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Anatomy, Physiology and Pathology Diploma (ITEC)

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Introduction to Anatomy & Physiology

It is important for a Holistic Therapist to have a detailed knowledge of how the body works. You must be able to identify parts of the body and to know their structures and functions. You must have sound knowledge of how the body works and how different parts of the body integrate with one another.

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1. Cells, tissues, membranes
2. The Skeletal System and Joints
3. The Muscular System
4. The Skin
5. The Cardiovascular System
6. The Lymphatic System
7. The Digestive System
8. The Endocrine System
9. The Nervous System
10. The Respiratory System
11. The Urinary System
12. The Reproductive System

Anatomy is the study of the structures of the body and the relationship of its parts.
Physiology is the study of how the body works.

Anatomical Terms

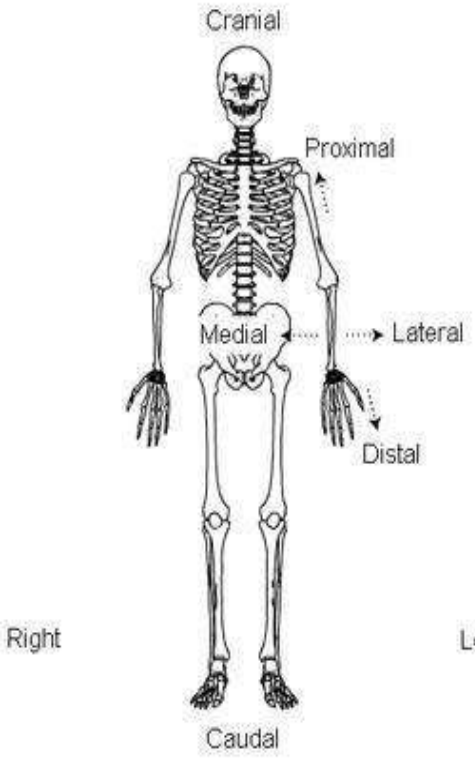
The Anatomical Position is with a person standing up, facing observer, feet are flat on the ground and forward, arms are at the sides, with palms facing out.
Supine is when the body is lying down, face up.
Prone is when the body is lying down, face down.

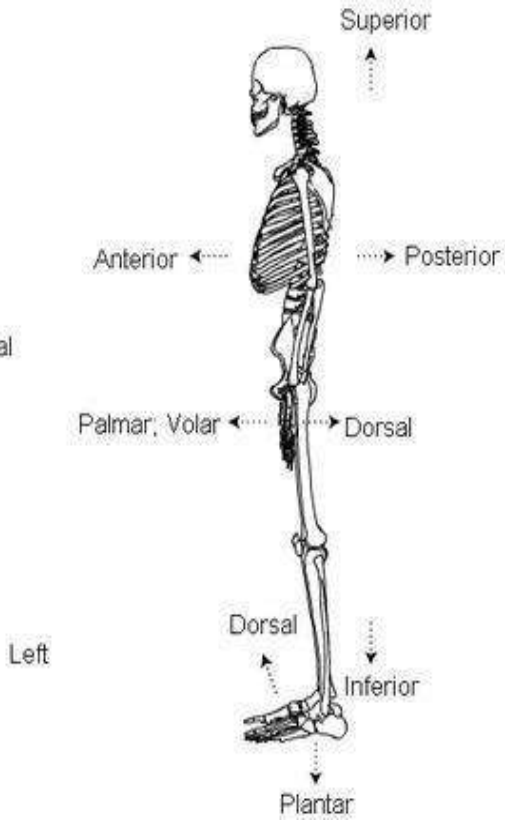
The principal Regions of the body are:

Head:	Skull and face
Neck:	Supports the head and attaches to truck
Trunk:	Chest, abdomen and pelvis
Upper limbs:	Shoulder, armpit, arm, forearm, wrist and hand
Lower limbs:	Buttock, thigh, leg, ankle, foot.

The main Directional terms are:

Superior:	towards the head/upper part of a structure
Inferior:	away from the head/lower part of a structure
Anterior:	to the front of the body
Posterior:	to the back of the body
Medial:	to the centre of the body/near the midline
Lateral:	to the outer parts of the body/away from the midline
Proximal:	close to the source/attachment/origin
Distal:	away from the source/attachment/origin
Superficial:	towards the surface of the body
Deep:	away from the surface of the body





Homeostasis (balance)

Homeostasis is the condition in which the body's internal environment remains relatively constant within certain limits. Each system in the body should function to maintain a constant internal environment for each cell to survive. Some factors have to be kept within certain limits to keep this consistency:

- ✧ Temperature
- ✧ Water concentration
- ✧ pH (acidity/alkalinity)
- ✧ Glucose levels
- ✧ Oxygen and carbon dioxide levels
- ✧ Blood pressure

This is done through communication systems within the body that detect changes in the environment, and through feedback mechanisms.

Survival Needs of the Body	*Systems involved*
Internal transportation	Circulatory & Lymphatic System
Communication to outside the body	Nervous system; Special senses; Respiratory; Skeletal; Muscular; Joints
Communication within the body	Nervous system; Endocrine System
Intake of food	Digestive system
Intake of Oxygen	Respiratory system
Elimination of Waste	Respiratory; Urinary; Digestive; Skin
Protection against external	Skin; membranes lining open passages
Movement in external environment	Skeletal; muscular; joints; nervous; special senses
Reproduction	Male and female reproductive organs; hormones

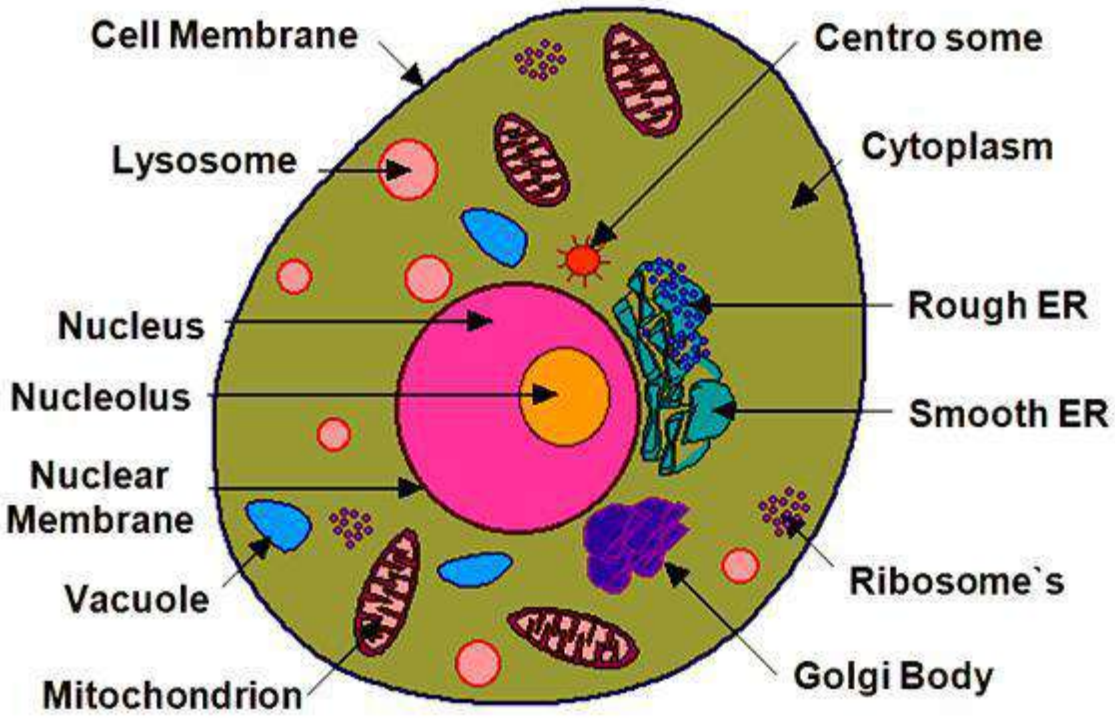
The Cell

The cell is the basic unit of life. There are the building blocks of the human body. They exist in many different shapes and sizes and depending on where they are in the body, have many different functions. All cells are made up of water, carbon, oxygen, hydrogen and nitrogen.

When learning about cells we learn from the 'Basic Structure' model. In this model we see that cells are made up of tiny different components called organelles. These are:

- Cell membrane
- Ribosomes
- Centrioles
- Vacuole
- Golgi Body
- Microvilli
- Cytoplasm
- Mitochondria
- Lysosomes
- Endoplasmic Reticulum
- Cilia

Each of these organelles has their own structure and function.



- Cell Membrane

This is the thin covering of the cell that gives it it's shape and keeps it intact. It is made up of a double layer of lipids (fats) and proteins. It is semi-permeable meaning it controls the movement of substances in and out of the cell. Substances essential for life must be allowed into the cell - oxygen, nutrients, hormones and water for example. Waste products that build up inside the cell, as a product of work, must be allowed to exit the cell - carbon dioxide for example.

Movement across cell membrane –

When substances need to enter or exit the cell, it does so via the semi-permeable membrane. This can happen in 5 ways:

1. Diffusion - this is the movement of gases such as carbon dioxide and oxygen across the semi-permeable membrane from a region of high concentration to an area of low concentration. For example, then work

is being done inside the cell, lots of waste carbon dioxide is building up inside. So, it passes by diffusion from inside the cell where its concentration is high, to outside the cells where its concentration is low.

2. Osmosis - this is the movement of water across a semi-permeable membrane from a region of high concentration to a region of low concentration until both sides are equal.

3. Dissolution - this method is used by substances that are able to dissolve in through the cell membrane. This is possible due to the understanding that 'Like dissolves Like'. Fats molecules can merge with the lipids in the cell membrane and pass from one side to the other.

4. Active Transport - this method is used for large substances that are not water, a gas or dissolvable fats. Active means that energy is required for this to occur. Glucose molecules for example, will attach itself onto a carrier protein in the cell membrane and this will 'transport' the glucose across the membrane.

5. Filtration - this process occurs in the presence of high pressure. In the kidneys, the liquid blood is filtered under high pressure, to extract waste from it and to eliminate this waste in form of urine.

- Protoplasm

The protoplasm is the gel-like fluid found within the cell. It is made up of water and dissolved substances like gases, glucose, waste, salts and hormones. The protoplasm that suspends the organelles in the cell is called cytoplasm. The protoplasm found within the nucleus is called the nucleoplasm.

- Mitochondria

This is the 'power house' of the cell. Like the ESB provides Ireland with energy called electricity, the mitochondria provide the cell with energy called ATP (adenosine triphosphate). This energy is provided through a process called respiration (see below). The mitochondria is made of a double membrane within the inside membrane folded.

- Ribosomes

These are 'protein factories'. The proteins made by ribosomes are either used within the cell or exported for use elsewhere
Ribosomes are tiny organelles made up of RNA and proteins. They are found floating in the cytoplasm or attached onto the Endoplasmic Reticulum (rough E.R.).

- Endoplasmic Reticulum (Smooth and Rough)

This consists of a network of tiny tubes, or channels running throughout the cytoplasm. One function is to act as a 'cell skeleton'. However, ribosomes are closely associated with the endoplasmic reticulum reflecting its role in protein production and transport. In fact, most enzyme activity in the cell takes place here. (Ribosomes attached to E.R. makes it look rough).

- Golgi Body

This is a large organelle responsible for processing proteins and lipids. These may include hormones, or other proteins required elsewhere in the body. The Golgi body packages and stores these in smaller organelles called the Golgi apparatus until they are required elsewhere. (Packaging centre).

- Lysosomes

These single membrane organelles act as the 'stomach' or 'waste disposal unit' of the cell. They contain digestive enzymes which can break down and metabolise nutrients, foreign bodies and worn out cell parts. Liver cells contain the greatest concentration of lysosomes, reflecting the liver's job of removing waste products from the body.

- Centrioles

There are always 2 centrioles found together in a dense area of the cytoplasm close to the nucleus. They are rod-like structures that lie at right angles to each other. They are essential for cell division (cell mitosis).

- Cilia

Some cells possess cilia, or hair-like projections on their surface. The cells lining the nose and lung passageways are a good example of this. These cilia beat like tiny fins to trap dust, bacteria and viruses and push them out of the body. Smokers have a greater chance of infections. This is because the toxins in tobacco smoke stop the cilia beating, allowing infections and bacteria an easier route in to the body.

- Microvilli

Some cells have finger-like projections called microvilli all over the cell surface. These are designed to increase the available surface area for absorption. Cells in the intestinal surface layers typically have lots of microvilli.

- Nucleus

This is the 'brain' of the cell. It controls all the functions and metabolic activities within the cells as well as its own growth, repair and reproduction. Without a nucleus the cell would die. The nucleus contains genetic information called DNA (deoxyribonucleic acid). This DNA is arranged in threads called chromosomes. Every normal cell contains 23 pairs of chromosomes (total 46). The nucleus is surrounded by a membrane called the nuclear membrane. Inside the protoplasm is called nucleoplasm. Things can pass between the nucleus and the cytoplasm.

- Nucleolus

This is a small spherical body found inside the nucleus. This contains RNA (ribonucleic acid) and forms ribosomes.

Functions of the Cell

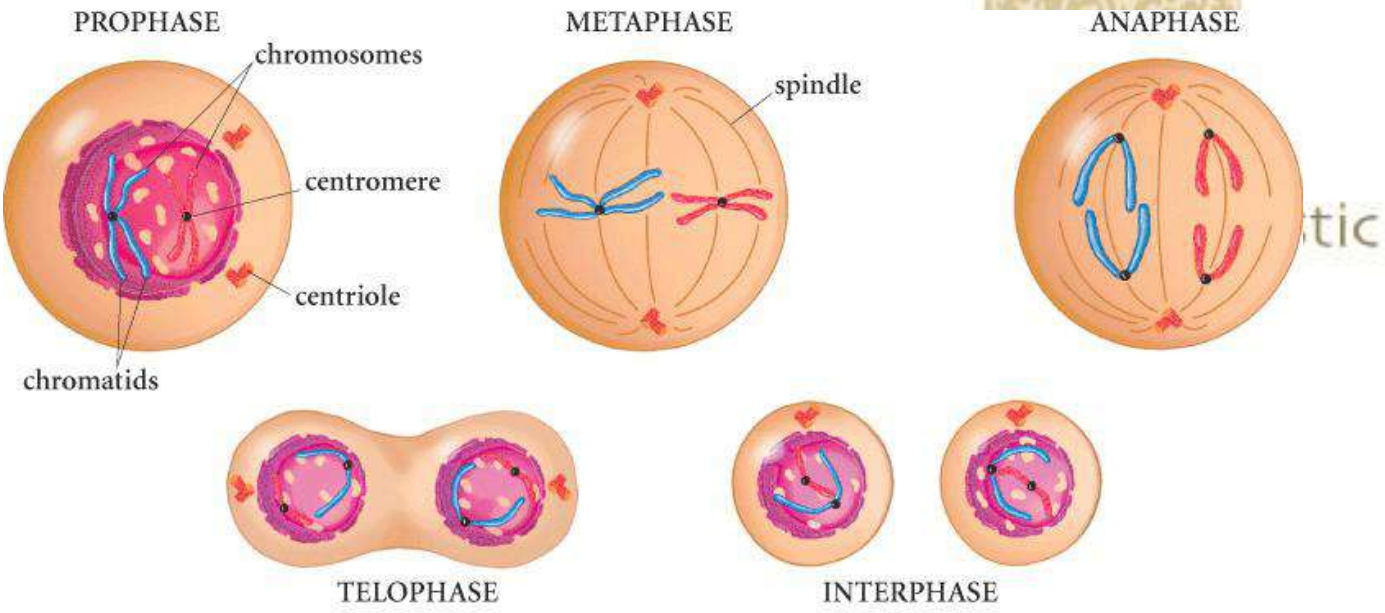
Cells have many functions that help them to survive.

1. Movement - whole cells can move (white blood cells) or parts of cells can move (cilia).
2. Respiration - we take in oxygen into our lungs during breathing and expel carbon dioxide as waste. This is essential for us to survive. Cells too must take in oxygen and use it to create energy and to carry out work (metabolism). Products of respiration are carbon dioxide, water, heat and energy (ATP).
3. Sensitivity - cells can respond to stimuli (physical, chemical or thermal).
4. Reproduction - when human body cells have grown to their full capacity, they divide and reproduce by the process of mitosis.
5. Excretion - cells must get rid of any waste produced from metabolism. The waste such as carbon dioxide, urea, is passed outside the cell via the cell membrane.
6. Metabolism - this is the term to describe all the chemical reactions and physiological processes that occur in a cell.

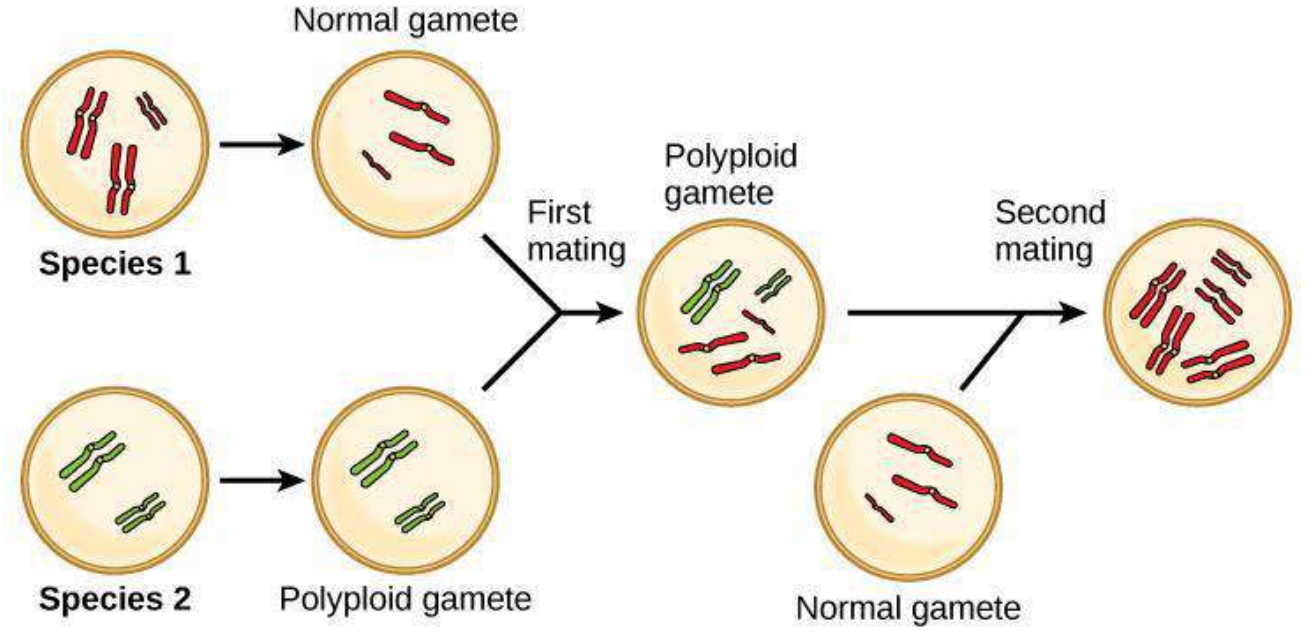
Cell Reproduction

From conception through to maturity normal human body cells reproduce many times to allow repair and growth of the body. The process by which this is done is called mitosis.

Mitosis is the process of cell division or reproduction which after a series of changes within the cell, it produces 2 new '*daughter cells*'. Each new '*daughter cell'* contains 46 chromosomes. It occurs over 4 stages - Prophase, Metaphase, Anaphase, Telophase. Mitosis occurs in human tissue like hair and skin.



Meiosis - is a special form of cell division that occurs only in the testes and ovaries and results in the formation of sperm and ova. It is a process of cell division whereby 4 daughter cells are produced, each with half the number of chromosomes of the original cells (23 chromosomes).
When cells in some areas of the body reproduce without control, a tumour can develop, which is the area of excess tissue growth. These can be benign or malignant.



Introduction to Tissues of the Body

Different cells of the body group together according to their size, shape and function to perform specialised functions. These groups of cells are now called tissues and there are 4 main groups of tissues found in the human body:

- Epithelial
- Nervous
- Muscular
- Connective

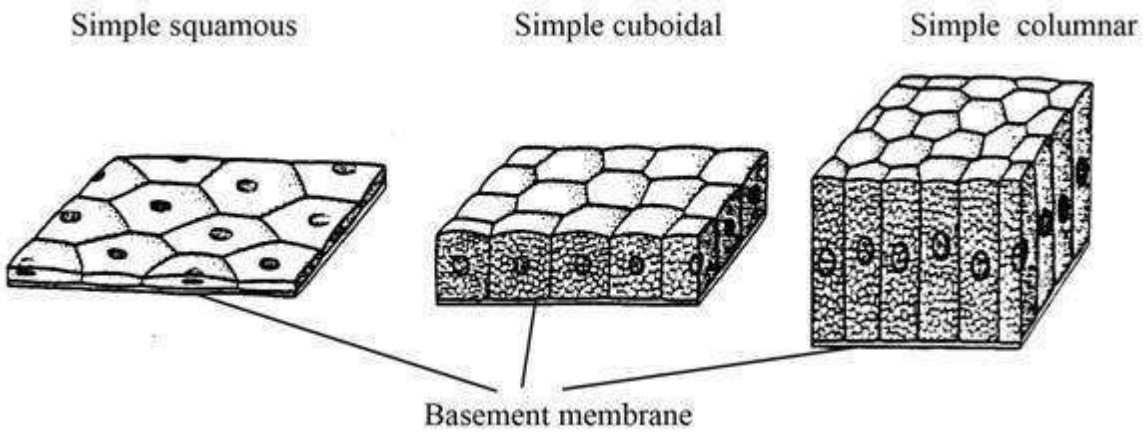
A Epithelial

The main function of the epithelial tissue is to protect underlying structures, secrete and absorb substances. This type of tissue is found lining hollow structures and also found covering internal and external surfaces of the body. This tissue reproduces very rapidly. Continuous sheets of cells are held together tightly and is attached to underlying connective tissue by a basement membrane. There are 2 categories of Epithelial tissue: *Simple (one layer of cells) and Compound (many layers of cells).*

Simple

There are 4 sub-groups found within simple epithelial tissue. Simple tissue is only one layer thick, meaning it is quite delicate and is found in areas that are not at high risk.

1. Squamous: Meaning squashed or flat and thin. Found lining the heart, alveoli of the lungs, blood and lymph vessels. Also known as endothelium.
2. Cuboidal: Meaning cube shaped, this tissue is found in areas of absorption and secretion such as the kidney tubules, glands and ovaries.
3. Columnar: Meaning tall and resilient. The nucleus is situated near the bottom of the cell. This tissue type is found in areas that can be stretched and recoil as required. For example, lining the stomach, arteries, intestines and urethra. It also secretes and absorbs substances.
4. Ciliated: This is a form of columnar epithelium with hair like projections called cilia from its surface. This type of cell is found lining the respiratory system, where it carries unwanted particles along with mucous out of the system to help protect it. It is also found in the fallopian tubes where it helps the movement of the ova towards the uterus.



Compound

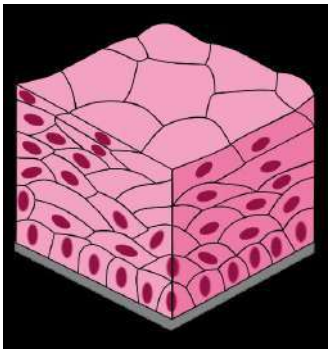
Its main function is protection of underlying structures. Compound means it is made up of many layers so it is tougher than simple epithelium. There are 2 sub-groups:

1. Stratified - this is made up of layers of cells of varying shapes. In deeper layers they are mainly columnar and towards the top they are flatter. There are 2 groups of stratified epithelium:

(i) Keratinised - meaning dried out by the presence of protein keratin. Found in the hair, skin and nails. They give protection and prevent drying out of structures.

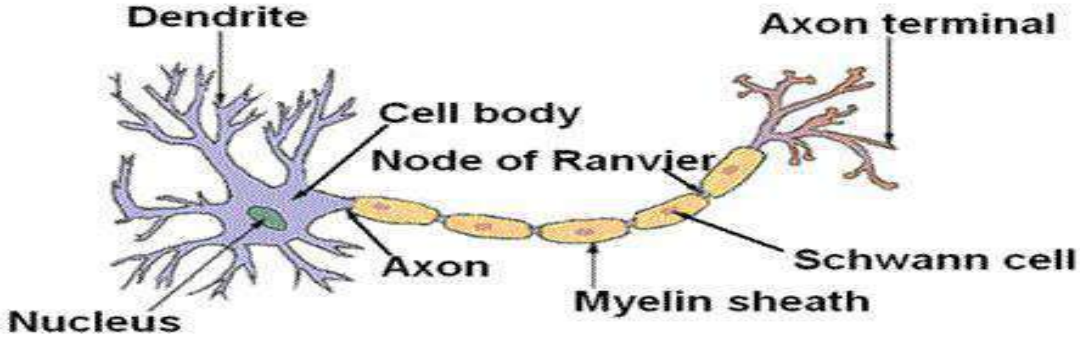
(ii) Non-keratinised - meaning moist. Found on wet surfaces such as the lining of the mouth, the eyes, pharynx and oesophagus.

2. Transitional - this is made up of several layers of pear-shaped cells that change shape when they are stretched. It is found in the bladder, lining the ureters and in the pelvis of the kidneys.



B Nervous Tissue

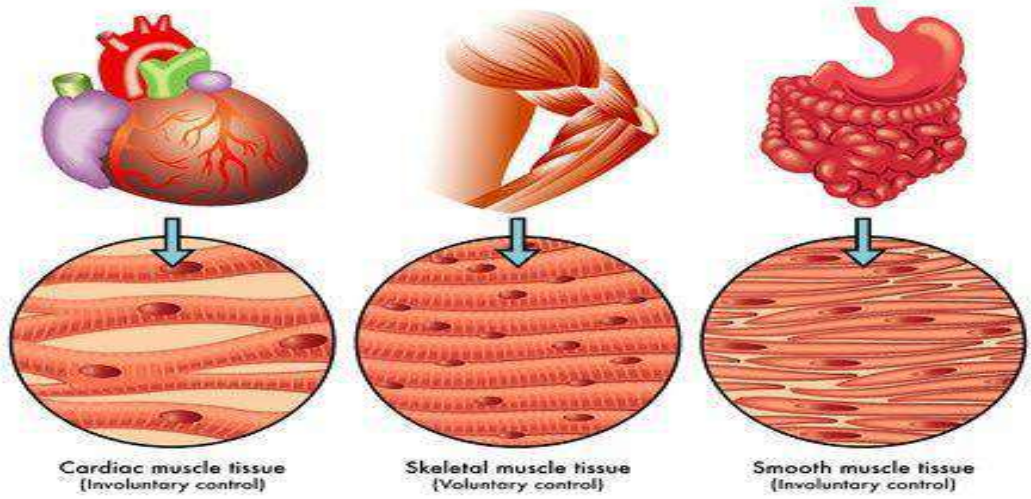
This tissue is made up of 1) nerves (neurones) and 2) neuroglia. Neurons transmit electrical signals by converting them into nerve impulses. Neuroglia are the supporting cells that provide nutrition and support to the neurons.



C Muscle Tissue

There are 3 different groups of muscle tissue found in the body.

1. Voluntary - this is muscle that we consciously control. It is also known as striated or skeletal muscle. It is found attached to bones and allow movement to occur. We control the actions of these muscles through our central nervous system.
2. Involuntary - This is muscle we have no control over. It is also known as smooth or visceral muscle. We do not consciously control the actions of these muscles. It is controlled by our autonomic nervous system. It is found in the walls of our digestive tract for example.
3. Cardiac - This is specialised muscle that is found in the wall of the heart only. We do not have any control over the contraction of this muscle; i.e. it is involuntary in function.



D Connective Tissue

Connective tissue is the most abundant tissue found in the body. Its main functions are:

1. Binding - other organs and tissues together
2. Supporting - structures and nutritional support
3. Protects and insulates
4. Defence

All connective tissues are made up of cells and matrix. The cells are more spaced apart from each other compared to epithelial tissue, which is tightly packed together.

Collagen - (glue) is a fibrous connective tissue. It is strong and resistant but not stiff. It is non-elastic but flexible. Found within many organs and structures. Collagen fibres lie parallel to each other in bundles. Found importantly in the skin for support. When it breaks down, it can result in wrinkles.
Elastin - Strong but can be stretched up to 150% of their relaxed length without breaking. The return to their original shape = 'elasticity'. Important in the skin for youthful appearance. Age and exposure to environment factors makes these fibres less effective.
Reticular fibres - made by fibroblasts, these fibres consist of the protein collagen and glycoproteins arranged in fine bundles. They are much thinner than collagen fibres but also provide support and strength.

The Cells of Connective Tissue
Fibroblasts - large, flat cells producing collagen and elastin fibres to help repair tissue.
Macrophages - Irregular shaped cells that 'eat' or 'mop up' bacteria and other unwanted substances in tissue. Protects the body.
Plasma cells - small cells that produce anti-bodies against foreign particles or bacteria that may damage the tissues of the body. They protect the body.

Mast cells - Found a lot near blood vessels. They produce heparin (blood thinner) and histamine (released in allergic responses).
Adipocytes - Fat cells found below the skin and around organs. Store fats for body use.

The 8 different types of Connective Tissues:
1. Areolar - contains white and reticular fibres and elastic fibres. Areolar is found under the skin, supporting blood vessels and found between muscles.
2. Adipose - Fatty tissue made up of cells called adipocytes. Few fibres are present. Its main function is to protect and insulate. It is found under the skin (hypodermis); supporting organs such as the kidneys and eyes.
3. Lymphoid - This is a semi-solid tissue with cells called lymphocytes that are involved in disease control. It is found in lymph nodes, spleen and the tonsils.
4. Yellow elastic - This tissue is *very* elastic, made up of yellow elastic fibres and fibrocytes. It is found in the stomach and arteries where stretching is required.
5. White fibrous Tissue - This tissue is tough and inelastic. It is made up of white collagen fibres. It is found in ligaments (connecting bone to bone); the fascia covering muscle; tendons (connecting muscle to bone).
6. Bone - this is the hardest tissue in the body. It is made up of compact and cancellous tissue, collagenous fibres for strength and mineral salts for hardness.
7. Blood - This is a fluid tissue made up of 45% cells and 55% plasma. It protects the body by transporting substances around the body and fighting infection._
8. Cartilage - This is a firm, tough and solid tissue. There are 3 different types:

Hyaline - smooth and blueish in colour. It contains cells called chondrocytes that produce the cartilage. It is very abundant and found on the surfaces of bones in joints, forms the costal cartilage in the ribs, the larynx and trachea.
Yellow elastin - This is made up of yellow elastin fibres with fibrocytes found in-between. It is found in the pinna and epiglottis.
White Fibrocartilage - Made up of collagenous white fibres with chondrocytes. It is tough but flexible. It is found in the shock absorbing areas of the public symphysis, hips and intervertebral discs.

Membranes

Membranes are layers of tissue made up of a combination of epithelial tissue and connective tissues. Membranes can either cover internal organs, line internal organs and also line body cavities.

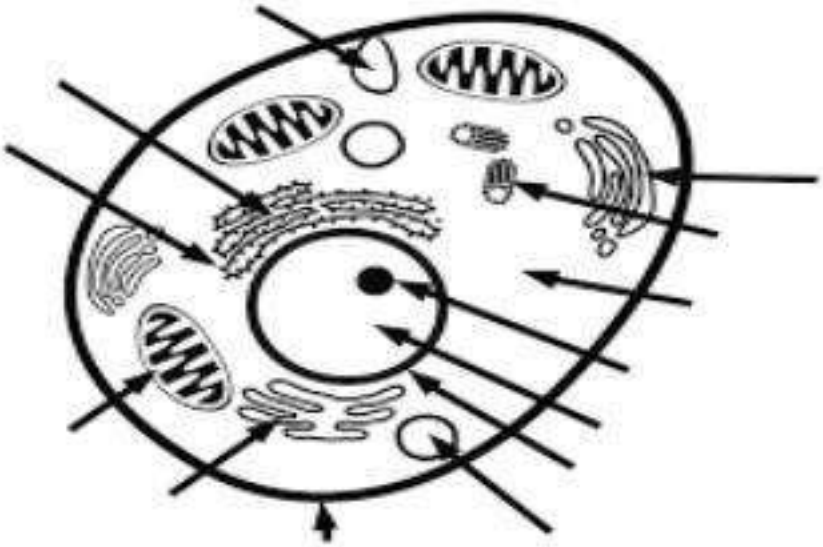
There are 3 main types of membranes found in the body:
1. Mucous
2. Serous
3. Synovial

Mucous Membrane (Mucosa)
These are found lining cavities and openings to the external environment such as respiratory, digestive, urinary and reproductive tracts. They are moist membranes as they secrete a slippery fluid called mucus. Its function is to protect underlying cells from mechanical and chemical injury.

