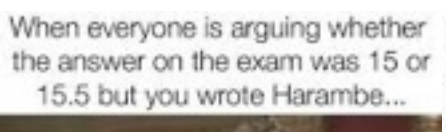
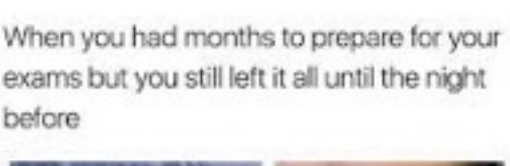
UNIT 3 + 4

HUMAN BIOLOGY NOTES

CONTENTS:

- Science Inquiry page 2 - 5
- The Endocrine System page 6 - 14
- The Central Nervous System page 15 - 29
- Homeostasis page 30 -





Science Inquiry

Important Concepts of Syllabus Context

- identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes.
- design investigations, including the procedure(s) to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics, including animal ethics.
- conduct investigations, including the collection of data related to homeostasis and the use of models of disease transmission, safely, competently and methodically for the collection of valid and reliable data.
- represent data in meaningful and useful ways, including the use of mean, median, range and probability; organise and analyse data to identify trends, patterns and relationships; discuss the ways in which measurement error, instrumental accuracy, the nature of the procedure and the sample size may influence uncertainty and limitations in data; and select, synthesise and use evidence to make and justify conclusions.
- interpret a range of scientific and media texts, and evaluate models, processes, claims and conclusions by considering the quality of available evidence, including interpreting confidence intervals in secondary data; and use reasoning to construct scientific arguments.
- select, use and/or construct appropriate representations, including diagrams, models and flow charts, to communicate conceptual understanding, solve problems and make predictions.
- communicate to specific audiences, and for specific purposes, using appropriate language, nomenclature, genres and modes, including scientific reports.

Science Inquiry

Experimental Set Up:

Hypothesis - any statement that includes directional change between independent and dependent variables

e.g. Exercise will increase your heart rate.

Independent Variable - the variable that is being changed.

e.g. Exercise or no exercise

Dependent Variable - the variable that is being measured.

e.g. Heart Rate (bpm)

Controlled Variable - the variables that stay unchanged throughout the experiment.

e.g. SAME exercise performed, SAME meal eaten before exercise, SAME clothing worn during exercise, SAME weight range of the tested group, SAME age range of the tested group, SAME level of fitness of the tested group ect.

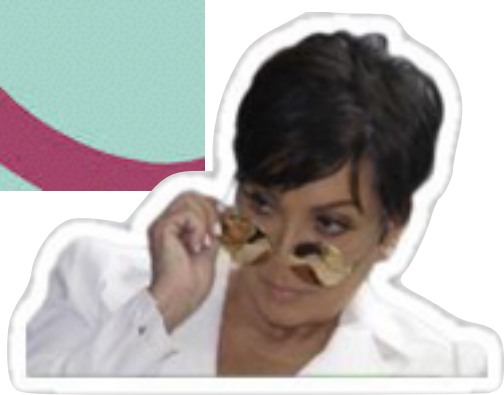
Control group - group in an experiment or study that does not receive treatment by the researchers and is then used as a benchmark to measure how the other tested subjects do.

e.g. The tested group that does not perform any exercise.

Experimental Group - group of participants who receive the drug or treatment being studied in a clinical experiment, as opposed to the control group.

e.g. The tested group that does exercise.

Placebo - a substance that has no therapeutic effect, used as a control in testing new drugs.

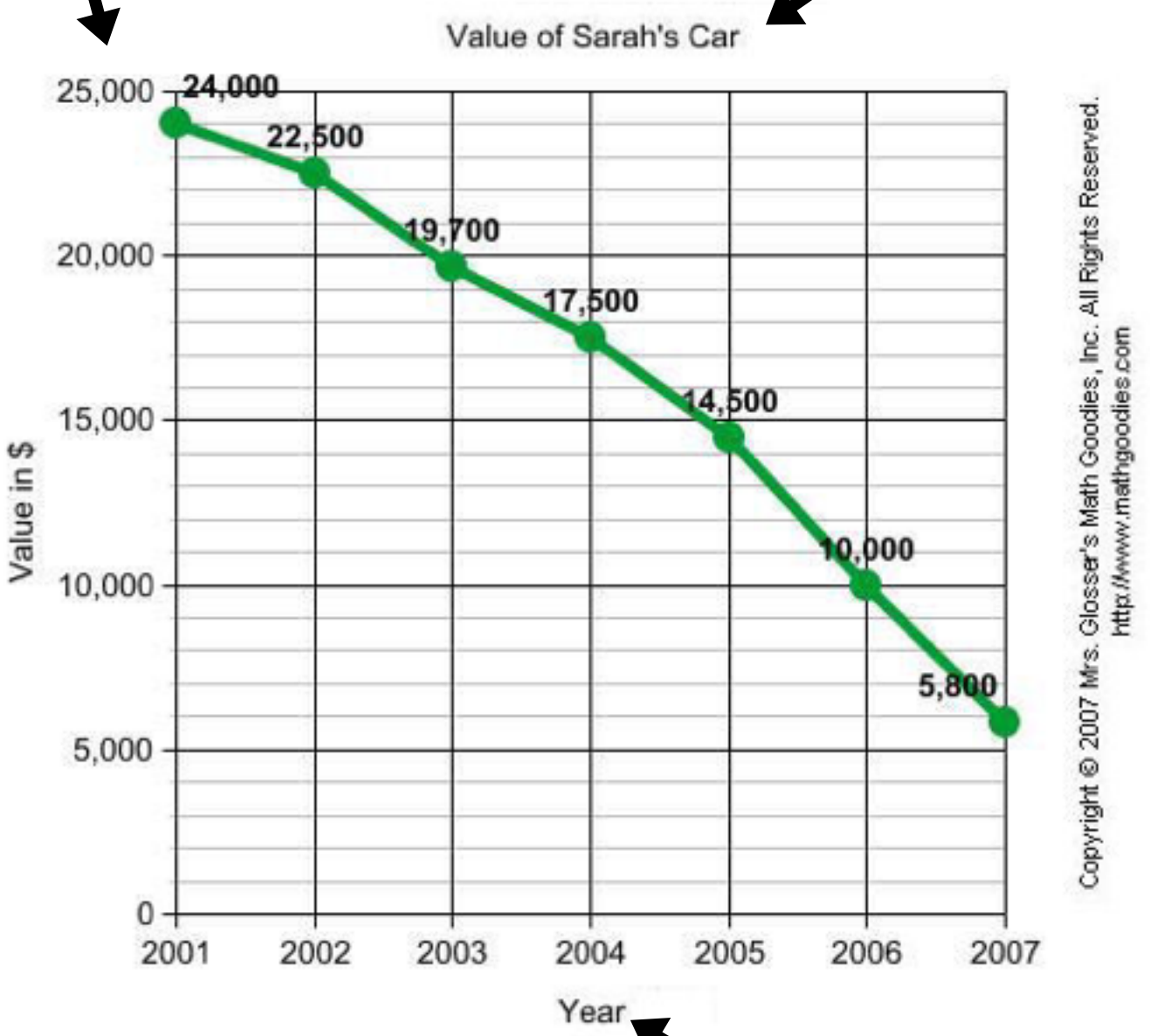


Science Inquiry

Making Graphs

Scale – keep the same scale throughout the graph [equal intervals].

Title - state the relationship between the independent and dependent variable. Could begin with "The effect of …



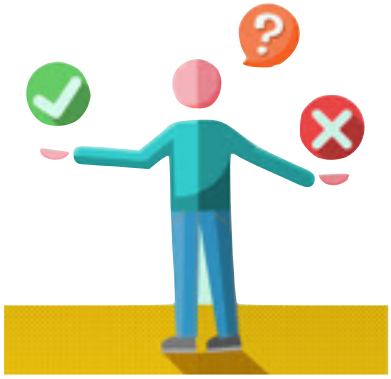
Plotting points – join each point using a ruler.

Key – when comparing two categorical data sets e.g. control v experimental group, a key should be used

Axis – independent on the x [horizontal axis] and dependent on the y [vertical axis).

Science Inquiry

Data Analysis & Fair Testing



Reliability - a measure of the extent to which the experiment gives the same result every time through repetition or replication

e.g. repeat experiment again/replicate/increase sample size/using the same equipment

Validity - the degree to which the investigation tests the question being asked

e.g. establish more controlled variables/ improve experimental design/set up fairly with precision and reliably

Patterns, Trends & Relationships - Increase/decrease, how does one variable act when another is applied.

e.g. use evidence to make and justify conclusions [from tables or graphs]

Errors:

- uncontrolled variables
- sample size uncertainty & limitations in data
- experimental error [measurement/instrument accuracy/nature of procedure]

Ethics:

e.g. voluntary participation – the subjects should not be pressured into taking part in the investigation.
informed consent – the subjects should be fully informed about the objectives of the research, the procedures to be followed, any possible risks and the potential benefits of the research; consent should only be sought after all information has been given.
risk of harm – as mentioned in the section on safety, there should be no risk of physical or psychological harm.
confidentiality – the identities of participants will not be revealed except to people directly involved in the study.

The Endocrine System

Important Concepts of Syllabus Context

- the hypothalamus, pituitary, thyroid, parathyroid, pancreas, thymus, gonads, pineal and adrenal glands, are endocrine glands found in the human body.
- hormones secreted from the hypothalamus, pituitary, thyroid, parathyroid, pancreas and adrenal glands are involved in homeostasis by affecting specific target organs.
- the secretions of the pituitary gland are controlled by the hypothalamus through transport of hormones, either via nerve cells or the vascular link between them.
- hormones can be lipid-soluble and able to cross cell membranes to bind with and activate intracellular receptors or, water-soluble and able to bind with and activate receptors on cell membranes, and require secondary messengers to affect cell functioning.
- the nervous and endocrine systems work together to co-ordinate functions of all body systems, but differ in terms of:
  - speed of action
  - duration of action
  - nature and transmission of the message
  - specificity of message

(the fifth syllabus point touches on the comparison between the endocrine & nervous systems so it's at the end of the nervous system note)

The Endocrine System

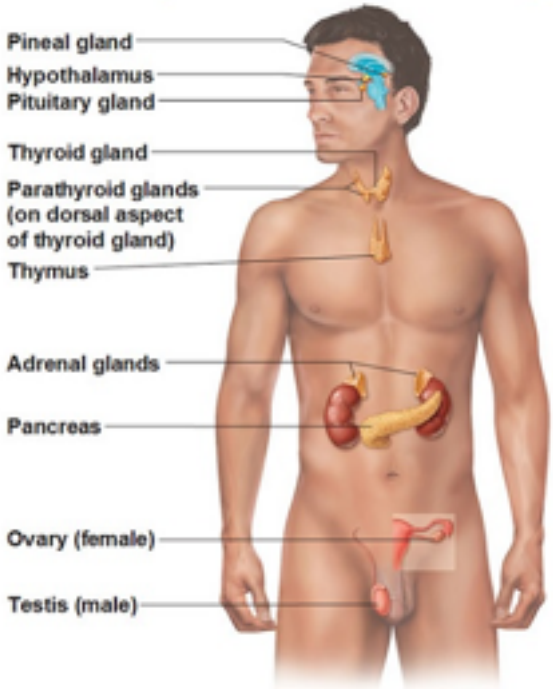
What is it?

