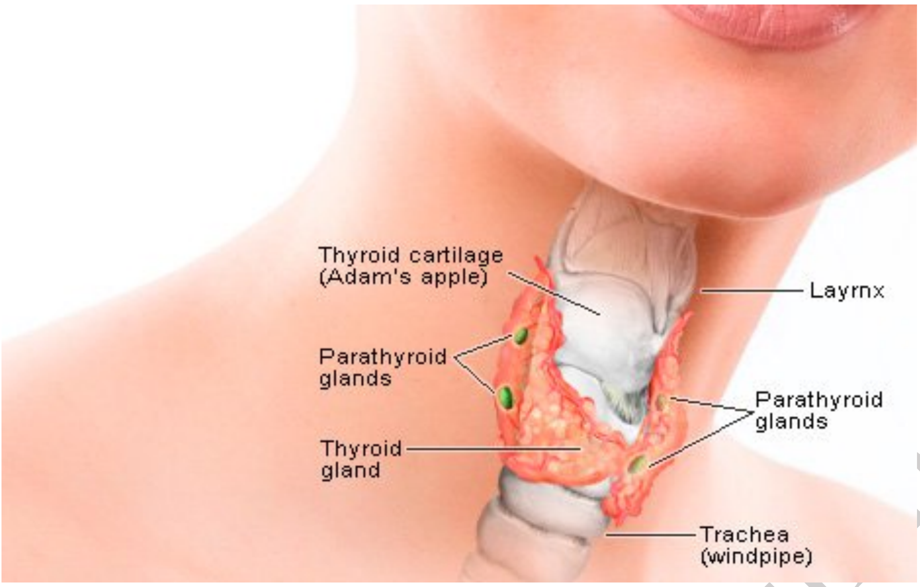
- The posterior stores and releases the hormones from the hypothalamus without making any hormones itself. For example the antidiurectic hormone is released as it prevents excess water being excreted by the kidneys.

The pituitary gland also secretes endorphins that act on the nervous system to respond to pain as well as secreting the hormone FSH and luteinizing hormone that are vital for reproduction.

Thyroid Gland and Parathyroid

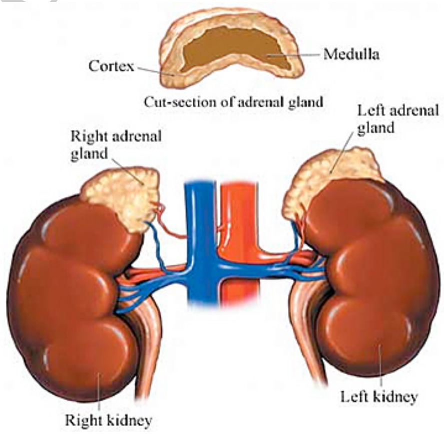
This gland is located in the front part of the lower neck and is shaped like a butterfly. It produces the hormone Thyroxine and triiodothyronine, which controls the rate at which cells burn fuels from food to produce energy. This phrase is called metabolism and deals with body temperature and weight. Iodine is found in the thyroid hormones which the thyroid needs to make the hormones.

If there is a lack of iodine in the diet, the thyroid cannot make the hormones. Hormones produced by the thyroid also aid in the development of the brain and nervous system in children. The release of these hormones is controlled by thyrotopin, secreted by the pituitary gland. Attached to the pituitary are four small glands, called the parathyroid's which release the parathyroid hormone that regulates the levels of calcium in the blood.



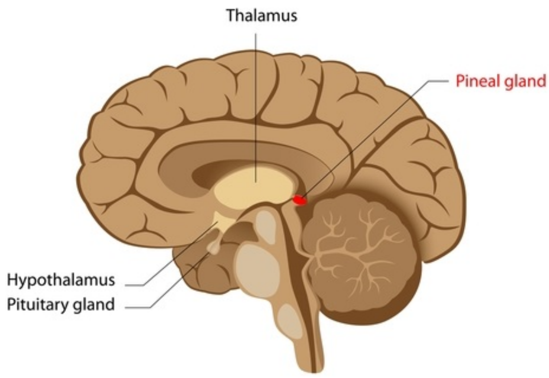
Thymus
The thymus is a small gland that is situated behind the top of the breastbone in front of the trachea and plays an important role in immunity. The thymus increases in size and activity until puberty then begins to shrink. The thymus secretes several hormones which help develop the immune system, one in particular called thymosin are produced that stimulate the development of antibodies as well as producing T-lymphocytes which are white blood cells that fight infection and destroy any abnormal cells.

The Adrenal Glands
The body has two triangular adrenal glands, one on top of each kidney. The adrenals work with the hypothalamus and the pituitary gland by stimulating the adrenals to produce corticosteroid hormones. The adrenal glands consist of two parts, each one producing a set of hormones which has a different function. The adrenal cortex, which is the outer part,



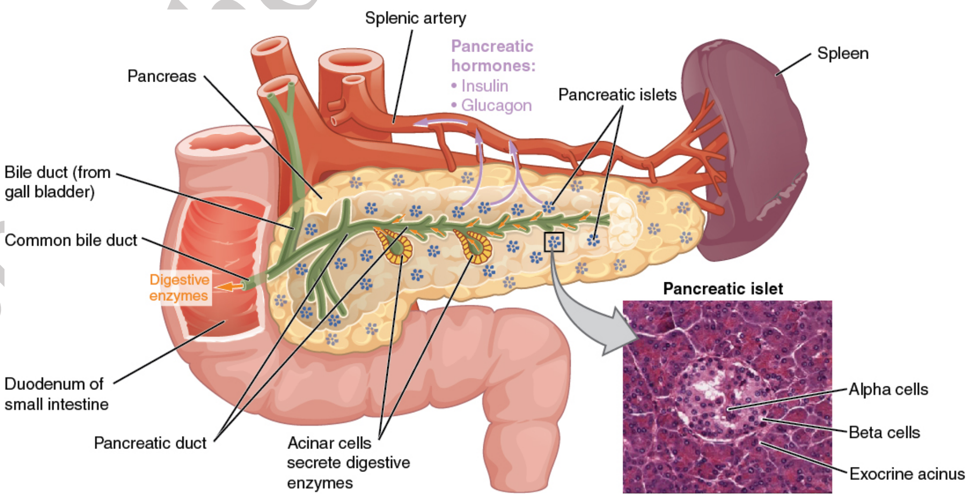
produces hormones called corticosteroids directly into the blood stream which help regulate the salt and water balance in the body. The cortex also controls the body's use of fats, proteins, and carbohydrates. The adrenal medulla, which is the inner part of the gland, is not essential for life but secretes epinephrine which increases blood pressure and the heart rate when under stress – also called adrenaline.