Serous Membrane (Serosa)
The serosa covers internal organs and lines cavities that do not open to the external environment. It is a double-layered membrane that secretes a watery serous fluid. The double layer is made of a visceral layer that covers the organ and parietal layer that lines the space the organ is in.
Examples are the Pericardium that surrounds the heart; the Pleura that surrounds the lungs and the Peritoneum that surrounds the abdominal organs.
Its function is to protect and cushion the organs from friction within the body cavities.

Synovial Membranes

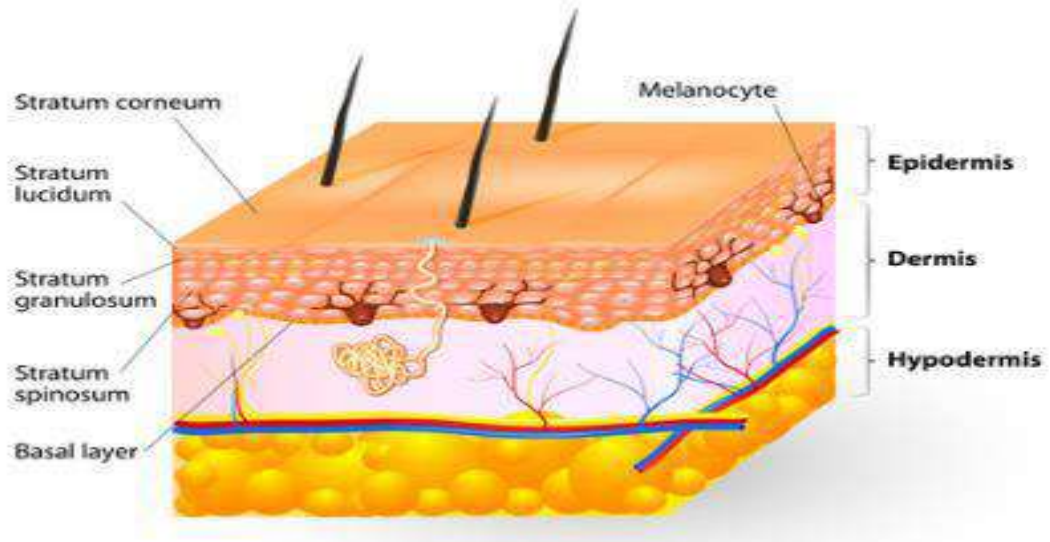
Synovial membranes are made up of elastic fibres and connective tissue. They are found lining joint cavities and surrounding tendons. The secrete *synovial fluid* that is sticky, clear and oily. This fluid lubricates and nourishes the joint so it can move freely without undue friction.
Phagocytes are also present in these membranes to remove damaging material from cavity. Synovial membranes are also found in the bursae which are protective sacs found around joint cavities, between layers of muscle and connective tissue and wherever the body needs extra protection.



The largest organ of the body. It provides a protective layer covering underlying structures of the body. It is the bodies first line of defence against bacteria - it prevents them entering the body.

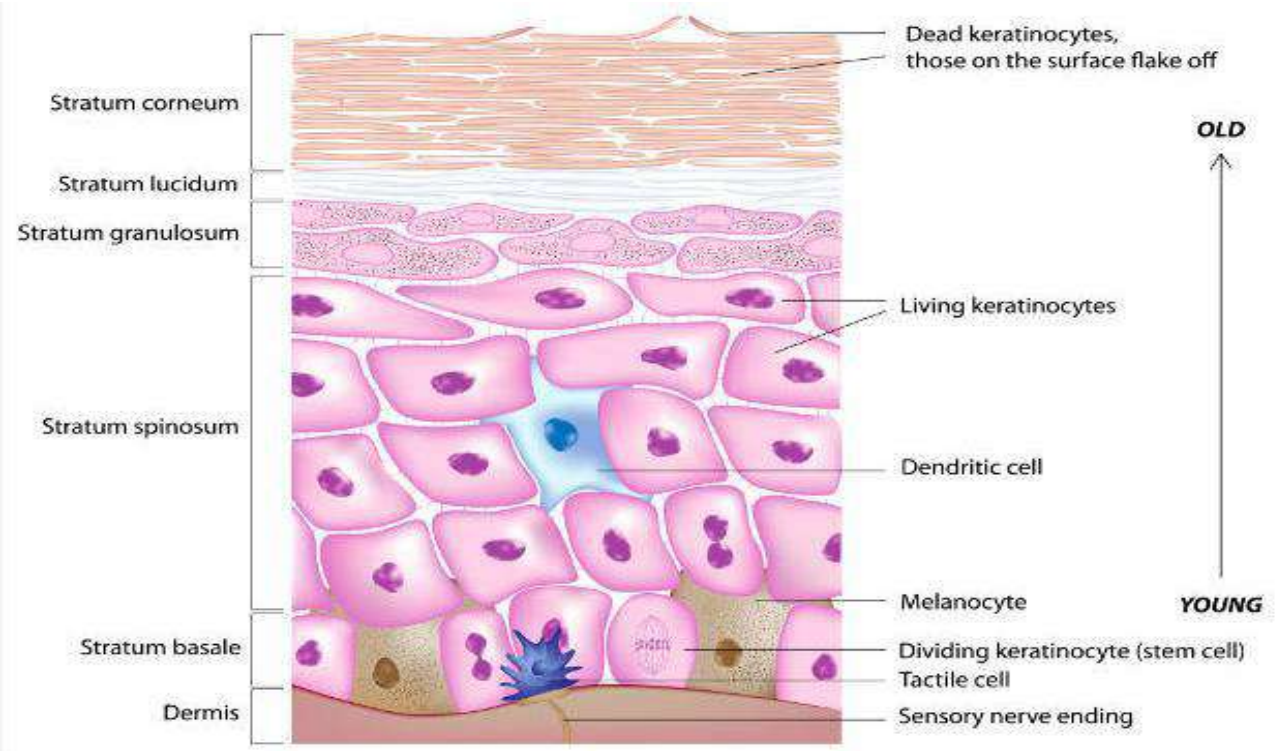
3 main areas:

1. The Epidermis - surface of the skin (5 layers)
2. The Dermis - supports the epidermis and provides shape and elasticity
3. Hypodermis/subcutaneous layer - made of adipose tissue, muscles and blood vessels.



The Epidermis

Superficial layer of stratified epithelium. It does not have its own blood supply. Its thickness varies - thinnest on eyelids and thickest on the soles of the feet. There are five layers.
The top 3 layers are dying - turning from living to dead cells.
The bottom 2 layers are alive and active. Cell renewal occurs here.



Stratum germinativum (Basal cell layer)
Deepest layer of the epidermis. Lower surface is attached to the dermis. Dermis supplies it with nutrients. Mitosis occurs here. Cells born here are pushed up into the next layer.
Melanocytes are also found here. These are cells that produce the pigment melanin. This is the skin's natural protection from UV rays.

Stratum spinosum (Prickle cell layer)
Next layer up containing living cells and also langerhan cells. These are cells that engulf foreign particles to protect the skin. All cells in this layer are connected to each other by filaments. On the upper most layers of this section, keratinisation begins. *This is the change of living cells containing a nucleus into layers of flat cells composed of a hard durable protein called keratin.*

Stratum granulosum (Granular layer)
Cells from below have pushed up and are becoming flattened and full of keratin giving them a 'grainy' appearance. The nucleus dies = cells die.

Stratum lucidum (Clear layer)
At this stage all the cells are filled with keratin and therefore look clear as opposed to 'grainy'. No nucleus is found here in any of the flattened cells. It is very evident in thick areas of skin (soles of feet). It is said to be very important in controlling the passage of water through the skin.

Stratum corneum (Horny layer)
Several layers of keratinised epithelial cells packed tightly together. Keratin has made them tough, dry, no nucleus and horny. The superficial layers are constantly being shed by a process known as desquamation.

The cells below have a fatty substance that helps to prevent the skin from drying out and keeps it waterproof.

The Dermis

Made of dense connective tissue that is tough, elastic and flexible. It gives strength, shape, elasticity and smoothness to the skin. It is highly sensitive and consists of:

- Collagen - protein collagen makes these white fibres. They run in parallel bundles with each other. Gives the skin strength and shape - they are inelastic but flexible.
- Elastin - protein elastin makes up these yellow fibres. These are thinner than collagen fibres and are very elastic. They give the skin its elasticity.
- Fibroblasts - these are cells that produce collagen and elastin fibres. Found in the dermis of the skin.
- Mast cells - these produce heparin to thin the blood and histamine that is released during an allergic response. These cells are found very close to blood vessels.
- Plasma cells - these cells produce anti-bodies to foreign particles, so help to fight infection in the skin.

It has a lot of water and provides nourishment to the epidermis to help keep the cells in the basal cell layer alive and reproducing.

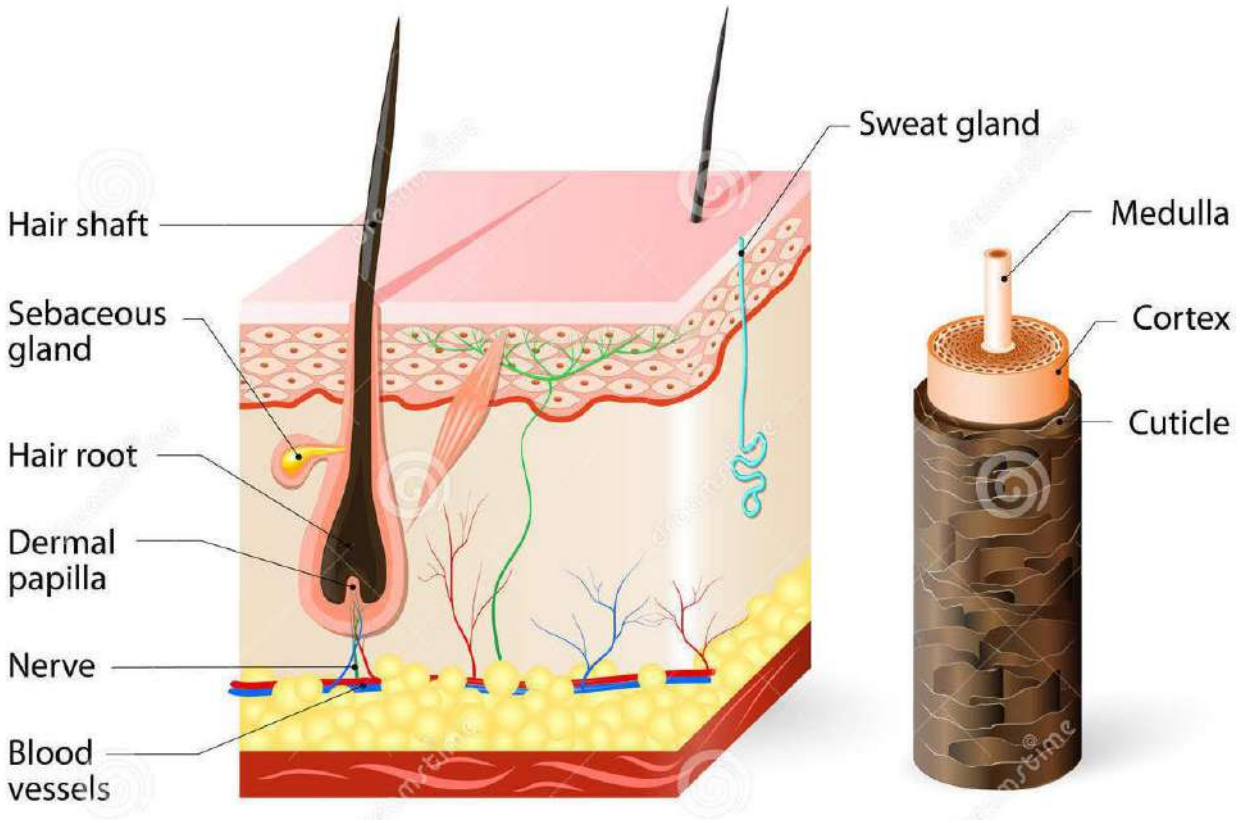
It has 2 main areas:

1. Upper papillary layer: this layer is below the epidermis and the upper part of the dermis (1/5th of total dermis depth). It runs between these 2 in a wave-like manner with protrusions into the epidermis called *papillae*. Capillaries are found here delivering oxygen and nutrients to the skin and carrying away waste. Also nerve endings are found here sensitive to touch, cold, heat, pressure, pain.

2. Deep reticular layer: This layer provides elasticity and tone to the skin. It contains collagen and elastin fibres. Sweat and sebaceous glands are found here and other appendages of the skin. Many fine arteries and veins pass through here which connect up with the papillary capillaries.

Appendages of the dermis

1. **Specialised cells** – Fibroblasts, Mast cells, Histiocytes, Leucocytes
2. **Nerve endings** - pick up on pain, heat, cold, pressure, touch.
3. **Hair follicles** - travel from deep in the dermis up through the epidermis via an opening. Tiny erector pili muscles are attached to help the hair to 'stand on end' and create goose bumps.
4. **Sweat glands** - eccrine produce a water + salt sweat for body temperature control. Found in non-hairy parts of the body. Apocrine produces a thicker sweat of water + salts + fatty acids + waste and this produces body odour. Found in hairy parts of the body, attached mainly to hair follicles.
5. **Sebaceous glands** - connected to hair follicles. Not found on palms or soles. Produce sebum, a protective oily film on the skin. It forms the acid mantle and is the skin's natural moisturiser. It prevents the skin from drying out. But it attracts dirt and this can cause blackheads, papules and pustules to form. Dry skin is when little sebum is produced and irritation can occur. Overproduction of sebum is called seborrhoea.
6. **Blood vessels** - blood capillaries feed up through the dermis but are not found in the epidermis. They deliver oxygen and nutrients to the skin and remove waste products.
7. **Lymphatic vessels** – work in conjunction with blood supply to carry waste products away from area.
8. **Papilla** - a little projection at the base of hair root that contains blood capillary and nerve to keep the hair alive.



The Hypodermis

An area where fats are made and stored. It is made of adipose tissue (energy reserve, support and protection) and areolar tissue (loose with collagen, elastin and reticular fibres). The hypodermis helps to insulate the body by preventing loss of heat through the skin.

Functions of the Skin

Secretion - of sweat and sebum. Sweat removes waste from the skin and also helps control body temperature. Sebum from the sebaceous glands is a natural moisturiser and waterproof layer for the skin. The mixture of sebum + sweat on the skin surface = acid mantle. A protective layer against bacteria.

Heat regulation - the skin allows the body to either lose heat or retain it. It does this through the blood that is flowing in the blood vessels. Vasoconstriction is when the blood capillaries tighten up to stop blood from reaching the skin surface. It happens if the body is cold. If no blood is getting to the skin surface, then no heat will be lost by radiation, conduction or convection. Vasodilation is when the blood capillaries relax and allow a lot of blood to reach the skin surface. This causes the skin to flush and heat is lost by radiation, conduction or convection. The body is also able to promote shivering to increase body temperature.

Absorption - the skin cannot absorb a lot of substances as it is a waterproof layer. Essential oils, drugs and some conditioning creams can be absorbed via pores and follicles in the epidermis.

Protection - the skin is a natural layered barrier against entry of bacteria etc. It also has the protective acid mantle to stop microbes growing on the skin surface. The pigment melanin protects us against burning UV rays of the skin. Langerhans cells protect us from infection and boost the immune system. Nerve endings give us warning signs of extremes and danger. Waterproof layer prevents the loss of essential body fluids.

Elimination - toxins such as salts, urea and waste water are lost through sweat glands of the skin.

Sensation - the nerve endings and other receptors of the skin can detect pain, cold, heat, pressure and touch. Different receptors lie at different levels in the skin.

Vitamin D production - sunlight converts a substance called ergosterol found in sebum into Vitamin D. Vitamin D is essential for calcium and phosphorus absorption for healthy teeth and bones. A lack of vitamin D leads to rickets in children.

Melanin production - UV rays from sunlight causes an increase in natural skin pigment melanin to be released. This pigment absorbs the damaging rays of sunlight and protects us from burning and damage.

Disorders of the Skin

Congenital

- **Eczema:** The skin in any area of the body can become dry, itchy, flaky and cause great discomfort. Bleeding and oozing will occur due to itching. Common areas for eczema are elbows, behind knees, face, hands, scalp. Causes may be endogenous or exogenous. It is **not contagious**.
- **Psoriasis:** A chronic inflammatory disorder of the skin. It is characterised by areas of red patches covered with silvery scaling skin. Bleeding, oozing, irritation and itching occurs. Can be very sore and irritating and can be found anywhere on the body. There is no 'cure'. It is **not contagious**.

Bacterial

- **Acne vulgaris**: This starts out as a hormonal imbalance that causes excess sebum to be produced. This in turn attracts dirt and promotes bacterial infection. The result is blocked pores, blackheads, papules, pustules and marked skin. Pitting and scaring can result. Main areas affected are the face, neck, back, chest and shoulders. It is **not contagious.**
- **Acne rosacea:** This occurs on the face and neck and starts out as an irritation due to factors such as diet, hormones, environment changes, alcohol, etc. This results in vasodilation of surface blood capillaries and reddened appearance. This leads to raised papules, pustules and erythema. It is **not contagious.**
- **Folliculitis:** This is a bacterial infection of the pilo-sebaceous duct (sebaceous gland + hair follicle). It causes redness and inflammation. It is connected with acne vulgaris and hormonal imbalances.
- **Boils (furuncles):** This is a bacterial infection of the skin, causing an infection locally around a hair follicle. Can be contagious - **mostly not.**
- **Impetigo:** A bacterial infection caused by the bacteria staphylococcus aureus from the nose. It is found mainly on the face area and causes blisters that ooze and form a yellow crust. This is **highly contagious.**

Viral

- **Warts:** Small horny tumours on the skin caused by a viral infection - **Highly contagious.**
- **Verruca:** 'Plantar warts'. These are warts found only on the feet. They appear more spread out and 'see through' with a small black dot in the centre. They are **highly contagious**.
- **Herpes Simplex (HSV):** This is an infection known as the 'common cold sore'. They can be found on the mouth, cheeks, chin and other body parts. Red area with small blisters. **Highly contagious.**
- **Herpes zoster:** A viral infection known as the 'shingles'. This is the adult form of chicken pox. It affects the spinal nerves and is extremely painful. Can take up to 2 years to recover. **Highly contagious.**

Fungal

- **Tinea pedis:** 'Athletes Foot'. This is an infection caused by the presence of fungus, found on the feet and between the toes. Fungal infections thrive in warm, moist and dark conditions. They attach themselves onto and live off the keratinised skin cells. Causes redness, itching, bleeding, white peeling skin. **Highly contagious** and can be moved from the feet to other parts of the body.
- **Tinea corporis:** Fungal infection of the skin on the body. It is the 'common ringworm' that appears in a red circle on the skin and spreads out. **Highly contagious.**
- **Tinea ungium:** Fungal infection of the nail. **Highly contagious.**

Infestations

- **Scabies:** An animal parasite that burrows beneath the skin and invades the hair follicles. Tiny papules and grey lines appear. Secondary bacterial infections can occur. **Highly infectious.**
- **Pediculosis:** Lice. Pediculosis capitas (headlice). Pediculosis pubis (pubic lice). These are animal parasites that infect the hair. They bite onto the skin and draw blood to survive. They lay eggs. When the eggs have hatched, the empty shell oxidises and looks white - these are the nits. **Highly contagious.**

Pigmentation (not contagious)

- **Vitiligo:** A complete loss of colour in well-defined areas of the body. It is a form of leukoderma. The melanocytes stop producing melanin. It is more obvious in darker skins. White patches may start small but develop and merge.
- **Albinism:** This is a genetic/inherited disorder where there is a complete lack of melanocytes, therefore, the pigment melanin cannot be produced. People are very photosensitive.
- **Chloasma:** This is hyper-pigmentation normally seen as a butterfly mask on the face. Due to hormonal changes or imbalances - e.g. pregnancy, contraceptive pill.
- **Ephelides:** Freckles. Small pigmented areas that become darker on exposure to the sunlight.
- **Lentigo:** Liver spots are darker than freckles with a slightly raised appearance.
- **Papilloma:** Moles. Pigmented areas of the skin found in varying parts of the body. Sessile moles are flat. Pedunculated moles are raised.
- **Naevae:** Birthmarks are areas of pigmentation (light to dark) found in different parts of the body. Some are associated with strong hair growth. Strawberry naevae are found on babies and are a pink colour. They normally disappear as the child grows.
- **Port wine stains:** Larger areas normally of dilated capillaries. Colour can vary from pink to dark red. They are commonly found on the face.

General (not contagious)

- **Broken capillaries:** Dilated capillaries on fine skin, normally seen on the face. Ruptured blood vessels can become bulbous and blue if congested. Due to irritation and stimulation.
- **Crows feet:** Fine expression lines around the eyes - 'laughter lines'.
- **Urticaria:** Hives, nettle rash. An allergic reaction to some stimulant. Characterised by weals/welts of pink colour. Very itchy and can lead to secondary bacterial infection.
- **Comedones:** Blackheads. Due to build-up of sebum and dirt on the skin and pores. The sebum is oxidised and gives the colour. Common with acne vulgaris.
- **Milia:** Whiteheads. When sebum becomes trapped in a duct with no opening/below the epidermis. Common on the orbicularis oculi muscles areas around the eyes.
- **Dermatitis:** Allergic reaction to being in contact with some irritant like shampoos or detergents (contact dermatitis).
- **Seborrhoea:** Excessive oiliness due to hyperactivity of the sebaceous glands. Caused by hormonal imbalances.

Skin Cancer

Non-melanoma cancers: more common in women than men

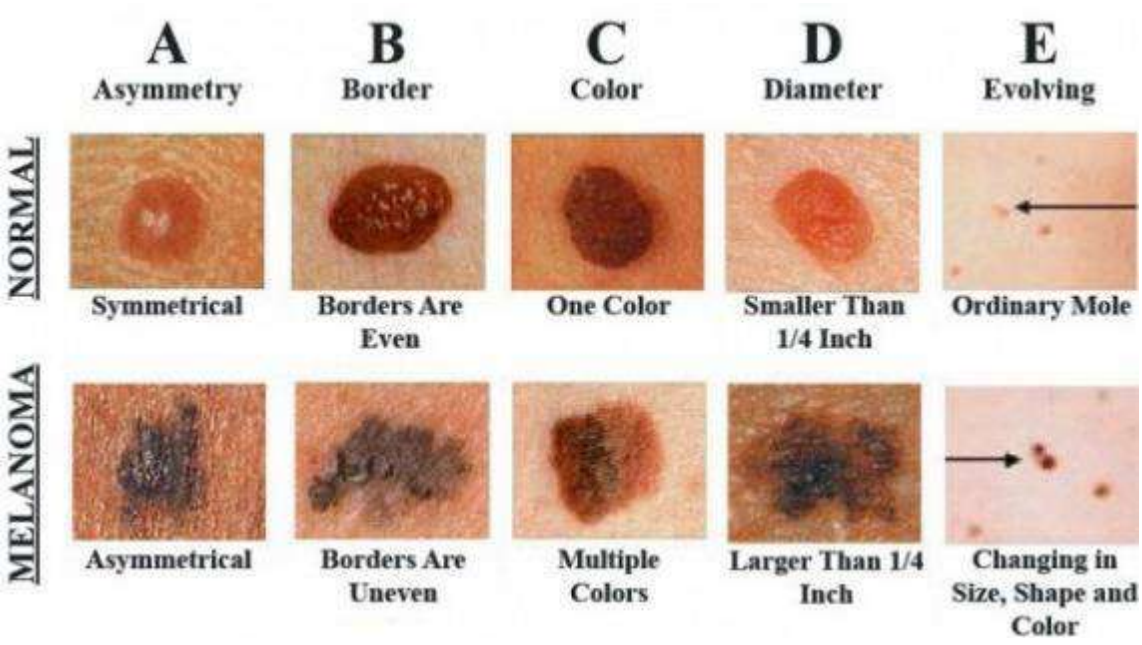
- **Basal cell carcinoma:** Tumours arise in cell of the stratum germinativum of the epidermis. They rarely metastasize (spread). Usually on face, nose, eyelids.
- **Squamous cell carcinoma:** Tumours arise in the squamous cells of the epidermis. Most arise from pre-existing lesions or damage due to chemicals, sun-exposure, etc. Some metastasize, others don't.

Melanomas

- **Malignant melanomas:** Arise from melanocytes in the epidermis. Can develop from a previously benign mole. They metastasise rapidly.

Key to early detection of melanomas

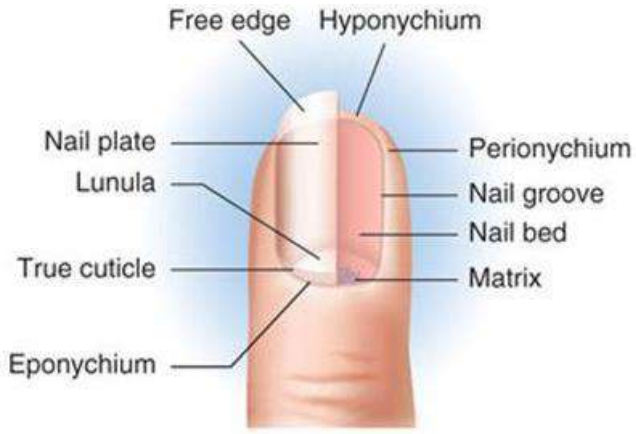
A ASYMMETRY
B BORDER
C COLOUR
D DIAMETER

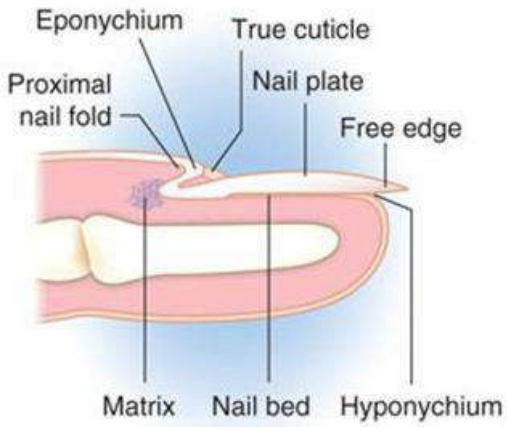


The nail is an appendage of the skin. It forms a protective covering for the ends of fingers and toes. A healthy nail is pink in colour with smooth, slightly curved surface and clear of any marks or defects. If the nail matrix is damaged, a deformed nail may grow. The technical term for the nail is onyx.

Nail Structure

1. **Nail root/matrix** - the living part of the nail situated below the cuticle. Mitosis occurs here to produce new nail cells. New cells are pushed forward to form the nail plate. They receive nourishment from blood supply and undergoing mitosis. As they dry out and become keratinised, they push towards the nail plate.
2. **Nail plate** - Stratum lucidium and corneum. These cells are fully keratinised and dead. There is no blood supply or nerves. It protects the nail bed. It is the visible portion of the nail and terminates at the free edge.
3. **Nail bed** - Stratum germinativum / spinosum / granulosum. It is a continuation of the root. It is to nourish and protect the nail structure. It has a blood supply and nerve supply. The nail bed has parallel ridges which 'slot in' with corresponding ridges on the under surface of the nail plate.
4. **Lanula** - point where the matrix and the nail bed meet. It is the 'half moon' at the base of the nail. Here, cells are so closely packed together that the blood supply below cannot be seen. That is why it is white in colour.
5. **Free edge** - extension of the nail plate which overlaps the hyponychium.
6. **Hyponychium** - a portion of skin at the end of the finger underneath the free edge.
7. **Cuticle** - overlapping epidermis surrounding the nail. It protects the matrix from invasion of bacteria and other damage. ***Eponychium*** is the cuticle at the base of the nail. *Perionychium* is the cuticle at the sides of the nail.
8. **Nail walls** - folds of skin that overlap the side of the nails.





Nail Growth

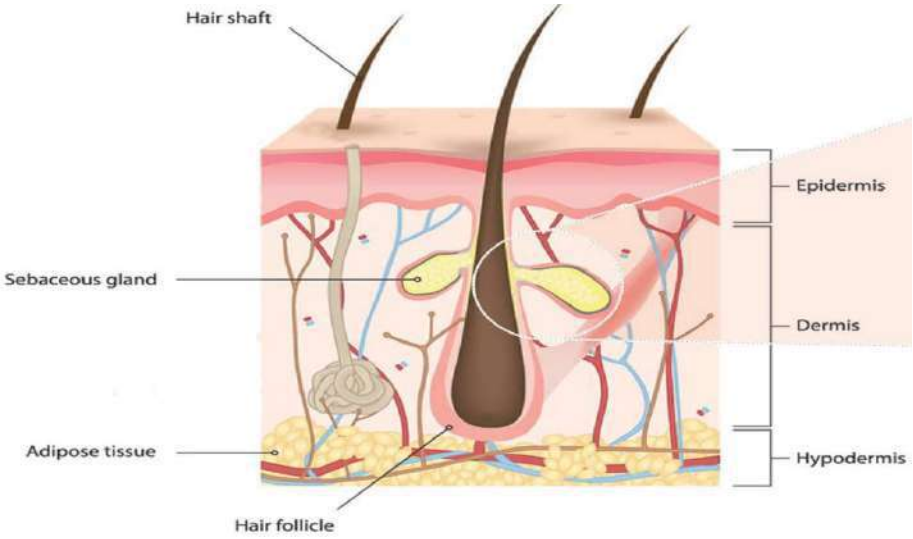
1. Cells divide in the matrix.
2. Nail grows forward over the nail bed.
3. Translucent and soft cells are present at first
4. As they grow towards the free edge, they become harder and flatter.
5. The top 2 layers of the epidermis form the nail plate.
6. The bottom 3 layers form the nail bed.
7. Interlocking grooves found on surface of nail bed and under surface of nail plate allow the nail to grow in correct direction.
8. It takes approximately 6 months for a finger nail to grow and 12 months for a toe nail to grow from matrix to free edge.

Hair Structure

Hairs are dead structures composed of keratinised cells that are cemented together. They grow out of hair follicles. It has 2 main portions - the Hair Root and the Hair Shaft.

The Root

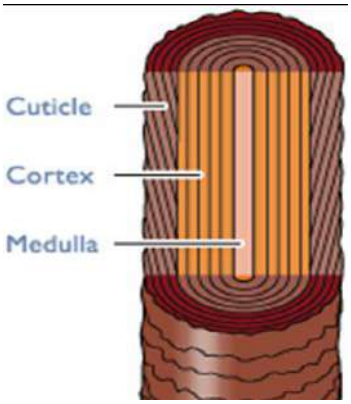
1 Found below the surface of the skin.
2 It includes the hair bulb /matrix, which is an enlarged area of cell division.
3 It includes the dermal papilla, which is an elevation at the hair root providing blood supply through capillaries. It provides nourishment to the dividing hair matrix.
4 Inner root sheath - single layer of keratinised cells that grows up with the hair from the papilla up to the level of the sebaceous gland. It connects with the cuticle cells.
5 Outer root sheath - this forms the follicle wall and does not grow up with the hair. It is a continuation of the basal layer of the epidermis. It is a permanent layer of growth and renewal.
6 Connective sheath - surrounds the follicle and sebaceous gland. It provides the blood and nerve supply to the hair.



The Shaft

Extends beyond the surface of the skin.
It is made up of 3 parts:

1. Cuticle - layer of scales pointing towards the hair tip. Scales are translucent and free of colour. Cuticle cells interlock with the inner root sheath in the follicle. This anchors the hair. It protects the underlying cortex of the hair.
2. Cortex - Bulk of the hair. Many layers of cells with keratin. The pigment melanin is here giving hair its colour.
3. Medulla - inner core of the hair made of soft keratin and pigment. No medulla is present in very fine hair.