The endocrine system is a series of glands that produce and secrete hormones that the body uses to regulate functions such as Respiration, Metabolism, Reproduction, Sensory perception, Movement, Sexual development & Growth.

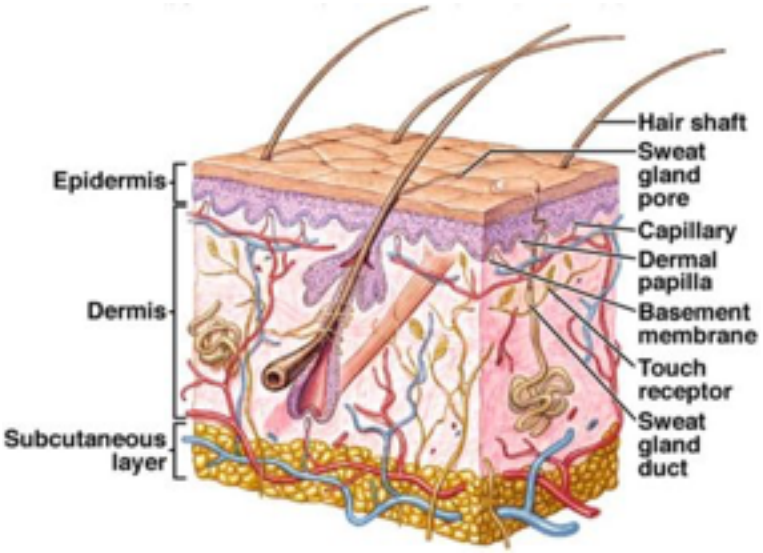
Endocrine Glands -
Endocrine glands are ductless and release their secretions directly into the intercellular fluid or into the blood.

Exocrine Glands -
Glands that secrete a substance out to the exterior of the body through ducts.

The Major Endocrine Organs

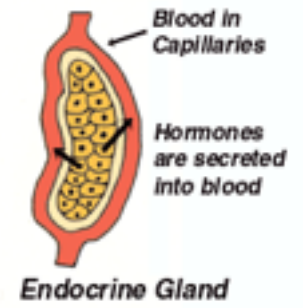


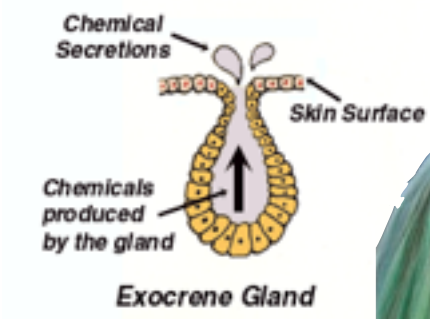
The Sweat Gland Diagram



Examples include pineal gland, hypothalamus, pituitary gland, adrenal glands, testes/ ovaries, parathyroid gland, thymus & the thyroid gland.

Some Examples are the exocrine glands include the salivary glands, sweat glands and glands within the gastrointestinal tract.



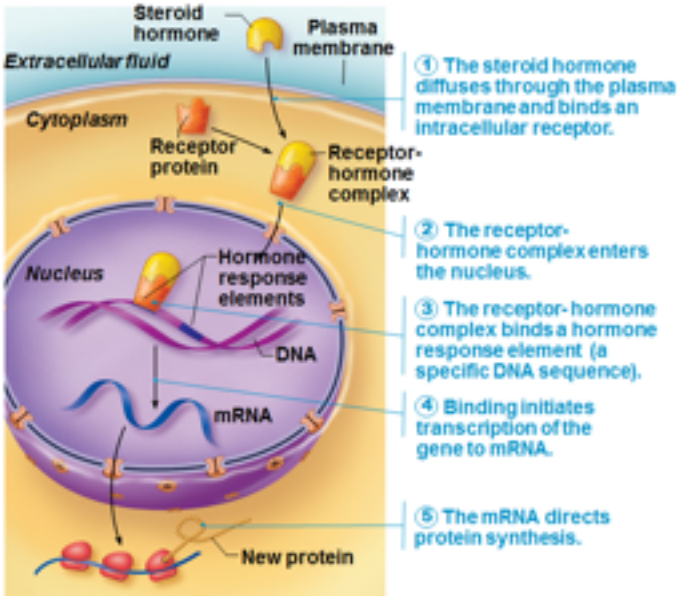


The Endocrine System

Hormones

The secretion of an endocrine gland - hormones - are chemical messengers carried in the blood stream. These include proteins, amines or steroids which act on target organs/cells to change the way they function. Hormones change the functioning of cells by altering type, activities and quantities of proteins produced through:

- activating certain genes in the nucleus so that particular enzymes/ structural proteins are produced;
- changing the shape or structure of an enzyme so that it is turned on/off;
- changing the rate of production of an enzyme/ structural protein by changing the rate of transcription or translation during protein production.



Steroid Hormones

- Made of lipid molecules, dissolving through the cell membrane as the cell membrane is made of a phosphoLIPID bilayer.

- work by entering target cells and attaching to a receptor protein in the cytoplasm of the cell.

- this complex activates protein production, acting in hours/ days.

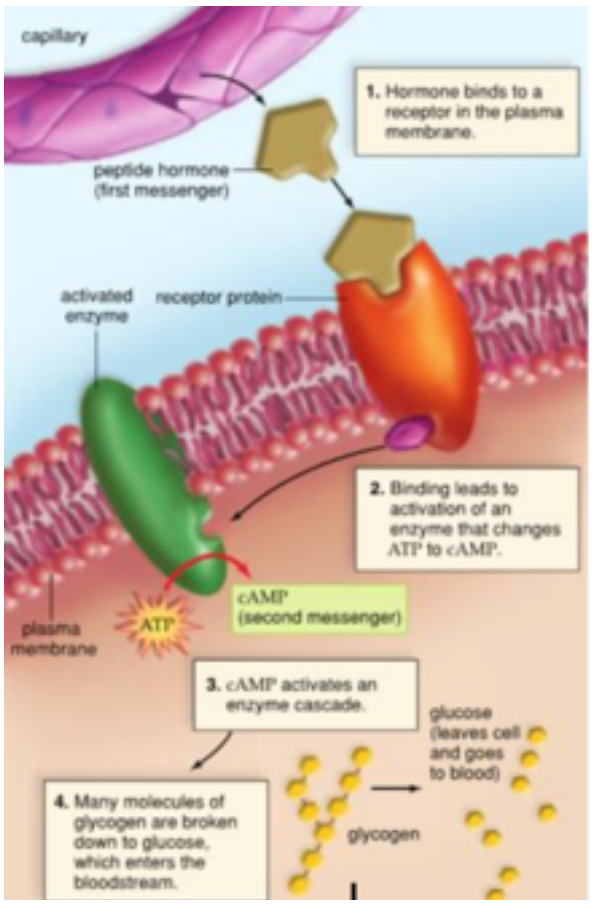
Protein/ Amine Hormones

- Made of amino acid chains, and are water soluble. Thus they can't dissolve through the partially permeable membrane without a receptor protein.

- A secondary messenger is released through the membrane to alter cell activity.

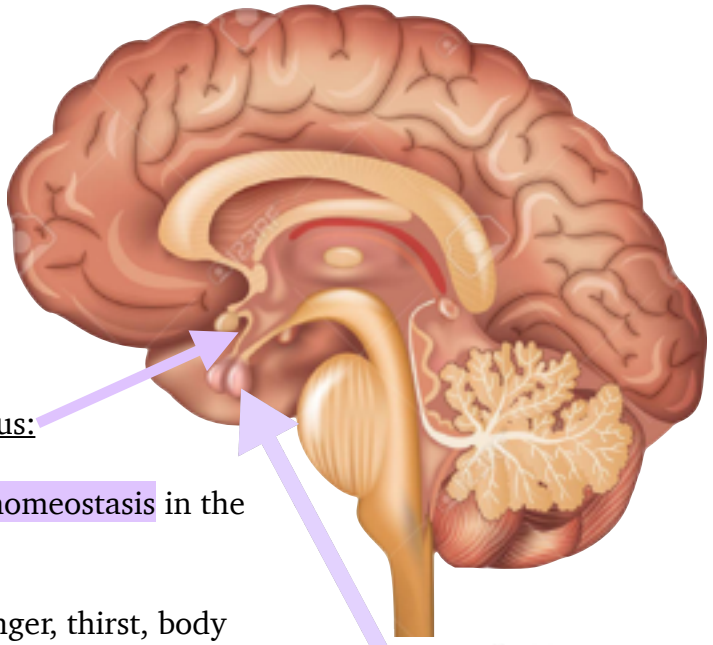
- Acts in seconds/ minutes.

- One hormone can trigger the activation of millions of enzymes. Meaning that a very small stimulus can cause a very large effect.



The Endocrine System

The Hypothalamus & The Pituitary Gland



Hypothalamus:

- The hypothalamus is the most important centre for homeostasis in the human body.
- It controls many vital bodily functions, including hunger, thirst, body temperature, and hormone secretion.
- Releases hormones stimulate the anterior pituitary gland to release its own hormones, or release inhibiting hormones that inhibit the release of pituitary hormones.
- The hypothalamus ultimately controls most of the endocrine system through its own hormones, because the pituitary gland produces the hormones that control the functions of the other endocrine glands.

Pituitary Gland:

- Connected to the hypothalamus of the brain by a tiny isthmus of nervous tissue called the infundibulum.
- Consists of two lobes - the anterior & the posterior, which function separately.

The Anterior Pituitary

- The anterior lobe has no nerves connected to the hypothalamus but is connected via a complex hypophyseal capillary network.
- Releases a number of hormones that regulate bodily functions.
- These secretions are controlled by the releasing/ inhibiting factors secreted by the hypothalamus.
- Releasing/ Inhibiting factors are really hormones themselves as they are released into the extracellular fluid and are carried by the blood to the anterior lobe of the pituitary.

The Posterior Pituitary

- The posterior lobe is not technically a true gland as it does not manufacture chemical messengers - it is joined to the hypothalamus via nerve fibres through the infundibulum to the posterior lobe.
- Hormones released from the posterior pituitary are produced in special nerve cells in the hypothalamus of the brain.
- The nerve cells have long extensions through the infundibulum.
- Hormones are stored in this lobe ready or release, triggered by nerve impulses initiated by the hypothalamus.

