COORDINATION

Coordination refers to the ability of an organism to detect and respond to changes in their internal and external environment.

Common terms used.

1. **Irritability**; this is the ability of an organism to detect and respond to a stimulus in the environment.
2. **Stimulu**s; this is a change in the external or internal environment to which an organism responds.
3. **Response**; this is a change shown by an organism in reaction to a stimulus
4. **Impulse**; this is a nervous information transported along nerves in a nervous system.
5. **Effectors**; these are cells or organs where a response to a stimulus occurs.
6. **Receptors**; these are cells or organs that receive the stimulus and change it into a nervous impulse.

COORDINATION AND IRRITABILITY IN PLANTS

Plants do not have the nervous system and coordination and control is carried out by **hormones**. Plants' response involves growth movements of part of the. Parts of the plant move towards or away from a stimulus due to changes in **auxins concentration** in the part concerned.

Plant responses are divided into three categories.

1. **Nastic response**
   This is the movement of part of the plant in response to a non-directional stimulus. This can be observed in the closing of the leaves of *Mimosa pudica* when touched (thigmonasty).
2. **Tactic response**
   This is a type of response where the whole organism moves towards or away from a unidirectional stimulus. This response is common in lower plants such as Chlamydomonas and chlorella.
3. **Tropisms**
   This is a growth movement of part of the plant towards or away in response to a unidirectional stimulus.

Note

Tactic responses and tropisms can be described as negative if movement is away from the stimulus or positive if the movement is towards the stimulus. The responses are of different types depending on the nature of the stimulus.

TROPISM

This is the growth movement of the plant part in response to the direction of stimulus. The direction of response is related to stimulus and the plants move towards or away from it.

Characteristics of tropism

1. It involves growth.
2. It is a slow response.
3. It occurs at the shoots and root tips.
4. It is related to the direction of stimulus.
5. It is induced by directional stimulus.

Importance of tropism to plants

1. It enables plants leaves to trap maximum sunlight by enabling plant shoots to grow upright.
2. It enables plants to become firmly anchored in the soil by the roots growing towards the ground.
3. It enables plant roots to absorb or obtain water which is necessary for plant growth.
4. It enhances fertilization in plants since the pollen tubes grow towards the chemicals of the embryo sac.
5. It enables climbing plants to gain support by twinning around the support.
6. Tropisms allow plant parts to alter direction in response to changing conditions in the environment.

TYPES OF TROPISMS

Tropism is divided into different types depending on the nature of the stimulus.
The table below shows the name of tropism and corresponding stimulus

Name of tropism	**Stimulus**
Hydrotropism	Water
Geotropism	Gravity
Phototropism	Light
Thigmotropism	Touch
Chemotropism	Chemicals

1. **Hydrotropism**; this is the growth movement of part of a plant towards or away from water.
2. **Geotropism**; this is the growth movement of part of the plant in
3. response to gravity.
4. Phototropism: This is the growth movement of part of the plant in response to unidirectional light.
5. **Thigmotropism**; this is the growth movement of part of a plant in response to touch.
6. **Chemotropism**; this is the growth movement of part of the plant towards or away from a particular chemical e.g. pollen tube grows towards the embryo sac through the style during fertilization by responding to the source of chemicals produced by the embryo sac.

Summary of the tropic movements shown by plants

Type of tropism	Stimulus	Positive response	Negative response
Phototropism	Light	Shoot	Root
Geotropism	Gravity	Root	Shoot
Hydrotropism	Water	Roots	Shoots

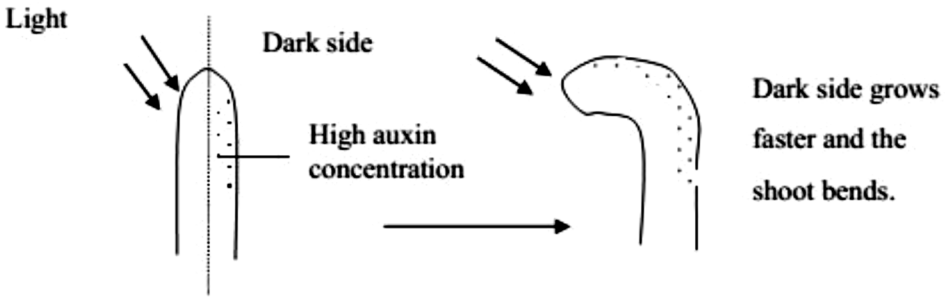
PHOTOTROPISM

This is the growth movement of part of the plant in response to unidirectional light. Plant shoots are positively phototropic that is, they grow towards the direction of light while the roots are negatively phototropic (they grow away from the direction of light).

AUXINS AND PHOTOTROPISM

Light from one direction of the shoot causes auxins on that side to escape to the opposite side without light. The side without light receives more auxins than one receiving more light. A high concentration of auxins on the side with little or no light increases the rate of cell division and elongation on that side. This causes the shoot to bend towards the direction of light (positive phototropism). However, high auxins concentration limits growth in plant roots