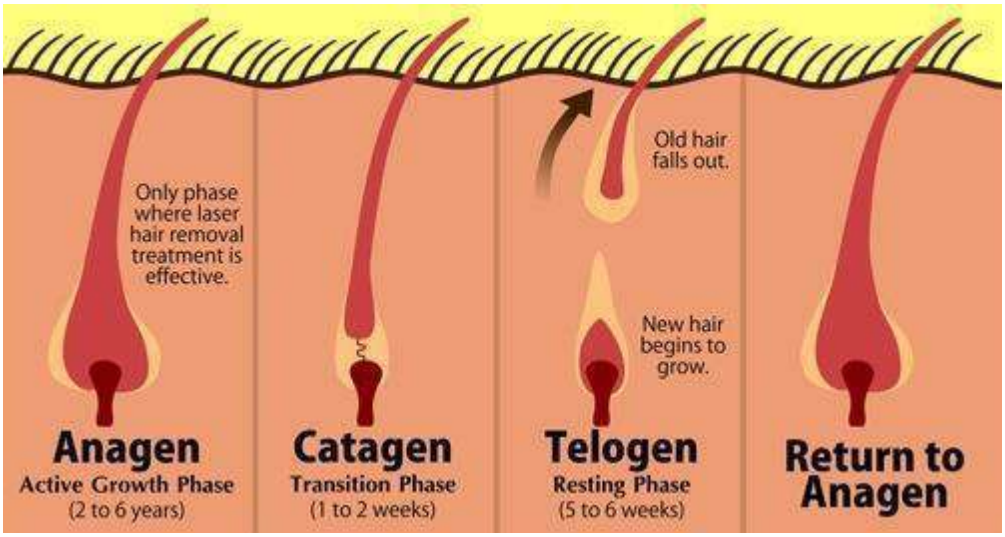


Hair Types

Lanugo - Fine soft hair with no medulla. It has no colour. Present in foetus from 3rd - 8th month. Replaced later by vellus hair. Eyelashes and eyebrows and scalp hair is replaced by terminal hair.
Vellus - Fine soft hair with no colour. Found on the face and body. It can become terminal hair with hormonal changes.
Terminal - Long coarse hair. Coloured and has varying thickness. It has deep follicles and strong bulb.

Hair Growth

Hair grows in 3 stages of a cycle:
Anagen - This is the active stage of hair growth. The follicle forms afresh and the hair bulb develops around the dermal papilla. Hair grows up from the matrix. This stage ends when the dermal papilla stops nourishing the hair.
Catagen - The hair separates from the dermal papilla and is carried upwards by the inner root sheath to the level of the sebaceous gland. Hair stays here until it falls out or is pushed out by a new hair.
Telogen - This is resting stage of hair growth. At this stage all that is left at the end of the follicle is a thread of germ hair cells that will reconnect to the dermal papilla and start a new hair growth cycle.



Hair Shape

- Determined by the hair follicle
- Angled or bent follicle will produce an oval (wavy) or flat (curly) hair.
- Straight follicle will produce a round hair (straight).

N. B. During waxing, curly hairs break off easier than straight hairs.

The skeletal system provides a framework for the body. It is made up of bone, cartilage, ligaments and tendons. There are 206 bones in the human body.

The main **functions** of the skeletal system are:

1. Support -All parts of the skeletal system support the body and all systems.
2. Movement - It allows movement to occur. This is allowed by the presence of joints where 2 bones meet.
3. Protection - It protects vital organs such as the brain, lungs, heart and spinal cord.
4. Attachment - It provides a point of attachment for muscles. Without muscles attached to bones, movement would not occur.
5. Mineral source - It is a reservoir for minerals such as calcium and phosphorus.
6. Makes blood cells - Red blood cells and platelets are made in the red bone marrow found inside bone.

Bone is the hardest connective tissue found in the body. Made of 20% WATER, 40% ORGANIC MAERIAL AND 40% INORGANIC MATERIAL. It gets its strength from the large amounts of calcium and phosphorus deposits in its matrix. It is living tissue.

Development of Bone

Ossification is the terms used to describe the development of bone. This is where cells produce collagen fibres as the matrix for bone.
Calcification is the deposition of calcium salts into the matrix for strength.

The cells of bone are:

Cells	Location	Function
Osteoblasts	Deep in the periosteum At sites of ossification At sites of fractures	Bone forming cells. These cells produce bone matrix and will become trapped within
Osteocytes	Trapped within formed bones	To maintain bone - helps to move calcium between bones and blood
Osteoclasts	Under the periosteum Within bones	To reabsorb bone Maintains bones optimum shape Recycles bone. Keeps bone shape

Structure of Long Bone

Long bones have a diaphysis (shaft) made of compact bone with a central medullary canal that contains yellow bone marrow. Long bones also have 2 epiphysis at either end that are made mostly of cancellous tissue. This is where you find red bone marrow.

All blood cells originate from stem cells (haemoblasts) and go through developmental stages before entering the blood. The process of blood cell formation (hemopoiesis) takes place in the red bone marrow. Red bone marrow consists of developing blood cells, adipocytes, fibroblasts and macrophages within reticular fibres.
In life, for the first few years, red bone marrow is found in all bones. However, as we grow older, the red bone marrow is replaced with fatty yellow marrow that has nothing to do with blood cell formation.
Yellow bone marrow contains adipose cells and stores triglycerides for energy source. It is found in the medullary/cavity of long bones.
In adults, hemopoiesis takes place only in the red bone marrow of spongy bone found in the ends of long bones, in flat bones (pelvis, ribs, sternum, cranium) and irregular shaped bones (vertebrae).

Periosteum
This is a layer of white fibrous connective tissue that covers most bones and parts of bones. It provides the site of attachment for muscles and tendons. It also provides protection to the bone. Its inner surface has living cells that thicken compact tissue and maintain the shape of bone.
The periosteum is not found at the ends of long bones (i.e. in a joint). Here you find hyaline cartilage instead.

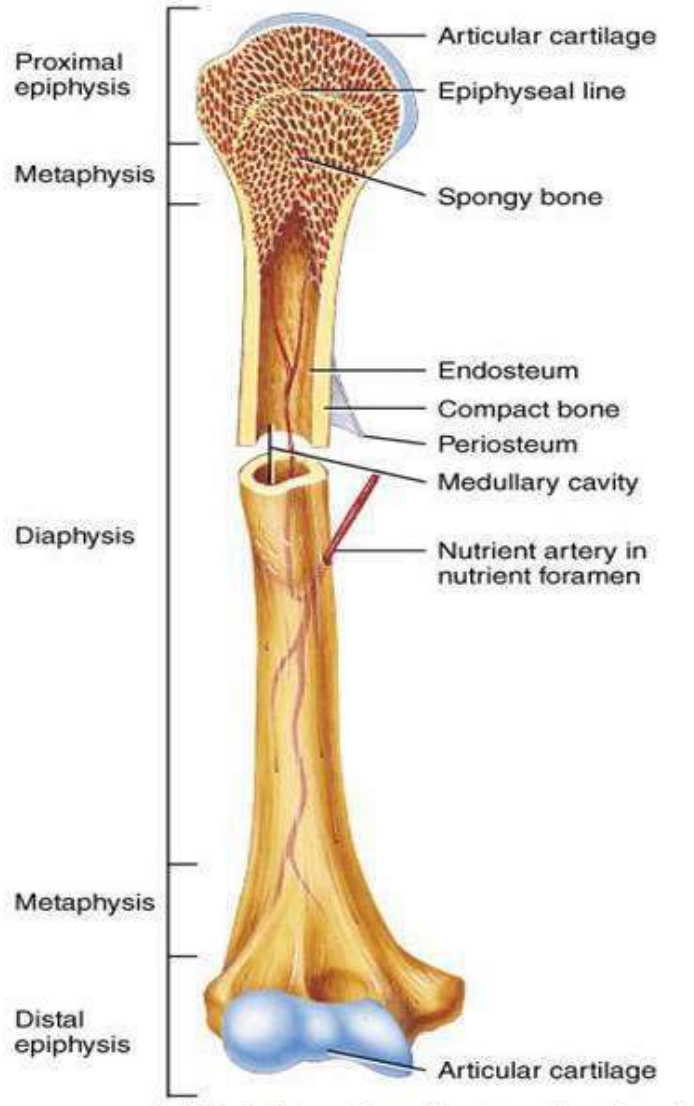
Bone is made up of **2 tissue types:**

1. **Compact tissue:**

- Honeycomb in appearance (full of holes)
- Holes are called 'Haversian canals'
- Haversian canals contain blood vessels, lymph vessels, nerves which run through the tissue
- Found on the outside of most bones and the shaft of long bones

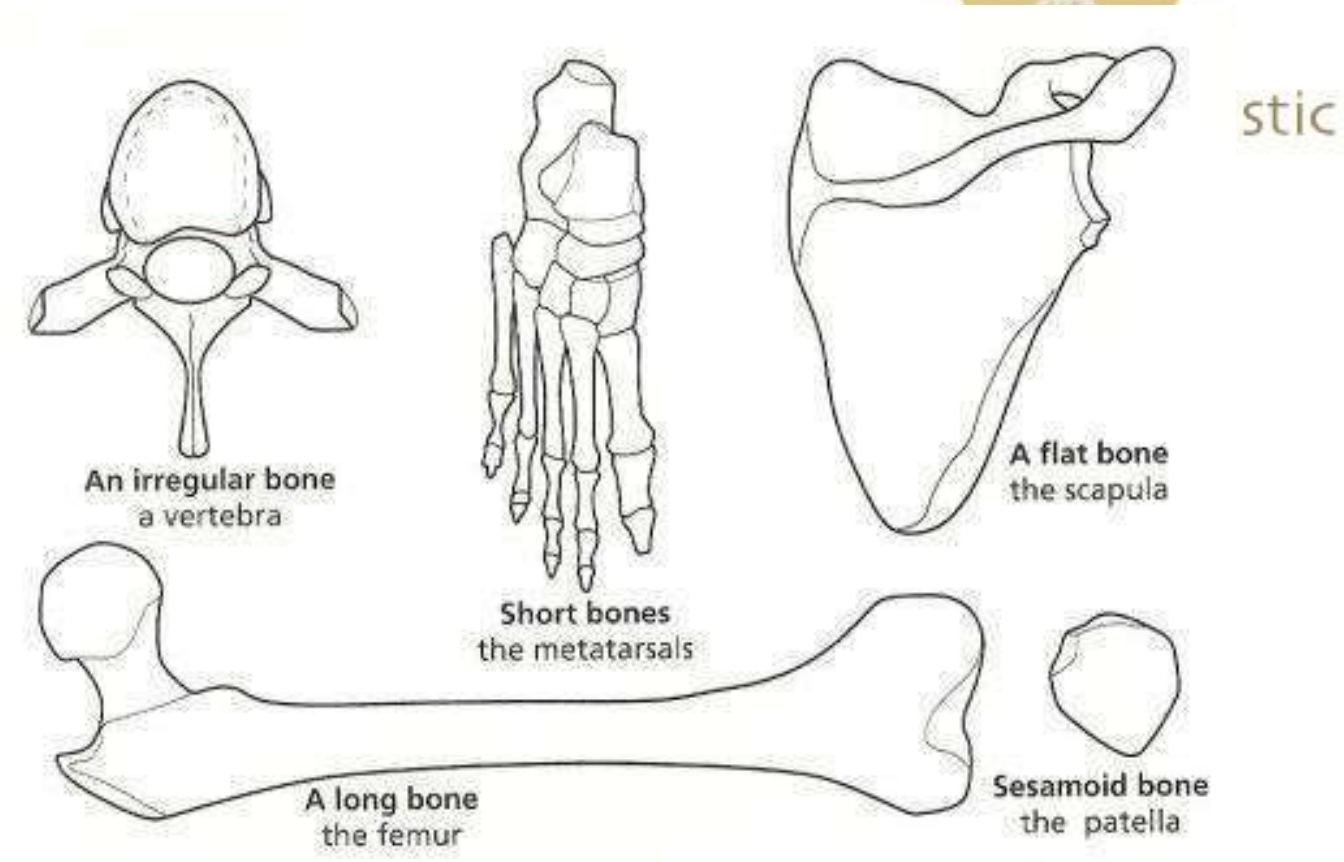
2. **Cancellous tissue:**

- Spongy in appearance
- Does NOT have haversian canals but still has blood & lymph vessels and nerves
- Found in the ends of long bones
- Inside all other bone types
- Contains red bone marrow - where blood cells are produced



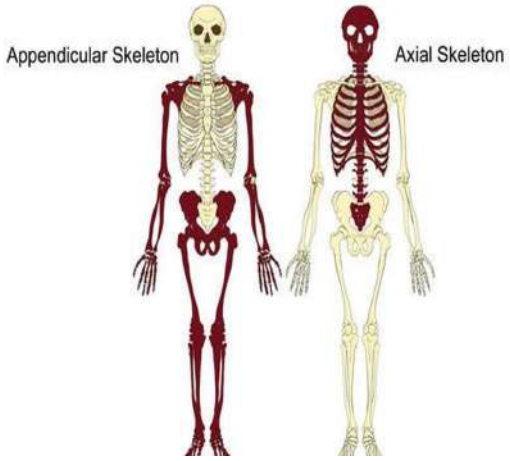
(a) Partially sectioned humerus (arm bone)

Types of bone: There are 5 groups of bones as follows:



1. Long - Levers of the body to allow movement. Found in limbs (arm, leg).
   Examples: humerus and femur.
2. Short - Strong and compact bones. Provide strength and little movement.
   Examples: bones of the wrist and ankles.
3. Flat - Broad and flat, these provide protection to underlying structures and a site of attachment for muscles.
   Examples: Bones of the skull; scapula; ribs + shoulder blades.
4. Irregular - Different shaped bones. Do not fit into other categories.
   Examples: Vertebrae in the spinal column; bones in the face.
5. Sesamoid - These are little bones found within tendons.
   Examples: Patella of the knee and hyoid attached to the tongue.

The Skeleton

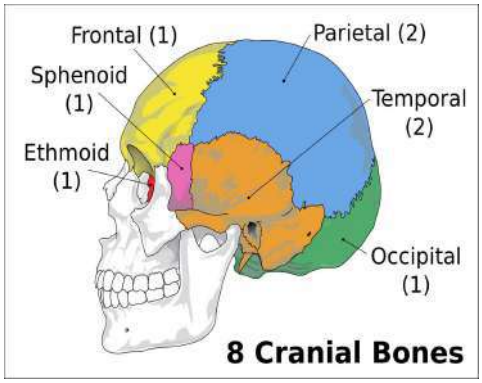


There are 2 sections of the skeleton:
1. Axial skeleton - Skull (cranium & face), Ribcage & Sternum, Vertebral column
2. Appendicular skeleton - shoulder girdle & upper limbs; pelvic girdle & lower limbs

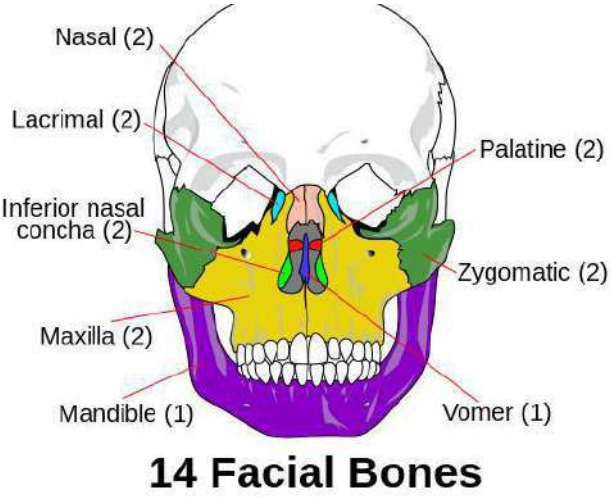
1. The Axial Skeleton

The Skull

The cranium is made up of the following 8 flat bones:
1. Frontal - 1 bone in the forehead
2. Parietal - 2 bones of the sides and roof of the skull
3. Occipital - 1 bone of the back and base of the skull
4. Temporal - 2 bones on either side of the head. Contains the mastoid process.
5. Sphenoid - 1 bone that articulates with frontal, parietal and temporal bones. Forms the base of the skull.
6. Ethmoid - 1 bone below the frontal and in front of the sphenoid bones. Forms part of the orbital cavity and nasal cavities.



The face is made up of the following 14 irregular bones:
1. Zygomatic - 2 cheek bones
2. Maxilla - 2 bones fused that form the upper jaw
3. Nasal bones - 2 bones that form the bridge of the nose
4. Lacrimal bones - 2 small bones forming part of the medial eye socket. It contains a hole through which a duct passes to carry tears to the nasal cavity.
5. Vomer - 1 think and flat bone that points upwards from the roof of the mouth to separate the 2 nasal cavities. It is the beginning of the nasal septum.
6. Palatine - 2 L-shaped bones forming the posterior hard palate; lateral nasal cavities; part of eye sockets.
7. Turbinated - 2 scroll shaped bones forms part of lateral wall of nasal cavity.
8. Mandible - 1 bone forming the lower jaw. It is the only moveable bone of the skull.

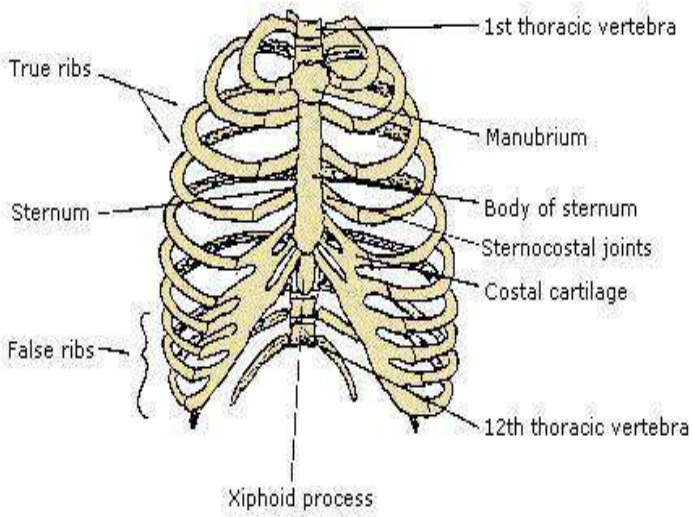


The Vertebral Column

This is the spine or backbone. In total there are 33 irregular bones found here.
There are 5 different regions to the vertebral column:
1. **Cervical** (neck) - 7 bones (C1 - C7). The first cervical bones is called the ATLAS.
2. **Thoracic** (chest) - 12 bones (T1 - T12). These bones articulate the 12 pairs of ribs.
3. **Lumbar** (lower) - 5 bones (L1 - L5). These bones form the lower back.
4. **Sacrum** (pelvis) - 5 bones fused together to form 1. It connects the 2 hip bones at the back to form part of the pelvis. Sacro-iliac joint.
5. **Coccyx** (tail) - 4 tiny bones fused together as 1.

Intervertebral discs are found between all individual vertebrae from C3 - L5. There are no discs found between C1 and C2.

The Ribcage & Sternum



The bones of the thorax or thoracic cage include:

1. **Sternum** - This is a flat bone also known as the breastbone. It has a manubrium (top) and xiphoid process (bottom 'dagger' part). Provides attachment for ribs via hyaline 'costal' cartilage.

2. **12 pairs of ribs** - all the ribs are flat bones. The first 7 pairs are known as 'true ribs' because they each have hyaline cartilage joining them to the sternum. The next 3 pairs are known as 'false ribs' as they share the same piece of hyaline cartilage to join them to the sternum. The last 2 pairs are known as 'floating ribs' as they are not joined to the sternum at all.

2. The Appendicular Skeleton

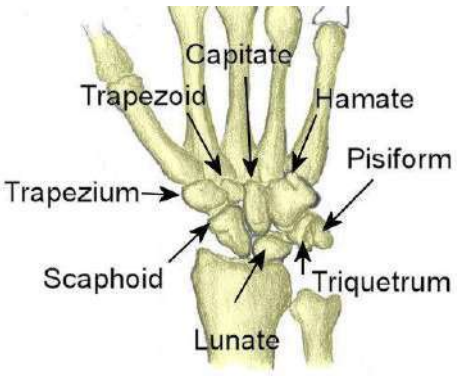
The Shoulder Girdle

There are 2 shoulder girdles (right and left). Each one consists of:
1. Clavicle - 1 long bone also known as the collarbone.
2. Scapula - 1 flat triangular bone also known as the shoulder blade.

The Upper Limb

There are 2 upper limbs each one consisting of:

1. Humerus - 1 long bone of the upper arm. The head of this bone forms the shoulder joint. At the other end (elbow) it meets with the 2 bones of the lower arm.
2. Radius - 1 long bone that runs from the elbow joint to the wrist - on the side of the thumb.
3. Ulna - 1 long thin bone that runs from the elbow joint to the wrist - on the side of the little finger.
4. The Carpals (wrist bones) - 8 short bones arranged in 2 rows of 4. They are: *Scaphoid, Lunate, Triquetral, Pisiform, Trapezium, Trapezoia Capitate, Hamate.*
5. Metacarpals - 5 long bones forming the palm of the hand.
6. Phalanges - 14 long bones of the fingers. There are 3 in each finger, only 2 in each thumb.



The Pelvic Girdle

There are 2 pelvic girdles (right and left). Each pelvic girdle consists of hip bones (innominate bones). The innominate bones consist of 3 fused bones:

1. Ilium - upper flat part of the hip
2. Ischium - bone that has a looped appearance
3. Pubis - front part of the bone joined at the pubis symphysis.

Both innominate bones are joined at the back by the sacrum of the vertebral column.

The Lower Limb

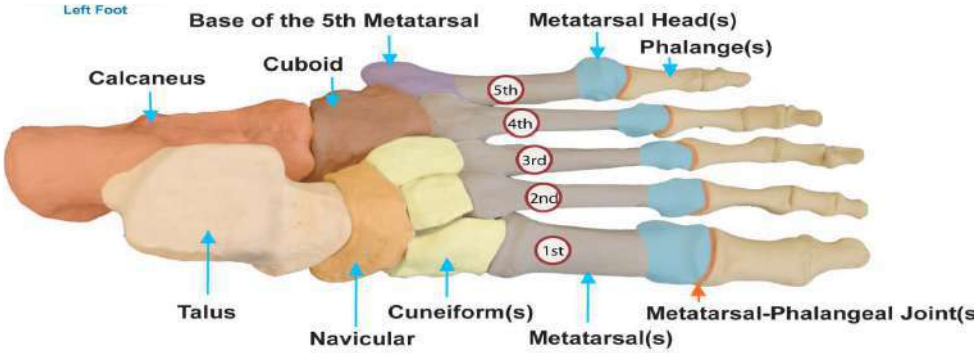
There are 2 lower limbs each one consisting of:

1. Femur - 1 long bone of the thigh. The strongest bone of the body. The head of this bone forms the hip joint. At the knee joint it meets with 2 bones of the lower leg.
2. Patella - the knee cap - 1 sesamoid bone.
3. Tibia - 1 bone also known as the shin bone. It runs from the knee to the ankle on the side of the big toe (medial).
4. Fibula - 1 bone that runs from the knee to the ankle on the side of the little toe (lateral).
5. The tarsals (ankle bones) - 7 short bones consisting of:
   Calcaneus, Talus, Navicular, Cuboid, 3 x Cuniforms.
6. Metatarsals - 5 long bones forming the sole and arches of the foot
7. Phalanges - 14 long bones of the toes. There are 3 in each toe, only 2 in the big toe.

Arches of the Feet

The bones of the feet are arranged in a way to support the body weight and to distribute the body weight evenly. The bones have a bridge-like arrangement supported with muscles and ligaments. There are 3 different arches:

1. Medial longitudinal arch - the highest of the arches. Runs from the calcaneus to the medial metatarsal bones.
2. Lateral longitudinal arch - less obvious and low. Runs from the calcaneus to the lateral metatarsal bones.
3. Transverse arch - arch that runs across the base of the foot. Most obvious from the cuboid across to the cuneiforms.



Joints

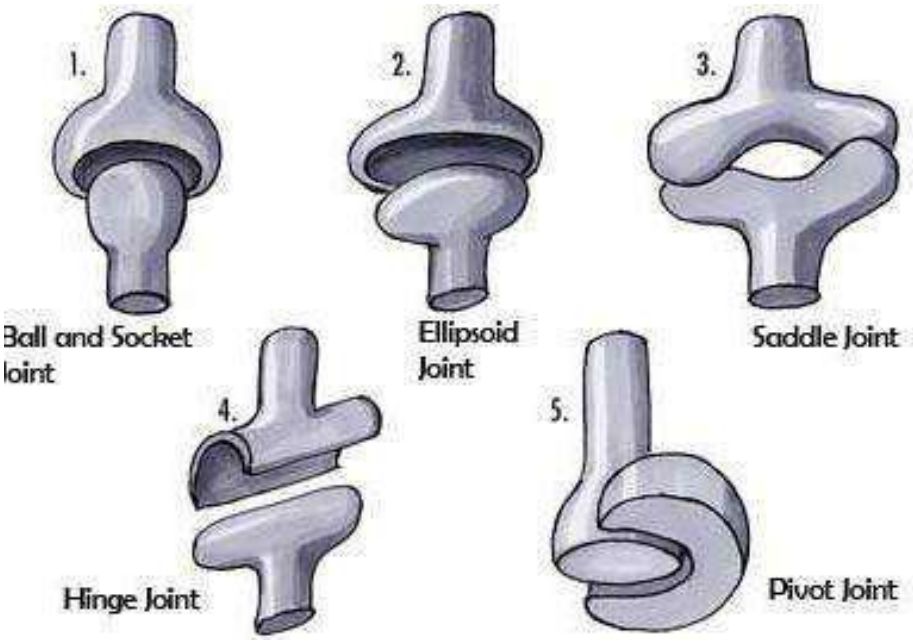
Joints are formed where 2 or more bones meet or *articulate*. There are 3 groups of joints as follows:

Name	**Fixed Joint**	**Cartilaginous Joint**	**Synovial Joint**
Type	Fibrous	Slightly movable	Freely movable
Movement Allowed	No movement between bones	A little movement between bones - by compression	A lot of movement allowed - depends on where you find them
Structure	Fibrous tissue found between the bones	Fibrocartilage is found between the bones	Hyaline cartilage + Capsule + Synovial membranes + synovial fluid is found between bones
Examples	Structures of the skull; innominate bone joints	Pubis symphysis; Joints between the vertebrae	There are 5 types: 1. Ball & Socket 2. Hinge 3. Gliding 4. Pivot 5. Saddle

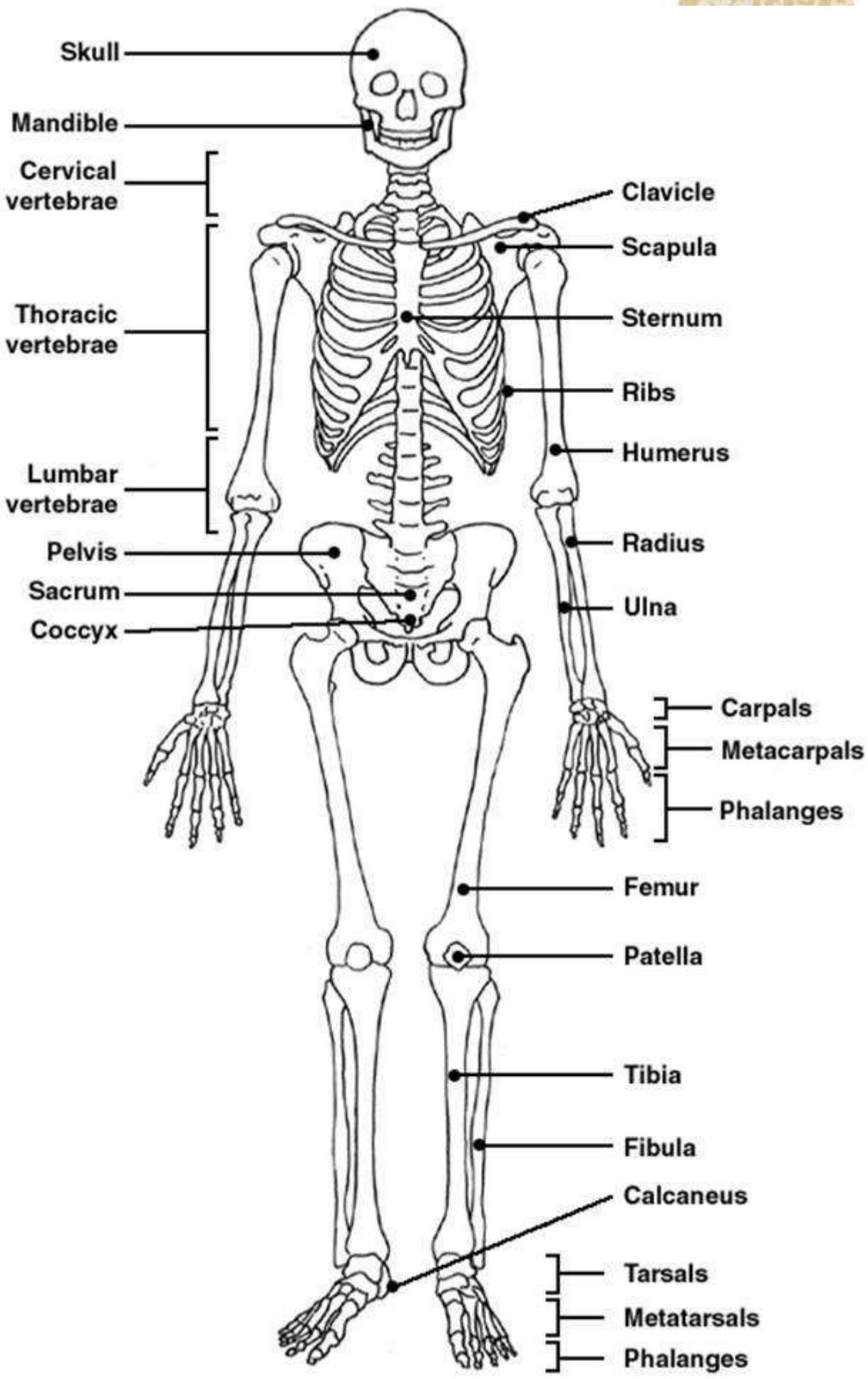
Detail on Synovial Joints

Type	Location	Movement allowed
Ball & Socket	Shoulder Hip	Flexion, extension, abduction, adduction, rotation, circumduction
Hinge	Elbow Knee	Flexion & Extension only
Gliding	Joints between the bones of the carpals and tarsals	Movement allowed is gliding between each other
Pivot	Between the atlas and the axis	Movement in one axis (rotation). Allows us to gesture 'no'
Saddle	The thumb joint	Movement in 2 axes - allows for Flexion, extension, abduction, adduction and circumduction.

Movement allowed in Synovial Joints:



Flexion	Decrease in the angle of a joint - normally bending
Extension	Increase in the angle of a joint - normally straightening
Abduction	Movement away from the midline of the body
Adduction	Movement towards the midline of the body
Circumduction	Movement including all of flexion, extension, abduction & adduction
Rotation	Movement around a long axis of a bone
Pronation	Movement to turn the palm down
Supination	Movement to turn the palm up
Inversion	Movement to turn the soles of the feet facing each other (inwards)
Eversion	Movement to turn the soles of the feet away from each other (outwards)
Dorsi-flexion	Movement so that the top of the foot is brought upwards (toes up, heel down)
Plantar-flexion	Movement so that the sole of the foot is brought downwards (toes up, heel down)


Skull
Mandible
Cervical vertebrae
Thoracic vertebrae
Lumbar vertebrae
Pelvis
Sacrum
Coccyx
Clavicle
Scapula
Sternum
Ribs
Humerus
Radius
Ulna
Carpals
Metacarpals
Phalanges
Femur
Patella
Tibia
Fibula
Calcaneus
Tarsals
Metatarsals
Phalanges

Disorders of the Skeletal System

1. Abnormal curvatures of the spine:

Kyphosis - this is an exaggeration of the outward curvature of the thoracic spine. It is also known as 'hunchback'. It is common in old people due to generation of discs. It can also be associated with rickets, poor posture and osteoporosis.

Scoliosis - this is a sideways or lateral curvature of the spine. It is usually seen in the thoracic region of the spine. It can be congenital or associated with poor posture, a short leg or chronic sciatica.

Lordosis - this is an exaggeration of the inward curvature of the lumbar spine. It is also known as 'swayback'. Causes include increased weight, pregnancy, obesity, poor posture and rickets.

2. Fractures

***Simple* - this is a clean break in a bone. Broken in one place with no complications**

Compound - this is an open fracture where the bone has broken through the skin.

Comminuted - this is where the bone is broken in many places and has shattered / has splinters

Greenstick - this is an incomplete break in a bone. A small part of the bone is fractured but because the bone is soft, bends instead of breaking completely.

Impacted - this is where a bone breaks in 2. Then one end of the broken bone is shunted into the other end.

Complicated - broken bone (simple or comminuted) that has also pierced or damaged tissue surrounding it.

3. Osteoarthritis - this is a degenerative disease of synovial joints where the cartilage is gradually lost due to wear and tear. It is caused by aging, irritation and wear and tear. It is progressive, meaning it occurs over time. It normally affects the weight bearing joints first - e.g. hips.