The Pineal Gland
This gland is situated in the middle of the brain, around a quarter or an inch long and secretes a hormone called melatonin when it's dark that regulates the sleep – wake cycle. This is why some people feel depressed in the dark winter months when they may be producing too little melatonin. The pineal gland is shaped like a pine cone and helps to promote sleep as it is sensitive to light. But can also affect reproduction by depressing the activity of the gonads.



The ovaries secrete two female hormones; oestrogen and progesterone, with the former being involved in the development of features such as breast growth and the accumulation of body fat around the hips and thighs. Progesterone causes the uterine lining to thicken in preparation for pregnancy.

The Pancreas
This organ is situated in the abdominal cavity behind the stomach, with the right side being the widest part and being attached to the duodenum. This organ is classed as a compound gland as it works as both an exocrine and endocrine gland, with the exocrine part secreting digestive hormones and the endocrine part producing two important hormones; insulin and glucagon.



A part of the pancreas, called the Islets of Langerhans secretes glucagon which tells the liver to take carbohydrate out of storage to raise a low blood sugar level if there is one. If the blood sugar level is too highthe islet cells secrete insulin to tell the liver to take excess glucose out of circulation to lower it. Both hormones insulin and glucagon therefore work together to maintain a steady level of glucose,

or sugar, in the blood and to keep the body supplied with fuel to produce and maintain stores of energy. If there is not enough insulin made by the body, the blood sugar will rise and become diabetes mellitus.
The exocrine part makes pancreatic juices, and as they are made they flow into the main pancreatic duct which joins the common bile duct. This connects the pancreas to the liver and also the gallbladder.

The workings of the endocrine system
Once a hormone is secreted, it travels from the endocrine gland through the bloodstream to target cells designed to receive the message. During the transit to the cells, the hormones have special proteins bound to them. These proteins act as carriers that control the amount of hormones that are available to interact with and affect the target cells. Once at the target cells, receptors within the cells attach themselves to specific hormones so that only those hormones communicate with the cells. The hormone locks onto the cells receptors and chemical instructions are transmitted to inside the cell. Once the hormone level reaches the required amount, any further secretions are controlled by mechanisms to maintain it.

Gland/Organ	**Hormone**	**Process**
Pituitary Gland	Trophic hormones, Growth hormones, luteinising hormone (LH), Follicle stimulating hormone (FSH)	Stimulates production of hormones from other glands Milk production
Hypothalamus	Hormone releasing factors, anti-diuretic hormones, Oxytocin	Stimulates pituitary gland to produce hormones, control of water Helps uterine contraction in childbirth and stimulates the let down reflex for breastfeeding
Thyroid	Thyroxine	Controls rate of body processes and heat production and energy production from food
Parathyroid glands	Parathormone or parathyroid hormone	Controls the amount of calcium in blood and hormones
Pancreas	Insulin	Controls blood sugar

Adrenal glands	Adrenaline Cortisol Aldosterone Androgens	Controls emergency action,response to stress Stress control, conversion of fats, proteins and carbohydrates to glucose. Acts on the kidneys to control salt and water balance
Testes	Testosterone	Control of sperm, growth and development of male features at puberty, beard growth
Ovaries	Progesterone Oestrogen Placental hormone (pregnancy only)	Helps control normal progress of pregnancy. Interacts with FSH and LH and oestrogen to control the menstrual cycle
Stomach wall	Gastrin	Starts acid production by stomach
Small intestine	Secretin	Triggers release of digestive enzymes from pancreas

Pathologies of the Endocrine System

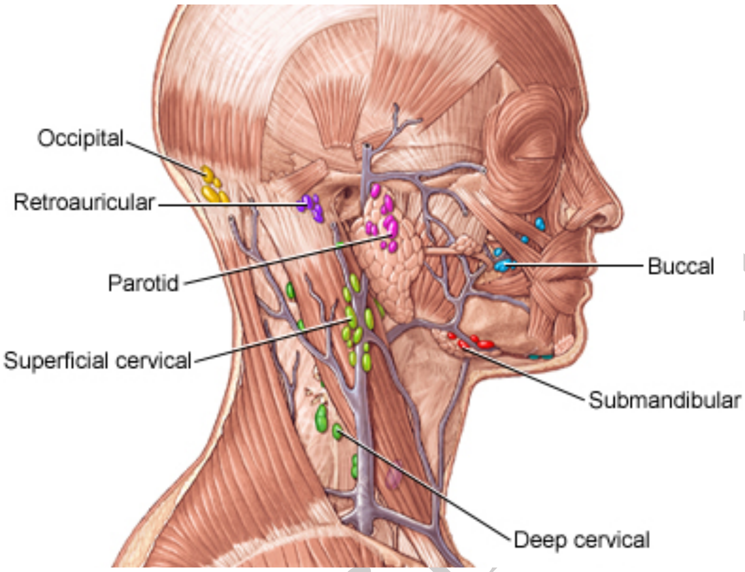
Disease	**Meaning**
Acromegaly	Too much growth hormone, causing body tissues to gradually enlarge.
Thyrotoxicosis	When there is too much thyroid hormone in the body
Addison's Syndrome	Disorder of the adrenal glands affecting the production of adrenaline and cortisol.
Cushing's syndrome	A range of symptoms if there is too much cortisol in the blood.
Goitre	An abnormal swelling of the thyroid gland.
Diabetes	The amount of glucose in the blood is too high because the body cannot use it properly.
Polycystic Ovary Syndrome	Condition which affects the workings of the ovaries, causing cysts to form around the edge of the ovaries.

The Lymphatic System

The lymph system is a collection of thin tubes that carries colourless liquid called lymph. As discovered in the circulatory system, blood travels around the body and delivers oxygen and other nutrients. On its journey, fluid leaks into the bodies tissues and it is this fluid which makes the lymph, along with substances such as fibrinogen, water and lymphocytes. It travels around the tissues of the body and carries white blood cells. After travelling around the body, lymph enters one of the major lymphatic vessels, the thoracic duct, which begins near the lower part of the spine and collects lymph from the pelvis, abdomen, and lower chest. This duct runs up through the chest and empties into the blood through a large vein near the left side of the neck. The right lymphatic duct is the other major lymphatic vessel and collects lymph from the right side of the neck, chest, and arm, and empties into a large vein near the right side of the neck. This means that lymph is continuously emptied into the blood where it mixes with the plasma. The system has no heart or arteries, but capillaries that extend into most tissues, which run parallel to the blood capillaries. In conclusion, Lymph is formed when plasma seeps from the blood into the surrounding tissues and becomes tissue fluid where it is collected by the lymph vessels. The main function of the lymphatic system is to fight infection, distribute excess fluid and transport fats around the body.