The Endocrine System

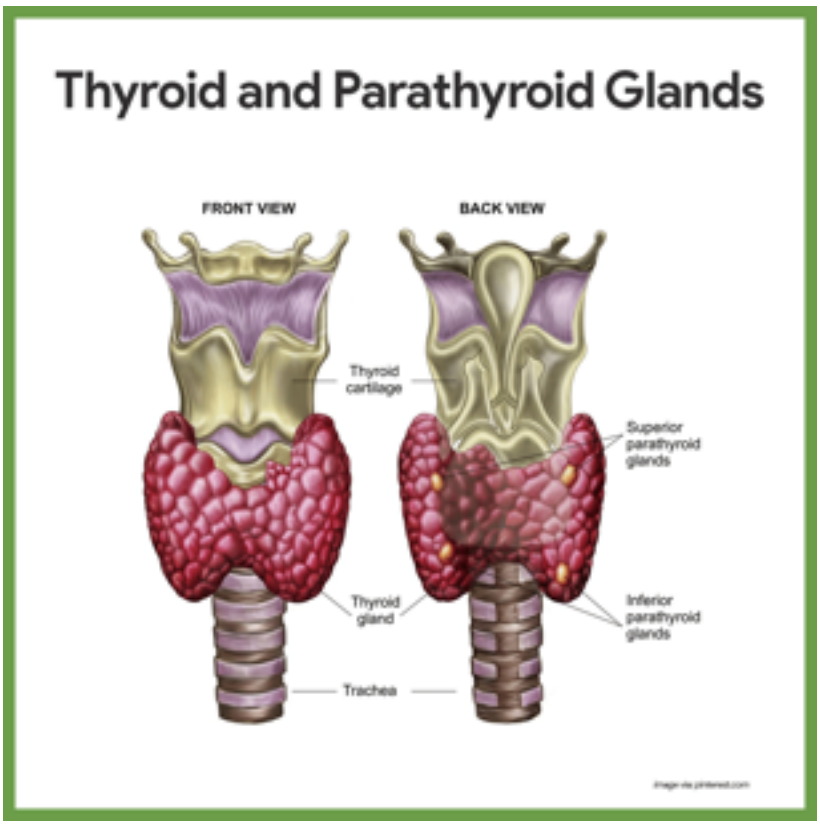
The Anterior and Posterior Pituitary Gland

Anterior Lobe of The Pituitary

Hormone	Target	Effect
Adrenocorticotropic Hormone (ACTH)	Adrenal Cortex	Secretion of Corticosteroids from the Adrenal Cortex
Follicle Stimulating Hormone (FSH)	Follicle of Ovaries Seminiferous Tubules of Testes	Growth of Follicles Production of Sperm
Growth Hormone (GH)	All cells (affects muscle tissues, skeletal tissues and damaged tissues most)	Growth and Protein Synthesis
Lutenising Hormone (LH)	Follicle of Ovaries Interstitial Cells of Testes	Ovulation & Corpus Luteum Maintenance Secretion of Testosterone
Prolactin	Mammory Glands	Milk Production
Thyroid Stimulating Hormone (TSH)	Thyroid Gland	Secretion of Thyroxine from the Thyroid Gland

Posterior Lobe of The Pituitary

Hormone	Target	Effect
Antidiuretic Hormone (ADH)	Collecting Duct and Distal Convoluted Tubule of Nephron	Increased Reabsorption of Water
Oxytocin (OT)	Uterus Mammary Glands	Release of Milk from Suckling Reflex Contractions during Childbirth



The Endocrine System

The Thyroid & Parathyroid Glands

The thyroid is a butterfly shaped gland located around the larynx and is responsible for maintaining Thyroxine levels balanced for optimal metabolic function of the body & production of Calcitonin that regulates calcium in the body. There are 4 tiny glands that are situated behind the thyroid and have a main function of producing the Parathyroid Hormone to regulate blood calcium levels.

Importance of Calcium in the Body

- To provide the means for electrical impulses to travel along nerves. Calcium is what the nervous system of our body uses to conduct electricity. This is the most important function of calcium as it provides proper functioning of our nervous system
- To provide the electrical energy for our muscular system.
- To provide strength to our skeletal system by using the bones themselves as the storage system that we use to make sure we will always have a good supply of calcium. Just like a bank vault where we constantly make deposits and withdrawals, we are constantly putting calcium into our
- bones, and constantly taking calcium out of our bones.

Gland	Hormone	Effect
Thyroid	Thyroxine - targets most cells. Calcitonin - targets osteocytes.	Stimulates metabolic activities and thus raises the metabolic rate. Reduces blood calcium levels.
Thyroid	Parathyroid Hormone - targets osteoclasts & the small intestine.	Increases blood calcium levels.

The Endocrine System

The Adrenal Glands

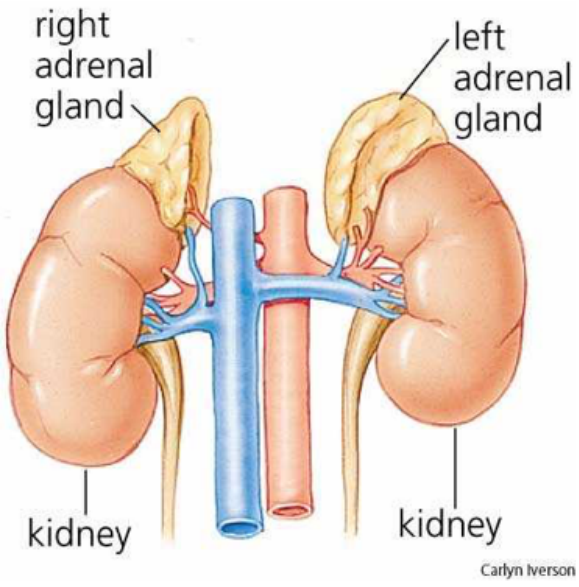
Two glands located on top of each kidney. They are composed of an adrenal medulla on the inside and an adrenal cortex on the outside. These two parts have different responsibility in the body & thus considered as separate glands.

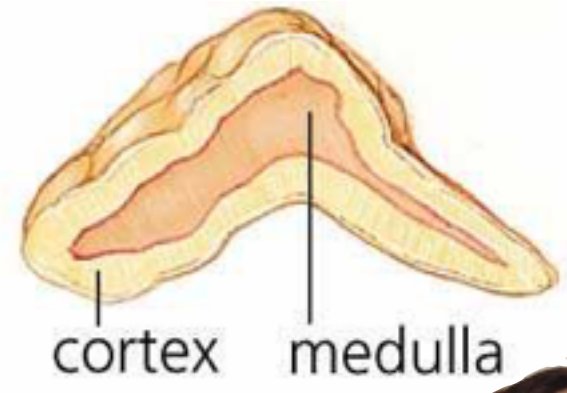
Adrenal Medulla

Hormone	Target	Effect
Adrenaline	Most Cells	Fight/ Flight Responses
Noradrenaline	Most Cells	Fight / Flight Responses (particularly increasing the rate & force of the heartbeat)

Adrenal Cortex

Hormone	Target	Effect
Aldosterone	Loop Of Henle, Distal Convoluted Tubule & The Collecting duct in the nephron.	Reduces amount of sodium & increase amount of potassium in the urine (increases sodium levels in the blood)
Cortisol	Most Cells	Promotes normal metabolism to withstand stress & increase blood glucose





The Endocrine System

The Pancreas

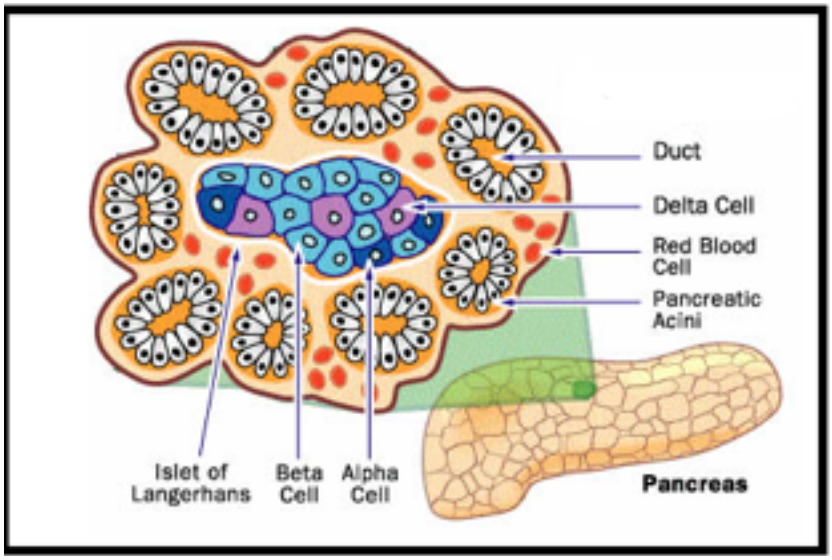
Functioning as an exocrine gland, the pancreas excretes enzymes to break down the proteins, lipids, carbohydrates, and nucleic acids in food.
Functioning as an endocrine gland, the pancreas secretes the hormones insulin and glucagon to control blood sugar levels throughout the day.

The Islets of Langerhans

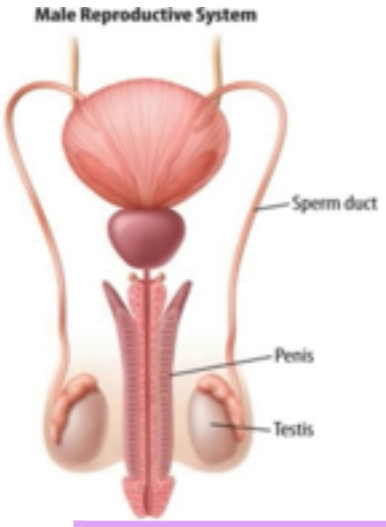
These irregularly shaped patches of endocrine tissue located within the pancreas are comprised of two types of cells - the beta cell & the alpha cell.

The beta cells produce insulin which:
- promotes the uptake and metabolism of glucose by the body cells.
- prevents the release of glucose by the liver (conversion of glucose to glycogen & fat).
- causes muscle cells to form glycogen from glucose.
- promotes the conversion of glucose in fat storage tissue to fat.

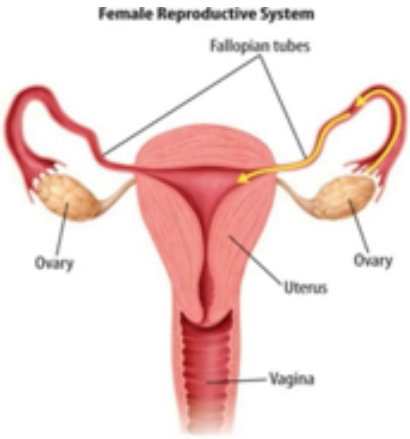
The alpha cells produce glucagon which:
- promote breakdown of glycogen to glucose in the liver.
- stimulates the breakdown of fat in the liver & fat storages.



Hormone	Target	Effect
Insulin	Most Cells Liver Skeletal Muscles Fat Storage Tissue	Lowers blood glucose levels
Glucagon	Liver Fat Storages	Raises blood glucose levels



The Endocrine System

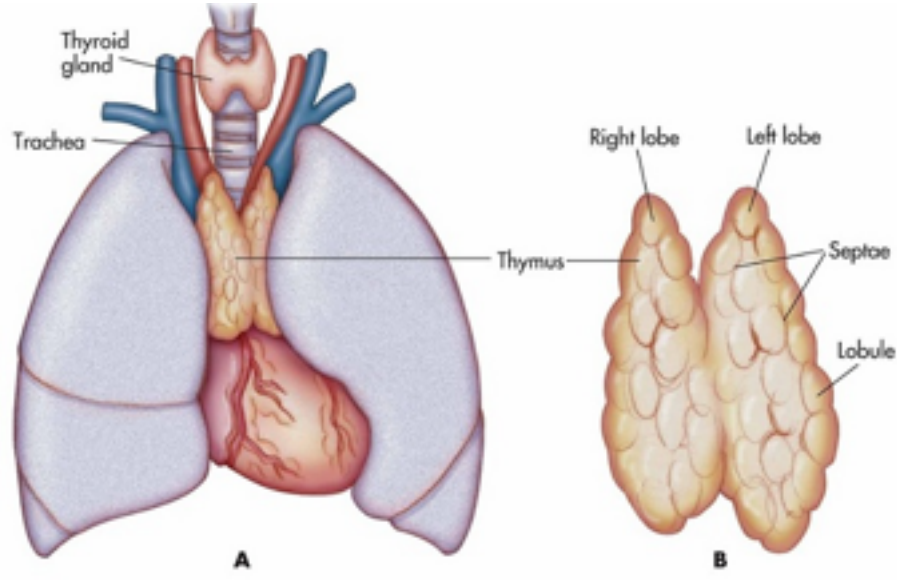


The Gonads

Gland	Hormone	Effect
Testes	Testosterone - targets many tissues.	Stimulates sperm production, male sexual characteristics & grows the skeleton and muscles.
Ovaries	Oestrogen - targets many tissues.	Stimulates the development of female sexual characteristics and the regulation of the menstrual cycle.
	Progesterone - targets the uterus and mammary glands.	Regulates the menstrual cycle and pregnancy and prepares the mammary glands of milk production.