4. Rheumatoid arthritis - This is an autoimmune disease that causes pain in joints. The body attacks itself and its tissues - cartilage and bones in joints. This causes inflammation, swelling, pain and a lack of function. Inflammation at a synovial joint causes the synovial membrane to thicken and an increase in internal pressure. Cartilage gets eroded and the joints can become fixed. It normally affects the smaller joints first e.g. fingers, wrists, but can spread to larger joints. It is bi-lateral meaning if one wrist is affected, the other will be too.

5. **Gout** - this is a metabolic disorder of joints where there is a build-up of uric acid crystals in joints. It is also known as 'rich man's disease' and is aggravated by rich foods and drinks - e.g. red meat and red wines. The uric acid crystals in the joints and soft tissue irritates and erodes the cartilage. There is inflammation, swelling and acute pain. It normally affects men and the joints at the big toe. Diet has a major role to play - a wholefood approach should be taken avoiding rich or heavy foods, high protein foods & alcohol (especially red wine). It is important to drink plenty of water to help the body to flush out metabolic waste.

6. Osteoporosis - this is known as 'brittle bone disease'. The bones become porous and brittle due to a lack of calcium being deposited into the bone matrix. Too much calcium maybe lost through excretion or maybe not enough is taken in the diet. Bones fracture under normal strains - hips, wrists and vertebrae. Bones shrink and there will be pain, loss of height and perhaps kyphosis. It normally affects the middle aged and 80% affected are women. This is normally seen at post-menopausal stage of a woman's life. This is because the female hormone oestrogen facilities the deposition of calcium into bone. After the menopause, women produce less oestrogen so therefore, less calcium will be put into bone. Factors affecting this include: genetics, body size, physical strength and fitness, habits.

7. Rickets (children)/osteomalacia (adults) - this is a condition where the ones fail to calcify. It results in 'soft bones'. It is primarily due to a lack of vitamin D. Vitamin D is vital for strong bones and teeth. A lack of vitamin D can occur due to poor diet or when people do not get regular normal exposure to daylight. For example, it was very common in children in London during the industrial revolution when smog filled the sky and blocked out the daylight.

8. Slipped Disc - this is also known as a herniated disc. Between the vertebrae in the spinal column, are intervertebral discs. These are made up of an outer ring of tough fibro-cartilage and an inner soft pulpous nucleus. When too much pressure is put on the spine, or an awkward movement is made, the pressure forces the inner soft pulpous nucleus out through a weak point on the outer fibrocartilage ring. This can put pressure on a spinal nerve and cause intense pain. It is common in the lower thoracic or lumbar regions. Traction is one treatment method whereby stretching the spine will allow the pulpous nucleus to move back inside the fibrocartilage.

Bones provide leverage in the body. They provide support for the body. They do not move on their own however. **Muscles**, through relaxing and contracting, allow movement to occur in the body.

Women: approx. 23% body weight is muscle
Men: approx. 40% body weight is muscle

Muscle is made up of 20% Protein; 75% Water; 5% Salts, Glycogen, Fats.

FUNCTION

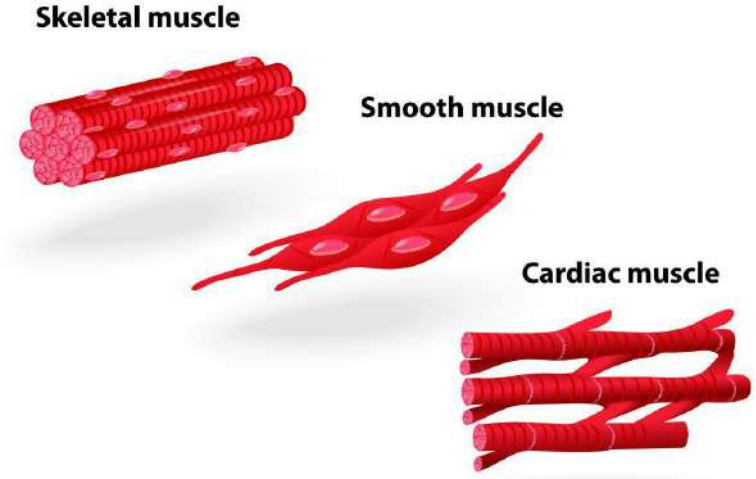
Functions of muscles:

1. Produce movement in the body - walking and running
2. Stabilises body positions - stabilises joints and maintains posture (standing/sitting)
3. Aid movement and storage of substances within the body. Examples are: containing/ releasing food of the stomach via ***sphincter*** muscles (ring like muscle/structures); bladder control; cardiac muscle pumps blood into blood vessels; blood vessels contract and relax to allow movement of the blood.
4. Heat generation - contraction of muscle generates heat. Shivering can generate heat.

Muscle Characteristics:

Contractibility - **can shorten and thicken**
Extensibility - **can stretch when muscle fibres relax**
Elasticity - **can return to original shape after contraction**
Irritability - **can respond to stimuli by nerve impulses**

3 different types of muscle: Skeletal, Cardiac and Smooth

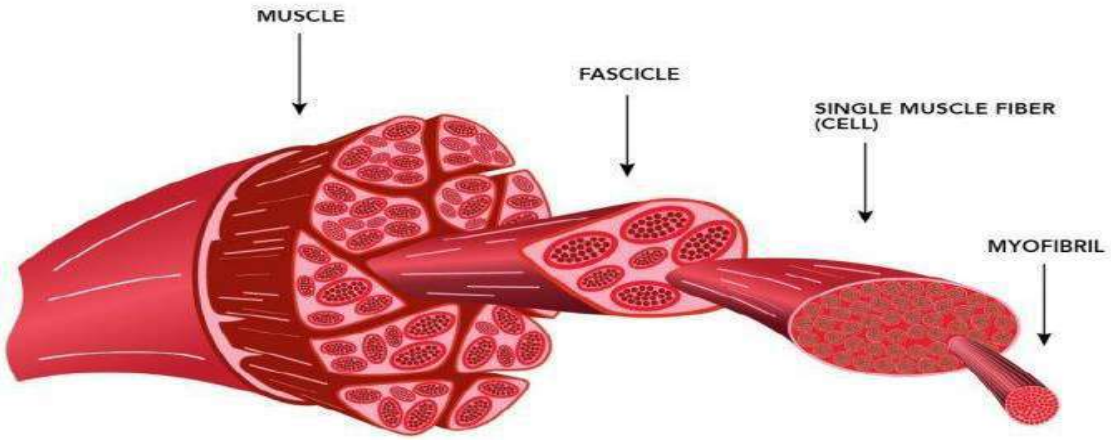


1. Skeletal

- Moves the bones of the body
- Attached to bones etc. via tendons /fascia
- Voluntary control - we have conscious control over their movements through the somatic (voluntary) division of our nervous system
- Most can also be controlled subconsciously - e.g. when maintaining posture
- Striated in appearance (alternating light and dark stripped appearance) under a microscope

Structure of Skeletal (Voluntary/Striated) muscle:
Each skeletal muscle is composed of thousands of **muscle fibres.** These are cylindrical cells with many nuclei and are surrounded by a sheath called a **sarcolemma (cell membrane of each fibre).** These fibres form bundles and run parallel to each other.

Myofibrils are smaller *contractile or elastic* fibres within a muscle fibre. Here, proteins called **actin (thin)** and **myosin (thick)** form the light and dark bands that give this muscle the striated appearance. These contractile filaments are vital for contraction of the muscle.
Fascia is a connective tissue that surrounds an entire muscle. **Tendons** are layers of connective tissue from within the muscle that extend beyond the muscle to attach it to the periosteum of bone.



2. Cardiac
- Only found in our heart
- Forms the wall of the heart
- Appearance is *striated*
- Action is *involuntary* - i.e. we do not consciously control the relaxation and contraction of our heart
- The heart has a 'pacemaker' that causes each contraction
- Chemicals and hormones can alter the rate of the heartbeat

Structure of Cardiac muscle:
Found only in the heart wall. Fibres are short and less cylindrical than skeletal muscle. Usually each cell has one nucleus. The ends of each cardiac muscle fibre / cells connect to each other via an **intercalated disc.** Cardiac cells can have many branches. There are much more mitochondria in cardiac cells than in skeletal cells.
Cardiac muscle looks like skeletal (voluntary) muscle but acts like smooth (involuntary) muscle.

3. Smooth
- Found in the walls of hollow structures like blood vessels, airways & of most organs in abdominal and pelvic region.
- Involuntary control - we have no conscious control over the contraction and relaxation of these muscles.
- Movement is regulated through autonomic (involuntary) division of our nervous system and also by hormones.
- Smooth in appearance - i.e. does not have light/dark variations, under a microscope.

Structure of Smooth (Involuntary) muscle:
These are spindle shaped with only one nucleus per cell. Each cell is thickest in the middle. Bundles of fibres form sheets of muscle found in the walls of hollow organs such as blood and lymph vessels, ducts of glands, alimentary tract, respiratory tract, urinary bladder, uterus. There is no appearance of striations in smooth muscle.

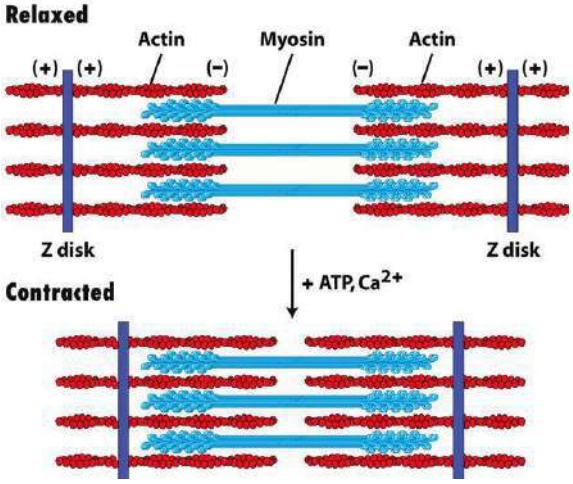
HOW DO MUSCLES WORK?

Skeletal muscles work in pairs by contracting and relaxing.
They transform chemical energy into mechanical energy so to exert a force

All or nothing Law: A muscle will contract completely or not at all. A muscle will never 'half' contract. Once a strong enough stimulus has been received by a muscle from a nerve, it will contract.

A muscle will contract if:
1. A strong stimulus from a nerve has been received
2. A good blood supply is available to bring oxygen and nutrients it needs
3. Enough energy is available to the muscle and if it is not already overworked
4. The temperature is favourable (warm is better than cold)
5. There is little or no waste building up in the muscle

Contraction:
1. The shortening and thickening of a muscle due to the movement of the protein actin sliding between myosin filaments in the fibre.
2. Calcium and ATP is needed for this to occur.
3. During contraction a sliding movement occurs within the contractile fibres. Actin filaments move IN towards the Myosin and both merge.
4. Muscle shortens and thickens
5. Muscle pulls on the limb its attached to.



Relaxation:
Muscle fibres elongate and return to original shape.

Energy and ATP:
ATP, Adenosine Triphosphate, (chemical energy) is available from the catabolism of carbohydrates, i.e. glucose. Glucose is stored in the body in the liver and muscle as glycogen. It is mainly Glycogen that fuels muscle contraction.
1. Glycogen in muscle cells breaks down and forms Pyruvic Acid by a process of oxidation.
2. During this oxidation, ATP is formed that stores energy from food.
3. When the muscle is stimulated, ATP is converted to ADP (adenosine diphosphate), which releases a lot of energy needed for muscle contraction.
4. If plenty of oxygen is available, pyruvic acid breaks down to Carbon Dioxide, Water, ATP and Heat. This is Aerobic Respiration that occurs when we are at rest or doing light work/exercise.
5. If there is a lack of oxygen in the body, pyruvic acid is converted to Lactic Acid. This is Anaerobic Respiration that occurs during strenuous exercise.

Skeletal muscles must pass over a joint to create movement. Skeletal muscles can work as **antagonist pairs.** This means one muscle moves a bone in one way and the other muscle moves it back. The **Agonist** is the contracting muscle. The **Antagonist** is opposing or relaxing muscle.

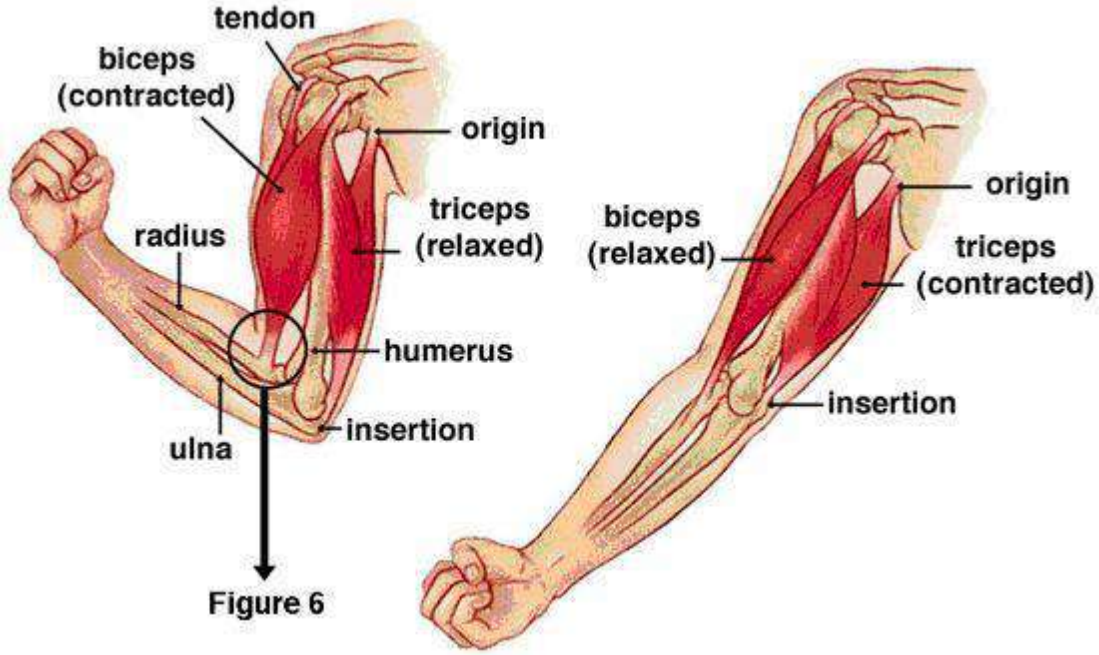


Figure 6

Isotonic contraction: Used for body movement and moving objects. Tension in the muscle remains the same. It occurs when a constant load is moved through the range of motions possible at a joint. For example, picking a book up (biceps contract) and putting the book back down (biceps lengthen).

Isometric contraction: Used for maintaining posture and for supporting objects (e.g. holding a book away from the body). Tension in the muscle increases but there is only little shortening so no movement is produced.

Muscle Tone: A sustained partial contraction of portions of a skeletal or smooth muscle in response to nervous stimulation. Even at rest muscle maintains a small amount of tension - posture when sitting upright. Some muscles contract while others are at rest.

Muscle Fatigue: The inability of a muscle to maintain its strength of contraction or tension. This may be caused by lack of oxygen, depletion of glycogen and / or a build-up of lactic acid.
Glycogen is combined with oxygen from the blood to produce energy for muscle contraction. If a lot of work is being done then more oxygen is needed. Also, all the waste must be successfully brought away from the muscle to prevent build up. If there is a lack of oxygen and rest during work, then the waste by-product **lactic acid** will build up and cause a burning sensation with stiffness and pain in that muscle. Rest and a fresh supply of oxygen is required to alleviate this.

Muscle Origin: Fixed end of a muscle. This does not move during contraction.

Muscle Insertion: The moving end of a muscle. Muscles always work from its insertion *towards* its origin.
Belly: Thickest part of the muscle, normally in the middle.

Attachment: Muscles attach to the bones, other muscles, skin, etc. They are attached by tendons, fascia, etc.

DISORDERS OF THE MUSCULAR SYSTEM

Fibrositis
Inflammation of the fibrous tissue causing pain and stiffness particularly in the muscle fascia. It can follow an injury, repeated strain or prolonged muscle tension.

Fibromyalgia
Chronic condition that produces musculo-skeletal pain. Predominant symptoms are pain, lethargy and fatigue. Other characteristics are non-refreshing sleep, feeling exhausted and tired later in the day. Interrupted sleep patterns. Also, early morning stiffness, pins and needles, headaches, poor concentration, memory loss, low moods, urinary frequency, abdominal pain, IBS.

Lumbago
Lower back ache caused by inflammation and pain in lumbar muscles. May be due to incorrect lifting/bending, slipped disc or strained muscles or ligaments.

Muscular Dystrophy
Progressive muscle destroying disease caused by degeneration of muscle cells. This results in the atrophy (wasting away of tissue) of muscle. May be due to disuse of muscle tissue, genetics, lack of nourishment, lack of nerve supply.

Sprain
Complete or incomplete tear in ligaments around a joint. Usually follows a sudden sharp twist to a joint that stretches ligaments and tears some fibres.

Strain
Injury to muscle or tendon due to excessive stretching or work. Tear can be partial or complete. Pain, swelling, tenderness and stiffness in affected area results. Common in lower back and neck.

Tendonitis
Inflammation of a tendon after excessive overuse. Achilles tendonitis is common in sports people. Also, may be due to incorrect footwear / insufficient warm up / cool down.

Muscle Cramp
Acute painful contraction of a single muscle or a group of muscles associated with mineral deficiency, irritated nerve or muscle fatigue.

Muscle Spasm
Increase in muscle tension due to excessive motor neuron activity resulting in a knot in the muscle.

Torticollis
'Wryneck'. Involuntary contraction of the neck muscles - sternocleidomastoids.

Whiplash
Caused by damage to the muscles, ligaments and intervertebral discs or nerve tissues of the cervical region by sudden hyperextension and/or flexion of the neck. Common in road traffic accidents when acceleration/deceleration causes sudden stretch of the tissue around the cervical spine. Pain, limited neck movements and tenderness result.

MUSCLES OF THE HEAD AND NECK

NAME	POSITION	ACTION
Occipitalis		
Frontalis		
Corrugator		
Zygomaticus		
Orbicularis Oris		
Mentalis		
Buccinator		
Risorius		
Masseter		
Temporalis		
Orbicularis Oculi		
Sternomastoid		
Platysma		
Trapezius		
Deltoid		
Serratus Anterior		

Rhomboids Teres Major		
Teres Minor		
Levator scapula		
Supraspinatus		
Infraspinatus		
Subscapularis		
Biceps		
Coraco-brachialis		
Brachialis		
Pronator teres		
Brachioradialis		
Flexors Wrist & Digits		
Triceps		
Extensors Wrist & Digits		

MUSCLES OF THE LEG

NAME	POSITION	ACTION
Quadriceps		
Adductors		
Tensor fascia lata		
Sartorius		
Tibialis anterior		
Peroneus longus		
Soleus		
Gastrocnemius		
Hamstrings		
Tibialis posterior		
Flexor of toes		
Extensor of toes		
Pectoralis major		
Pectoralis minor		
External obliques		
Internal obliques		

Rectus abdominus Diaphragm		
Transversalis		
Latissimus dorsi		
Erector spinae		
Psoas		
Iliacus		
Quadratus Lumborum		
Gluteus maximus		
Gluteus medius		
Gluteus minimus		

The cardiovascular system is made up of blood, the heart, blood vessels. We will also be looking at the Coronary Circulation, Pulmonary Circulation, Portal Circulation & the Systemic Circulation.

BLOOD

- Fluid connective tissue pumped by the heart through blood vessels of the cardiovascular system.
- 55% of blood is composed of a fluid called plasma, a clear straw-coloured fluid that consists of 90% water and 10% of plasma proteins (albumin, globulin, fibrinogen and prothrombin), waste, digested food materials, mineral salts and hormones.
- 45% of blood is composed of what we collectively call *farmed elements*. These are the red blood cells. There are 3 different types:
  1. Red blood cells - erythrocytes
  2. White blood cells - leucocytes
  3. Platelets - thrombocytes

BLOOD FUNCTIONS

1. Transport:

- Delivers oxygen from the lungs to the organs and cells of the body.
- Nutrients (glucose, amino acids, vitamins) are collected from the small intestine and delivered to the cells of the body.
- Carbon dioxide is removed by the blood from tissue and returned to the lungs for excretion
- Waste material (e.g. lactic acid) is carried by the blood for excretion.
- Hormones are transported by the blood from glands to target organs.

2. Defence

White blood cells combat disease by gathering at an infected site / tissue and ingest the micro-organism or foreign body by **phagocytosis.** This means the wbc's ingest microbes, dead cells and tissue to eliminate chance of infection. Also, some wbc's produce antibody's which fight against disease.

3. Regulation

- Blood helps to regulate body temperature by carrying heat away from organs and distributing it around the body to maintain body temperature.
- Blood regulates the pH levels of the body to help maintain homeostasis.

4. Clotting

Platelets are specialised cells that gather at site of damaged skin and they clot to prevent the loss of blood and also the entry of bacteria.

THE BLOOD CELLS

Erythrocytes

Red blood cells (rbc). These are biconcave shaped discs and they lack a nucleus. They are formed in the red bone marrow of bones. They make up 90% of the blood cells. They contain an iron containing protein called Haemoglobin. This gives blood its red colour. RBC's function is to carry oxygen in the blood as *oxyhaemoglobin* and to remove carbon dioxide from tissues. They have a life span of 120 days. Every second up to 2m rbc's die and 2m are replaced by process of erythropoiesis.

Leucocytes
White blood cells (wbc's). These are very large cells with nucleus. They lack haemoglobin therefore do not have a colour. There are 2 different types:

1. *Granulocytes:* Neutrophils, Eosinophils and Basophils. These originate in the red bone marrow and all have nuclei. They make up 75% of wbc's. Neutrophils and eosinophils use phagocytosis to fight infection. Basophils release heparin (anti-coagulant) and histamine (increases permeability of blood vessel walls).
2. *Agranulocytes:* Originate in lymphoid tissue. They have nuclei. Lymphocytes produce antibodies to fight infection. Monocytes use phagocytosis to engulf bacteria, etc.

Thrombocytes
Platelets. These are tiny fragments of cells with no nucleus. Originate in the red bone marrow and are very important in blood clotting.

THE BLOOD VESSELS

Arteries:
Carry blood away from heart under high pressure.
They have a fibrous outer layer, a thick muscular and elastic middle wall and an inner layer of epithelium.
This results in a thick elastic wall and a small lumen. Arteries do not have valves.
They carry oxygenated blood (except pulmonary artery to the lungs) from the heart to all around the body.
They are generally deep seated except those at a pulse site.
Arteries give rise to small blood vessels called arterioles which deliver blood to the capillaries.

Veins:
Carry blood towards the heart under low pressure.
They have a thin inelastic muscular wall and a thick lumen.
They have valves in the lumen to prevent backflow of blood.
They carry deoxygenated blood (except pulmonary vein from the lungs) from the body back to the heart.
They are generally superficial and they form small vessels called venules which join to capillaries.

Capillaries:
These are the smallest of the vessels.
Their walls are 1 cell thick - highly permeable - which allows diffusion and movement of substances between tissue fluid and the blood.
They have no valves and low pressure.
They unite arterioles and venules to form networks in tissues.
Their key function is to allow exchange of nutrients and waste between the blood and tissue cells. The process is known as *Capillary Exchange*. Oxygen, nutrients, vitamins, amino acids, minerals, etc. can pass through to the tissue fluid to nourish the cells.
Waste products like carbon dioxide, urea are passed out from the cells to the tissue fluid and picked up by the capillaries.

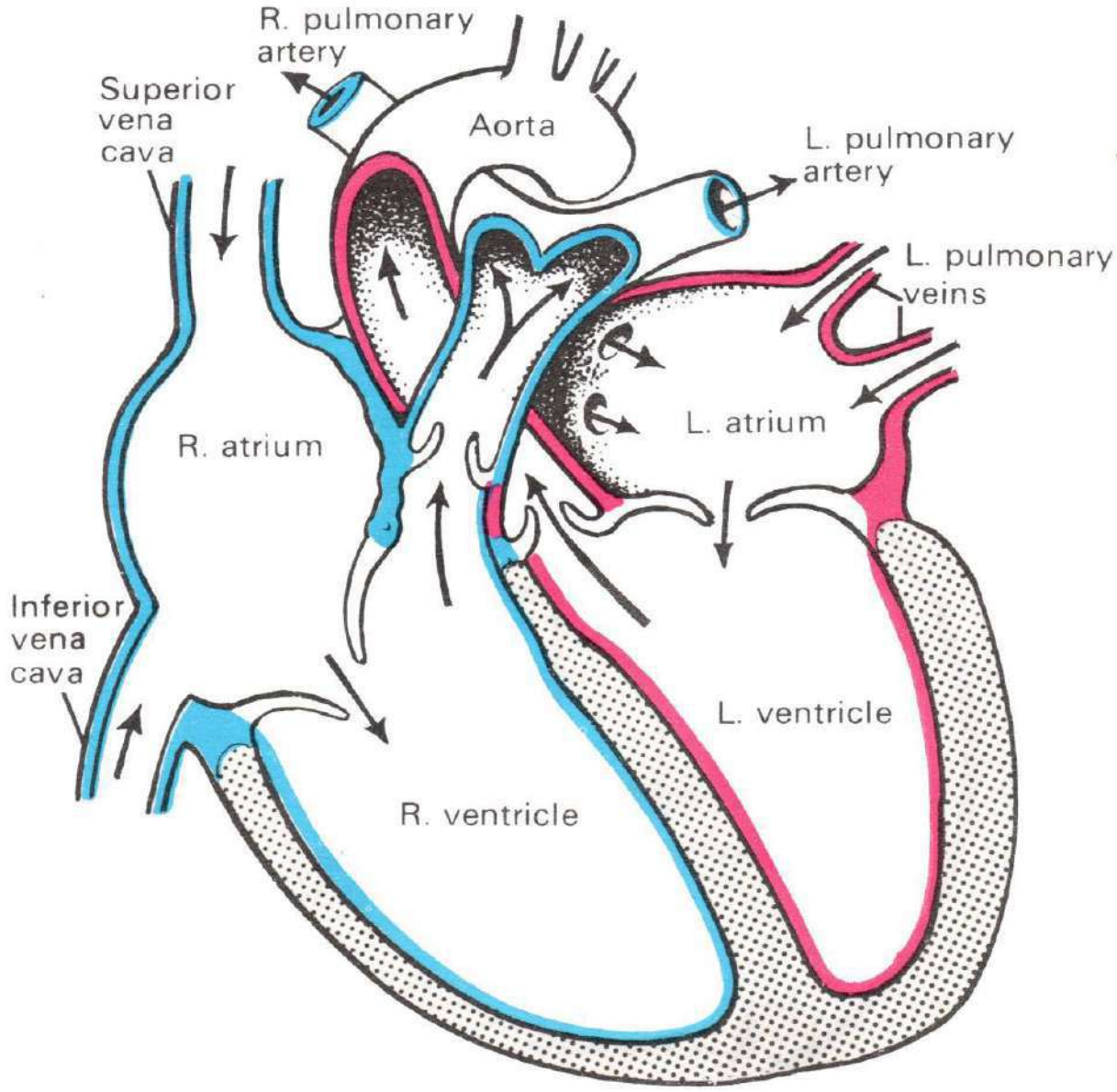
THE HEART

The heart is a hollow organ positioned above the diaphragm and between the two lungs.
It is composed of 3 layers:

1. Pericardium - serous membrane surrounding the heart
2. Myocardium - cardiac muscle in the wall of the heart
3. Endocardium - epithelial tissue lining the heart

It is divided into a right and left side by a partition called the *Septum*. There are 4 **Chambers** in its structure.

- 2 upper chambers called ***atrium*** (Right Atrium and Left Atrium) receive blood from large veins and pump it into the ventricles
- 2 lower chambers called ***ventricles*** (Right Ventricle and Left Ventricle) pump blood to the body organs/tissues via large arteries



The heart has some **major vessels** closely associated with it:

- *Superior and Inferior Vena cava:* The body's *blue* blood returns from the body tissues to the right atrium of the heart via these large vessels.
- *Pulmonary Artery:* The blue blood is then delivered from the right ventricle to the lungs via the pulmonary artery. This is the only artery in the body that carries deoxygenated blood.
- *Pulmonary Vein:* Once the blue blood has picked up oxygen in the lungs it is delivered back to the left atrium of the heart via the pulmonary vein. This is the only vein in the body that carries oxygenated blood.
- *Aorta:* The now oxygenated blood from the left ventricle is pumped around the body by the aorta.

Valves:

There are 4 valves (2 groups) found in the heart to help maintain blood flow direction and to prevent back flow between the different chambers.

Atrio-ventricular (A-V) Valves:

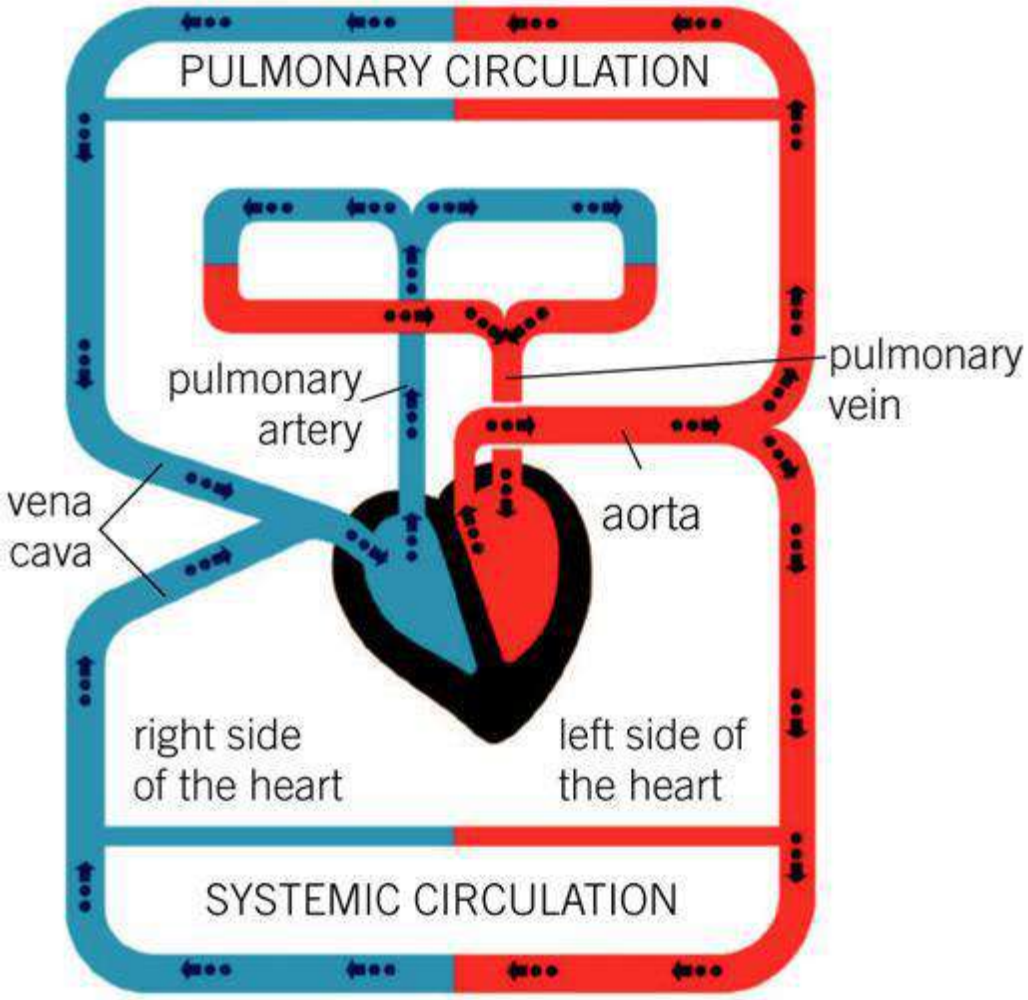
1. Bicuspid (Mitral): is found between the left atrium & left ventricle
2. Tricuspid: is found between the right atrium and right ventricle

Semi-lunar Valves:

3. Aortic: is found between the left ventricle & the aorta
4. Pulmonary: is found between the right ventricle and the pulmonary artery

GENERAL/SYSTEMIC CIRCULATION

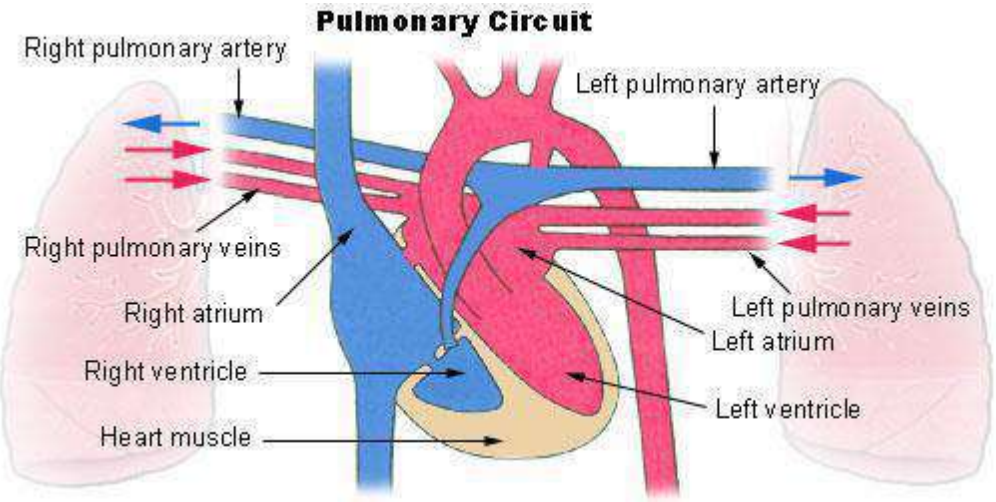
This is the largest circuit of the circulatory system comprised of many arteries and veins around the entire body. This system carries oxygenated blood from the Left Ventricle via the Aorta and arteries to the rest of the body.
Deoxygenated blood is then returned from the body, via the veins and vena cava to the Right Atrium. This blue blood then passes into the Pulmonary Circulation.