Nodes

Throughout the miles of lymph vessels, there are small round nodes or glands which are bean shaped structures covered in a capsule of connective tissue. They are packed full with lymphocytes which are used to filter the lymph. These structures are made of lymphatic tissue and here the white blood cells fight infection, that is why sometimes these glands can be felt, for example in the armpits, in the groin and neck, as the lymph nodes trap bacteria or viruses that they cannot destroy immediately. The lymph node may swell and become painful and sore. Some nodes cannot be felt, for example those in the abdomen, chest and pelvis. Occasionally the lymph nodes can trap cancer cells that it cannot destroy. The nodes then become swollen but not necessarily painful. This is why it is so important to check any swollen lymph node as cancers can develop in the lymph system.



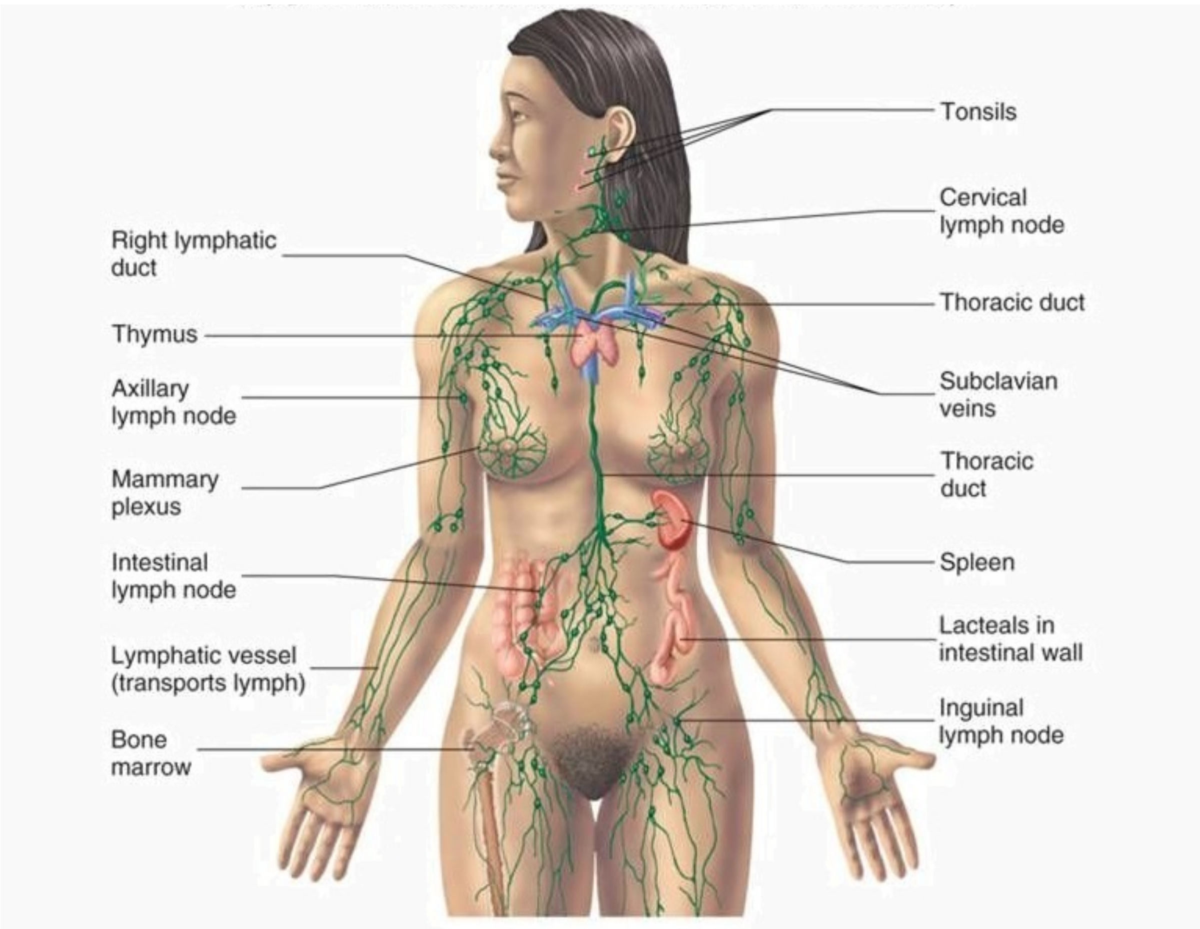
Lymph
As lymph flows through the node, lymphocytes (white blood cells) are added, which leaves the lymph cleaner due to breaking down bacteria. Lymph drains through around 8 – 10 nodes before returning to the blood. Most lymph nodes are solitary but some can be found in clusters. For example, a cluster is found in the ileum of the small intestine. These large masses of lymph nodules are known as Peyer's patches.

Lymph Vessels – carry lymph
These are microscopic, thin walled tubes which branch, interconnect and extend into almost all tissues of the body. They look like blood capillaries but they contain a larger inner space and also have a closed end. Lymph capillary walls are made up of overlapping cells that swing slightly inward when fluid outside the capillary pushes against them. This allows the milky fluid to enter the capillary, and is now referred to as lymph. Small amounts of diffuse lymphatic tissue are found in virtually every organ of the body.
Lymph capillaries join to form larger vessels called lymphatic's or sometimes called lymph veins. Lymphatic's are found in the subcutaneous tissue of the skin, following the same path as veins. Lymph vessels contain valves to prevent the back flow of lymph and they allow lymph to travel through lymphatic nodes.

Lympahtic
Lymphatic Ducts – collects lymph
Thoracic duct is the principal vessel of the lymphatic system and carries lymph as well as a substance called chyle, which is a milk fluid that contains lymph and emulsified fats. It begins in the abdomen and runs to the neck where it empties into the venous blood stream at the left subclavian vein. This duct receives the lymph from smaller vessels of the lower limbs and the upper left side of the head and neck.

Right lymphatic duct is a vessel that collects lymph from the right upper side of the body and drains it into the right subclavian vein.