The Thymus

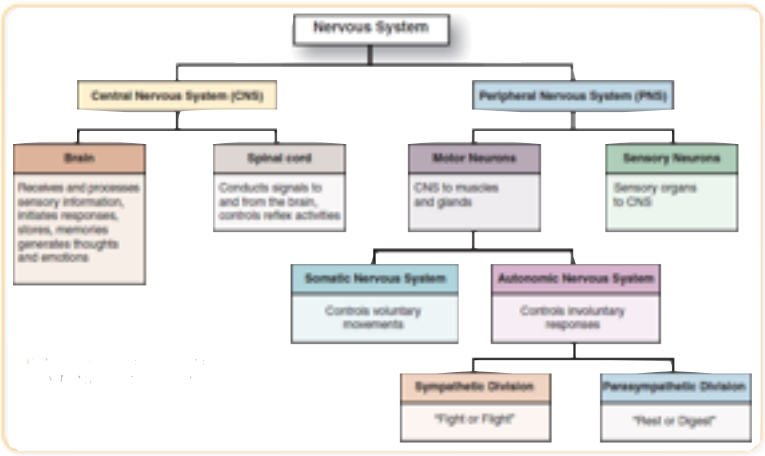
Located just above the heart the thymus plays a very important part in response to disease. The thymus releases a group of hormones called thymosins which influences the maturation of disease fighting cells (T- Lymphocytes).



The Nervous System

Important Concepts of Syllabus Context

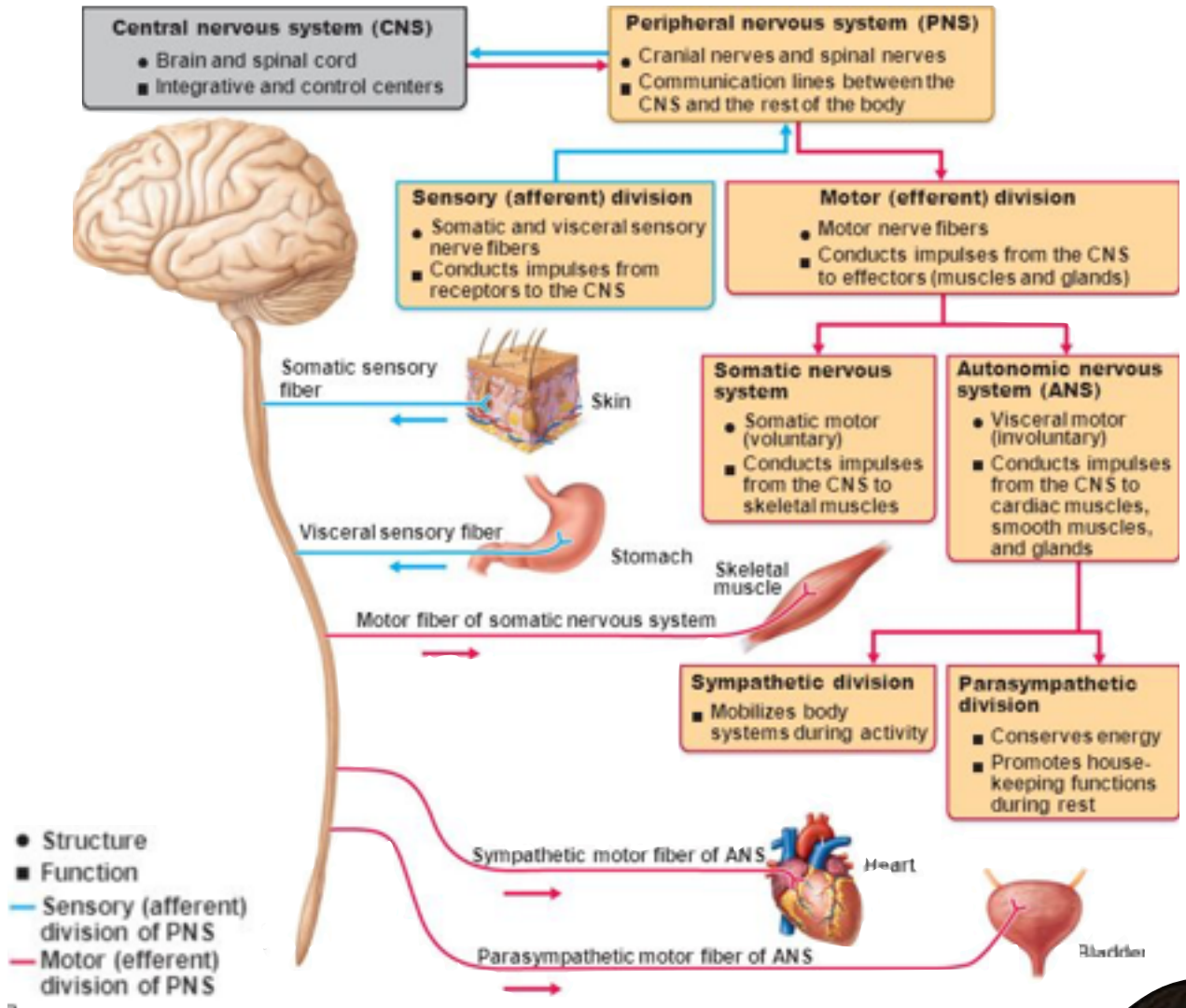
- structure and function of the divisions of the nervous system can be observed and compared at different levels in detecting and responding to the changes in the internal and external environments including:
  - central-peripheral
  - afferent-efferent
  - autonomic-somatic
  - sympathetic-parasympathetic
- the parts of the central nervous system, including the brain (cerebrum, cerebellum, medulla oblongata, hypothalamus, corpus callosum) and spinal cord, have specific roles in the co-ordination of body functions and are protected by the meninges and cerebrospinal fluid.
- different receptors detect changes in the internal and external environments, including thermoreceptors, osmoreceptors, chemoreceptors and receptors for touch and pain
- the reflex arc comprises of specially structured neurons, including sensory, interneuron and motor neurons, to transmit information from the receptor to the effector to respond rapidly to stimuli
- transmission of nerve impulses is via electro-chemical changes that occur at the generation of the impulse, the propagation of the impulse along the nerve fibre, and the transfer of the impulse across the synapse
- the nervous and endocrine systems work together to co-ordinate functions of all body systems, but differ in terms of:
  - speed of action
  - duration of action
  - nature and transmission of the message
  - specificity of message



The Nervous System

The Divisions of the Nervous System

The nervous system consists of the *brain, spinal cord, sensory organs, and all of the nerves that connect these organs with the rest of the body*. Together, these organs are responsible for the control of the body and communication among its parts. The central nervous system (CNS) is the brain and spinal cord, and the peripheral nervous system (PNS) is everything else.



The Nervous System

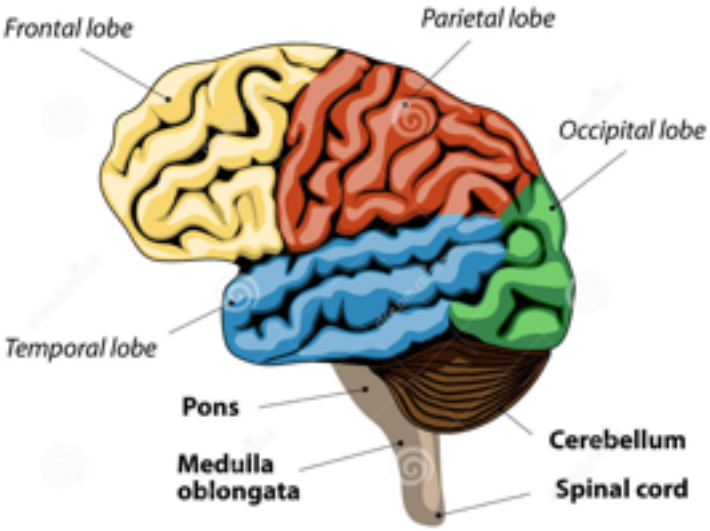
Central Nervous System

Made up of the brain and spinal cord.

- The brain plays a central role in the control of most bodily functions, including awareness, movements, sensations, thoughts, speech, and memory.

- The spinal cord is connected to a section of the brain called the brainstem and runs through the spinal canal. Cranial nerves exit the brainstem. The spinal cord carries signals (messages) back and forth between the brain and the peripheral nerves. Some reflex movements can occur via spinal cord pathways without the participation of brain structures.

The Brain

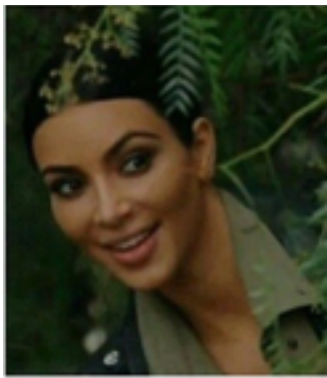


The brain is composed of the cerebrum, cerebellum, and brainstem. It is highly convoluted - meaning it has many folds and creases (fissures, sulci, and gyri). The folds in the brain add to its surface area and therefore increase the quantity of information that can be processed. The brain receives information through our five senses - often many at one time. It assembles the messages in a way that has meaning for us, and can store that information in our memory. The brain controls our thoughts, memory and speech, movement of the arms and legs, and the function of many organs within our body.

Cerebrum - is the largest part of the brain and is composed of right and left hemispheres. It performs higher functions like interpreting touch, vision and hearing, as well as speech, reasoning, emotions, learning, and fine control of movement.

It is made up of grey matter on the outside (cerebral cortex), then white matter underneath the cerebral cortex and is finished off with grey matter on the deepest region of the cerebrum.

Cerebral Cortex - thin layer of the brain that covers the outer portion of the cerebrum and the cerebellum. The cortex is often referred to as grey matter.