BLOOD FLOW THROUGH THE HEART/PULMONARY CIRCULATION

Deoxygenated blood from body
Inferior & Superior Vena Cava
Right Atrium
Tricuspid valve
Right Ventricle
Pulmonary valve
Pulmonary Artery
Right Lung Left Lung
(Pick up oxygen)

Oxygenated blood from Lungs
4 Pulmonary veins
Left Atrium
Bicuspid valve
Left Ventricle
Aortic valve
Aorta
Body organs & tissues

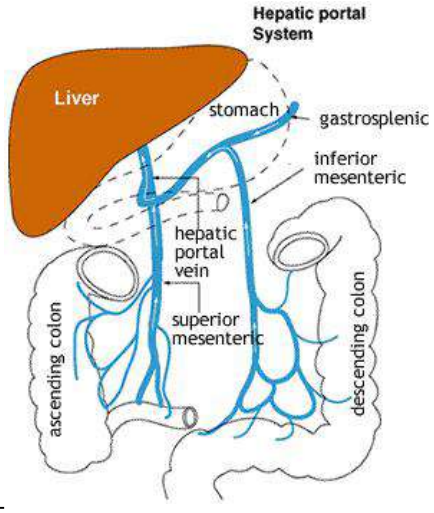


CORONARY CIRCULATION

The heart itself is a tissue carrying out work and the muscle needs a good blood supply for delivery and removal of substances. Coronary circulation is the supply of blood to the Myocardium. A ***right and left coronary artery*** feeds into the heart wall from the aorta. The used up blood returns into the RA via coronary sinus and from here enters the pulmonary circuit.

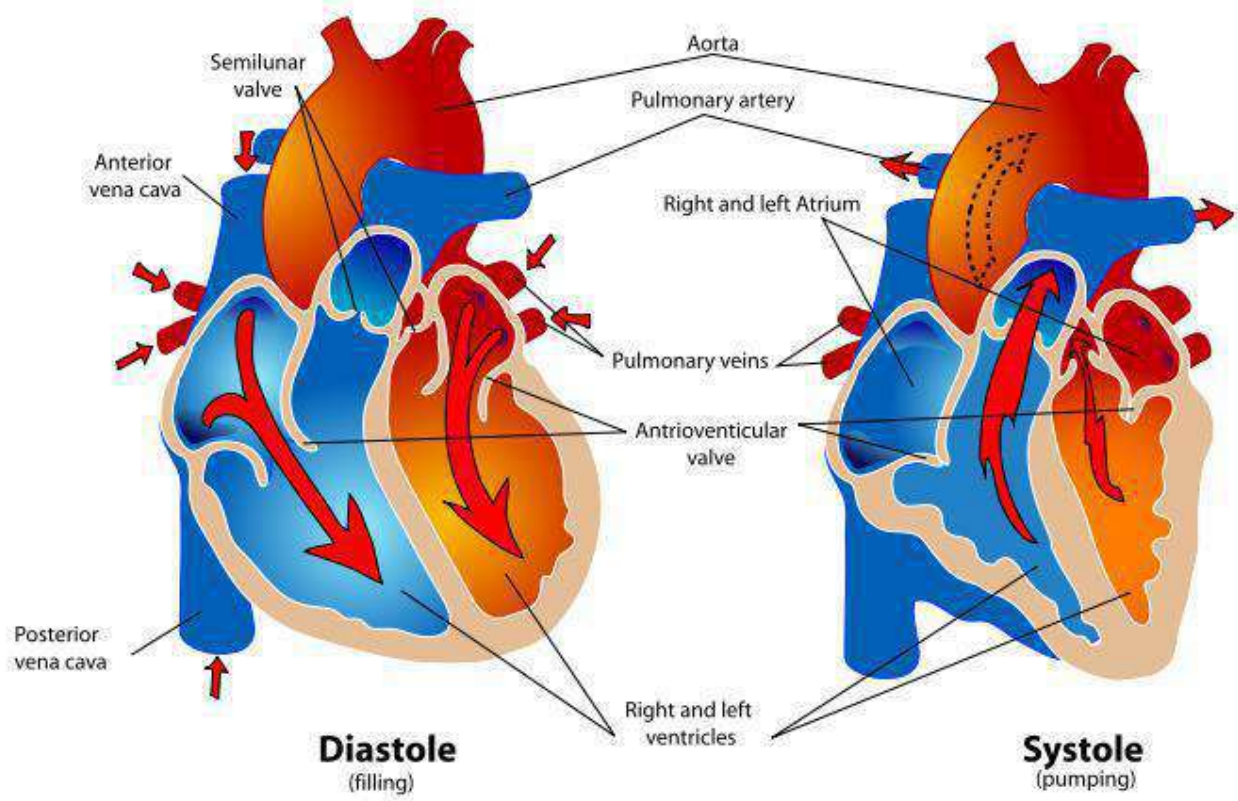
THE PORTAL CIRCULATION

This is part of the systemic circuit but involves only the organs of digestion and the liver. The portal circuit collects blood from the stomach, intestines, gall bladder, pancreas and spleen. This blood, which is very rich in nutrients and low in oxygen, is delivered to the liver via the **hepatic portal vein.** The liver then processes the substances in the blood before continuing on in the systemic system. The liver plays a vital role in maintaining proper concentrations of glucose (carbohydrate), fats and proteins in the blood. The hepatic vein carries the processed blood away from the liver to the inferior vena cava for return to the right side of the heart.



THE CARDIAC CYCLE - a sequence of events between one heartbeat and the next. Duration of 0.8 sec. Your heart rate is the number of cardiac cycles in one minute

1. Both Atria fill with blood
2. Atria contract simultaneously (systole)
3. Blood enters relaxed Ventricles
4. A-V valves close (lubb of heart beat)
5. Ventricles contract (diastole)
6. Blood sent to Aorta & Pulmonary Artery
   Semi-lunar valves close (dubb of heart beat)



BLOOD PRESSURE (BP)

This is the amount of pressure exerted by the blood on an arterial wall due to the contraction of the left ventricle. The pressure can vary from heartbeat to heartbeat.

During systole (ventricle contraction) the pressure felt is the highest. During diastole (ventricle relaxation) the pressure felt is the lowest. A sphygmomanometer is used to measure BP. Normal BP is between 100-140mmHg / 60-90mmHg. 120mmHg/80mmHg is optimal.

Many factors affect BP. Anything that makes the heart beat faster will cause an increase in BP. Such as exercise, anger, stress, smoking, drugs, pain, fright and excitement. Blood Pressure is regulated by the sympathetic nerves in the wall of the arterioles. An increase in the stimulation of the sympathetic nervous system will result in temporary increase in BP, e.g. stress, exercise, etc.

PULSE

This is the wave of pressure originating in the left ventricle of the heart that can be felt in the arteries of the body. Pulse corresponds to the beating of the heart. Radial pulse is found over the radial artery in the wrist / at the base of the thumb. The brachial pulse is found at the elbow. The carotid pulse is found in the side of the neck.

All blood cells originate from stem cells (haemoblasts) and go through developmental stages before entering the blood. The 3 different groups of blood cells take different paths. The process of blood cell formation is called hemopoiesis. This takes place in the red bone marrow. Red bone marrow consists of developing blood cells, adipocytes, fibroblasts and macrophages within reticular fibres. In life, for the first few years, red bone marrow is found in all bones. However, as we grow older, the red bone marrow is replaced with fatty yellow marrow that has nothing to do with blood cell formation. Yellow bone marrow contains adipose cells and stores triglycerides for energy source. It is found in the medullary / marrow cavity of long bones.

In adults, hemopoieses takes place in the red bone marrow of spongy bone found in the end of long bones, in flat bones (pelvis, ribs, sternum, cranium) and irregular shaped bones (vertebrae).

Blood Shunting

Along certain circulatory pathways, there are certain points where small arteries have direct contact with veins. This is present, for example, in the intestines. When these connections are open and working, it allows for the arterial blood to enter veins. This is in place to allow for sudden and major diversions of blood volume depending on what the body needs.

As a therapist, it is important not to treat someone after a heavy meal because of this scenario. There is increased blood flow to the intestines and this means there is less blood being supplied to other areas of the body.

Disorders of the Circulatory System

Anaemia: A condition where the blood haemoglobin level is below normal. This means less oxygen is being delivered around the entire body. Causes can be loss of blood; chronic bleeding; iron deficiency; blood disease like leukaemia. Effects felt are excessive tiredness, breathlessness on exertion, pallor, poor resistance to infection.

Varicose veins: Leaky venous valves cause the veins to become dilated and twisted. Blood flow can become reversed or static. Because valves are present to prevent backflow, if they are damaged, gravity wins and blood pools in the veins instead of returning to the heart. Caused by hereditary, ageing, obesity, pregnancy, sitting/standing motionless for long periods of time. Can be extremely painful. Treatment is contra-indicated in the area affected by varicose veins.

Haemophilia: A hereditary condition where blood clots very slowly due to lack of 2 coagulation factors (Factor VIII - antihaemophiliac or Factor IX - Christmas factor). Patients may have prolonged bleeding after injury or wound. Some may have spontaneous bleeding in muscles and joints.
The gene for this is carried on X chromosomes only. Females have XX and males have XY chromosomes It mainly affects men as it is passed from a mother to her son. Women can carry the disease but not be affected.

Arteriosclerosis: A circulatory condition characterised by the thickening, narrowing, hardening and loss of elasticity of the walls of the arteries. High cholesterol levels in the blood causes excessive build-up of cholesterol on the walls of arteries and thus cause high BP.

High Blood Pressure (Hypertension): This is when resting blood is above normal. The World Health Organisation (WHO) states high blood pressure to be consistently exceeding 160mmHg/95mmHg. If serious, it may lead to heart attack or stroke. The heart has to work hard to pump blood through the systems. Causes include: smoking, obesity, lack of exercise, excess salt consumption, excess alcohol consumption, stress.

Control it by: drugs, decreasing salt, fat, alcohol and smoke intake; keep weight down and relaxation to de-stress.

Low Blood Pressure (Hypotension): This is when BP is below normal and defined by WHO as 99mmHg/59mmHg or less. It is normal for people in good health, during rest and after fatigue. The danger of hypotension is not enough blood reaching vital organs - brain for example. Treatment can be medicated.

Thrombosis: A condition where blood changes from liquid to solid and produces a clot. It can obstruct blood flow in an artery and to the tissues being supplied. In the brain, a clot can cause a stroke. In the heart, it can cause a heart attack. In a vein it is called DVT.

Septicaemia: Poisoning of the blood. Associated with multiplication of toxic bacteria in the circulation.

Phlebitis: Inflammation of the wall of a vein - common in legs as a complication of varicose veins. Surrounding skin may appear hot and red. Thrombosis may develop as a result of this phlebitis and also Deep Vein Thrombosis (DVT). This can result in clots in lungs and elsewhere.

Leukaemia: Cancer of the blood caused by over production of immature/ abnormal white blood cells. This suppresses the production of *normal*/wbc, rbc and platelets. Major cause for concern is increased susceptibility to infection. Other effects or signs are enlarged spleen, liver and lymph nodes, spontaneous bruising and anaemia.

Aneurysm: An abnormal balloon-like swelling that bulges outward from the wall of an artery. This may be due to congenital defects, arteriosclerosis, trauma, infection or hypertension. If untreated, it enlarges and the blood vessel wall becomes so thin that it bursts = haemorrhage with shock, severe pain, stroke and death.

Angina: Pain in the left side of the chest usually radiating to the left arm. Caused by insufficient blood to the heart muscle. Mainly during exertion or excitement. Patients become pale and sweaty.

Stroke: A blocking of blood flow to the brain by a clot in the cerebral blood flow. Result can be sudden attack of weakness on one side of the body. A stroke can vary in strength - slight tingle in limb to paralysis or coma.
Stroke can also be caused by bleeding from a burst artery in the brain. Bleeding is usually associated with headaches and stiff neck.

Heart Attack: Myocardial infarction. Damage to the heart muscles which result from a blockage of the coronary arteries. Can cause serious complications and heart failure.

Congenital Heart Disease: A defect in the formation of the heart that usually decreases its efficiency. Defects may be:
Opening in the wall (septum) of the heart between ventricles and atrium. Narrowing of the aorta or pulmonary artery. Symptoms vary depending on the severity.

HIV and AIDS

Since the early 1980's, Acquired Immunodeficiency Syndrome has been dramatically spreading throughout the world. AIDS is caused by a human retrovirus called Human Immunodeficiency Virus (HIV). It is believed that this virus was first present in African nonhuman primates and passed onto humans.

Retrovirus *is a type of RNA virus that invades a host cell to produce a DNA copy of its RNA.*

This DNA produced by the retrovirus is able to incorporate itself into the cell DNA of its host. The host cells then reproduces itself and the virus spreads through tissue fluids and blood to infect other cells in the body.

HIV has an affinity for cells such as lymphocyte, monocytes and epithelial cells, particularly in the gastrointestinal tract and brain neuroglia. With cells like these being attacked, the immunity of the host will be adversely affected and suppressed.

HIV has been isolated from:
- Semen
- Cervical secretions
- Lymphocytes
- Blood Plasma
- Cerebrospinal Fluid

Infections are spread by:
- Sexual intercourse
- Contaminated needles (treatment of patients; drug abusers)
- Mother to child (across placenta, during birth)

A few weeks after infection, there may be an acute influenza-like illness. After this there may be no symptoms for up to 2 years.

When AIDS develops, the main complications are:
- Pneumonia
- Nausea, diarrhoea, weight loss
- Meningitis, brain abscesses
- Deterioration of nervous function - forgetfulness, loss of concentration, confusion, incontinence
- Skin breakouts - psoriasis, eczema, shingles, impetigo
- Non-infected enlargement of the lymph nodes (lymphadenopathy)
- Malignant lymphomas
- Kaposi's sarcoma - tumours under the skin and in internal organs

Blood Types

There are different human blood types, depending on what types of antigen is found on the surface of red blood cells in a particular individual.

An antigen is any substance that, in certain circumstances, can stimulate the production of antibodies.

The different types of antigens found on red blood cells are A and B antigens. A person can be:

- Blood Type A - red blood cells have antigen A on the surface. Blood serum will have antibodies to antigen B. Can only receive blood from Type A or Type O. Can give blood to Type A and Type AB.
- Blood Type B - red blood cells have antigen B on the surface. Blood serum will have antibodies to antigen A. Can only receive blood from Type B or Type O. Can give blood to Type B or Type AB.

- Blood Type AB - ***Universal recipient***. These red blood cells have antigens A & B on the surface. Blood serum will not have antibodies to antigen A or antigen B. Therefore, it can receive blood from any group. Can only give to AB.
- Blood Type O - ***Universal donor.*** These red blood cells have no antigens on the surface. Blood serum has antibodies to antigen A and antigen B. Type O can be given to any blood type. It can only receive blood from Type O.

Type	Can give to	Can receive from
A	A and AB	A and O
B	B and AB	B and O
AB	AB	Any type
O	Any type	O

Rhesus Factor

Rh^+ indicates that someone is rhesus positive. This means they have an antigen called rhesus factor on the surface of their red blood cells. Rh^- indicates that someone is rhesus negative. This means they do not have the antigen rhesus factor on the surface of their red blood cells.

Haemolytic disease can develop in a newborn when there is a mixing of blood from a Rh^- mother to a Rh^+ foetus. During pregnancy, foetal blood cells are separated from the mother's circulation by a layer of cells in the placenta. During her first pregnancy, there is normally not enough exposure to trigger the production of anti-Rh^+ antibodies. During childbirth however, there may be enough mixing of blood to trigger this response. What this means is that the mother who is Rh^- has been exposed to Rh^+ and is now producing antibodies against it. This does not pose a threat to this newborn baby or mother. However, if subsequent pregnancy results in a Rh^+ foetus, the mother's antibodies will damage the foetal red blood cells.

Mild to severe anaemia may occur. Sometimes this can be fatal. In a newborn baby, the haemoglobin will be converted into lipid soluble bilirubin, which may accumulate in the brain and cause brain damage.

A way of preventing this from happening is to administer antibodies to the Rh antigen to the mother after the first birth of a Rh^+ baby. This way, the antibodies will bind to the antigens and prevent memory cells being produced, which will reduce or eliminate the immune response at the second pregnancy.

We are continuously exposed to pathogens (disease causing micro organisms), like bacteria, viruses, etc. Despite this exposure, most of us remain healthy. It is a case of human resistance vs human susceptibility. Our bodies are continuously striving to maintain homeostasis by combating these threats.

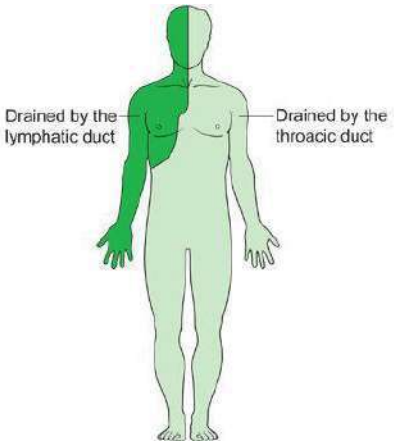
The Lymphatic System plays a major role in this task and works closely with Blood and the Immune System.

1. Subsidiary circulation - It delivers fluid & nutrients around the body as it ***drains*** excess fluid from tissues
2. Returns lost plasma protein molecules to the blood that were too big to pass back into the blood capillaries from the tissue fluid.
3. Transports dietary lipids and lipid soluble vitamins from the small intestine into the blood. Products of carbohydrate and protein digestion pass directly into the blood stream. Fats pass directly into specialised intestinal lymph vessels called ***lacteals***. The presence of these fats in lymph gives it a milky colour and this lymph is called ***chyme.***
4. Immunity - lymph nodes help to fight infection by filtering lymph and destroying invading micro-organisms. Lymphocytes are produced in the lymph nodes and produce antibodies to fight infection.

The system is made up of:

1. Lymph - a colourless watery fluid. It is tissue fluid that has passed into a lymph vessel. It resembles blood plasma except it has less plasma proteins.
2. Lymph Capillaries - are like blood capillaries. 1 endothelial cell thick so very permeable. They are more permeable than blood capillaries. They have a blind ended origin in the interstitial space as lymph flows in one direction. These join together to form vessels.
3. Lymph vessels (lymphatics) - Resemble veins. They have an outer layer of elastic and muscle and an inner layer of endothelium. They have valves to prevent backflow. They carry lymph towards the heart. 3-4 litres of lymph passes into venous blood every day. Once lymph passes into vessels, it must pass through at least 1 lymph node before returning to the blood.
4. Lymph Nodes - more than 100 are found scattered around the body. They are made of a fibrous capsule surrounding an inner network of reticular and lymphatic tissue. They can be found deep or superficial. Contains lymphocytes and macrophages (monocytes). It filters lymph delivered by the lymph vessels to remove cell debris, toxins, disease and infection. Clean lymph leaves the nodes in efferent vessels.
5. Lymph Ducts - efferent lymph vessels join together to form trunks and these drain into 2 main lymphatic ducts: the thoracic duct and the right lymphatic duct.

- The **thoracic** duct is the main collecting duct in the system. 40cm long and runs from the 2nd lumbar vertebrae to the neck. Its starting point is called the **cisterna chyli**, an expanded area of the duct. It collects lymph from the left head, neck, arm, lower limbs and thorax. It drains into the left subclavian vein to return to the blood stream.
- The **right lymphatic duct**s very short at 1.5cm long, found at the root of the neck. It collects lymph from the right head, neck, arm and chest. It drains into the right subclavian vein.



Iden egg holistic

How is Lymph formed?
Blood is distributed to tissues in capillaries. Some plasma leaves these capillaries to bathe the tissue in order to deliver oxygen, nutrients and water to the cells of the tissue. This plasma also picks up waste from the tissue like carbon dioxide and urea. Once this plasma is outside the capillaries, it is now called *tissue fluid*.

Some of this tissue fluid does go back into the blood stream by entering veins. The remaining fluid is collected by the lymph capillaries and vessels. The fluid is now called *lymph* and will eventually be returned to the heart. This help to maintain blood volume, blood pressure and to prevent oedema.

Lymphatic Drainage
Movement of lymph throughout the lymphatic system is called lymphatic drainage. It begins in the lymph capillaries. Movement of lymph out of tissue spaces is helped by:

- Pressure and movement of skeletal muscle against the vessels
- Changes in internal pressure during inspiration
- Compression of lymph vessels from the pull of the skin and fascia during movement

Muscle tension can inhibit or block lymph vessels as they may put too much pressure on them. This results in less drainage and a build-up of tissue fluid.
During massage muscles relax, lymphatic vessels open and assist drainage. A client can help the drainage process by taking slow deep breaths that help to stimulate lymph flow.

Summary of Lymph Flow

Blood in blood capillary feeding tissue

Plasma escapes capillary and bathes tissue cells

Excess tissue fluid enters lymph capillaries

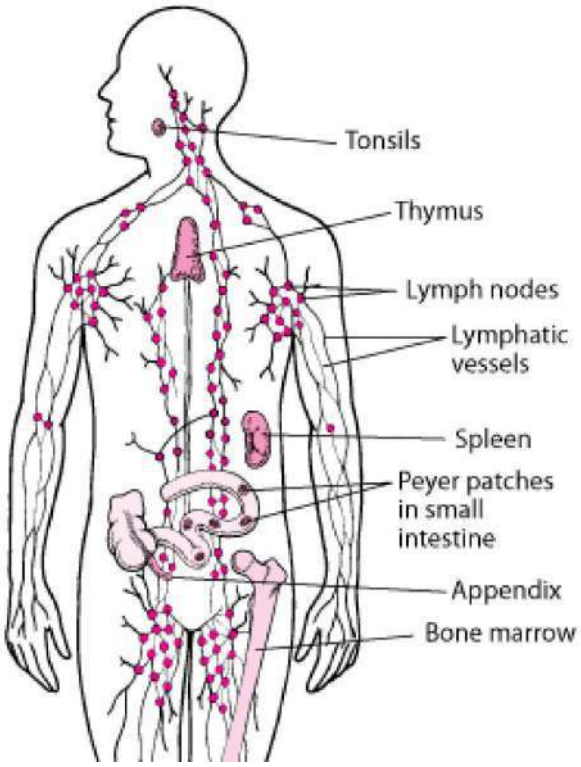
Fluid enters lymph vessels (lymphatics) and is now called lymph

Lymph flows into larger lymph vessels that lead to nodes

Lymph is filtered through at least 1 node

Filtered lymph is collected into lymph ducts

Lymph drains from ducts into venous blood via subclavian veins



Other Lymphoid Tissue

The Tonsils

Made of lymphatic tissue and located in the oral cavity and pharynx. There are 3 sets of tonsils. All provide defence against micro-organisms that enter the mouth and nose.

1. Palatine - *'the tonsils'* found at the back of the throat, one either side
2. Pharyngeal - *'adenoids'* lie in the wall of the nasal part of the pharynx
3. Lingual - found below the tongue.

The Thymus

Located in the upper chest, above the superior vena cava and below the thyroid. It lies against the trachea. It is larger in children than in adults. It shrinks with age. In children, it is a reservoir of lymphocytes - it makes special T-lymphocytes to attack disease / microorganism. In adults before it atrophies, T-cells are carried by the blood from the thymus to other lymphoid tissue like lymph nodes and the spleen which they colonise. Some T-cells can continue to reproduce in the thymus throughout adult life.
The thymus is affected in adults by prolonged stress and can contribute to the onset of low immunity and disease associated with stress.

Peyers Patches

Found in the walls (villi) of the small intestine - grouped nodules found in the ileum of the small intestine.

The Spleen

Largest lymphatic mass of lymphoid tissue found on the left side of the body between the stomach and the diaphragm. It is very vulnerable to trauma and it is not a vital organ in adults. It produces lymphocytes to produce antibodies and monocytes that engulf debris; filters blood and destroys infection, disease and old red blood cells; can release blood in times of emergency and blood loss; it is a reservoir for new red blood cells in children (acts like bone marrow).

Appendix

Lymphatic nodules are found in the appendix.

Disorders and Diseases

Oedema: An excessive accumulation of tissue fluid in tissue spaces. Can be caused by obstruction of lymph flow, e.g. infected lymph node or blocked lymphatic vessel. Also, can be due to increased capillary pressure, heart failure, liver or kidney disease. Subcutaneous oedema commonly occurs in ankles and legs due to gravity. It is a common problem for premenstrual and pregnant women.

Lymphomas: Cancers of the lymphatic system, especially lymph nodes. There are 2 types:

1. Hodgins Disease - painless, non-tender enlargement of one or more nodes in the neck, armpit, groin, chest or abdomen. Liver, spleen, bone marrow and bones can also be affected. This will result in night sweats, itching, weight loss and bone pain. Common age group is 15-35 or over 60. Early diagnosis has 90-95% cure rate.
2. Non-Hodgins Lymphoma - More common than HD. It may start with symptoms of HD but also have enlarged spleen, anaemia, general discomfort and illness. Affects all ages. Up to half of all sufferers are cured or survive for a lengthy period. Treatment for lymphomas is radiation, chemotherapy or bone marrow transplant.

The Nervous System is the body's control centre. It is the communication network of the body. It works very closely with the endocrine system to maintain homeostasis. The nervous system responds rapidly to stimuli using nerve impulses (action potentials). It is also responsible for our perceptions, behaviours and memories.

Functions

The functions of the Nervous System are as follows:

1. To sense internal and external changes relative to the body
2. To interpret these changes or stimuli
3. To respond to these changes or stimuli to maintain homeostasis
4. Responses result in muscular contraction or glandular secretions
5. Programs instinctual behaviour
6. Assimilates experiences as required by memory, learning and intelligence.

Nervous Tissue

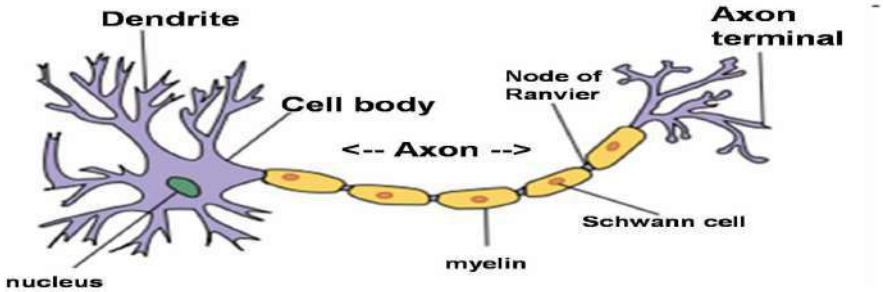
Nervous tissue is made up of nerve cells called Neurones and special connective tissue called Neuroglia.
Neuroglia: these small cells do not transmit impulses. They make up the connective tissue that is there to support, insulate and protect the neurones. They are 5 times more abundant than neurones as they can divide by mitosis. They help in the transfer of nutrients and waste to and from neurones. Oligodendrocytes (produce myelin sheath in CNS), Schwann cells (produce myelin sheath in PNS) and microglia (phagocytes) are examples of neuroglia cells.

Neurones: these are the basic functional units of the nervous system. Also known as a nerve cell. These cells do not divide by mitosis. Therefore, if damaged, the cell will degenerate. Neurones are designed to receive stimuli and conduct messages around the body. There are billions of interconnecting neurones in the nervous system. All neurones have 2 properties:

1. Excitability - the ability to respond to a stimulus and change that stimulus into a nerve impulse.
2. Conductibility - the ability to convey or transmit impulses to other neurones, muscles and glands.

There are many different types, shapes and sizes of neurones, but they all have a basic structure as follows:

1. Cell body - this is the centre of the neuron that contains all organelles of the basic cell structure.
2. Dendrites - these are filaments branching from the cell body that carry impulses *towards* the cell body from other neurones.
3. Some Axons have a myelin sheath, which acts as an insulator, protects the nerve cell and increases the speed of impulse transmission. This myelin sheath is secreted by oligodendrocytes in the CNS and Schwann cells in the PNS.
4. There are Nodes of Ranvier present along the axons of the PNS. These function in improving impulse transmission along the axon.
5. Axon - these are long filaments that extend from the cell body and carry impulses *away* from the cell body to other neurones /muscles /glands.
6. An important Neurotransmitter in the nervous system is Acetylcholine.
7. Synaptic knobs - these are nodules found at the ends of axons that release neurotransmitters (NT) into a synaptic cleft. This NT is then picked up by the next neuron.



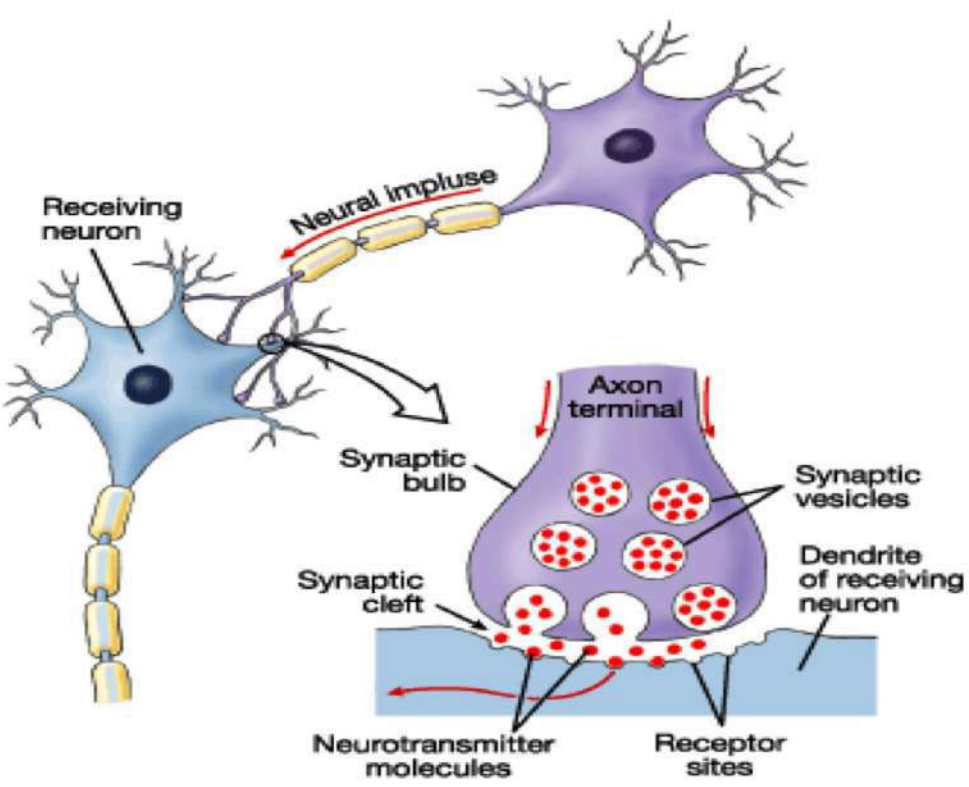
There are 3 types of neurones:

1. Sensory (afferent) Nerve: these nerves receive stimuli from sensory organs and receptors and send this impulse / message to the spinal cord and brain.
   Temperature, pain, taste, smell, sight and hearing are included.
2. Motor (efferent) Nerve: these nerves send impulses away from the brain and spinal cord towards muscles and glands of the body. This stimulates them to carry out the functions.
3. Associated Nerve: these link the sensory and motor neurones, helping the brain to interpret incoming sensory impulses, decide what is to be done and send out instructions along the motor neurones.