Cisterna Chyli vessels drains lymph from the intestines which is laden with digested fats



Bone Marrow

Bone marrow is found in the hollow of bones and is a spongy material that makes red and white blood cells and plasma. Once mature enough, two types of white blood cells, lymphocytes and myeloid cells made by the bone marrow enter the bloodstream and circulate around the body. The lymphocytes also circulate in the lymph system. These cells only live for a few days so it is essential that the bone marrow constantly renews the old ones.

There are four main organs that are involved with the lymphatic system. They are the spleen, thymus, tonsils and adenoids.

The Spleen

This organ is found in the upper left abdominal cavity and is the largest lymphatic organ in the body. The spleen consists of two types of tissue called the white and red pulp. The white pulp consists mainly of lymphocytes and the red pulp consists of venous sinuses which are filled with blood and cords of lymphatic cells.

The function of the spleen is to filter blood, similar to the way lymph nodes filter lymph, but it also breaks down and destroys old red blood cells, which have a life span of around 120 days. The spleen holds extra blood that can be released into the circulatory system if needed.

The Thymus
As already discovered, the thymus is an endocrine gland but it also helps to produce white blood cells, so that puts it in the lymphatic system as well.

The Tonsils
The tonsils are two glands in the back of your throat, and they help to protect the entrance of the digestive system by preventing bacteria from entering. When the tonsils become infected, a condition called tonsillitis occurs. The lymphoid tissues in the back of the mouth at the top of the throat that normally help to filter out bacteria.

The Adenoids
The adenoids are lumps of tissue found at the back of the nose above the tonsils but are only present in children as they begin to shrink by the age of 7. The appendix also needs to be mentioned as, although its function is unclear, it has a rich supply of lymph tissue.

Pathologies of the Lymphatic System

Disease	**Meaning**
Oedema	Soft tissue swelling – fluid retention.
Hodgkin's	Cancer of the lymphatic system.
Non Hodgkin's lymphoma	Cancer of the lymphoid tissue.
Glandular fever	Viral infection causing sore throat and temperature.
Lymphadenitis	An infection of the lymph nodes.
Lupus	An autoimmune disease where the body starts to attack healthy cells, tissues and organs.

The Nervous System

The nervous system is the means by which the body co-ordinates bodily systems and informs the body about any changes in the environment.

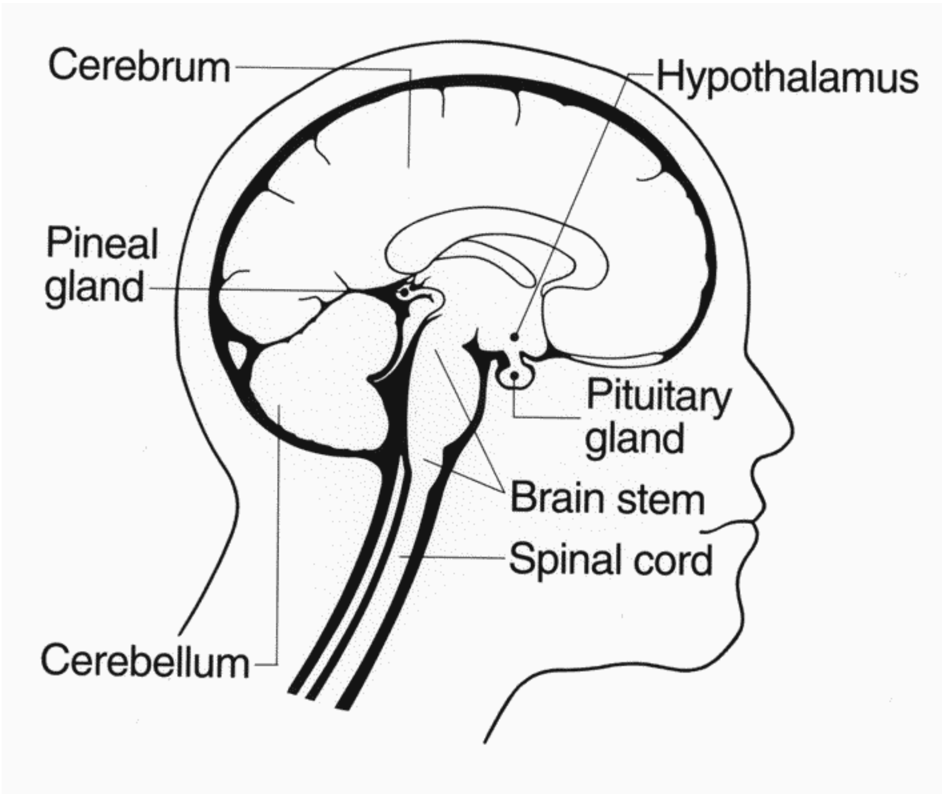
The nerves carry brief electro-chemical messages that trigger appropriate responses in the various parts of the body. The messages (impulses) then react and will do certain tasks such as make the muscles contract, the glands secrete and the blood vessels widen or narrow.

The nervous system is a very complex system in the body but is divided up into two main parts. The Central Nervous System (CNS) and the Peripheral Nervous System (PNS).

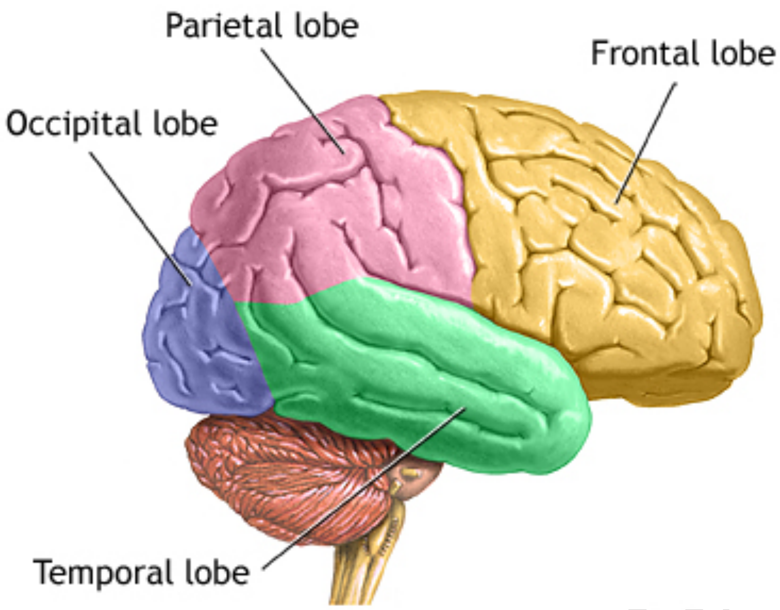
The CNS
The Central Nervous System consists of the brain and spinal cord. The main function of this part of the system is to get information from the body and send out instructions, and to maintain equilibrium in the body. The CNS receives sensory information from all parts of the body. On receipt of this information, the CNS analyses the information, and thoughts, emotions and memories are then generated and stored. The CNS usually responds to nerve impulses by stimulating muscles or glands, which creates an appropriate response to the original stimulus such as a change in temperature.