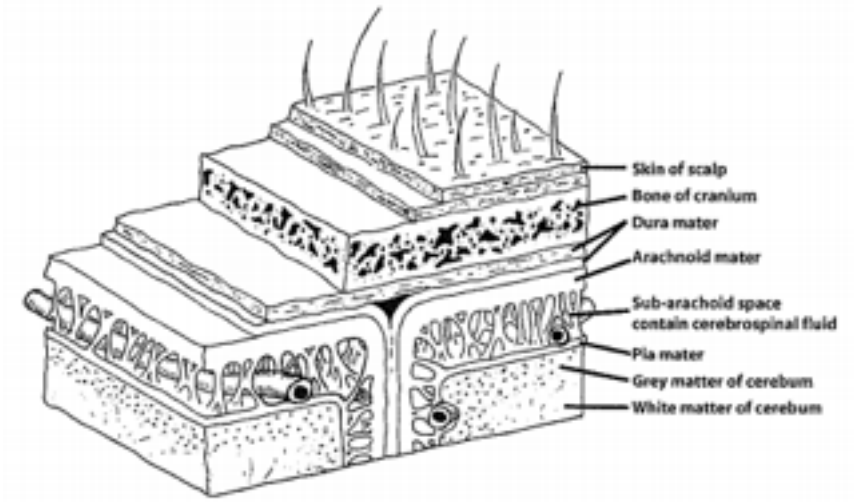


The Nervous System

Protection of the Central Nervous System

The Meninges:

The entire central nervous system is wrapped in three layers of the meninges that function to protect the delicate tissues of the brain and the spinal cord. While the skull protects the brain from blunt force trauma, the meninges protect the brain from getting damaged due to contact inside of the skull.



The first layer is the ***dura mater.*** The dura mater is the outermost layer that is a dense, tough and fibrous membrane that is made up of bundles of collagen fibres. It contains larger blood vessels that split into capillaries in the pia matter.

The middle layer is the ***arachnoid mater*** loose spider- like mesh of (collagen) fibres with the supply of blood vessels. It is a thin, transparent membrane that is impermeable to fluid.

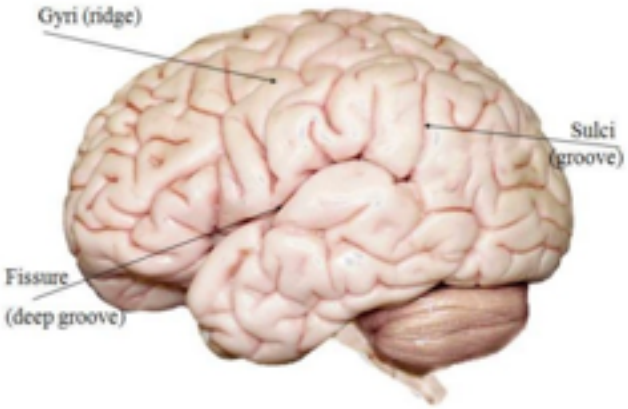
The ***pia mater*** is the innermost layer of the meninges and is directly adherent to the surface of the brain and spinal cord itself to protect delicate tissues. The void in between the arachnoid and pia mater is called the subarachnoid space. This space holds the central nervous system's cerebrospinal fluid.

The Cerebrospinal fluid:

A clear, water fluid that contains glucose, protein, urea and salts and sits in between the arachnoid and pia mater. It circulates through the cavities of the brain, providing nutrients to the brain and spinal cord and removing waste products. The cerebrospinal fluid acts as a shock absorber, cushioning the central nervous system from any shocks it may receive.

The Nervous System

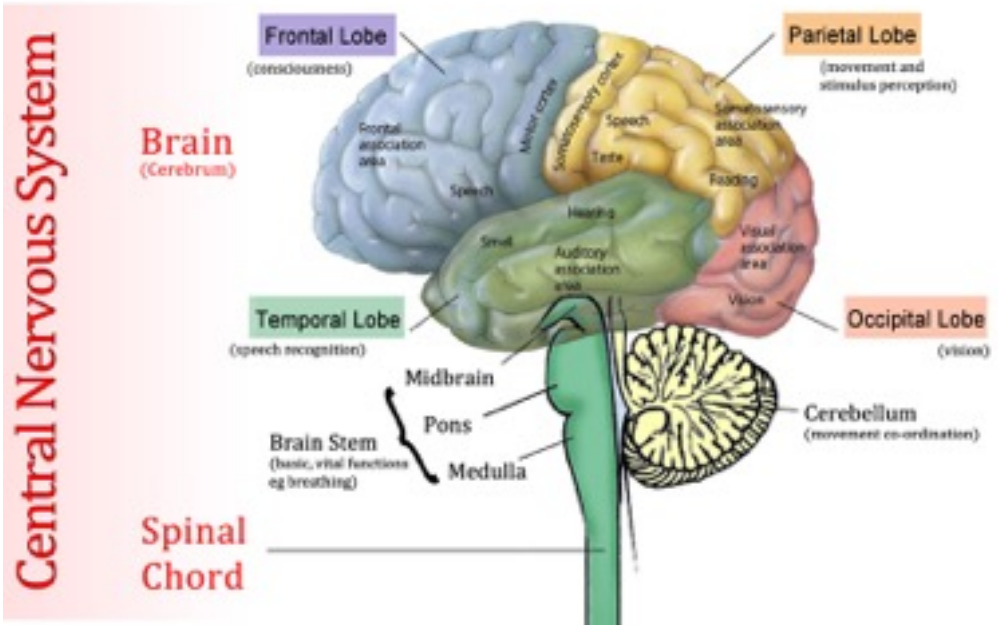
Cerebrum



Gyri - ridge on the surface of the brain.

Sulci - is a groove in the cerebral cortex.

Fissure - the deep furrows in the cerebral cortex.



Frontal Lobe - located at the front of the brain and is associated with reasoning, motor skills, higher level cognition, and expressive language. Damage to the frontal lobe can lead to changes in socialisation, and attention as well as increased risk-taking.

Parietal Lobe - located in the middle section of the brain and is associated with processing tactile sensory information such as pressure, touch, and pain. Damage to this area would make it difficult to receive and process sensory information.

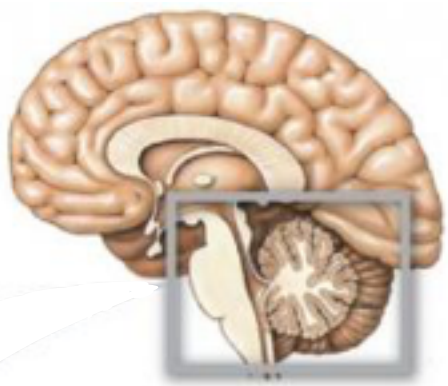
Temporal Lobe - located on the bottom section of the brain. This lobe also locates the primary auditory cortex, which is important for interpreting sounds and the language we hear. Damage to the temporal lobe can lead to problems with memory, speech perception, and language skills.

Occipital Lobe - located at the back portion of the brain and is associated with interpreting visual stimuli and information. Damage to this lobe can cause visual problems such as difficulty recognising objects, an inability to identify colours, and trouble recognising words.

The Nervous System

Structures of the Brain

The Cerebellum:



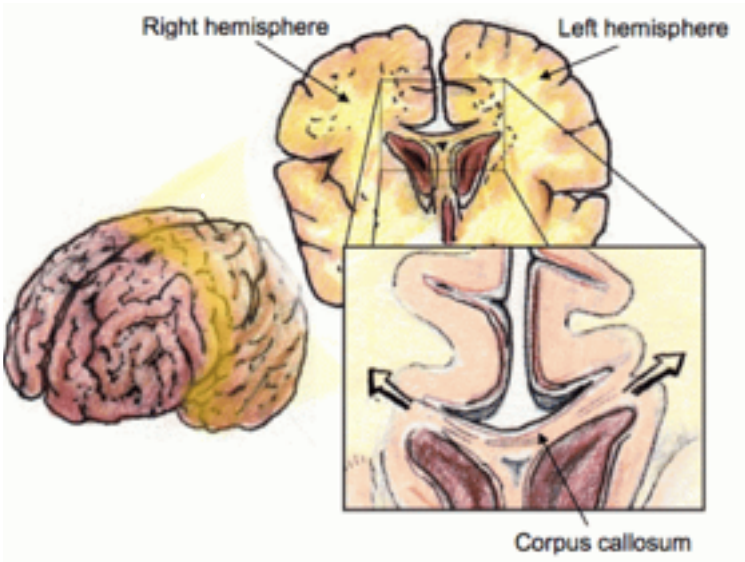
Located behind the top part of the brain stem (where the spinal cord meets the brain) and is made of two hemispheres. Its main functions are:

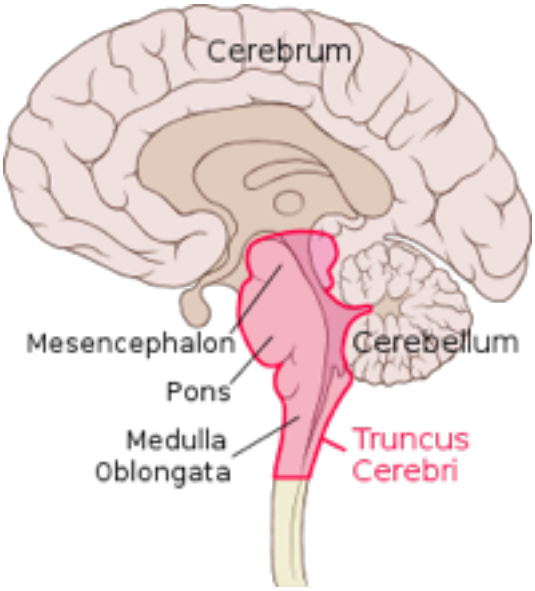
• Coordinating movement: Most body movements require the coordination of multiple muscle groups. The cerebellum fine tunes muscle actions so that the body can move smoothly.

• Maintaining balance: The cerebellum has special sensors that detect shifts in balance and movement that come from our ears. It then sends signals for the body to adjust and move.

The Corpus Callosum

Located between the two hemispheres of the cerebellum, the Corpus Callosum is the part of the mind that allows communication between the two hemispheres of the brain. It is responsible for transmitting neural messages between both the right and left hemispheres.