Nerve Transmission

Nerve impulses are the signals of the nervous system that travel along the neurone from dendrite to axon.

Each neuron is an individual unit and is not connected or joined to another neuron. Instead, there is a junction between them called a ***synapse,*** where nerve impulses are transmitted from one neuron to another by the release of a neurotransmitter. This synapse is also found at the junction between a neuron and a muscle or a gland. A synapse between a neuron and a muscle is given a special name - **motor point**. In a synapse, impulses flow in one direction only.



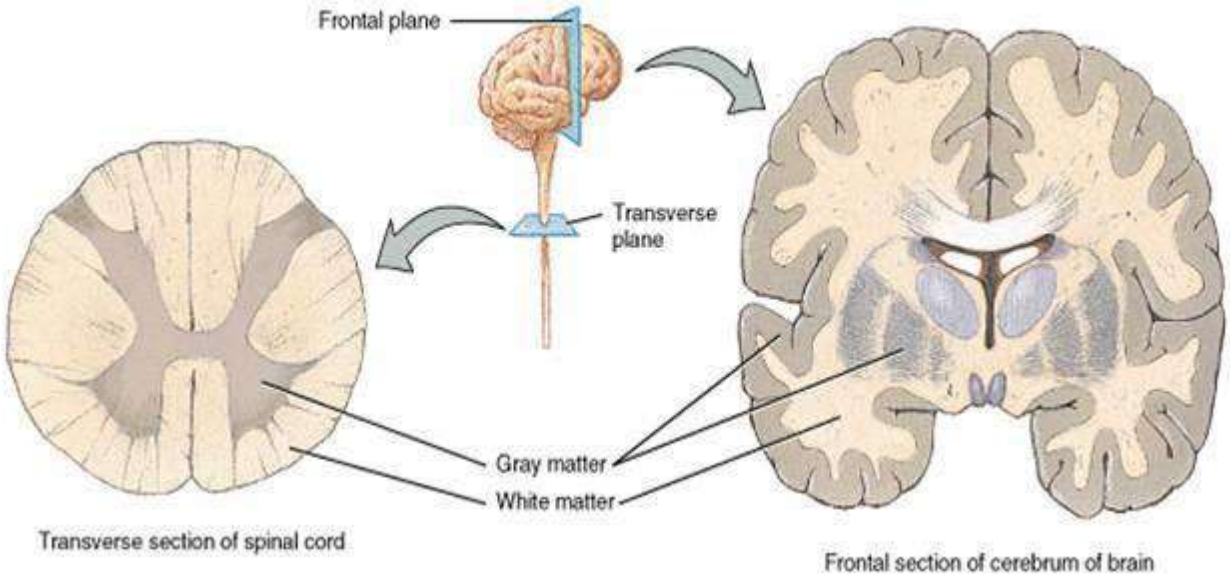
Organisation

Structurally, the Nervous System has 2 divisions:

1. The Central Nervous System (CNS): The Brain and the Spinal Cord
2. The Peripheral Nervous system (PNS): All of the nervous system outside of the CNS (The spinal nerves, the cranial nerves and the nerve plexus).

THE CENTRAL NERVOUS SYSTEM

The CNS is composed of the brain and the spinal cord. CNS is composed of grey and white matter.
Grey matter is made up of cell bodies, dendrites, axon terminals and neuroglia. White matter is made up of axons. In the brain, grey matter surrounds the white. In the spinal cord, white matter surrounds the grey. Both the brain and the spinal cord are protected by bony enclosures - the cranium and the vertebral column respectively and also by a series of membranes called the Meninges.



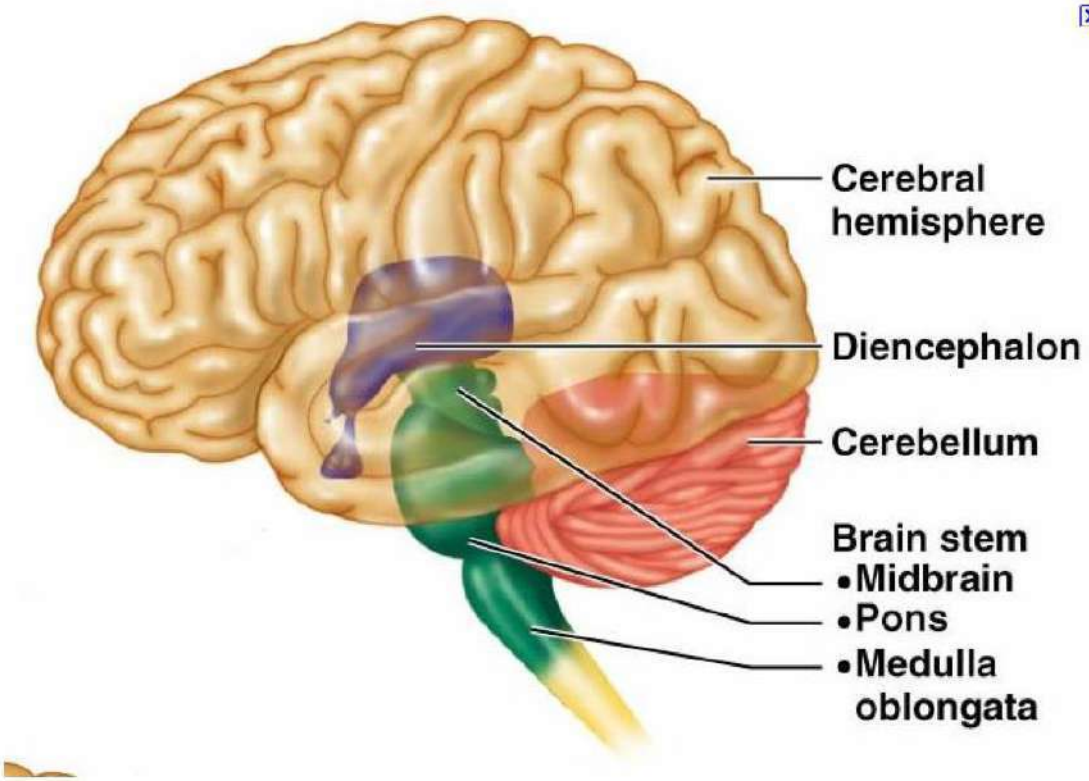
The Brain

The brain is found in the skull. It has many different parts with many different functions. Overall, its general function is to coordinate the nerve stimuli received and effect the correct responses.

Blood-Brain Barrier

Blood goes to the brain via internal carotid and vertebral arteries. Internal jugular veins return blood to the heart. Brain is 2% of adult body weight but uses 20% oxygen and glucose uses the rest. The brain must be supplied with a constant supply of glucose as it cannot store it like the liver and muscles can.

The Blood Brain Barrier protects the brain from harmful substances and pathogens. The brain does not have a lymphatic system to help protect it against infection or disease. This very important BBB is made up of capillaries with tight junctions that allow only certain things through to brain matter, for example, glucose, oxygen, carbon dioxide and some anaesthetic agents. Trauma, some toxins and inflammation can cause a breakdown of the BBB.



STRUCTURE	DETAIL	FUNCTION
Cerebrum	● 80% brain mass ● 2 cerebral hemispheres - Connected by corpus callosum ● Outer convoluted **cortex** of Grey matter ● Inner **medulla** of white matter Communication occurs between all areas of the brain. Each lobe is concerned with a particular sense.	● Perception of sensory impulses - vision, touch, hearing, smell ● Control voluntary movements ● Memory ● Thought ● Reasoning
Frontal lobe	**Front of the brain**	*Voluntary motor control Personality, intelligence, verbal communication*
Parietal lobe	*Upper side of the brain*	*Speech understanding and utterance*
Temporal lobe	*Lower side of the brain*	*Auditory interpretation; Audio & visual memory*
Thalamus	● Large mass of grey & white matter	● Relay centre of sensory impulses - except smell - to the cerebral cortex
Hypothalamus	● Small mass of grey & white matter	● Regulates ANS and endocrine systems. Controls thirst, hunger, BT, sleep, sexual response, emotions
Pituitary	● Pea-shaped gland attached to the hypothalamus	● Master gland of the endocrine system
Pineal	● Attached to the thalamus	● Regulation of circadian rhythms - patterns of repeated activity - day/night & sleep/wake
Cerebellum	● Small brain found at the back of the cranium, below the cerebrum. 2 hemispheres of outer grey & inner white matter	● Balance & co-ordination ● Muscle tone & posture ● Sub-conscious level
Brain Stem	**3 Parts:**	
1. Midbrain	● Short section between cerebrum & pons varolii ● Made up of main nerve pathways connecting cerebrum to lower nervous system	● Relays messages to and from the spinal cord ● Visual, auditory & coordinating centre
2. Pons varolii	● Below the midbrain	● Relays messages from cerebral cortex to spinal cord
3. Medulla Oblongata	● Lowest & largest part of brain stem. Mainly white matter, connects brain to spinal cord	● Rate & force of heart beat ● Rate & depth of breathing ● Constriction & dilation of blood vessels ● Vomiting, sneezing, coughing & other reflexes

The Spinal Cord

This is an extension of the brain stem. It extends from the base of the skull to the 2nd lumbar vertebrae. Its main function is to relay impulses to and from the brain. Sensory tracts convey messages to the brain; motor tracts convey messages from the brain. The spinal cord has white matter on the outer part and grey matter inside. 31 pairs of spinal nerves arise from the spinal cord. These are part of the PNS.

The spinal cord is the centre for reflex actions that provide fast and efficient responses to external and internal stimuli.

A reflex is a fast, involuntary and unplanned sequence of events that occurs in response to a stimulus. Some are innate (hand away from hot iron; knee jerk); others are acquired (breaking in a car). Integration that occurs in the spinal grey matter is called a spinal reflex. The pathway of a nerve impulse that produces a reflex is called a **Reflex Arc**.

There are 5 functional components of a Reflex Arc:

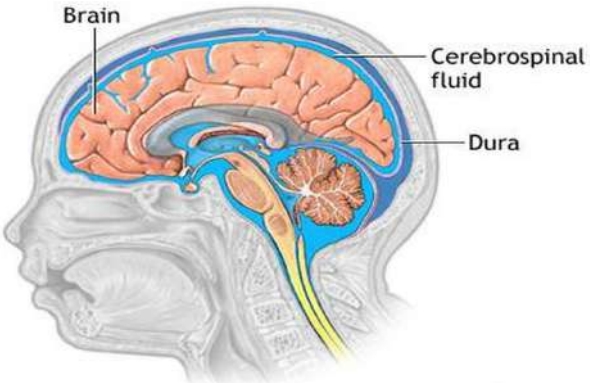
1. **Sensory Receptor** - a stimulus is picked up by dendrites of a neurone in PNS
2. - impulse travels from dendrite, to cell body and along the axon to synapse in the spinal cord **Sensory Neuron** (CNS)
3. **Integrating Centre** - sensory and motor neurons meet within the CNS and communicate the impulse along its way
4. **Motor Neuron** - impulse is picked up, leaves the CNS and travels along axon to specific part of the body
5. **Effector** - a reaction occurs in muscles or glands

The **Meninges** have 3 layers:

1. Outer Dura Mater - this protective fibrous tissue covers the brain and spinal cord.
2. Middle Arachnoid Mater - contains blood vessels and cerebrospinal fluid. Between the arachnoid and pia mater, is the subarachnoid space, which contains circulating cerebrospinal fluid.
3. Inner Pia Mater - this closely covers the brain and spinal cord. Blood vessels supply oxygen and nutrients to the brain and spinal cord from here.

Cerebrospinal fluid (CSF) is clear lymph-like liquid that gives protective cushioning to the CNS. This fluid is derived from blood in the ventricles (cavities) of the brain. From the ventricles, the CSF circulates around the brain and spinal cord, delivering nutrients and removing waste.
Its main functions therefore are:

- Protects the brain and spinal cord
- Acts as a shock absorber
- Controls pressure
- Supplies nutrients
- Removes waste
- Buoys the brain



THE PERIPHERAL NERVOUS SYSTEM

The PNS can be broken down into the:
1. Afferent System which carries information from sense organs and receptors to the CNS (Arrives at CNS).
2. Efferent System which carries information away from the CNS to effector muscles and glands (Exits CNS).

The Efferent PNS can then be further broken down into 2 *Functionally* different systems:
1. The Somatic Nervous System which conveys messages from the CNS to the skeletal muscle.
2. The Autonomic Nervous System which conveys messages from the CNS to the smooth muscle in the body, controlling internal organs and secretions.

The Autonomic Nervous System has 2 divisions:
1. The Sympathetic Nervous System - promotes activity 'Fight or Flight'
2. The Parasympathetic Nervous System - inhibits activity 'Rest & Digest'

The Peripheral nervous system contains cable-like nerves that link the CNS to the rest of the body. It is made up of 31 pairs of Spinal nerves; nerve plexuses and 12 pairs of Cranial nerves.

The Cranial Nerves
These nerves connect the brain to different structures of the head, neck and trunk. There are 12 pairs - some are mixed, while others are either sensory or motor only.

	Cranial Nerve	**Type**	**Functions / Areas concerned**
I	Olfactory **(nose)**	Sensory	Smell
II	Optic **(eye)**	Sensory	Sight
III	Oculomotor **(eye)**	Mixed motor	Movement of eyeball/eyelid; pupil size; focusing
IV	Trochlear (smallest) **(eye)**	Mixed motor	Movement of the eyeball upward
V	Trigeminal (largest) **(face)** **It has 3 branches:**	Mixed	Controls muscles of mastication. Sensations from facial organs (eye, skin, tongue, teeth).
	Ophthalmic branch		Eye, nose, forehead, upper eyelid, eyebrow.
	Maxillary		Lower eyelid, upper lip, gums, teeth, cheek, nose, palate, pharynx
	Mandibular		Lower gums, teeth, lip, palate
VI	Abducens **(eye)**	Mixed motor	Proprioception. Movement of eyeball to the side
VII	Facial **(face)**	Mixed	Facial expression; saliva and tear secretion; taste; muscle sense
VIII	Vestibulomotor **(ear)**	Sensory	Hearing, balance and posture
IX	Glossopharyngeal **(mouth & throat)**	Mixed	Swallowing; saliva secretion and taste
X	Vagus **(neck, thorax, abdomen)**	Mixed	Visceral muscle movement and sensation
XI	Accessory **(throat, neck, upper back)**	Mixed motor	Swallowing, movement of head and shoulders
XII	Hypoglossal **(tongue)**	Motor	Speech and swallowing

Note: **Only I and II are truly sensory nerves.** All the rest of cranial nerves are mixed but have a predominate functional side as stated above in chart.

The Spinal Nerves

Spinal nerves are mixed nerves (sensory & motor functions). This means they can receiver *and* send messages to and from the CNS and the body. Spinal nerves pass out from the spinal cord. They are numbered and named according to the level of the spinal column from which they emerge, as follows:

1. 8 cervical nerves
2. 12 thoracic nerves
3. 5 lumbar nerves
4. 5 sacral nerves
5. 1 coccygeal nerve

These nerves do not go directly to the body structures that they supply. Instead, they branch off and form networks of nerves known as **plexuses,** on either side of the spinal column. These plexus then go onto supply different parts of the body. The thoracic nerves are the only ones that do not form plexuses - they supply directly into the ribcage and are called Intercostal Nerves.

<u>There are 5 plexus:</u>

1. (C1-C5) **Cervical** Plexus of the neck supplies the skin and muscles of the head, neck & upper shoulder region. Includes phrenic nerve to the diaphragm.
2. (C5-T1) **Brachial** Plexus at the top of the shoulder supplies the skin & muscle of the arm, shoulder and upper chest. Includes axillary, radial and ulnar of the arm.
3. (L1-L4) **Lumbar** Plexus between the waist and the hip supplies the front and sides of the abdominal wall and part of the thigh. Includes femoral nerve of the leg.
4. (L4-S4) **Sacral** Plexus at the base of the abdomen supply the skin, muscle and organs of the pelvis. Includes the sciatic nerve - the largest in the body.
5. (C1) **Coccygeal** Plexus supplies the skin of the coccyx area and the muscles of the pelvic floor.

THE AUTONOMIC NERVOUS SYSTEM

This is part of the Peripheral Nervous System and is concerned with the automatic functions of the internal organs and vessels of the body - those that do not occur at conscious level. This action occurs mainly in smooth and cardiac muscle as well as glands of the body.

Structurally, the ANS has sensory and motor neurons. Functionally, these operate on a subconscious level.

ANS Sensory neurones are connected to special receptors found in internal viscera, organs and vessels. These receptors monitor things like blood waste products, degree of stretch on the walls of an organ or blood vessel. These sensory neurons convey impulses to the CNS. A response is then initiated through either of the 2 motor divisions of the ANS: The **Sympathetic** or the **Parasympathetic Division.**

Every organ in the body has a sympathetic and a parasympathetic nerve supply - they complement and oppose each other's actions in order to maintain homeostasis.

Sympathetic motor neurons originate from Spinal Nerves T1-L2.
Parasympathetic motor neurons originate from the Cranial Nerves (III, VII, IX, X), and Spinal Nerves S2-S4.
The parasympathetic division is often referred to as the craniosacral division/outflow.

Sympathetic Responses

- Dominates in physical and emotional responses
- Supports vigorous physical activity
- Works in the E situations: Emergency, Exercise, Excitement and Embarrassment

- Promotes physiological responses of the Fight or Flight Response to a perceived threat.
- Results are as follows:
  - Pupils dilate
  - Increased heart rate
  - Increased blood pressure
  - Increased respiration rate
  - Airways dilate
  - Decrease in blood to the kidneys and digestive tract
  - Increased blood supply to organs in need, muscles, heart and liver
  - Increase in blood glucose levels
  - Decrease in saliva secretion

The actions of the sympathetic ANS is increased by the release of adrenaline from the adrenal medulla.

Parasympathetic Responses:
The parasympathetic balances the actions of the sympathetic division. It slows the body down and promotes recovery.

- Promotes 'Rest and Digest' responses
- Works to conserve energy and to restore body energy

Acronym SLUDD
- Salivation
- Lacrimation
- Urination
- Digestion
- Defaecation

3 Decreases:
- Decreased heart rate
- Decreased diameter of airways
- Decreased diameter of pupils

Disorders and Diseases

Neuritis: Inflammation of the nerve. Can be caused by infection, injury, poison. Causes pain along the nerve and loss of use of the structures supplied by the nerve.

Bell's Palsy: A disorder of the 7th cranial nerve (facial nerve). Results in paralysis on one side of the face. Usually occurs suddenly and is brought on by inflammation around the facial nerve. Tumours, injury, infection or dental surgery can also bring it on. Diabetes, pregnancy and hypertension are other causes. Drooping mouth can result; lack of taste; ability to close eye fully; pain.

Carpal Tunnel Syndrome: Pain and numbness in the thumb or hand as a result of pressure on the median nerve of the wrist. Pain, pins and needles can radiate to the elbow. Can eventually cause muscle wasting of the hand. Repetitive strain is a factor.

Cerebral Palsy: Caused damage to the CNS of a baby during pregnancy, delivery or soon after birth. Due to bleeding, lack of oxygen or other injuries to the brain. Affects motor system control and results can include impaired speech, difficulty swallowing, mental retardation; muscles can increase tone to state of spasticity, abnormal posture, hearing and sight difficulties.

Multiple Sclerosis: Progressive disorder where the myelin sheath is destroyed and various functions become impaired - movement and sensation. MS is characterised by relapses and remissions. It can present with blindness or reduced vision. Can progress rapidly. Effects include: incontinence, loss of balance, tremor and depression.

Sciatica: Injury to the sciatic nerve or its branches can cause lower back pain affecting the buttock and thigh. Can radiate down the leg and foot. In severe cases it can cause numbness and weakness of the lower limb. Causes can be prolapsed disc, pregnancy, tumour or blood clot.

Parkinson's Disease: Progressive disease with damage to the grey matter of the brain called the basal ganglia. Neurotransmitter Dopamine is no longer produced. Results in involuntary tremor, stiffness and shuffling. Face lacks expression and movements are slow. Depression, confusion and anxiety can be associated.

Meningitis: Inflammation of the meninges due to viral or bacterial infection. Presents with intense headaches, fever, anorexia, light and sound intolerance and stiff neck muscles. May be convulsions, vomiting and delirium in extreme cases.

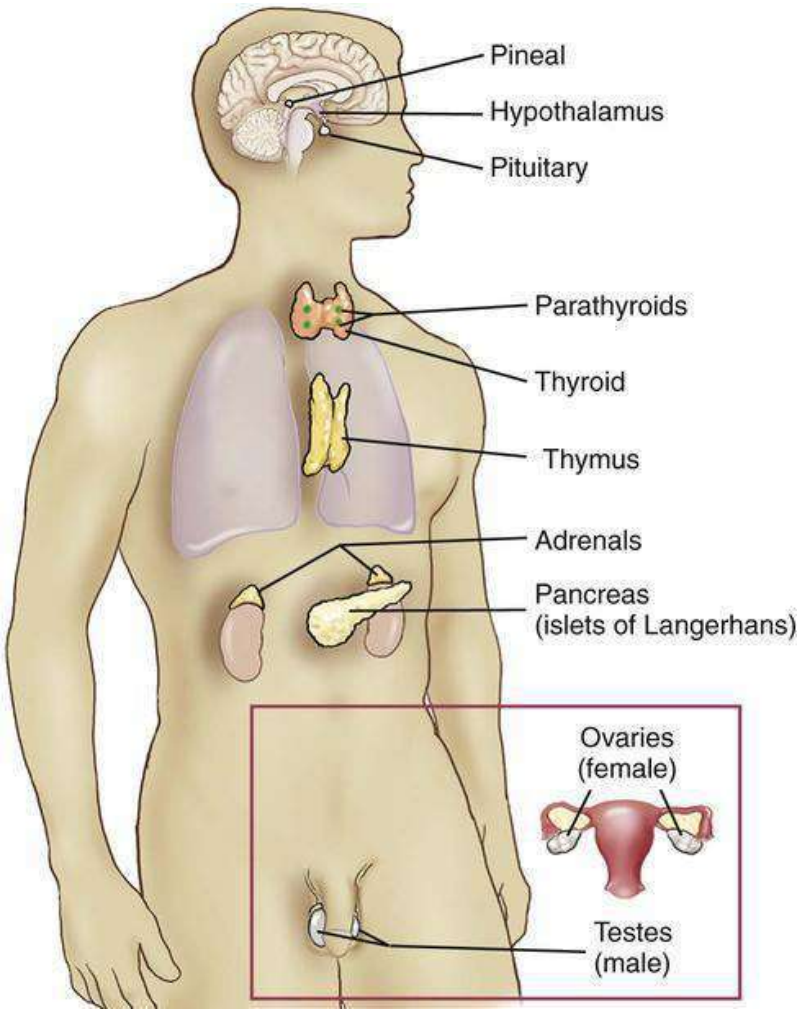
Migraine: Specific form of headache - usually on one side of the head. Associated with nausea, vomiting, visual disturbances, numbness in different parts of the head and neck. Can be treated with analgesia or anti-migraine medication.

Depression: Can be a result of chemical imbalance - usually serotonin and noradrenalin. Causes can be endogenous where there is no apparent cause or reason. Also, can be due to genetics, illness, death of relative, object or relationship. Symptoms include lowered mood, anorexia, poor sleep, lack of self-interest, poor concentration, loss of libido. A person may look miserable, downcast and avoid eye contact.

Epilepsy: A neurological disorder that makes an individual susceptible to recurrent and temporary seizures.

The Endocrine System consists of ***endocrine glands*** that secrete specific chemicals called ***hormones*** into the blood/tissue fluid.
The Endocrine System is one of the body's communication systems and uses these *hormones* as messengers to help to regulate cellular activity by providing a constant internal environment, i.e. homeostasis.
A hormone is a chemical substance that is generated in one organ and carried by the blood to a target organ where it excites activity.
The Endocrine System works very closely with the nervous system to help control the body.
Endocrine glands are ductless and secrete their hormones directly into the bloodstream.

The Endocrine Glands in the body are: (Hypothalamus); Pituitary; Pineal; Thyroid; Parathyroids; Adrenals; Pancreas - Islets of Langerhans; Thymus; Ovaries; Testes.



The Hypothalamus and Pituitary Gland act as a unit to regulate activity of each other:

- Pituitary has 2 lobes - anterior lobe and posterior lobe
- The Pituitary is attached to the Hypothalamus of the brain by a stalk
- This stalk brings blood from the hypothalamus rich in 0_2, nutrients, releasing and inhibiting hormones (RH; IH) to the anterior lobe to influence its secretions: 'Pituitary Portal System'
- The stalk brings nerves from the hypothalamus to the posterior lobe
- The Pituitary is often referred to as the ***'Master Gland'*** because it produces several hormones or releasing factors that influence the secretion of hormones of other endocrine glands.

Anterior Pituitary	Function	Target
Growth Hormone (GH)	Stimulate growth of skeletal muscle, organs + connective tissue e.g. bone	Many tissues
Thyroid Stimulating Hormone (TSH)	Stimulates growth & activity of the thyroid gland	Thyroid
Adrenocorticotrophin (ACTH)	Stimulates & controls the growth and hormonal output of the adrenal cortex	Adrenal Cortex
Prolactin	Stimulates lactation Release is stimulated by suckling	Breast
Follicle Stimulating Hormone or	**FSH:** stimulates the development and ripening of ovarian / graafian follicle that secretes oestrogen (female) Stimulates testes to produce sperm (male)	Ovaries/testes
Luteinising Hormone	**LH:** stimulates final maturation of ovarian follicle and ovulation Promotes formation of Corpus luteum that secretes Progesterone (female) Stimulates testes to produce testosterone (male)	
Melanocyte Stimulating Hormone (MSH)	Stimulates the production of melanin in the basal cell layer of the epidermis	Skin

Posterior Pituitary		
Oxytocin	Promotes uterine contraction and expression of milk	Uterus & Breast
Vasopressin/ antidiuretic Hormone (ADH)	Contraction of smooth muscle (blood vessels) = increase BP Increase permeability of kidneys to water = more water absorbed	Blood vessels Kidney tubules

- 'Pituitary Portal System' The anterior secretions of the pituitary are dependent on stimulation from the hypothalamus and are involved in 'Negative feedback mechanism'.
- 'Negative Feedback Mechanism': If a hormone blood level is low - stimulation of the hypothalamus to produce its stimulating hormone - stimulate pituitary to release hormone - increase blood hormone level - signal hypothalamus to release its inhibiting hormone - goes to pituitary - amount of hormone released is decreased.

The Pineal Gland

- Pea-sized mass of nerve tissue deep in the brain
- It secretes the hormone melatonin (made from serotonin
- More melatonin is released in the darkness and can promote sleepiness
- It functions to co-ordinate circadian rhythms / day & night rhythms / biological clock
- Overproduction of melatonin during winter months can cause Seasonal Affected Disorder (SAD) as daylight hours are shortened. It is also thought to be associated with Jet Lag

The Thyroid Gland

- A 2-loved gland in the neck in front of the larynx and trachea. 2 parathyroid glands lie on the posterior of each
- It is controlled by the pituitary gland
- The gland contains hormones and colloid (thick sticky semifluid protein)
- It has 3 major secretions: T3 (tri-iodothyronine), T4 (Thyroxine) and Calcitonin
- C-Cells (parafollicular cells) produce the hormone *Calcitonin* which reduces Calcium levels in the blood. It inhibits calcium reabsorption from bones and renal tubules. An increase in calcium blood levels = increase in calcitonin levels.
- Iodine is essential for formation of T3 and T4 and has to be ingested.
- After formation, T3 and T4 combine with colloid = 'Thyroglobulin'
- Function of T3 and T4 are: Physical growth / Mental development /metabolic rate control / Peristalsis / Nervous function.

The Parathyroid Gland

- 4 of them - 2 on either side of thyroid. Posterior to the thyroid.
- The secrete Parathormone (PTH)
- A drop in blood calcium levels = increase in PTH secretion
- PTH promotes calcium reabsorption from bones and in the small intestine and renal tubules
- PTH and calcitonin from the thyroid help maintain blood calcium levels which is very important for muscle contraction, blood clotting and nerve impulse transmission.

The Thymus Gland

- Is found behind the sternum, between the lungs
- It has 2 lobes made of epithelial cells and lymphocytes
- Thymosin and thymic factor are the hormones secreted by epithelial cells
- It stimulates the maturation of the thymus and t-lymphocytes
- Required for development and activity of t-lymphocytes

The Islets of Langerhans (Pancreas)

- The ductless parts of the pancreas secrete the 2 hormones: Glucagon and Insulin
- Both of these are vital for the control of blood glucose levels
- Glucagon secretion = increases blood glucose levels
- Insulin secretion = decreases blood glucose levels
- GHRIH from the hypothalamus can inhibit insulin and glucagon secretion

GLUCAGON	**INSULIN**
Increases blood glucose	Decreases blood glucose
Converts Glycogen to Glucose (especially in liver & muscles)	Converts Glucose to Glycogen (especially in liver & muscles

The Adrenal Glands

- There are 2 of them - each lie on top of a kidney
- They have a structure of an outer cortex and an inner medulla

The **Adrenal Cortex** produces Glucocorticoids, Mineralocorticoids and Androgens from cholesterol.

- **Glucocorticoids:** Cortisone/Hydrocortisone. Stimulated by ACTH or by stress. They regulate carbohydrate, protein and fat metabolism / promote sodium and water absorption in kidneys /have anti-inflammatory properties.

- **Mineralocorticoids:** Aldosterone is the major one. It is very important for electrolyte balance within the body and stimulates reabsorption of sodium and water in the kidney tubules. Decrease in blood sodium = increased release of aldosterone = increased blood sodium.
- **Androgens**: Sex hormones produced in very small amounts here.

The **Adrenal Medulla** is made of nervous tissue closely related to the nervous system. It is stimulated by Sympathetic Nervous supply in a big way to release catecholamines - Adrenaline and Noradrenaline.
Adrenaline is very important in stress - 'fight or flight' response.

- Constricts skin and intestinal blood vessels
- Dilates bronchioles (more O_2)
- Dilates muscle blood vessels (O_2 and nutrient delivery/waste removal)
- Increases metabolic rate (energy)
- Dilates pupils (Alert! Vision)
- Coverts glycogen to glucose (energy)

Noradrenaline also works when stress occurs to increase blood pressure. But it is mainly involved in what we call 'Rest & Digest' to promote recovery.

- Vasoconstriction of small blood vessels = increased BP
- Increased rate and depth of breathing
- Relaxation of smooth muscle in intestinal wall

The Ovaries
Found in the lower abdomen of females, below the kidneys. There are 2 ovaries each attached to the upper part of the uterus by ligaments. Affected by FSH and LH form the Pituitary.
Main Functions:

1. Production of ova at ovulation
2. Production of sex hormones Oestrogen and Progesterone. These influence the secondary sex characteristics in females and affect the process of reproduction.

The Testes
Found in the groin of males. There are 2, each held in a sac called the scrotum. Main functions:

1. Secretion of the hormone testosterone which controls the development of secondary sex characteristics in the male at puberty (affected by LH).
2. The production of sperm (affected by FSH).

Life Changes

Puberty: Internal organs of reproduction of boys and girls reach maturity and start to function. There is a surge of hormones released into the blood stream.

In girls:

- The ovaries are stimulated by FSH and LH. This results in the production of Oestrogen and Progesterone.
- The adrenals are stimulated to produce androgens.

Overall results are development and maturation of breasts, vulva and vagina. There is increased subcutaneous fat giving the curved female shape. Ovulation and the menstrual cycle begin. There is growth of pubic and axillary hair. It is the androgens that are responsible for **hair growth in target areas**. If there is an imbalance at this stage and too much androgens are produced, then excess hair may develop. Once the correct balance of oestrogens and androgens is restored after puberty, excess hair should balance and disappear.
In boys the testes are stimulated by FSH and LH. This results in the production of Testosterone. Results are growth of muscle and bone; voice breaks and larynx enlarges; growth of pubic, facial and axillary, abdominal and chest hair; sexual organs develop; semen and sperm is produced.

The Menstrual Cycle
Regular sequence of events in females. Lasts approx. 28 days.

1. Menstrual Stage: Days 1 - 7. If pregnancy does not occur after 8 - 24 hours, the CL shrinks and the endometrium is shed. This is **menstruation**. Over a period of 5 days, the uterus walls contract to allow the shedding of the endometrium.