The Brain

The brain is the most highly developed part of the nervous system and is protected by the skull. A vast network of arteries supply the brain with blood and twelve pairs of cranial nerves originate from the brain. Most of these nerves supply the sense organs and muscles in the head, but some do extend to other parts of the body. The cranial nerves are not part of the CNS but are part of the peripheral nervous system. The surface layer of the brain is called the cerebral cortex, and is often referred to as the gray matter because of the lack of insulation which gives it the white appearance.



The largest part of the brain is called the cerebrum, which in Latin means “brain” and is divided into two sections called hemispheres, which are joined by a band of nerve fibres. These hemispheres are both responsible for different behaviours such as hearing smell and touch.



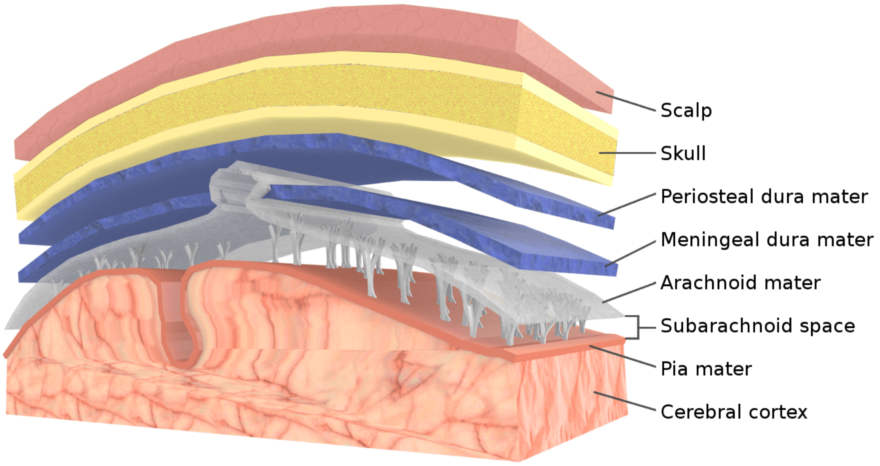
Each hemisphere has four lobes, as you can see from the diagram.

- The front part of the frontal lobe deals with problem solving and personality and the rear part are concerned with movement. There is a strip here called the motor area which moves different muscles.
- The parietal lobe deals with sensation and perception, with an area called the somatosensory. It is also concerned with speech and processing information.
- The temporal lobes at the side of the head contain auditory areas which deal with hearing as well as emotional responses. The Wernicke's area found in the left temporal lobe deals with understanding speech.
- The occipital lobe is the prominent bone which can be felt at the back of the head. This part deals with receiving visual information.

The rear part of the brain is called the cerebellum and is responsible for monitoring the position of the limbs. Fine movements are controlled by this part of the brain.

The base of the brain extends into the spinal cord.

Meninges
Around the brain and spinal cord is a covering called the meninges. This is made up of three layers, with the outer layer called the dura mater, the middle layer called the arachnoid and the inner layer called the pia mater. The dura mater is thick and tough and can restrict the movement of the brain within the skull. The arachnoid contains projections which transfers cerebrospinal fluid from the ventricles back into the bloodstream. The pia mater contains tissues which adhere to the brain, making it difficult to dissect.



Brainstem

The brainstem is the lower extension of the brain where it connects to the spinal cord. Neurological functions located in the brainstem include those necessary for survival (breathing, digestion, heart rate, blood pressure) and for arousal (being awake and alert).

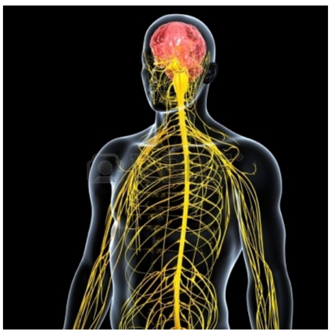
Most of the cranial nerves come from the brainstem. The brainstem is the pathway for all fibre tracts passing up and down from peripheral nerves and spinal cord to the highest parts of the brain
The Spinal Cord

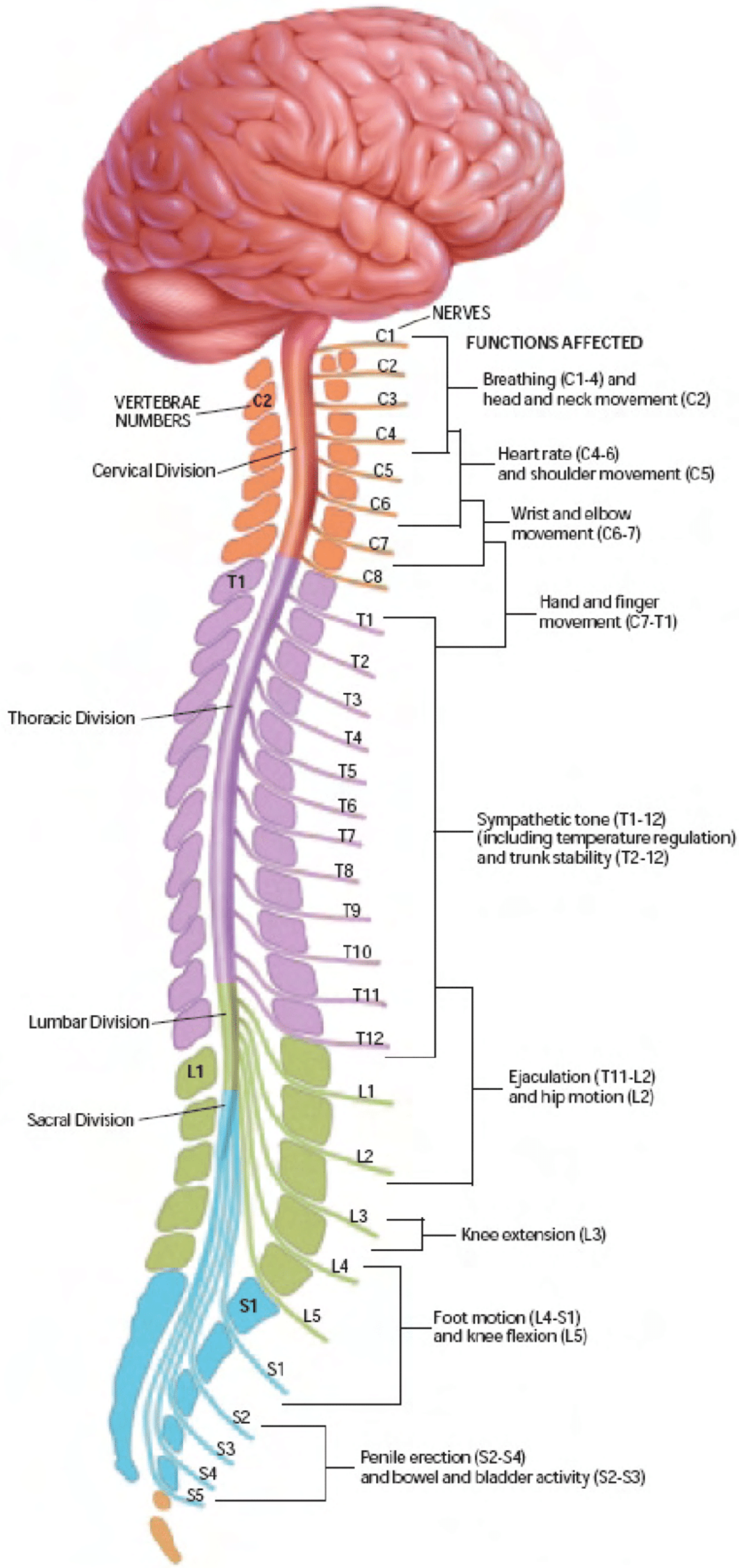
The spinal cord is a long nerve tract that runs from the base of the brain, down through the vertebral column. It consists of millions of nerve fibres which will allow messages to be transmitted.