The Medulla Oblongata

The medulla oblongata is located in the brain stem. It regulates all primary bodily functions. The medulla oblongata helps regulate breathing, heart and blood vessel function, digestion, sneezing, and swallowing. This part of the brain is the centre for respiration and circulation

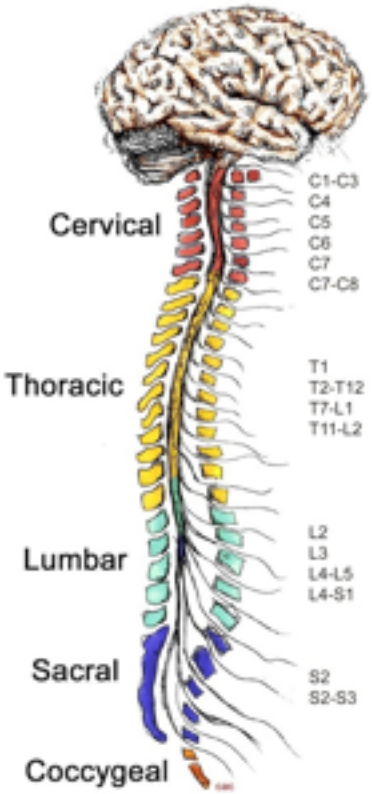
The Nervous System

Structures of the Brain

The Hypothalamus

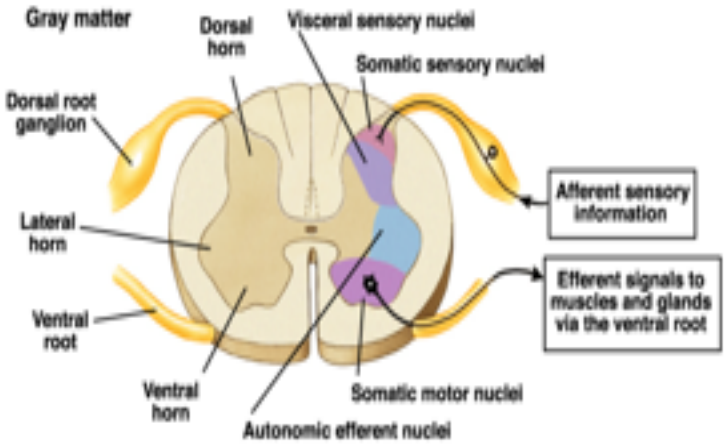
The hypothalamus is a small region of the brain. It's located at the base of the brain, near the pituitary gland accounting for the following:

- releasing hormones
- regulating body temperature
- regulating heart rate & blood pressure
- controlling appetite
- managing of sexual behaviour
- regulating sleep patterns



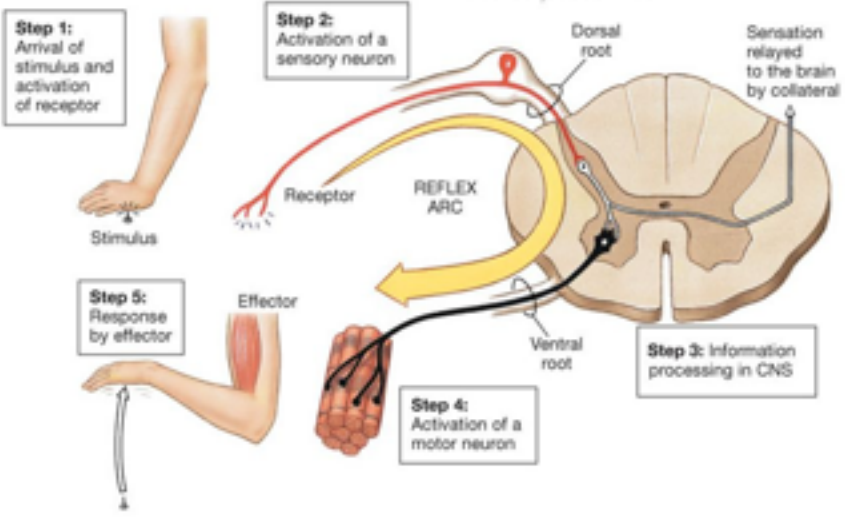
The Spinal Cord

Is made up of a cylinder of nerves that relay messages between the brain and the rest of the body. It stretches from the medulla oblongata (the stem of the brain), at the base of the brain, to the lower back, and is housed in a tunnel made by the vertebrae (bones) of the spinal column.



In each of the spinal cord's many segments lives a pair of roots that are made up of nerve fibres. These roots are referred to as the *dorsal* (which is towards the back) and the *ventral* (which is away from the back).

- conducts sensory information from the peripheral nervous system (both somatic and autonomic) to the brain.
- conducts motor information from the brain to our various effectors in skeletal muscles,cardiac muscle, smooth muscle, glands
- serves as a minor reflex center



The Nervous System

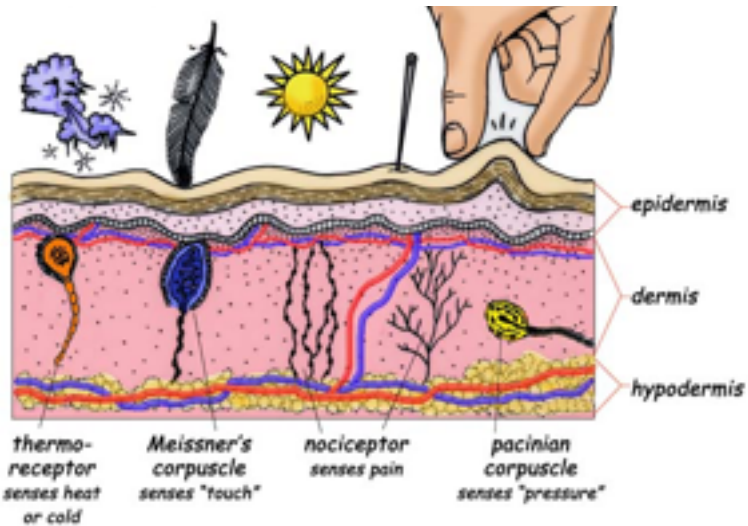
Reflex Arc

A reflex action, is an involuntary and nearly instantaneous movement in response to a stimulus. A reflex does not require any thought input. Example: When a person accidentally touches a hot object, they automatically jerk their hand away without thinking.

The path taken by the nerve impulses in a reflex is called a reflex arc, the reflex message most often does not reach the brain. This characteristic allows reflex actions to occur relatively quickly by activating spinal motor neurons without the delay of routing signals through the brain, although the brain will receive sensory input while the reflex action occurs.

The reflex arc involves only three neurons. The **stimulus**, such as a needle stick, stimulates the pain receptors of the skin, which initiate an impulse in a **sensory neuron**. This travels to the spinal cord where it connects, via a **synapse**, to a connecting neuron called the relay neurone situated in the spinal cord. The **relay neurone** in turn makes a synapse with one or more **motor neurones** that transmit the impulse to the muscles of the limb causing them to contract and pull away from the sharp object.

Receptor	Stimulus	Location
Pain Receptors	damage to cells and tissues	All of the body (they are free nerve endings)
Touch Receptors	Pressure, vibrations and light touch	The skin
Temperature receptor (Thermoreceptors)	temperature - two types (hot/cold) both internal & external temperatures	Hypothalamus & Skin
Chemoreceptors	Oxygen, PH and Carbon Dioxide level changes	Medulla Oblongata, carotid and aortic bodies.
Osmoreceptors	Osmotic pressure	Hypothalamus



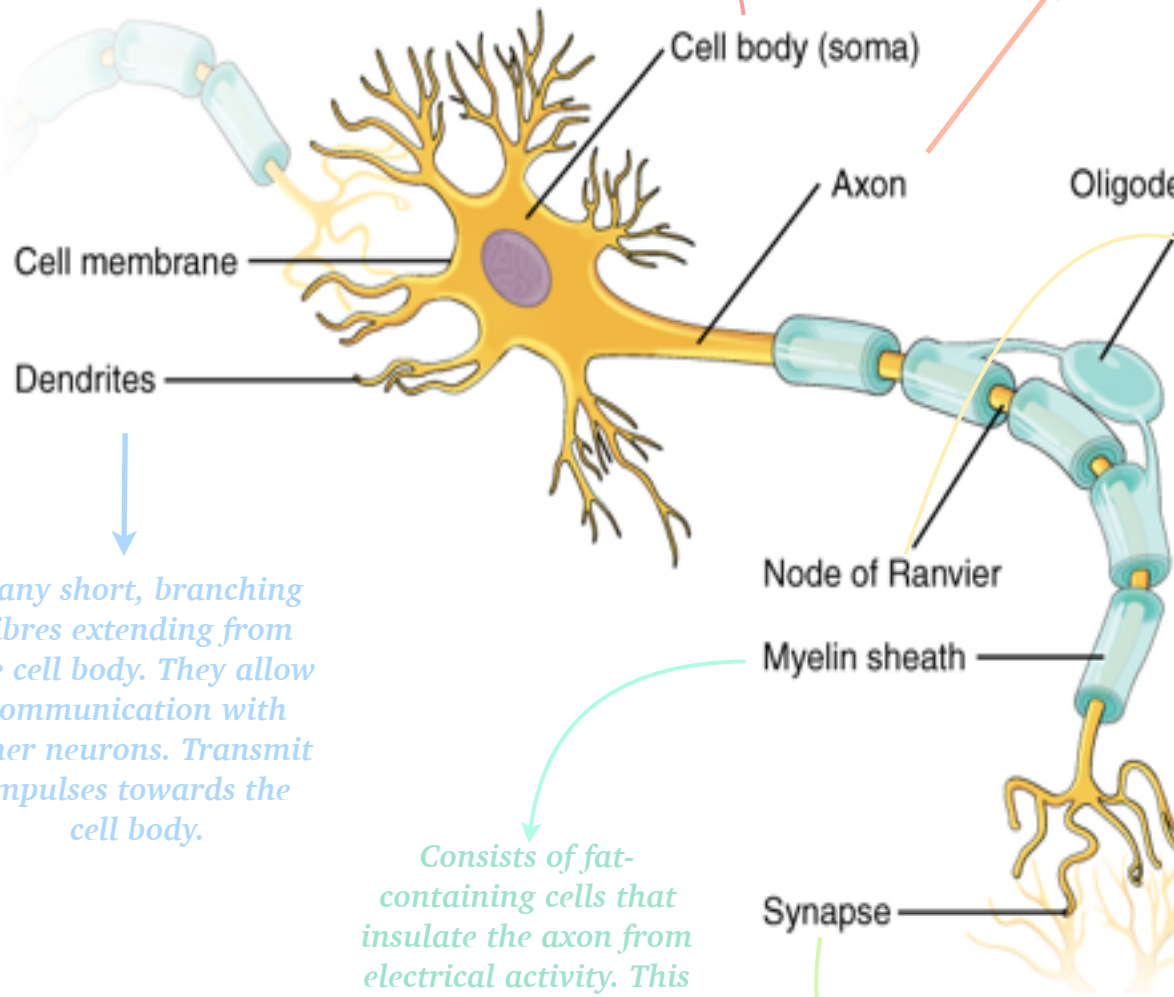
The Nervous System

Neuron Structure

Neurons are the basic units of the nervous system that transmit information to other nerve cells, gland cells or muscle cells.

The nucleus of the cell, which contains all of the genetic material for replication and protein production.

Long slender projection of a nerve cell that conducts electrical impulses away from the neuron's cell body.



Many short, branching fibres extending from the cell body. They allow communication with other neurons. Transmit impulses towards the cell body.

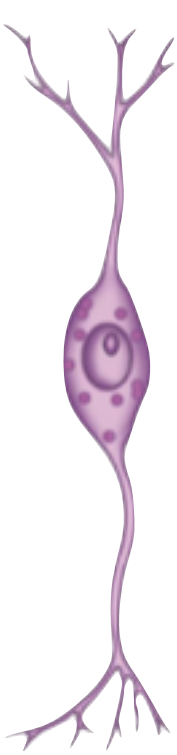
The spaces between the myelin coating on the neuron's axon for better propagation of a signal along the neuron.

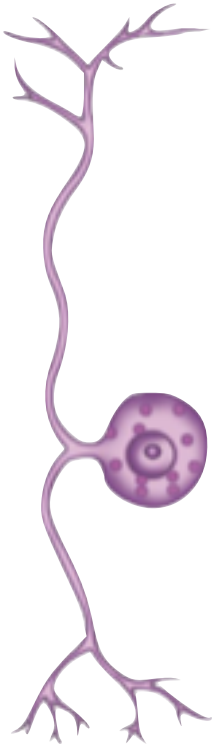
Consists of fat-containing cells that insulate the axon from electrical activity. This insulation acts to increase the rate of transmission of signals.