2. Proliferative Stage: Days 7 - 14. Ovum develops within ovarian follicle due to release of FSH from anterior pituitary. Oestrogen is released by the ovaries to promote growth of new blood vessels and mucous cells in the endometrium. The ovum bursts from the follicle when mature and travels along the fallopian tubes. This is **ovulation** and is said to occur normally at day 14.

3. Secretory Stage: Days 14 - 28. LH (luteinising hormone) is released from the anterior pituitary. A temporary endocrine gland called the Corpus Luteum develops from the ruptured ovarian follicle. Corpus Luteum secretes Progesterone. This along with oestrogen causes the endometrium to thicken in preparation for pregnancy. If fertilisation does occur, the egg is attached to the endometrium and the CL continues to secrete progesterone. It continues to do so until the 4th month. After this, the placenta secretes progesterone to maintain pregnancy.

Pregnancy: Progesterone is the pregnancy hormone. It maintains the uterus lining and develops the placenta. It also prepares the breasts for lactation. Oestrogen is also secreted in large amounts. This is accompanied by increase in secretions of androgens to try to maintain a balance. This can also result in excess **hair growth in target areas,** particularly on the upper lip, chin, side of face. It is normally vellus hair, which should disappear after birth of the child.

Menopause: This marks the end of a woman's reproductive life when oestrogen levels decline. Ovulation and the menstrual cycle become irregular until they cease altogether. There is a fall in the levels of oestrogen production that can result in the following symptoms:

- ✧ Hot flushes
- ✧ Palpitations
- ✧ Anxiety
- ✧ Irritability
- ✧ Fatigue
- ✧ Lack of concentration
- ✧ Osteoporosis

Normally, the hormones from the ovaries will have a feedback relationship with the anterior pituitary to control hormone levels in the body. However, in menopause, the ovaries stop working, which means the master gland will be confused about what stimulating hormones to release. This can result in over-stimulation of the adrenal cortex which can lead to excess androgens released. Sometimes, women of menopausal age find they develop excess facial and body hair.

Disorders and Diseases

PITUITARY GLAND
Hypersecretion of growth from the pituitary leads to ***gigantism*** in children with rapid growth of the body to 7 - 8 feet.
If this occurs in adulthood, there would be abnormal enlargement of the hands, feet, coarsening of the facial features. This is called ***acromegaly.***

Hyposecretion of growth hormone in children lead to stunted growth - condition known as ***dwarfism.*** Hyposecretion of ADH from the posterior lobe of the pituitary can lead to ***Diabetes Insipidus,*** which causes dehydration, increased thirst and urine output.

PINEAL GLAND

S.A.D. - can be due to hyposecretion of melatonin, which can affect the mood leading to depression, excessive sleeping and over-eating and also a general slowing down of mind and body. SAD can also be caused due to hypersecretion of melatonin in the winter months when daytime is shorter.

THYROID

Hypersecretion of hormones can lead to ***Graves' Disease*** which is an autoimmune disease. It causes protruding eyes, increased metabolic rate, weight loss, sweating, restlessness, increased appetite, high temperature, frequent bowel movements and anxiety.
Hypersecretion of thyroxine can cause ***goitre***, which is an enlargement of the thyroid gland.

Hyposecretion leads to impaired mentality, small structure, coarse hair and skin and deposition of fat on the body. In children, this is called ***cretinism.***
In adults, hyposecretion leads to ***myxoedema*** which is characterised by slowing down of physical and mental activity with lethargy, oedema of face making it look puffy, brittle hair, coarse skin and slow metabolism.

PARATHYROID

Hypersecretion of parathormone with enlargement of the gland can cause very high blood calcium levels as more calcium is re-absorbed from bones. This causes kidney stones, kidney failure, calcification of soft tissue and tumours.

Hyposecretion of parathormone means there would be less calcium in the blood. This can cause muscle twitching and tetany. Symptoms can be relieved by administration of calcium.

ADRENALS

Cortex Hypersecretion Hypersecretion of Aldosterone can lead to kidney failure, high blood pressure and excessive potassium in the blood causing irregular heartbeat. Hypersecretion of Corticoids leads to ***Cushing's Syndrome***. Weight gain, reddening of face and neck, excess growth of facial and body hair, high blood pressure, loss of mineral for bone and mental disturbances.
Hypersecretion of androgens can cause hirsutism and amenorrhea in females due to increased testosterone levels. In males, it can lead to atrophy and development of breasts due to increased oestrogen levels.
Cortex Hyposecretion: Lack of corticoids from the cortex can cause ***Addison's disease.*** Symptoms are loss of appetite, weight loss, brown pigmentation, low blood sugar, low blood pressure, tiredness and muscle weakness. This is treated with hormone therapy.

PANCREAS

Hypersecretion of insulin can lead to low blood sugar levels called ***hypoglycaemia***. This causes muscle weakness and incoordination, mental confusion and sweating. If severe, it can lead to a hypoglycaemic coma.

Hyposecretion of insulin can lead to ***Diabetes Mellitus***. This is due to the absence of insulin or can be caused by the body not being able to utilise insulin. Without insulin to move the glucose into body cells, there is a resulting rise in blood glucose levels called ***hyperglycaemia.*** Patients are dependent on administering insulin shots and eat a controlled diet. Symptoms include increased thirst, increased urination, weight loss, thin skin and impaired healing.

There are 2 types of DM:

1. IDDM - Insulin Dependent Diabetes Mellitus or early onset diabetes. This occurs mainly in children or young adults and is caused by the lack of insulin produced by the body. This Islet of Langerhans may be damaged. Genetic tendency.
2. NIDDM - Non-Insulin Dependent Diabetes Mellitus or late onset. Occurs later in life. Most people still produce insulin but are insulin resistant. It seems they are incapable of secreting enough to overcome this resistance. Weight gain and obesity are associated with NIDDM and patients control it through weight loss and strict diet.

SEX HORMONES

Hypersecretion: Hypersecretion of testosterone in women can lead to ***virilism***; ***hirsutism*** (hair growth in the male pattern) and ***amenorrhoea*** (an absence of periods).

Hypersecretion of oestrogen and progesterone in males can lead to muscle atrophy and breast development (***Gynaecomastia).***

Hyposecretion: Hyposecretion of oestrogen and progesterone in females can lead to ***Polycystic Ovary Syndrome*** where cysts form on the ovaries, there is a cessation of periods, obesity, atrophy of breasts, hirsutism and sterility.

The Male Reproductive System

Prostate

Male accessory gland found in front of the rectum and behind the pubic symphysis. Function:

1. Secretes thin, milky fluid that enhances mobility of sperm
2. Neutralises semen and vaginal secretions

Testes

2 reproductive glands each in a scrotum sac. They are made of 200-300 lobules, separated by connective tissue filled with seminiferous tubules, where sperm cells are formed. Functions:

1. To produce sperm
2. To produce the male hormone Testosterone, responsible for male secondary characteristics.

Epididymis:

Coiled tubes that lead from the seminiferous tubules towards the vas deferens. Functions:

1. Store and nourish immature sperm cells and promote their maturation

Vas Deferens

Tubes leading from the epididymis to the urethra. Function:

1. To release sperm

Seminal vesicles

Pouches lying on the posterior aspect of the bladder, attached to the vas deferens. Function:

1. To secrete alkaline fluid with nutrients that add to sperm during ejaculation.

Spermatic cord

Supporting structure of the male reproductive system. It ascends from the scrotum and it contains vas deferens, testicular artery, autonomic nerves, veins to drain the testes and carry testosterone to the blood and lymphatic vessels.

Urethra

This is a common pathway in men for the flow of urine and the secretion of semen. A sphincter muscle prevents this occurring at the same time.

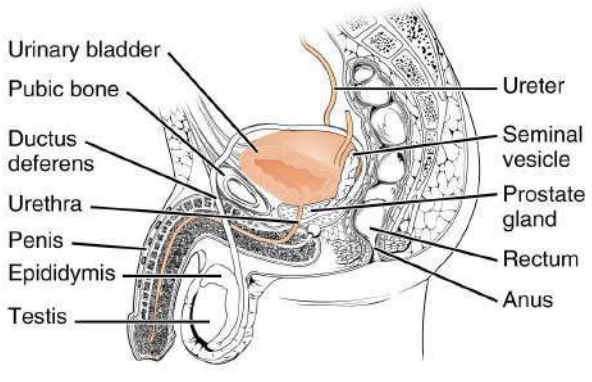
Penis

Erectile tissue richly supplied with blood vessels. Function:

1. Convey urine and semen

The overall functions of the Male Reproductive System:

1. Production of sperm
2. Impregnation



The Female Reproductive System

Ovaries

Sex glands found on the lateral walls of the pelvis. They are held in place on either side of the uterus by supporting ligaments. Ovarian follicles are found in the ovaries that contain the ova. Females are born with a predetermined number of ova - 2million, but over time some degenerate and 400,000 are left by puberty. These lie immature until they are stimulated into maturity by the release of FSH (follicle stimulating hormone). One egg ripens each month. 2 main functions:

1. Stimulation of ova
2. Release of oestrogen and progesterone: oestrogen stimulates primary female characteristics. It is released in the 1st half of the cycle. Progesterone, released in the 2nd half of the cycle, thickens the uterus lining ready for implantation of a fertilised egg.

Fallopian Tubes

2 tubes, each 5cm long, extending from each side of the uterus towards the ovary. Fimbriae are finger like projections that encircle the ovary. Functions:

1. Convey the mature ovum from ovary towards the uterus. Peristaltic contraction and cilia on the lining help this.
2. Fertilisation occurs in the fallopian tubes and this is passed to the uterus.

Uterus

Hollow organ behind the bladder, in front of the rectum. It has a thick muscular wall and inner mucous membrane called the **endometrium.** Functions:

1. Receives the ovum and is the area where the embryo grows and develops into a foetus.
2. After puberty, it has a regular cycle that prepares it to receive, nourish and protect a fertilised ovum.
3. Its walls relax during pregnancy to allow growth of the foetus.
4. Without fertilisation the surface endometrium degenerates and sheds during the menstrual cycle.

The Vagina

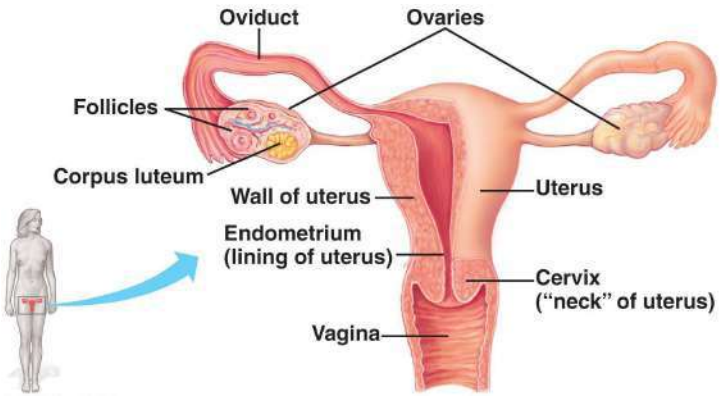
10-15cm tube of muscle and elastic tissue and moist epithelium lining. It connects the internal organs to the external organs. It has an acidic environment to prevent infection. Functions:

1. Reception of sperm
2. Passageway for birth

External genitalia

Collectively called the vulva. It is made up of:

1. Labia major and minor - folds at the entrance to the vagina
2. Clitoris - attached to symphysis pubis by ligaments and has erectile tissue
3. Hymen - thin mucous membrane
4. Glands - at either side of the labia majora that secrete mucous.



The Breast
Mammary glands are modified sweat glands that produce milk. They are accessory organs to female reproductive system. Their main functions are to produce and secrete milk after pregnancy.

Position
Located on the pectoral region in front of the chest, between the sternum and the axilla, from approximately the 2nd to the 6th rib. They lie over the Pectoralis Major and Serratus anterior muscles and are attached to them by connective tissue.

Structure
Glandular tissue arranged in lobules which lead into milk ducts that open to the surface of the breast at the nipple. Around each nipple is a pigmented area called the areola. Areola contain sebaceous glands. Between lobules is connective tissue. Adipose tissue is found around the surface of the gland. The skin here is more translucent than other body skin.

Support
Coopers ligaments are strands of connective tissue that suspend the breasts from the chest wall. These are supported by the pectoralis and serratus anterior muscles. These ligaments become looser with age. Enlargement, pregnancy, weight gain and lack of support, for example during exercise, can cause this.

Blood supply and venous drainage
The blood vessels supplying the breast include the subclavian and axillary arteries. Subclavian and axillary veins will remove waste.

Lymph drainage
Breasts contain many lymphatic vessels which drain lymph away towards the axillary nodes under the arm. During the monthly cycle, progesterone increases blood flow to the breast which causes fluid retention. This can cause swelling and tenderness. For this reason, lymph drainage is important for maintaining the health and condition of the breasts.

Hormones
Oestrogen is responsible for initial development of the breasts. Progesterone is responsible for the development of the lobules.

Puberty
2 - 3 years before menstruation, fat cells enlarge in response to oestrogen and progesterone released before adolescence.

Post-menopause
The reduction in female hormones during menopause causes glandular tissue to shrink. The supporting tissue and skin become thinner and lose their elasticity. The degree of loss depends on the lifelong health of the breast.

Factors determining the Size and Shape:
- Genetics is the major factor. Also
- Amount of adipose tissue present
- Fluid retention
- Coopers ligaments
- Exercise - can help tone the muscles and help support and lift the breasts. The wrong type of exercise without proper support cause ligaments to become irreparably stretched.
- Hormone levels

Puberty: Internal organs of reproduction of boys and girls as they reach maturity and start to function. In girls, hormones released cause development and maturation of breasts, vulva and vagina. There is increased subcutaneous fat giving the curved female shape. Ovulation and the menstrual cycle begins. There is growth of pubic and axillary hair.
In boys, hormones released cause growth of muscle and bone; voice breaks and larynx enlarges; growth of pubic, facial, axillary, abdominal and chest hair; sexual organs develop, semen and sperm is produced.

The Menstrual Cycle:
Regular sequence of events in females. Lasts approx. 28 days.
Menstrual Stage
Days 1 - 7. If pregnancy does not occur after 8 - 24 hours, the CL shrinks and the endometrium is shed. This is **menstruation**. Over a period of 5 days, the uterus walls contract to allow the shedding of the endometrium.
Proliferative Stage
Days 7 - 14. Ovum develops within ovarian follicle due to release of FSH from anterior pituitary. Oestrogen is released by the ovaries to promote growth of new blood vessels and mucous cells in the endometrium. The ovum bursts from the follicle when mature and travels along the fallopian tubes. This is **ovulation** and is said to occur normally at day 14.
Secretory Stage
Days 14 - 28. LH (luteinising hormone) is released from the anterior pituitary. A temporary endocrine gland called the Corpus Luteum develops from the ruptured ovarian follicle. Corpus Luteum secretes progesterone. This, along with oestrogen, causes the endometrium to thicken in preparation for pregnancy. If fertilisation does occur, the egg is attached to the endometrium and the CL continues to secrete progesterone. It continues to do so until the 4th month. After this the placenta secretes progesterone to maintain pregnancy.

Pregnancy

This is a result of sex cells called gametes fusing to form a zygote. The gametes (sperm and ova) each contain only 23 chromosomes. When they fuse, they form a zygote that contains 46 chromosomes and this is able to reproduce by mitosis to grow and develop into an embryo and foetus. Pregnancy takes approximately 9 months.
There are 3 stages: 1st, 2nd and 3rd trimesters.
During pregnancy, it is important that the levels of oestrogen and progesterone are maintained as they:

- Maintain the uterine wall
- Inhibit the release of FSH and LH
- Stimulate the development of mammary glands
- Inhibit uterine contractions until birth

Menopause

This occurs in women of the ages 40 - 55. The menstrual cycle becomes very irregular and finally ceases altogether. The ovaries stop responding to FSH which results in low levels of oestrogen and progesterone. Female Secondary sexual characteristics undergo changes: decreased size of vagina, uterus and breasts. Also, there is lone of bone mass and osteoporosis is a risk. Hot flushes in the face and neck areas can occur. Headaches, fatigue and emotional disturbances are also factors. Often, hormone replacement therapy (HRT) of oestrogen and progesterone is prescribed by doctors.

The overall function of the female reproductive system:

1. Ovulation
2. Menstruation
3. Pregnancy
4. Birth

The food we eat contains many nutrients used for building body tissue and repairing damaged tissues. We all need food as energy in order to survive. However, the foods we eat must be broken down into tiny molecules to enable them to enter the cells in our body. This process of **digestion** occurs in the **Alimentary Tract**, a long continuous muscular tube that starts at the mouth and ends at the anus.

Some Important Terms and Definitions:

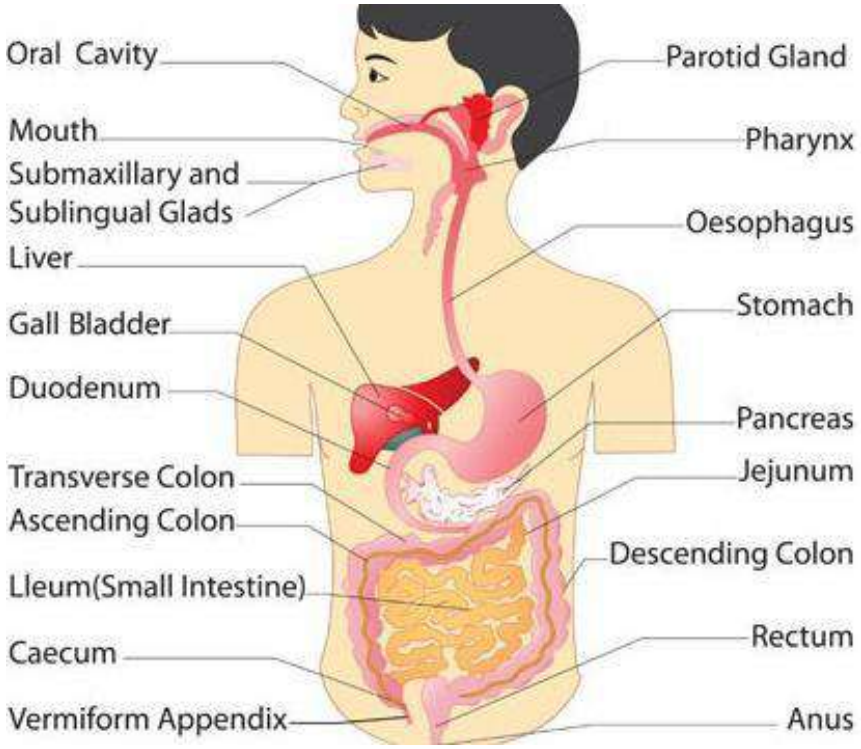
Ingestion is the process of taking foods and liquids into the mouth, i.e. eating.
Digestion is the mechanical and chemical breakdown of food into smaller foodstuff.
Absorption is the passage of smaller molecules into the cells that line the stomach and intestines and then taken into the blood and lymph systems.
Assimilation is using these digested foods to build and nourish the tissues of the body.
Elimination is the excretion of indigestible and unwanted foodstuff (faeces) through the anus.
Digestive enzymes are chemical substances that act as catalysts for food breakdown which enables food to be absorbed. They make chemical changes in food but they themselves remain unchanged.

The Alimentary Tract (10 metres) consists of:

- Mouth
- Pharynx
- Oesophagus
- Stomach
- Small Intestine (SI)
- Large Intestine (LI)
- Rectum & Anus

Accessory Organs to digestion:

- Liver
- Gall Bladder
- Pancreas



Basic Structure of Digestive Organs:

1. Inner mucosa layer with mucous membrane (protection, secretion and absorption); smooth muscle; connective tissue to support blood and lymph vessels; various cells that secrete digestive substances into the lumen of the tract. This layer is arranged to increase surface area for absorption.
2. Sub-mucosa layer containing connective and elastic tissue, blood, lymph and nerves.
3. Outer muscle layer made of longitudinal and circular muscle. This layer allows the movement of food along the tract by contraction and relaxation.
4. Serous membrane: The Peritoneum is the largest serous membrane of the body. The parietal layer lines the wall of the abdominal cavity. The visceral layer covers some organs in the cavity.

The Mouth

Mechanical breakdown of food by chewing with teeth occurs here. The tongue helps by forming a ball of food called a ***bolus***

Chemical breakdown occurs by saliva secreted from 3 pairs of salivary glands:

1. Parotid glands — above the masseter muscle, anterior to ear.
2. Submandibular glands — inside the arch of the mandible, below tongue.
3. Sublingual glands: — below the tongue.

Saliva is a clear thick liquid containing water, salts, mucin and salivary amylase. Salivary amylase is the enzyme that breaks down Carbohydrates (starch) to maltose. Saliva also lubricates food, cleanses the teeth and mouth and protects against bacteria.
Saliva is secreted once food enters the mouth. The smell, sight, sound or thought of food can also stimulate secretion of food.

The Pharynx and Oesophagus
The pharynx is the throat that leads the bolus into the oesophagus. The initial swallowing of food is voluntary but once in the pharynx, food moves along by involuntary muscular contraction called ***peristalsis***. No digestion occurs in the oesophagus. Only mucous is secreted to help the movement of the bolus along the oesophagus to the stomach.

The Stomach
Structure: J-shaped organ on the left-hand side of the body and below the diaphragm. The Cardiac Sphincter muscle allows food to enter stomach from oesophagus. The Pyloric Sphincter allows the exit of food from the stomach in to the duodenum of the SI. It has a basic structure (serous membrane, muscle and mucosa). The inner mucosa is arranged in folds called ***rugae***. These increase surface area for absorption and secretion and also aid mechanical churning of the food into a liquid state called ***chyme.***

Secretions: Gastric Juice is secreted by special glands called gastric glands. Gastric Juice contains:

1. **Pepsin:** secreted as pepsinogen by chief cells. It's an enzyme that breaks down proteins to polypeptides (peptones).
2. **Hydrochloric Acid (HCL):** made by oxyntic cells. The acidic environment of the stomach converts pepsinogen to pepsin and kills bacteria.
3. **Rennin** turns milk to curds in infants.
4. **Mucous** secreted by neck cells, lines the stomach to protect against acid erosion. Lubricates food.

Functions of Stomach:

1. Stores and digests food
2. Chemical digestion of proteins to polypeptides
3. Mechanical digestion via muscular contraction turns solid food to liquid chyme
4. Absorption of water, alcohol, drugs.

The Small Intestine (SI)

Structure: This area continues from the pyloric sphincter of the stomach and is approx. 7 meters long. The SI has the same basic structure as the stomach.
It also has special features called ***villi,*** which are tiny projections that contain blood capillaries and lacteals that absorb nutrients into the bloodstream.
Goblet cells are also present in the SI to secrete mucous into the lumen.
Peyers Patches of the lymphatic system are found in the wall of the SI.
Intestinal Glands are found in the SI walls. These secrete digestive Intestinal Juices.

The SI in divided into 3 parts:
1. Duodenum - first segment
2. Jejunum - middle segment (2 metres)
3. Ileum - 3 metres where the main absorption of food takes place. It leads into the ileo-caecal valve of the Large Intestine.

Secretions: There are 3 different groups of liquids secreted into the SI as follows:
1. **Bile** is made in the liver but stored & secreted from the gall bladder into the duodenum. It is an alkaline liquid of water, mucous, bile pigments, bile salts and cholesterol. Its function is to neutralise the acid chyme from the stomach and to emulsify fat (break big fat molecules into tiny fat droplets).
2. **Pancreatic Juice** is produced and secreted from the pancreas into the duodenum. This juice digests carbohydrates, proteins and fats. Pancreatic juice contains the enzymes:
   - *Pancreatic Amylase* - breaks down Complex Carbohydrates (Polysaccharides) to Simpler Carbohydrates (Disaccharides)
   - *Trypsin* - further breaks down proteins and polypeptides
   - *Pancreatic Lipase* - breaks down Lipids to Fatty Acids and Glycerol.
3. **Intestinal Juice** is produced and secreted by the Intestinal Glands in the wall of the SI. These juices complete the final breakdown of nutrients. Intestinal Juice contain:
   - *Amylase* - splits Polysaccharides into Disaccharides (Maltose, Sucrose, Lactose)
   - *Maltase* - splits Maltose into Glucose
   - *Sucrase* - splits Sucrose into Glucose and Fructose
   - *Lactase* - splits Lactose into Glucose and Galactose
   - *Peptidases* - splits Polypeptides into Amino Acids
   - *Lipase* - splits Fats into Fatty Acids and Glycerol

Functions of SI
1. Moves digested foodstuffs along by peristalsis towards the LI.
2. Completes digestion of Carbohydrates, Proteins and Fats
3. Protects against disease (lymphatic components)
4. Absorbs nutrients into blood and lymph systems.

Absorption of Digested Food

Absorption is the diffusion of nutrients through the epithelial cells lining the digestive tract and into the underlying blood capillaries and lacteals. 90% occurs in the SI. The other 10% occurs in the stomach and LI. Any undigested or unabsorbed material is left in the SI and passes into the LI.
1. Simple sugars: glucose, fructose and galactose, from carbohydrate digestion are absorbed into the blood capillaries.
2. Amino acids from protein digestion are absorbed into the blood capillaries.
3. Fatty acids and glycerol from lipid digestion are absorbed into the lacteals. These are carried into the lymph system before being delivered into the blood system.
4. Vitamins and minerals are absorbed into the blood capillaries of the villi. These assist in normal body functioning and cell metabolism.

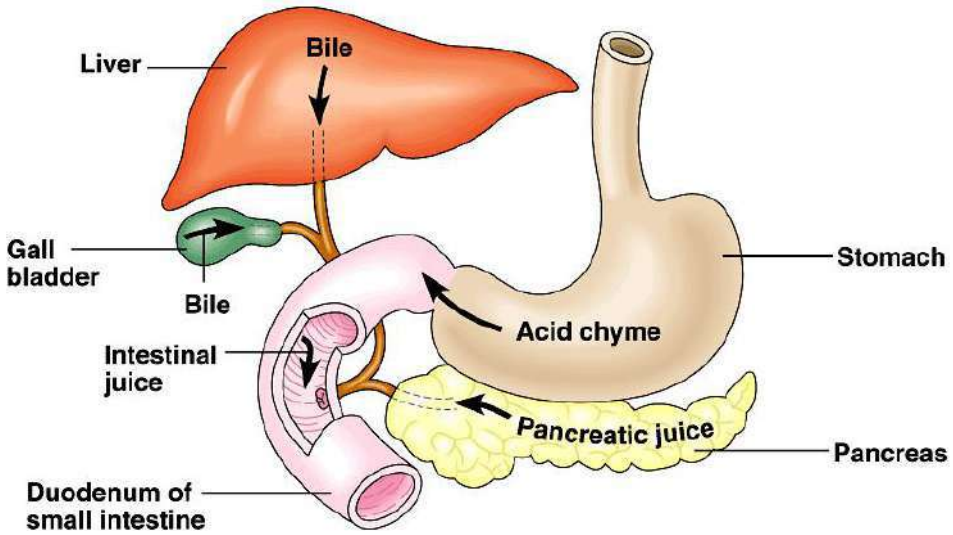
The Large Intestine (LI)

Structure: The LI is 1.5 metres long and borders the SI. The LI does not have any villi like the SI. It does have goblet cells that secrete mucous. It has many different regions:

- Caecum - pouch at the junction of the SI and LI on the right-hand side of the body. The ileo-caecal valve connects them. The appendix is attached onto the caecum.
- Ascending colon - passes up from the caecum to the lower edge of the liver. It turns at a point called the hepatic flexure.
- Transverse colon - extends across the abdomen at waist level from hepatic flexure to a downward turn at the left side of the body called the splenic flexure.
- Descending colon - passes down from splenic flexure to the brim of the pelvis.
- Sigmoid colon - s-shaped segment from the descending colon towards the rectum
- Rectum - 12cm long connecting the sigmoid colon to the anus. Faeces is stored here before defecation.
- Anus - opening at the end of alimentary tract. Faeces is discharged here. It has an internal sphincter of smooth muscle that is under involuntary control and external sphincter muscle that is under voluntary control. The anus is closed except during defecation.

Functions of LI:

1. Absorption of water, ions and vitamins
2. Formation and storage of faeces (undigested foodstuff, dead cells).
3. Secretes mucous to aid movement of faeces by peristalsis.
4. Production of Vitamin B and Vitamin K - some bacteria in the LI produce these vitamins.
5. Defecation.



The Liver - Accessory Organ

The liver is the largest gland in the body. It has 4 lobes and is found in the upper right-hand side of the abdominal cavity, below the diaphragm. Internally its cells are called hepatocytes. The liver is supplied with oxygenated blood via the Hepatic Artery, a branch of the aorta. It also receives blood, rich in nutrients and low in oxygen from the digestive system via the Hepatic Portal Vein. The liver is a vital organ that processes and metabolises the products of digestion to make them suitable for the body's cells to use. These are carried away by the Hepatic Vein that links up with the vena cava.

Functions:

1. Production of bile - the liver produces bile and sends it to be stored in the gall bladder via the hepatic duct.
2. Carbohydrate Metabolism - the liver regulates blood sugar levels. When blood sugar is high, the liver stores excess glucose as glycogen. When blood sugar is low, it converts stored glycogen to glucose. The muscles can also store excess glucose as glycogen. If both stores are full, the glucose is converted into fat by the liver.

3. Protein Metabolism - we cannot store excess proteins or amino acids. The liver breaks them down. It can deaminate amino acids (split amino acids into an amino group + ammonia). The ammonia is converted to urea in the liver and transported to the kidneys for excretion. The amino group can be used to make plasma proteins, ATP, or carbohydrates and fats.
4. Lipid Metabolism - some fats are stored in the liver. The liver can break down fats to make ATP. It can use fats to make cholesterol and use cholesterol to make bile salts.
5. Detoxification - the liver detoxifies alcohol, drugs, harmful waste and excretes them in bile or through the kidneys.
6. Storage - stores glycogen, vitamins A, D, E, K, B12 and minerals iron, potassium and copper. These are released when needed by the body.
7. Phagocytosis - the liver cells can phagocytise aged rbc, wbc and bacteria.

The Gall Bladder - Accessory Organ

A pear-shaped sac attached to the liver. The gall bladder stores bile produced by the liver. The Hepatic duct brings bile to the gall bladder from the liver. The Cystic duct carries bile to/from the gall bladder. The common hepatic duct is formed when the cystic, hepatic and pancreatic ducts meet and lead into the duodenum.

Functions:

1. Bile reservoir
2. Secretes mucous into bile
3. Absorbs water from bile to make it more concentrate
4. Releases bile into duodenum to emulsify fats

The Pancreas

This is a gland extending from the loop of the duodenum to behind the stomach. It has endocrine and exocrine functions. Its endocrine function is the production of insulin from the Islets of Langerhans. We look at this in more detail in the endocrine system.

Its exocrine function is that of the production and secretion of the Pancreatic Juices. This juice is produced by the secretory cells in the alveoli lobules of the pancreas. The contain digestive enzymes (as outlined above) to aid the digestion of carbohydrates, proteins and fats.

Organ	Digestive Juice	Enzyme	Substrate	Reaction
Mouth	Saliva	Salivary amalyse	Carbohydrates (Starch) (Polysaccharides)	Splits Complex Carbohydrates to Simpler Carbohydrates Polysaccharide (cooked starch) - Disaccharide (Maltose)
Stomach	Gastric Juice	HCL (acid - not an enzyme)	Pepsinogen	Converts inactive Pepsinogen to active Pepsin
		Pepsin	Proteins	Splits Proteins - Polypeptides (Peptones)
Small Intestine	Bile	Bile (not an enzyme)	Fats	Emulsifies Lipid. Splits large Fats to small Fat Droplets
	Pancreatic Juice	Pancreatic amylase	Carbohydrates (Polysaccharides)	Polysaccharide - Disaccharide (Maltose, Sucrose, Lactose)
		Trypsin	Proteins	Proteins - Polypeptides (peptones)
		Pancreatic Lipase	Fats	Fats - Fatty Acids & Glycerol)
	Intestinal Juice	Intestinal amylase	Carbohydrates (Polysaccharides	Polysaccharide - Disaccharide (Maltose, Sucrose, Lactose)
		Maltase	Carbohydrates (Disaccharides	Maltose - Glucose
		Sucrase	Carbohydrates (Disaccharides	Sucrose - Glucose & Fructose
		Lactase	Carbohydrates (Disaccharides	Lactose - Glucose & Galactose
		Peptidases	Proteins	Polypeptides - Amino Acids
		Lipases	Fats	Fats - Fatty Acids & Glycerol

SUMMARY OF DIGESTION OF CARBOHYDRATES, PROTEINS & FATS

Disorders of the Digestive System

Anorexia Nervosa: Loss of appetite due to psychological illness. Often affects young females and women. Sufferers starve themselves by not eating, inducing vomiting or taking laxatives. They have a phobia of becoming fat. Results can be severe weight loss, amenorrhea, systems breakdown and even death.