The spinal cord allows the brain to communicate to all areas of the body. It does this using 31 pairs of spinal nerves which branch off from the spinal cord and are part of the PNS.

The main function of the spinal cord is to transmit information from sense organs located in the skin and in muscles, to the brain, and to transmit information back from the brain to the muscles and glands. The nervous system, therefore works closely with other systems, such as the Integumentary, the muscular and the endocrine systems.

Nerves exit the spinal cord at the vertebra and are numbered accordingly. For example, a nerve that exits the foramen of the 3rd Thoracic vertebra will be numbered T3.



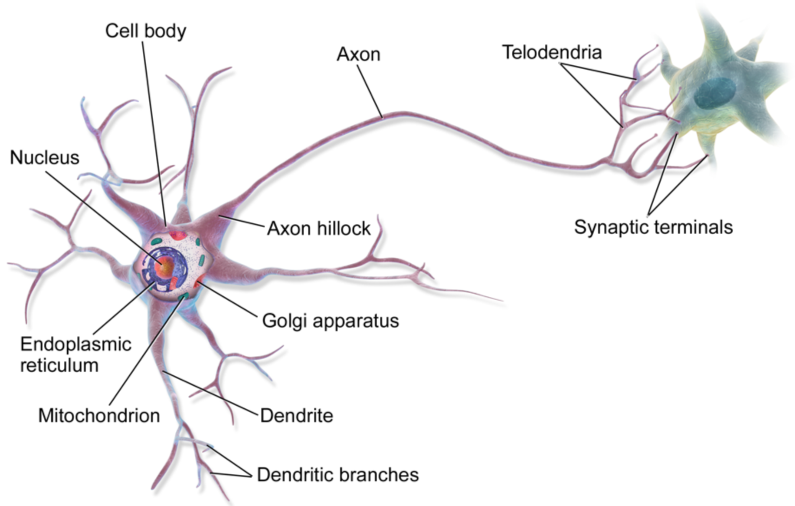

NERVES
FUNCTIONS AFFECTED
C1
C2
C3
C4
C5
C6
C7
C8
VERTEBRAE NUMBERS
C2
Cervical Division
Breathing (C1-4) and head and neck movement (C2)
Heart rate (C4-6) and shoulder movement (C5)
Wrist and elbow movement (C6-7)
Hand and finger movement (C7-T1)
T1
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
Thoracic Division
Sympathetic tone (T1-12) (including temperature regulation) and trunk stability (T2-12)
Lumbar Division
L1
L1
L2
L3
L4
L5
Sacral Division
Ejaculation (T11-L2) and hip motion (L2)
Knee extension (L3)
Foot motion (L4-S1) and knee flexion (L5)
S1
S1
S2
S3
S4
S5
Penile erection (S2-S4) and bowel and bladder activity (S2-S3)

Neurons

The spinal cord is a thick bundle containing millions of nerve cells called neurons. A neuron is a cell which is very long and is specialised to be able to transmit nerve impulses. Most of this length is made up of the part of the cell called an axon – this is a nerve fibre thinner than a hair.

A neuron is triggered to fire a nerve impulse, which travels along the axon, which then passes from one neuron to another by means of transmitter chemicals. Long axons enable nerve impulses to be transmitted very quickly. Most nerve fibres are encased in a fatty layer called the myelin sheath. This acts like insulation and gives the nerve its white appearance. Unlike an electrical wire, the axon of a neuron can only transmit impulses in one direction. This means that there has to be two types of neurons:

- Sensory neurons are needed to send information from the sense organ to the brain.
- Motor neurons are needed to transmit the information from the brain to muscles and glands.



The dendrites receive the nerve impulses, which are then carried away by the axon. The terminal button touches a dendrite of another neuron at a junction called a synapse. Dopamine; a chemical neurotransmitter then allows the nerve impulse to be transmitted across the synapse, which allows the message to be conveyed.

The Peripheral Nervous System

This part of the system is made up of all of the nerves and the wiring. This system sends the messages from the brain to the rest of the body. The 31 pairs of spinal nerves are part of the peripheral nervous system.

There are two types of cells in the peripheral nervous system which carries information to the sensory neuron cells and from the motor neuron cell. Cells of the sensory nervous system send information to the CNS from internal organs or from external stimuli. Much of the peripheral nervous system is concerned with voluntary response, but there are still involuntary responses that are dealt with. This part of the PNS is called the autonomic nervous system as it deals with automatic responses such as smooth and cardiac muscle. The autonomic nervous system comprises of the sympathetic and parasympathetic system. The differences between both of these are the responses that are generated as they work in opposition to each other. For example, the medulla of the adrenal glands is supplied with sympathetic fibres which trigger the release of adrenaline into the blood. The parasympathetic nervous system releases acetylcholine that decreases the heart.