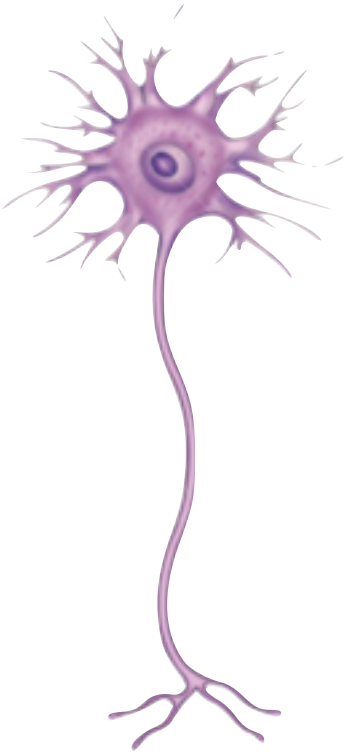
Point of connection between two neurons or between a neuron and a muscle or gland. Electrochemical exchange between neurons takes place at these junctions.

The Nervous System

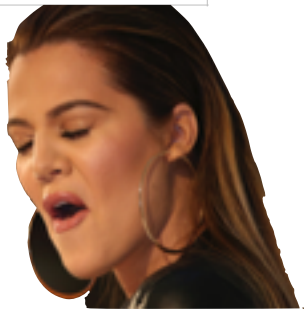
Types of Neurons







Type:	Relay/ Interneuron	Sensory Neuron	Motor Neuron
Structure:	Multipolar	Unipolar	Bipolar
Location:	- found exclusively in the central nervous system (the brain and spinal cord). - cell bodies in grey matter between the motor & sensory.	- sensory neurons going into the spinal cord has the cell body in the dorsal root ganglia and axons extending out from both sides.	- cell body is in the spinal cord connecting to the relay neuron and the axon extending from the spinal cord to the effector.
Function:	- connect the sensory and motor neurons to transfer signals between the two.	- afferent neurons that carry impulses towards the central nervous system. - passes through the **DORSAL** root of the spinal nerves.	- efferent neurons that carry impulses away from the central nervous system to the effector - passes through the **VENTRAL** root of the spinal nerves



The Nervous System

Electrical Propagation of The Nerve Impulse

The transmission of a nerve impulse from one end of a neuron to the other occurs because of *electrical changes* across the membrane of the neuron. The membrane of an unstimulated neuron is polarised, that means that the electrical charge of the inside of the membrane is negative compared to the outside.

Polarisation: Resting Potential

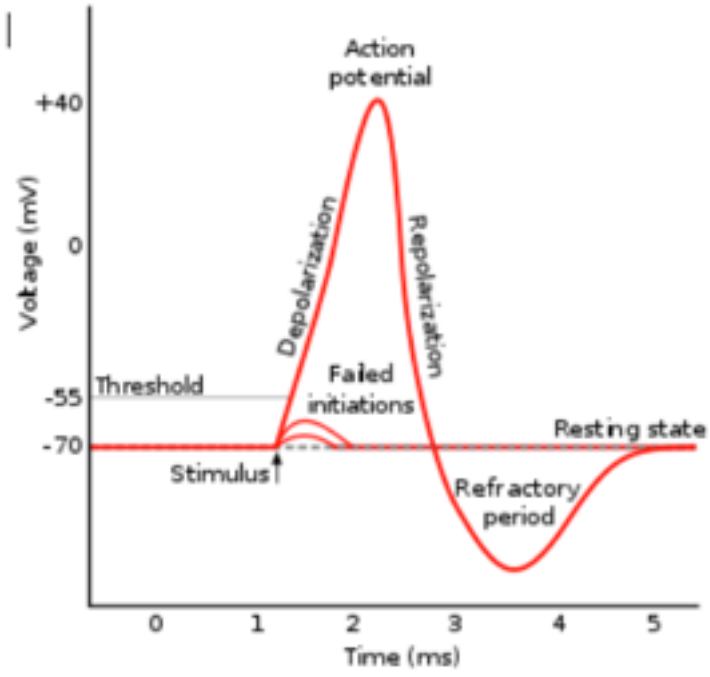
- Sodium is on the outside, and potassium is on the inside.
- When a neuron is unstimulated, it is just sitting there with no impulse to carry and the membrane is ***polarised***.
- When the neuron is inactive and polarised, it's said to be at its resting potential. It remains this way until a stimulus comes along.
- The concentration of ions isn't static though, ions are flowing in and out of the neuron constantly as the ions try to equalise their concentrations.

Stimulus:

- When a stimulus comes along to the resting neuron, gated ion channels open to allow the positive Na^+ ions to enter the cell.
- Sufficient current is required to initiate a voltage response in the cell membrane to start the propagation of the signal.
- The current has to reach over -55 mV to obtain the threshold for the impulse to travel.

Depolarisation:

- Is caused by the rapid rise in the membrane potential to further open more gated ion channels to let more Na^+ ions across the membrane.
- At this point, complete depolarisation occurs and the impulse is transmitted along the axon of the neuron.



Repolarisation:

- Potassium ion channels on the inside of the cell open after the cell is flooded with Sodium ions.
- Potassium ions flow out of the cell membrane.
- With K^+ moving to the outside, the cell membrane restores it's electrical balance to become depolarised.

Hyperpolarisation:

- Caused by more K^+ ions moving outside of the cell membrane than Na^+ ions on the inside.
- This causes the membrane potential to drop lower than the resting potential - hyperpolarised.

Refractory Period:

- when the Na+ and K+ are returned to their original sides: Na+ on the outside and K+ on the inside.
- while the neuron is busy putting everything back to normal, it doesn't respond to any incoming stimuli.
- neuron is back to its polarised state.

The Nervous System

Chemical Propagation of The Nerve Impulse

Neurons transmit signals to each other, gland cells or muscle cells without touching, but with a chemical release at the ***synapse*** of the connecting neurons. The gap between the axon of one neuron and the dendrites of another is called the ***synaptic cleft.*** This is where the impulse is diffused via the use of chemical substances - neurotransmitters. The process is outlined below:

Calcium Gates Open:

- as the impulse arrives at the end of the axon (the axon terminal), the calcium ion channels open.
- calcium ions are allowed to enter the cell.

Vesicles Move:

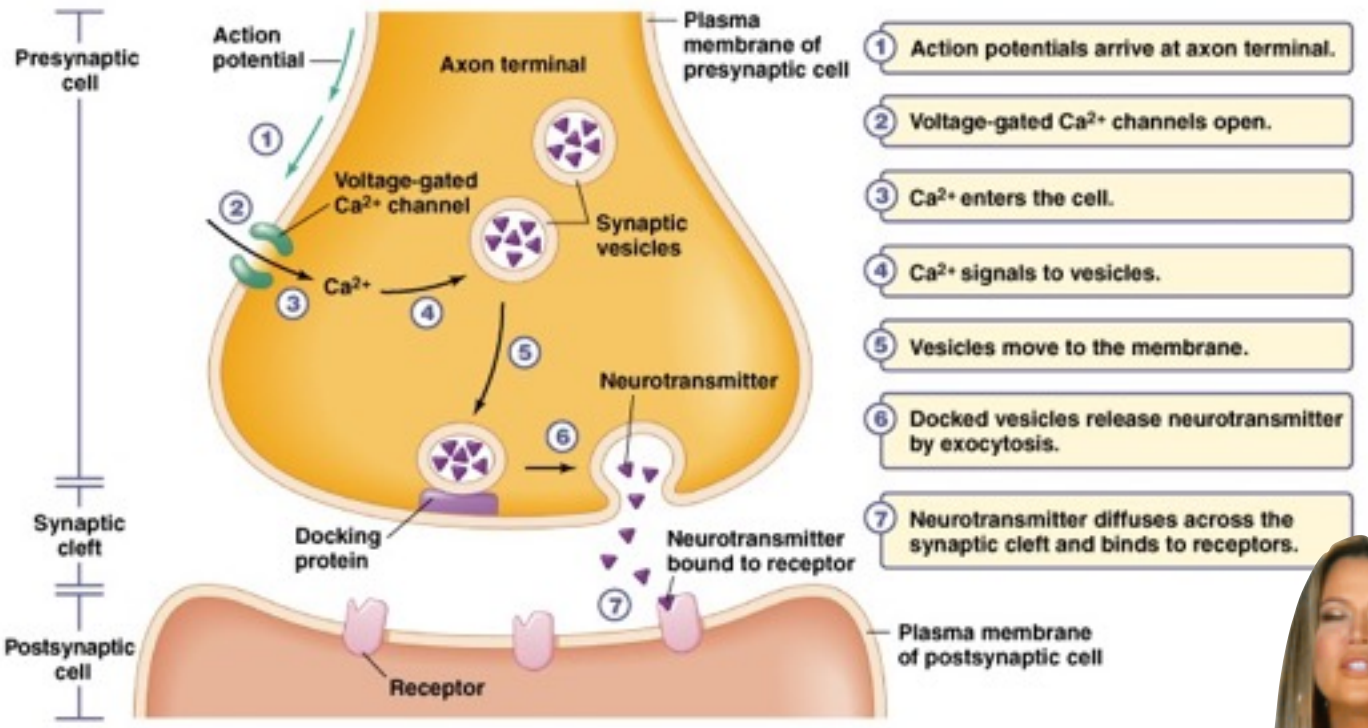
- as the calcium ions rush into the axon terminal, vesicles that carry neurotransmitters are stimulated to move to the membrane of the axon terminal.

Neurotransmitter Release:

- vesicles release neurotransmitters by exocytosis into the synaptic cleft.

Receptor Binding:

- Neurotransmitters bind to receptors on the membrane of the subsequent neuron/muscle cell/ gland cell.
- the impulse arrives at the neuron and stimulates electrical impulse transmission.



The Nervous System

Factors Affecting Speed Of Transmission

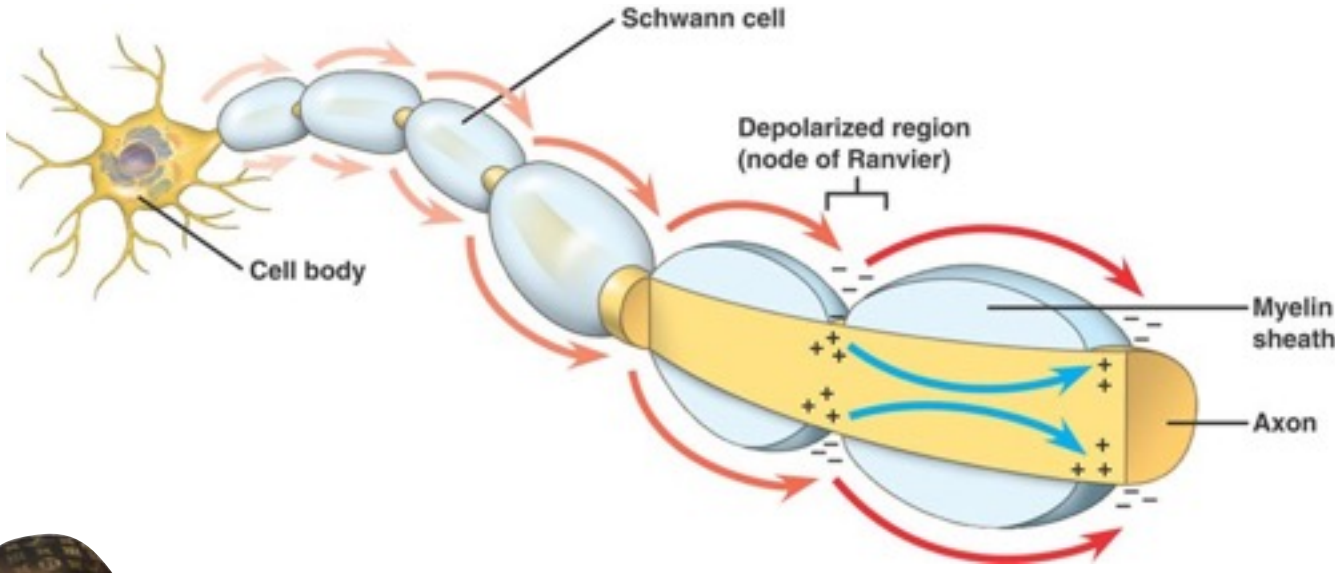
There are two main factors that influence the speed of conduction along a neuron:

1. The diameter of the axon: The greater the diameter (thiccness of the axon), the faster the speed of transmission.
2. The presence of the myelin sheath: The myelin sheath is a fatty material that produced by the Schwann cells on the neuron. The myelin sheath is unable to conduct electricity, so the action potential can only form at the gaps in the myelin sheath - known as the N***odes of Ranvier***. This is how the action potential is able to 'jump' from node to node. This is called Saltatory Conduction.