Appendicitis: Inflammation of the appendix. Can be caused by obstruction of opening by chyme inflammation, a foreign body or kinking. Usually starts with pain in the stomach region, anorexia, nausea and vomiting. Effects are high fever, high white blood cell count, oedema, gangrene & perforation. Usually removed by operation.

Bulimia Nervosa: A psychological illness characterised by binge eating followed by self-induced vomiting.

Cirrhosis: Hardening of an organ due to damage. Excessive alcohol consumption can lead to cirrhosis of the liver.

Colorectal Cancer: Very malignant form of cancer, ranked second to lung cancer in men. Third to breast cancer in women. Genetic predisposition contributes to more than half of all cases. Alcohol and diets high in animal fat and protein are associated with increased risk. Dietary fibre, calcium and selenium may be protective. Signs include diarrhoea, constipation, cramping, abdominal pain and rectal bleeding.

Constipation: Condition of difficulty in passing stools or infrequent evacuation of the bowel. Causes can be dietary, lack of fibre, lack of exercise, lack of water/fluid intake, medications, stress and intestinal obstruction.

Diarrhoea: Frequent bowel movements and evacuation or the passing of abnormally liquid faeces. Causes can be intestinal infection, stress, intestinal inflammation or IBS. Results in poor absorption of water, solutes and nutritional elements. Can cause dehydration.

Gall Stones: Stones found in the gall bladder formed by residues of bile pigments, cholesterol and calcium salts. They grow in size and number and can obstruct the flow of bile into the duodenum. Drugs can be used to dissolve them. For recurrent problems, the gall bladder can be removed.

Haemorrhoids (Piles): Varicose veins of the rectum. Veins are put under pressure and become engorged with blood. If this continues the vein wall becomes distended and leaks blood. Itching and bleeding are usually the first signs of haemorrhoids. Can be caused by constipation, low fibre diets and increased pressure upon defaecation.

Heartburn: Reflux of stomach contents into the oesophagus. HCl irritates the wall resulting in the burning pain called heartburn. It is called so because it is felt in and around the heart area. It is unrelated to any cardiac problem. Drinking alcohol, eating spicy foods, smoking, lying down after eating can cause this. Avoid foods that strongly stimulate stomach secretion like: caffeine, chocolate, tomatoes, fatty foods, orange juice, onions. Can be treated with over-the-counter remedies (rennie, gaviscon). Products like these however, should not be taken continuously as they are said to contain high amounts of aluminium.

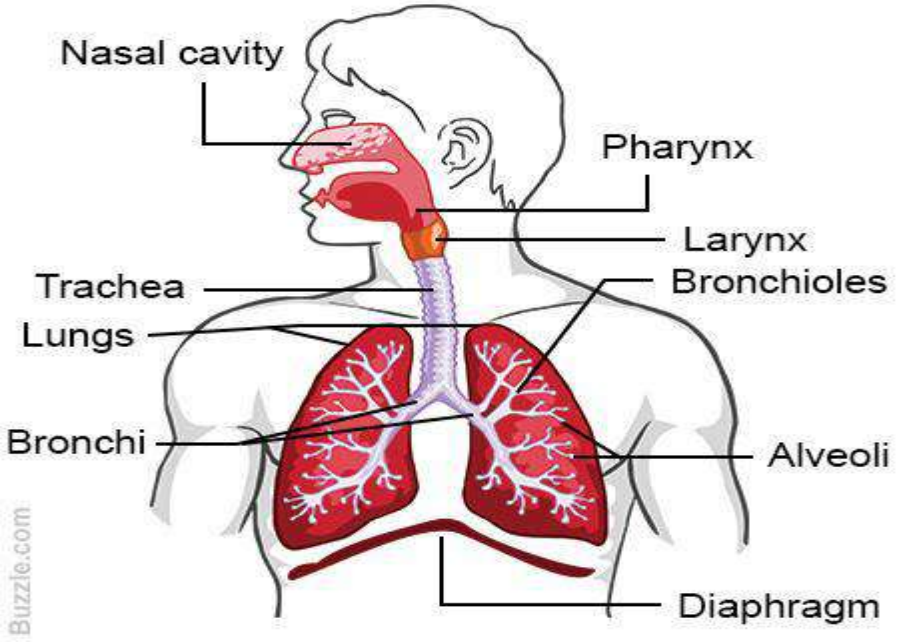
Hepatitis: Inflammation of the liver caused by viruses, drugs and chemicals, including alcohol. **A** is highly contagious transmitted via faecal-oral route - contaminated food, water or milk. **B** is more serious. It lasts longer and can lead to cirrhosis. Virus usually transmitted via infected blood, serum or plasma. Also spread by oral or sexual contact. **C** can cause acute or chronic hepatitis. Can lead to liver cancer. Transmitted via blood transfusions or blood products.

Hernia: Protrusion of all or part of an organ through a membrane or cavity wall. Usually in the abdominal cavity. *Hiatus Hernia* is the protrusion of the lower oesophagus, stomach or intestine into the thoracic cavity. Can cause acid reflux causing pain and heartburn.

Jaundice: is a yellowish coloration of the whites of the eyes, skin and mucous membranes due to a build-up of bilirubin. Bilirubin gives blood its colour. When rbc's are broken down, bilirubin travels to the liver to be processed and excreted as bile. Jaundice is caused by overproduction of bilirubin; liver damage/failure; blockage of the bile ducts.

IBS: A disease of the entire gastrointestinal tract whereby a person reacts to stress by developing symptoms such as cramp, abdominal pain and alternating patterns of diarrhoea and constipation. Flatulence, nausea and loss of appetite can occur.

Ulcer: Erosion of the walls of the digestive system, usually due to high acid levels. Inflammation occurs, pain and heartburn. Can get worse when hungry and also after irritating foods.



Structure

The Nose: Left and right cavities. Lined with cilia and mucous membrane. Nose moistens, warms and filters air on the way into lungs and it is an organ of smell.

The Nasal passage: Upper part of nasal cavity behind the nose, lined with mucous membrane. Filters, moistens and warms incoming air.

The Pharynx: Throat area behind the mouth that serves as a food and air passageway. It moistens and warms the air coming in.

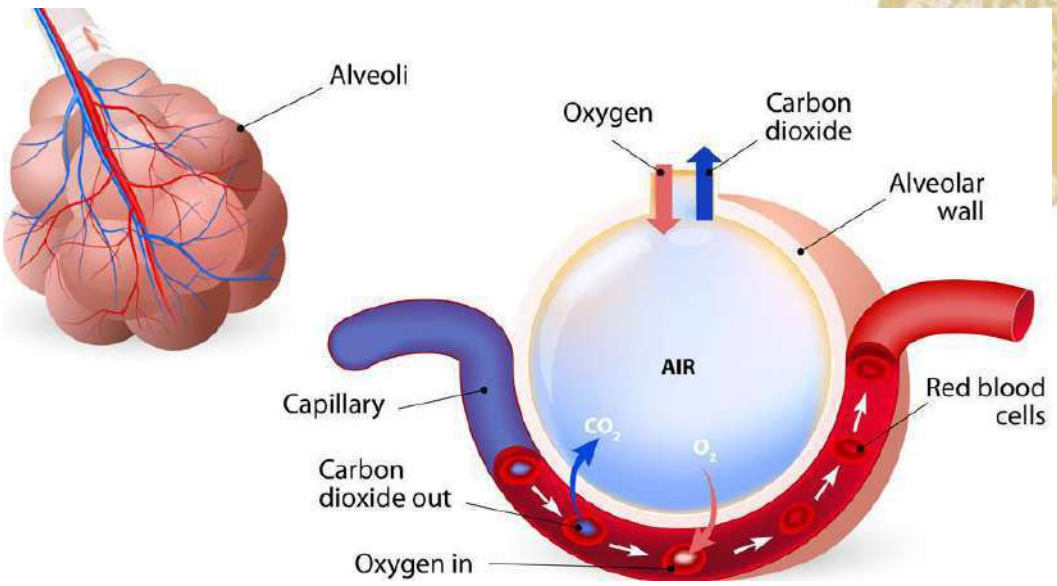
The Larynx: Connects the pharynx to the trachea. It contains the vocal cords. It is made of muscle and cartilage. This keeps the passageway open and prevents obstruction of the passageway.

The Trachea: The windpipe. Made up mainly of cartilage to keep the trachea permanently open. It passes into the thorax and connects the larynx to the bronchi, which pass into the lungs.

The Bronchi: 2 short tubes. Lead into the lungs and carry air. Lined with ciliated mucous membrane and also has cartilage to keep it open. Mucous traps dirt and the cilia move dirt upwards to prevent entry into the lungs. Bronchi divide into bronchioles in the lungs. Bronchioles further divide into alveoli which are air-filled sacs.

Lungs: Spongy organs made of elastic and connective tissue, in the thoracic cavity on either side of the heart. The pleura, a serous membrane surrounds the lungs. Internally they are made up of alveoli arranged in lobules (like a bunch of grapes). The main function of lungs is to facilitate the exchange of carbon dioxide for oxygen. The lungs have the following features:

- Large surface area
- Thin permeable membrane surrounding the alveoli
- Thin film of water lining the alveoli. This dissolves the oxygen from the air.
- Thin walled blood capillaries form a network around the alveoli. These absorb the oxygen from the air and release carbon dioxide from the body.



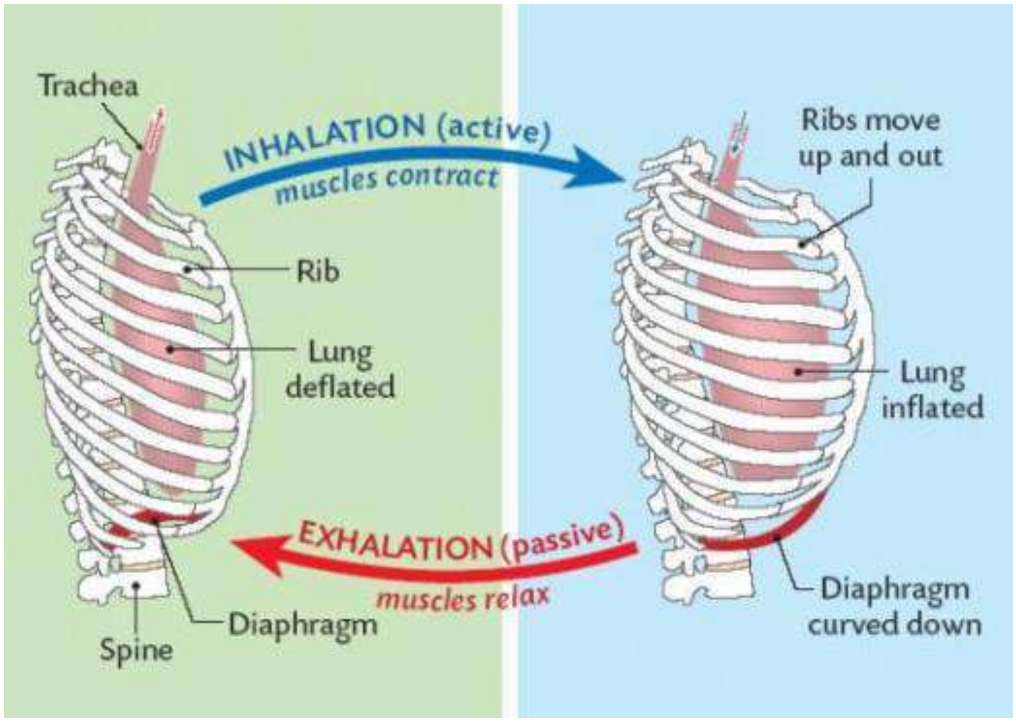
Exchange of Gases:

This involves the absorption of oxygen from the air in exchange of carbon dioxide which is released from the body as a result of normal metabolism.

- Oxygen is inhaled in air through the mouth and nose. It passes through the trachea and bronchial tubes of the alveoli. Oxygen diffuses through the thin film of moisture lining the alveoli.
- This oxygen then comes into contact with the capillaries surrounding the alveoli.
- Oxygen diffuses into the blood capillaries and is picked up by the red blood cells. This oxygen rich blood is carried away back to the heart to be pumped around the body.
- Carbon dioxide diffuses from the blood capillaries into the alveoli. It is passed from here into the bronchi and trachea and exhaled through the nose and mouth.

External & Internal Respiration

External respiration is the exchange of gases between the blood in the capillaries and the alveoli. Internal respiration is the exchange of gases between the blood capillaries and the tissue fluid.



Mechanism of Respiration

This is the means by which air is drawn in and out of the lungs. It is an active process where muscles of respiration contract to increase the volume in the **intercostal muscles.** During respiration, diaphragm contract and flattens. This increases the volume of the thoracic cavity.

External intercostals muscles contract during inspiration and increase the depth of the thoracic cavity by pulling ribs up and out.
The combined contraction of the diaphragm and the external intercostals cause an increase in thoracic volume, a decrease of internal pressure which results in air from outside the body being drawn into the lungs.

Expiration is normally a passive process whereby the muscles relax. This decreases internal thoracic volume, and causes an increase in internal pressure. The **internal intercostals** muscles facilitate this movement by depressing the rib cage. An increase in internal pressure = movement of air out of the lungs. Abdominal muscles also help on deep expiration such as during labour: the abdominal muscles such as external and internal obliques, rectus abdominus and transversalis abdominus all help to compress the abdomen and force the diaphragm upwards.

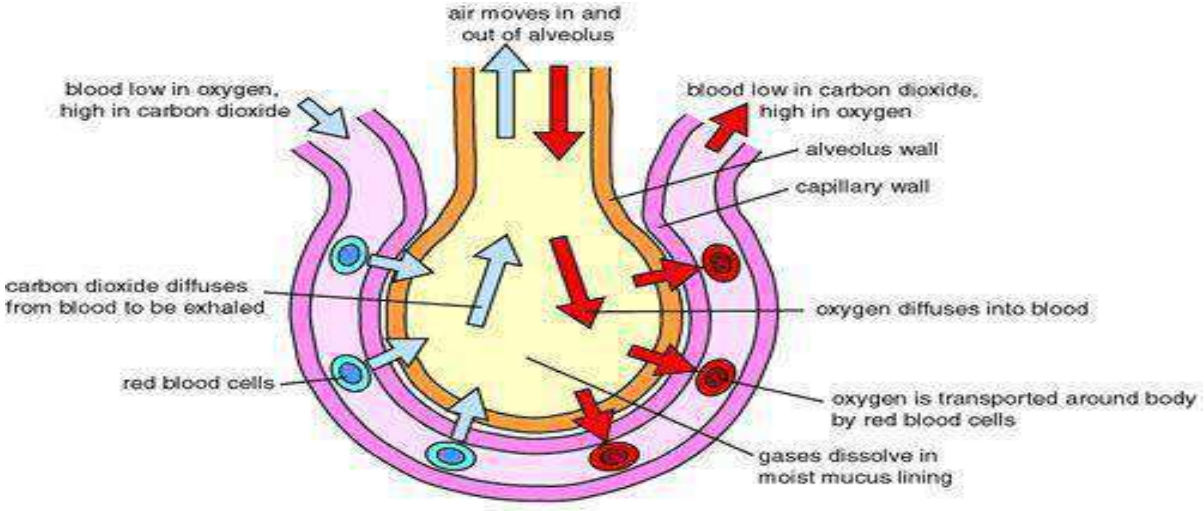
Other muscles that help our breathing processes are:
Sternomastoid, serratus anterior and the pectoralis major and minor.

Importance of correct breathing

Correct breathing is vital to ensure all cells in the body receive an adequate supply of oxygen and are able to get rid of enough carbon dioxide to allow them to function properly. Breathing affects our physiological and psychological state. Deep breathing exercises can help increase our functioning and capacity of the lungs.

Overall Functions of the Respiratory System:

1. **Ventilation:** The mechanism of flow of air into the out of the lungs
2. **Diffusion:** The diffusion of oxygen from the capillaries into the alveoli for delivery around the body and the diffusion of carbon dioxide from the blood into the lungs for expiration.
3. **Transport:** The lungs facilitate the transport of oxygen around the body in the blood and they also facilitate the transport of carbon dioxide from the blood/lungs out of the body.
4. **Tissue metabolism:** When the lungs are working efficiently, they help the body's metabolism by providing levels and oxygen sufficient for metabolism and also remove levels of carbon dioxide that could inhibit tissue metabolism.



The Olfactory System

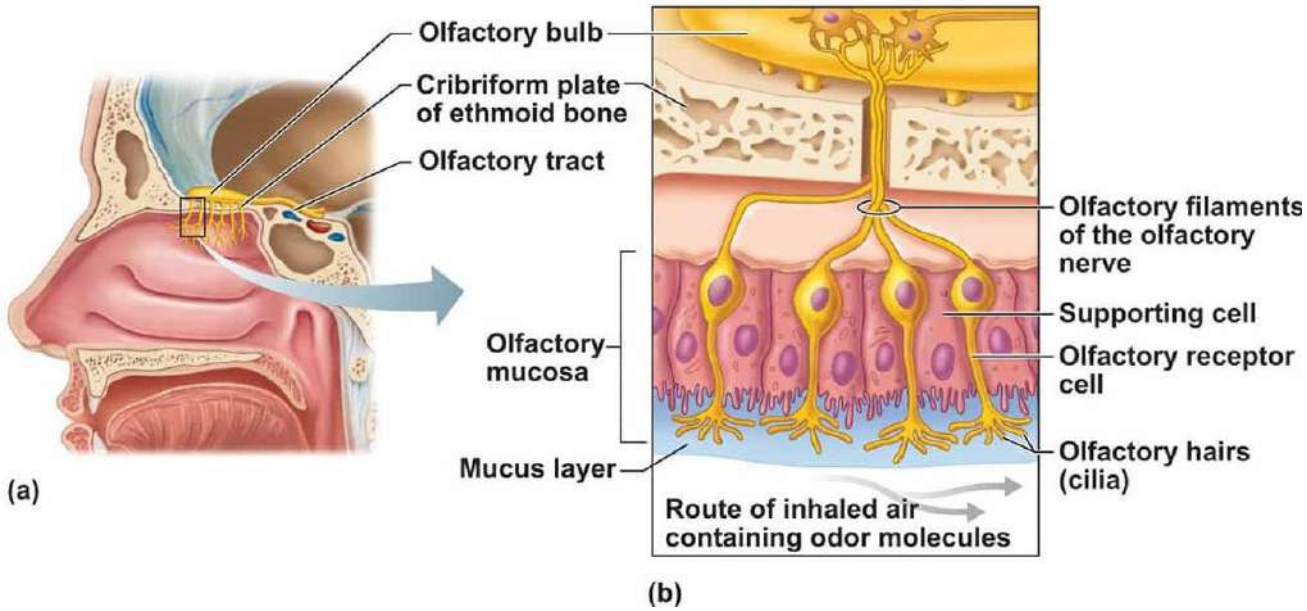
Olfaction is a special system of smell. Smells can evoke emotional responses and this is because of the close relationship to the endocrine system

Nose: This is the organ of olfaction or smell

Mucous membrane: lines the nose; moistens the air passing into the lungs. The mucous membrane helps to dissolve the odorous gas passing through the nasal cavity. Mucous membranes have a rich blood and nerve supply.

Cilia: These are able to detect odorous particles in the air and are directly connected to nerve fibres that connect to olfactory cells.

Olfactory cells: The area of the brain in the cerebral cortex that perceives smell.



Theory of Olfaction:

- Particles evaporate on contact with air
- Mucous membrane lining the nasal cavities dissolves the particles by warming and mixing them with water
- Cilia pick up olfactory information and pass it onto the olfactory cells
- Nerve fibres of the olfactory cells pass from the nose to the brain at the area of the olfactory bulb
- Smell is perceived here
- Smell can trigger physiological changes like the secretion of gastric juices in response to food smells. It can also trigger psychological changes by stimulating the **limbic** system. This is part of our brain that deals with mood, emotion, memory and motivation. This is how we react to burning essential oils (lavender = relaxation). The olfactory bulb connects closely with the hypothalamus which secretes hormones that can affect the rest of the endocrine system. For example: Endorphins help to reduce pain. Serotonin helps us to relax and be calm.

Excretion of waste products from the body is vital in order to maintain good health. There are a few different organs found within the body involved with excretion.

A The Skin

The skin functions as an excretory organ as it eliminates waste products through sweat glands.
Eccrine sweat glands are found deep in the dermis of the skin. They secrete mainly water and salts in their sweat, however, amounts of urea, uric acid, ammonia, amino acids, glucose and lactic acid are also secreted. These are found in most parts of the body, particularly in the forehead, palms and soles of the feet. These glands are not associated with body odour. Their main responsibility is to control body temperature and waste elimination.

Apocrine sweat glands are found in the dermis of the skin, sometimes attached onto a hair follicle. They are found mainly in the skin of armpits (axilla), groin, areolae and bearded regions of the face. The secretions are similar to eccrine glands except that it is more viscous and contains lipids and proteins. These glands are associated with body odour. They are stimulated during emotional stress and sexual excitement. Also involved in waste elimination.

B The Large Intestine

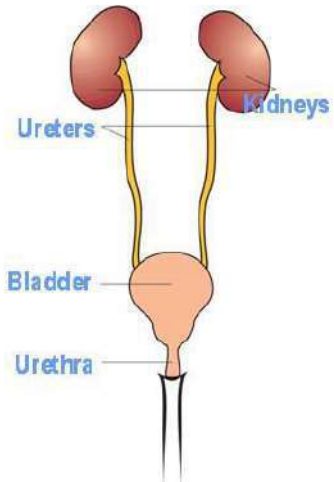
This part of the digestive system is also known as the colon. It has 4 sections: ascending, transverse, descending and sigmoid colons. The large intestine is considered an excretory organ as it rids the body of unwanted material. The nutritional substances have already been absorbed through previous digestive organs by the time the foodstuff reaches the LI. The functions of the LI are:

1. Formation and storage of faeces that contains undigested, unwanted foodstuff, dead cells and bacteria, i.e. waste.
2. Expulsion of faeces out of the body through the anus.
3. Production of mucous to lubricate the passage of faeces.
4. Absorption of most of the water from the faeces in order to conserve moisture in the body.

C The Urinary System

This system is made up of excretory organs that are involved in ***processing and eliminating normal metabolic waste*** from the body. Its primary function is to ***regulate the composition and volume of body fluids*** in order to provide a constant internal environment for the body, i.e. homeostasis.

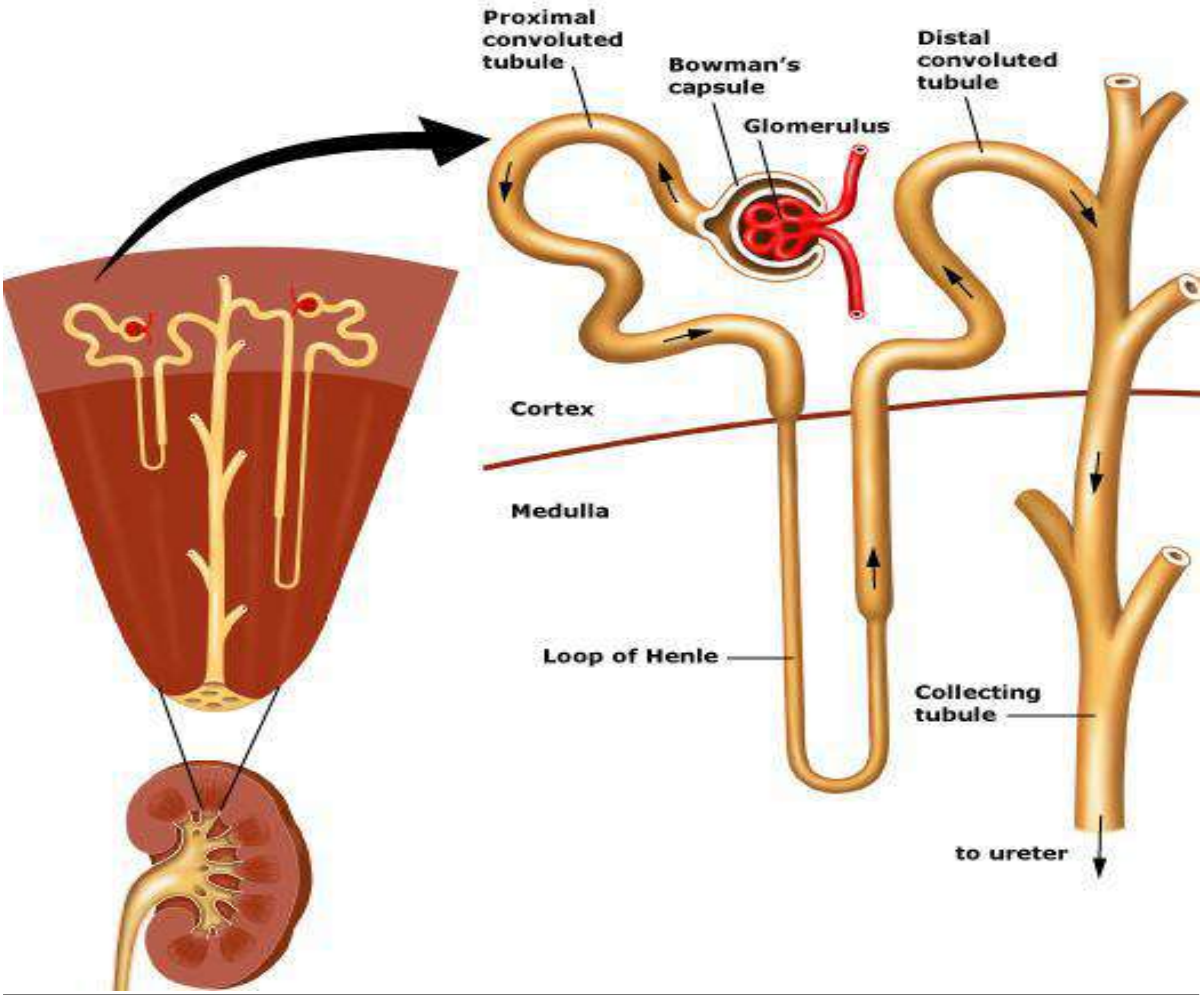
Urinary structure:
2 Kidneys
2 Ureters
1 Bladder
1 Urethra



2 Kidneys.

These lie on either side of the vertebral column between the 12th thoracic and 3rd lumbar vertebrae. They are bean shaped! 'kidney bean'. They are approximately 4 inches x 3 inches x 2.5 inches. They have an outer fibrous capsule supported by adipose tissue. Each kidney has an inner **medulla** and an outer **cortex.**

The outer cortex is deep red in colour and is where the fluid is filtered from the blood. The inner medulla is where some materials are selectively re-absorbed back to the bloodstream. The medulla is pale red and made up of conical shaped sections called **renal pyramids**. The base of the pyramids face the outer cortex, with the 'apex' facing the concave portion called the **hilum.** The hilum is where the renal artery, veins, lymphatics, nerves and ureter enters/exits the kidneys.



Functions of Kidneys

1. Regulates Blood Salt concentration: it regulates blood levels of sodium (Na+) and potassium (K+).
2. Regulates Blood pH: it excretes hydrogen ions (H+) in urine and keeps bicarbonate (HCO3) which is a vital buffer for the blood.
3. Regulates Blood Volume: it adjusts blood volume by keeping or eliminating water in the urine. This will affect Blood Pressure.
4. Regulates Blood Pressure: It secretes an enzyme Renin. Renin activates Renin-angiotensin system. High Renin = High Blood Pressure.
5. Produces Hormones: Calcitriol is active Vitamin D that regulates blood calcium levels. Erythropoietin stimulates the production of red blood cells.
6. Regulates Blood Glucose: it can use amino acids like the liver to make new glucose to add to the blood.
7. Excretes Waste for forming Urine. Wastes are ammonia, urea, uric acid, bilirubin, creatinine, drugs, toxins and foreign entities.

2 Ureters.
2 very fine muscular tubes that transport urine from the pelvis of the kidney to the urinary bladder. They have an outer fibrous layer, middle smooth muscle layer and an inner mucous membrane. They function to propel urine from the kidneys to the bladder by peristaltic contraction of their muscular walls.

1 bladder.
The reservoir for urine. Found behind the pubic symphysis. When empty the mucosa of the bladder is folded into layers called rugae. When full, the bladder expands and the rugae disappear. The bladder has an internal sphincter that relaxes when the walls contract and allows the bladder to empty.

1 Urethra.
This canal from the bladder to outside the body varies in length from men (18-20cm) to women (4cm). The urethra has an external sphincter to allow urination. Its function is to pass urine from the bladder to the exterior. In men, it also carries semen.

Formation of Urine:
The blood that needs to be processed enters the kidneys under very high pressure, via the renal artery. This blood is filtered and urine is formed in tiny structures called **nephrons** - the *functional* unit of the kidneys.
There are over 1 million nephrons per kidney. A nephron can be divided into different successive parts as follows:

Glomerulus (capillary network) - Bowman's Capsule (sac) - Proximal Convoluted tubule - Loop of Henle - Distal Convoluted Tubule - Collecting Duct.

The arteriole feeding into the glomerulus is larger than the one leaving it. This helps to maintain the high pressure needed for ***filtration*** to occur in the glomerulus. The filtered liquid continues through the convoluted tubules and Loop of Henle, which are surrounded by capillaries. Here ***reabsorption*** and ***secretion*** occur.
The 'good stuff' that the body cannot afford to lose, such as <u>water, salts (Na), glucose, minerals, amino acids and vitamins</u> are re-absorbed by these capillaries and brought back into the blood stream. 99% of filtrate is re-absorbed back into the body. 1% is excreted as urine.

The waste products of this filtration such as <u>excess</u> water, salts, urea are collected as urine in the collecting ducts, drained into the renal pelvis and passed into the ureters to drain into the bladder.

Urine is made up of water (approx. 96%), salts, protein wastes (uric acid, ammonia, urea) and it varies in colour depending on the composition and volume. Tests carried out on samples can indicate the state of health of the body and can determine the presence of illness and disease.

<u>Fluid Balance</u>
A balance between water retention and water output is controlled by the kidneys. There must be a balance between the two to try to maintain homeostasis.
We take water in through diet, digestion and metabolic activities. We lose water through the kidneys, the skin, digestion and the lungs.

1. Renin-angiotensin System: Low blood volume or low BP stimulates the release of the enzyme Renin. This induces the secretion of Angiotensin. This tells the kidneys to reabsorb Na+, H+ and water. The will raise blood volume and BP.
2. Aldosterone: High levels of Angiotensin causes the release of Aldosterone from the adrenal cortex. This results in secretion of K+ and the reabsorption of Na+ and water. This too raises blood volume and BP.

3. ADH (vasopressin: If there is a drop in blood volume, nerve receptors in the hypothalamus will tell the pituitary (posterior) to release ADH. ADH tells the kidneys to reabsorb water into the body which = high blood volume and BP.

Once the desired blood volume is reached, these processes will be inactivated. The process is ongoing in an effort to maintain homeostasis and fluid balance within the body.

Factors affecting Fluid Balance

1. Body Temperature: increased temp = increased sweating = loss of water
2. Diet: High salt intake can = high water reabsorption. This reduces volume of urine produced. Diuretics e.g. alcohol, tea, coffee can increase the volume of urine.
3. Emotions: nervousness can increase urine production.
4. Blood Pressure: High BP means more urine will be produced as blood volume is at sufficient levels already.

Some Definitions

Nephrology: The study of anatomy and physiology of the kidneys
Urology; The study of the male and female Urinary systems and the male reproductive system.
Urination: The voiding of urine from the bladder.
Micturition: Physiological process or urination, including nerve impulses and muscular responses.

Diuretics:
Substances that slow renal absorption of water and therefore increase urine flow rate. This reduces blood volume. Diuretics can be prescribed for hypertension as lowering blood volume lowers blood pressure. Naturally occurring diuretics such as caffeine are found in coffee, tea, sodas, and alcohol is in beers, spirits, etc.

Dialysis:
The removal of waste products from blood by diffusion through a selectively permeable membrane. An artificial kidney machine can do this - it directly filters a patient's blood of waste and the filtered blood returns to the body.

UTI:
Urinary Tract Infections are infections in any part of the urinary system or the presence of microbes in urine. More common in females due to shorter urethra. Painful burning on urination, urgency, low back pain and incontinence. Includes cystitis (inflammation of the bladder) and nephritis (inflammation of the kidney).

Kidney stones:
- crystals of salts present in urine solidify. They contain calcium oxalate, calcium phosphate and uric acid. Can be caused by ingestion of excessive calcium, low water intake or overactive parathyroid.