Types of Nerves

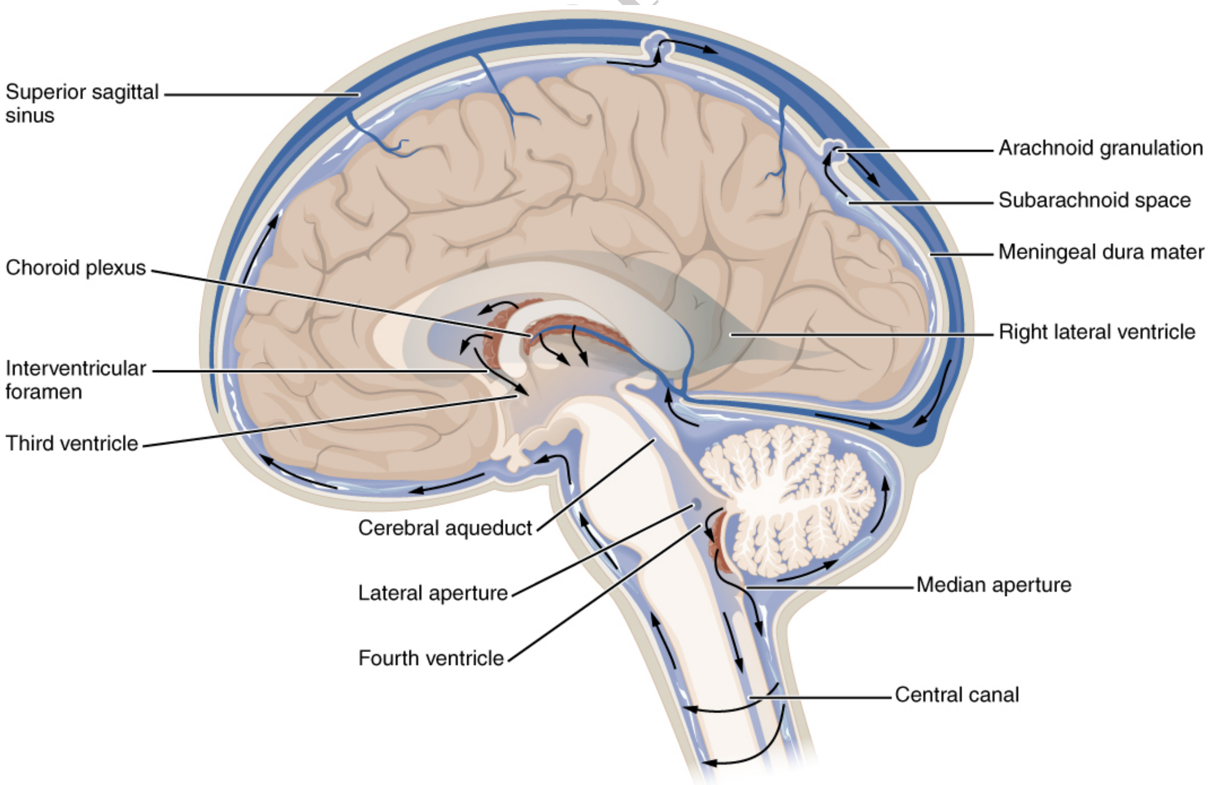
Sensory nerves send messages from the muscles to the spinal cord and the brain. Special sensors in the skin and deep inside the body help people identify if an object, for example if it is hot. Sensory nerve damage often results in tingling, numbness, pain, and extreme sensitivity to touch.

Motor nerves enable the brain to stimulate muscle contraction, by sending impulses from the brain and spinal cord to all of the muscles in the body. Damage to the motor nerve can lead to muscle weakness, difficulty walking or moving the arms, cramps and spasms.

Autonomic nerves control involuntary or semi-voluntary functions, such as heart rate. If the autonomic nerves are damaged, then a person's heart may beat faster or slower, and dizziness may occur. In addition, autonomic nerve damage may result in difficulty swallowing, nausea, vomiting, diarrhoea or constipation, problems with urination, abnormal pupil size, and sexual dysfunction.

Cerebrospinal Fluid

This fluid circulates throughout the CNS and is located between the ventricles of the brain and within the spinal canal. The choroid plexus is the area on the ventricles of the brain where cerebrospinal fluid is produced at the rate of 500 ml/day. It has two important functions. Firstly it is needed to deliver nutrients to structures of the nervous system and to remove any waste. It also acts as a shock absorber in the case of trauma to the head through an injury or accident.



Pathologies of the Nervous System

Disease	Signs & Symptoms	Cause
Bell's Palsy	Temporary paralysis of the muscles on one side of the face.	Due to an injury of the facial muscle where it becomes inflamed or compressed
Epilepsy	Condition affecting the brain, causing repeated seizures.	Not always known
Meningitis	An infection of the meninges, the membrane that surrounds the spinal cord and brain.	Bacteria or a virus.
Multiple Sclerosis	Scarring of the myelin sheath that protects and coats the nerves, creating problems with vision, sensation etc.	Many theories, such as genetics, environment, autoimmune disease.
Neuritis	An inflammation of a nerve.	Trauma or injury
Cerebral Palsy	Brain damage causing problems with movement and function.	Usually from birth or from trauma.
Depression	A mental or psychological condition which affects mood.	No single cause but can be linked to life events.
Alzheimer's Disease	A form of dementia with memory loss and action slips.	No single factor.
Sciatica	Pain, tingling and numbness in the leg.	When there is damage or pressure on the sciatic nerve.
Vertigo	Sensation that you are moving when you are not	Usually caused by problems to do with the balance mechanism in the ear.

The Autonomic Nervous System

The autonomic nervous system controls internal organs. It is the part of the nervous system which directs involuntary muscles, such as smooth and cardiac muscle and glands. You will remember the muscular system that smooth and cardiac muscles are responsible for such processes as digestion and respiration and the heart beating. This system is also called **the involuntary nervous system.**

The autonomic nervous system is what keeps our heart beating, our lungs breathing and our digestive system moving food through the body. You cannot control these action and they take place without even knowing about them. Autonomic motor nerves travel to cardiac muscle, smooth muscle and to glands.