When asked to differentiate between an unmyelinated and a myelinated neuron talk about how the action potential is conducted across every section of it's entire length, rather than just saying it travels down the whole length of the neuron since a myelinated neuron does this too.

The size of a nerve impulse is the same regardless of the size of the stimulus. Differences in the intensity are influenced by:

1. The Number of nerve fibres depolarised: A strong stimulus causes more of the nerve fibres to be depolarised compared to a weak stimulus (providing the weak stimulus is strong enough to pass the threshold level).
2. The frequency of nerve impulses: A strong stimulus results in more nerve impulses in a given time than a weak stimulus (again providing a weak stimulus is strong enough to pass the threshold level).



The Nervous System

Peripheral Nervous System

The Peripheral Nervous System carries messages to and from the CNS.

The PNS is divided into two main parts:

The afferent division - carries nerve impulses to the central nervous system.
The efferent division - carries nerve impulses away from the central nervous system.

It is also subdivided into:

- Somatic Division: nerve impulses from the central nervous system to the skeletal muscles.
- Autonomic Division: nerve impulses from the central nervous system to the involuntary muscles and glands.

It is further divided into the:
- Sympathetic Division: The 'Fight or Flight" division that produces signals that prepare the body for action.
- Parasympathetic Division: The 'Rest and Digest' division that produces actions that maintain the body during normal activity

Structure(s)	Sympathetic nervous division	Parasympathetic nervous division
Heart	Increases cardiac output	Decreases cardiac output
Eyes	Dilates pupils	Constricts pupils
Lungs	Dilates bronchioles	Constricts bronchioles
Lungs	Increases breathing rate	Decreases breathing rate
Bladder and anus	Contracts anal and bladder sphincters	Relaxes anal and bladder sphincters
Saliva production	Decreases saliva production (dry mouth)	Increases saliva production
Liver/gall bladder	Increases breakdown of glycogen to glucose/ inhibits gall bladder	Increases conversion of glucose to glycogen/stimulates gall bladder
Stomach, intestines	Inhibited movement	Stimulates movement
Adrenal medulla	Stimulates hormone secretion	No obvious effect
Sweat glands	Greater sweat production	No obvious effect

The Nervous System

Nervous System vs. Endocrine System

	speed of action	*nature of message*	*transmission*	*specificity*	*duration of response*
Nervous System	rapid - milliseconds	electrochemical	via neurons	specific/ local	brief
Endocrine System	slow - seconds to days	chemical	via bloodstream	widespread/ general	long lasting

Homeostasis

Important Concepts of Syllabus Context

- homeostatic processes involve nerves and hormones in maintaining the body's internal environment within tolerance limits through the control of metabolism and physiological and behavioural activities.

- thermoregulation occurs by the control of heat exchange and metabolic activity through *physiological and behavioural* mechanisms.

- blood sugar levels are maintained by controlling of sugar uptake, its storage and release by cells and use in metabolism; these processes involve the hormones of the pancreas and adrenal glands.

- body fluid concentrations are maintained by balancing water and salts via the skin, digestive system and the kidneys, which involve the actions of antidiuretic hormone (ADH) and aldosterone on the nephron, and the thirst reflex.

- gas concentrations are controlled by balancing the intake of oxygen and the removal of carbon dioxide via the lungs, through the actions of the medulla oblongata and the autonomic nervous system.

Homeostasis

What is Homeostasis?

Homeostasis - The ability of the body to keep a sustainable constant internal environment including the control of calcium levels, blood sugar levels, body fluid concentrations, thermoregulation and gas concentrations.

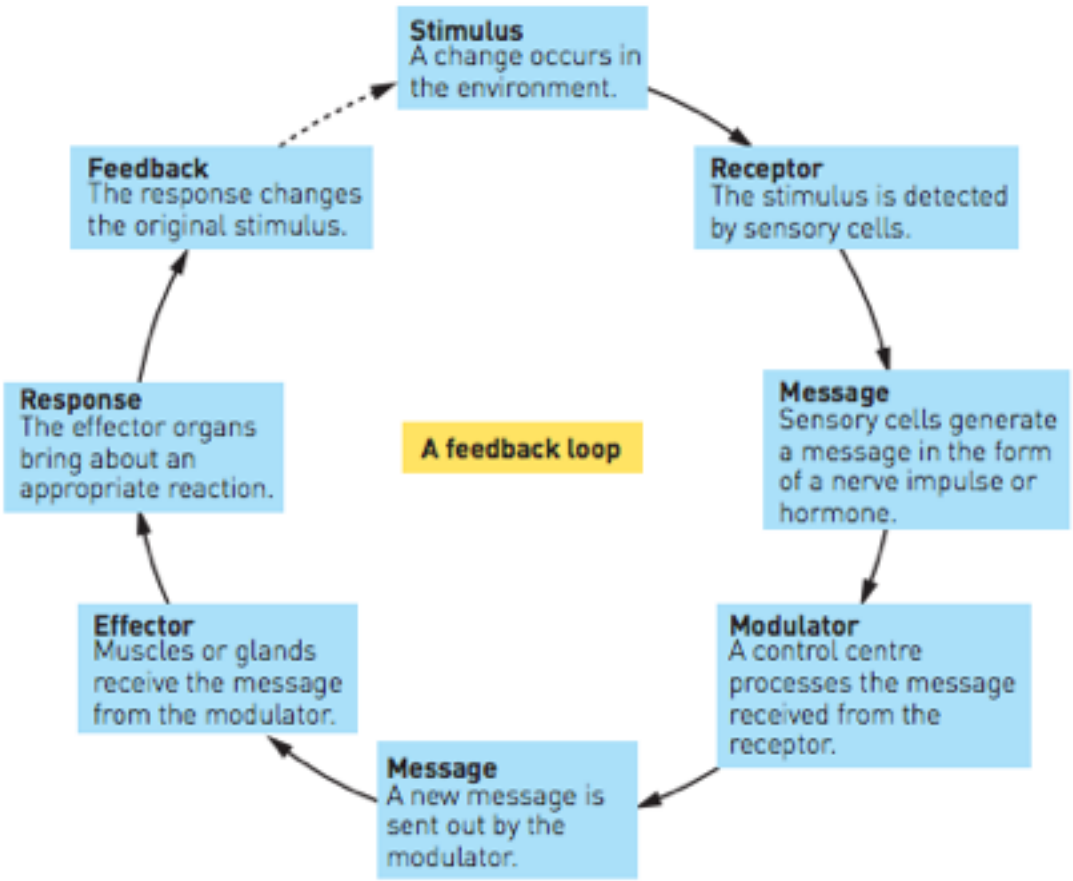
Feedback System - Feedback loop is defined as a system used to control the level of a variable affecting homeostasis. There is an identifiable stimuli, receptor (sensor), modulator, effectors, methods of communication / response and feedback.

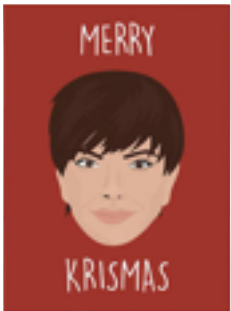
Negative Feedback

- Feedback that reduces the effect of the original stimulus.
- Involved in Homeostasis
- Example: Regulation of blood sugar, gas concentrations, osmoregulation, thermoregulation

Positive Feedback

- Feedback that reinforces or amplifies the original stimulus.
- Not involved in homeostasis
- Examples: Fever, blood clotting, childbirth and breast feeding





Homeostasis

Decreasing Blood Sugar Level Feedback Loop

Stimulus

After eating, there is an increase in glucose coming out of the small intestine.

Receptor

Detected by the beta cells in the islets of Langerhans in the pancreas.

Modulator

Beta cells of islet of Langerhans secrete insulin into the blood.

Effectors

- Glucose is taken up by all cells (mainly liver & skeletal muscle cells).
- Glucose is converted into glycogen via glycogenesis.
- Some glucose is converted to fat via lipogenesis.
- increased cellular respiration.

Response

Lowers levels of glucose in the blood.

Feedback

The initial stimulus has been eliminated or reduced, so the beta cells are no longer stimulated to release insulin. Negative feedback occurs.

Homeostasis

Increasing Blood Sugar Level Feedback Loop

Stimulus

When not eating, respiration still occurs, so the blood glucose levels start to fall below set point.

Receptor

Dropping levels detected by the alpha cells in the islets of Langerhans in the pancreas.

Modulator

Alpha cells of islet of Langerhans secrete glucagon into the blood.

Effectors

- Stored glycogen in the liver is converted to glucose in the glucogenolysis process.
- New glucose molecules are converted from fats and amino acids via the same process.

Response

Increasing levels of glucose in the blood.

Feedback

The initial stimulus has been eliminated or reduced, so the alpha cells are no longer stimulated to release glucagon. Negative feedback occurs.

Homeostasis

Increasing Calcium Level Feedback Loop

Stimulus

Low calcium levels in the blood.

Receptor

Dropping levels of calcium detected by the cells of the parathyroid gland.

Modulator

Parathyroid gland secretes parathyroid hormone into the bloodstream.

Effectors

- Increased calcium reabsorbed by the kidneys.
- Greater calcium absorption from the intestines.
- Calcium storages released from the osteoclasts in bone.

Response

Increasing levels of calcium in the blood.

Feedback

The initial stimulus has been eliminated or reduced, so the parathyroid is no longer stimulated to release parathormone. Negative feedback occurs.

Decreasing Calcium Level Feedback Loop

Stimulus

High calcium levels in the blood.

Receptor

Rising levels of calcium detected by the cells of the thyroid gland.

Modulator

Thyroid gland secretes calcitonin into the bloodstream.

Effectors

- Increased calcium loss by the kidneys.
- Reduced calcium absorption from the intestines.
- Excess calcium stored in the osteoblasts of the bones.

Response

Decreasing levels of calcium in the blood.

Feedback

The initial stimulus has been eliminated or reduced, so the thyroid gland is no longer stimulated to release calcitonin. Negative feedback occurs.