The autonomic nervous system can also be divided into two parts:

- **the sympathetic system** – which is concerned with mobilising body's energy during times of stress. It is involved in the fight or flight response.
- **the parasympathetic system** – concerned with the conservation of the body's energy. It slows down or relaxes the body and regulates the involuntary activity of glands, smooth muscle and cardiac muscle.

These two subsystems work together but in opposition to each other. The sympathetic nervous system prepares the body for sudden stress.

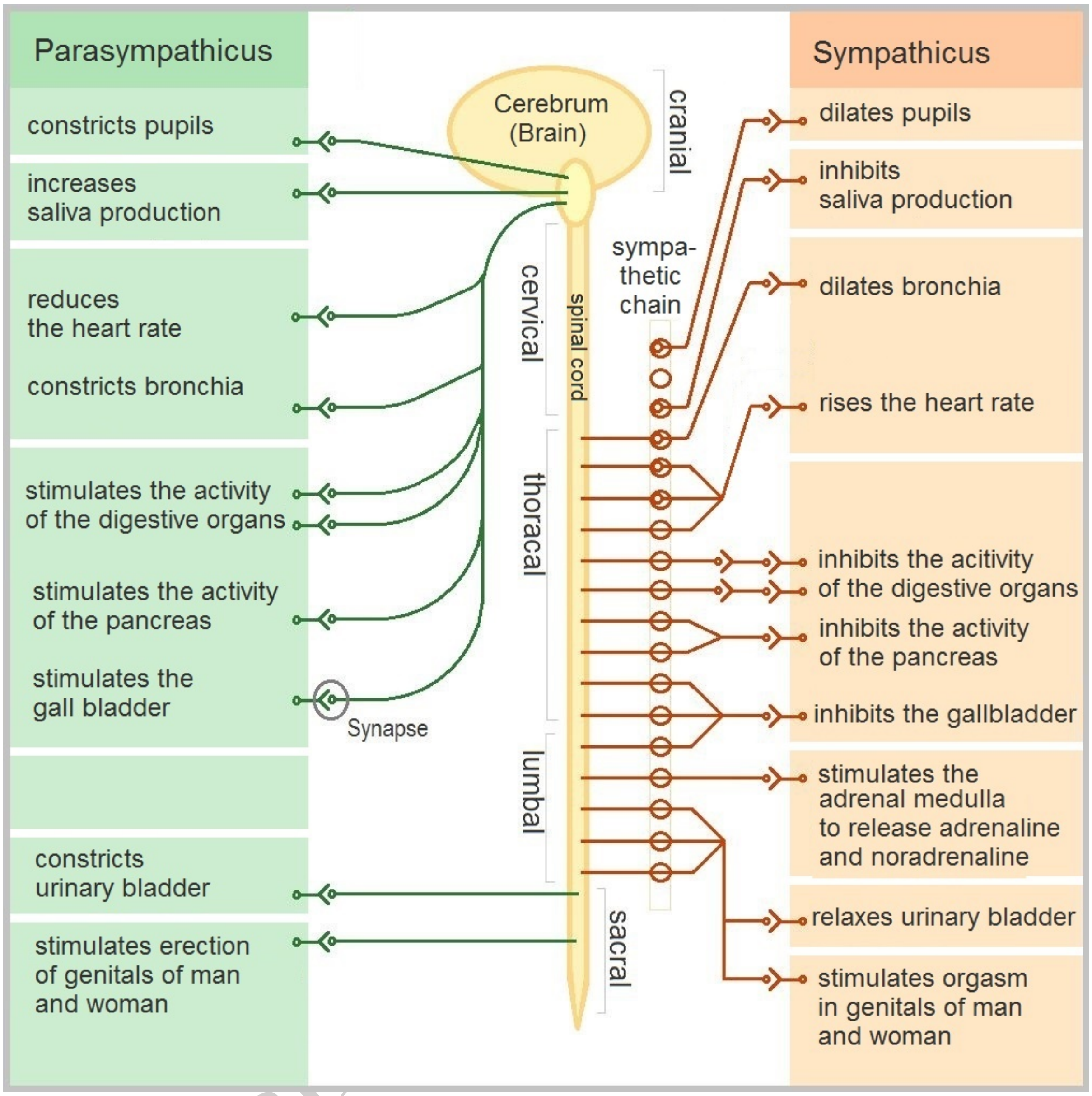
The 'fight or flight' response is what happens when a person is scared for their safety. Have you ever been really frightened by something and noticed what happens to your body? The things you might have noticed are that your heart beats faster, your blood pressure increases, your digestion slows down and you breathe more heavily.

What you don't know is happening is that the **sympathetic nervous system** sends an instant message to release the hormone adrenalin which causes the body to be ready to either have a fight with someone or run away- fight or flight!

This response goes back to when stone-age man lived in caves and chased animals for food. When he met a woolly mammoth when out hunting, the cave man would be very frightened and had to decide very quickly whether to try to kill the animal for food or to run away to avoid being killed himself!

The **parasympathetic nervous system** does the exact opposite. It prepares the body for rest and regulates the involuntary essential body functions.

Luckily, we no longer have to fight animals for food but we still have the same response when we get very scared. Here is a table which shows how the sympathetic system works and how the parasympathetic system works in opposition


Parasympathicus
constricts pupils
increases saliva production
reduces the heart rate
constricts bronchia
stimulates the activity of the digestive organs
stimulates the activity of the pancreas
stimulates the gall bladder
constricts urinary bladder
stimulates erection of genitals of man and woman
Cerebrum (Brain)
cranial
cervical
spinal cord
thoracal
lumbal
sacral
sympa-thetic chain
Synapse
Sympathicus
dilates pupils
inhibits saliva production
dilates bronchia
rises the heart rate
inhibits the acitivity of the digestive organs
inhibits the activity of the pancreas
inhibits the gallbladder
stimulates the adrenal medulla to release adrenaline and noradrenaline
relaxes urinary bladder
stimulates orgasm in genitals of man and woman

The Olfactory System

The Olfactory System is basically the body's system of smell and it begins at the roof of the mouth and nasal cavity.

Tiny molecules of aroma are inhaled by the nose and are trapped in the nose by hair like nerve endings that pass the aroma on to receptors. These are then carried to the Olfactory Bulb within the limbic region of the brain. As a neural circuit, the olfactory bulb has one source of sensory input (axons from olfactory receptor neurons of the olfactory epithelium), and one output (mitral cell axons).

The olfactory region of each of the two nasal passages in humans is a small area of about 2.5 square centimetres containing in total approximately 50 million primary sensory receptor cells