Illustration



EXPERIMENT TO SHOW THE EFFECT OF UNIDIRECTIONAL LIGHT ON GROWTH OF THE PLANT SHOOT

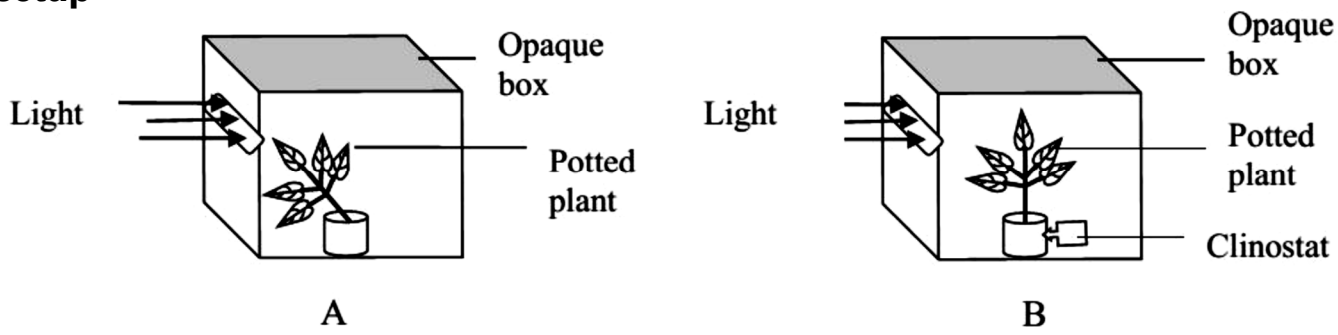
Materials

2 Potted plants, 2 opaque boxes, clinostat and razor blade

Procedure

a) Get two opaque boxes and using a razor blade cut a small hole on one side of each.
b) Get two potted plants of equivalent size.
c) Place one in box A and another in box B but fixed on a clinostat to serve as the control experiment. Place both boxes in light and start the klinostat to rotate the plant in box B.
d) Leave the experiment to run for 3-4 days.

Setup



Observation:
The shoot in A bent towards the direction of light while that in B continued to grow straight.

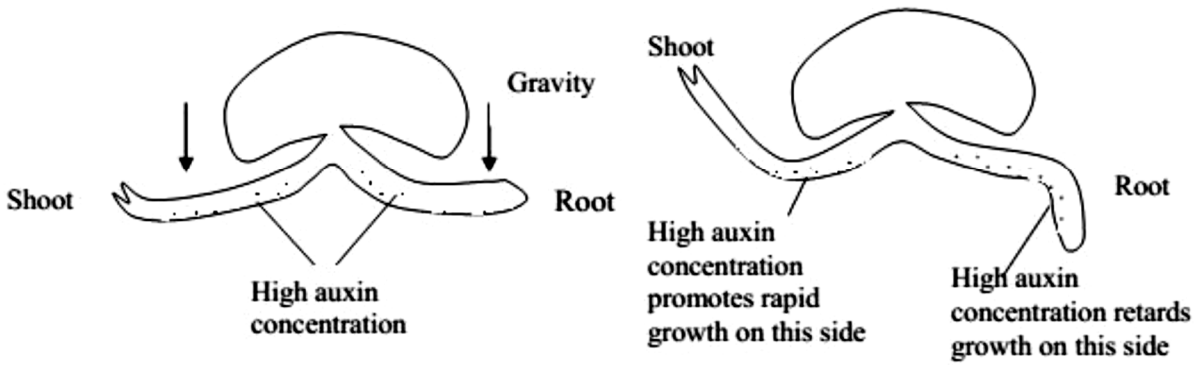
Explanation:
Light coming from one direction in A made the stationary shoot to bend towards the direction of light. Because the shoot in B was rotating on a clinostat all of its sides received equal amounts of light and there was no effect on growth.

Conclusion:
The shoot responds positively towards light.

GEOTROPISM
This is the growth movement of a plant part in response to the direction of the force of gravity. Roots grow towards the direction of force of gravity hence positive geotropism.

AUXIN AND GEOTROPISM
When a shoot is placed horizontally on the surface, auxins move in response to the gravitational force to the lower side. Cell division and elongation takes place more on the lower side than the upper side. This makes the shoot to bend upwards away from the gravitational pull (negative geotropism). In the root, a higher concentration of auxins on the lower side reduces the rate of cell division and elongation in the root. The upper side grows faster than the lower side causing the root to bend in the direction of the gravitational force (positive geotropism)

Illustration



EXPERIMENT TO DEMONSTRATE GEOTROPISM IN PLANT ROOTS (THE EFFECT OF GRAVITY ON ROOTS)

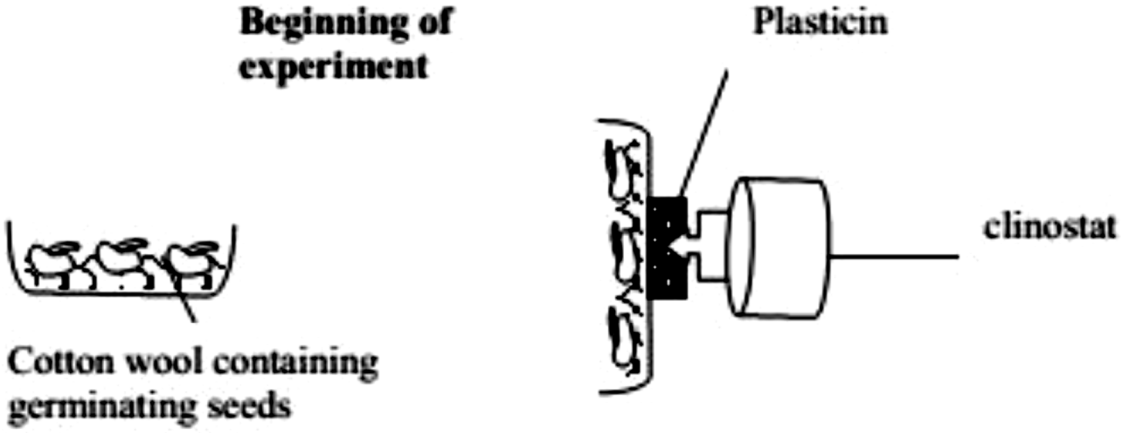
Materials

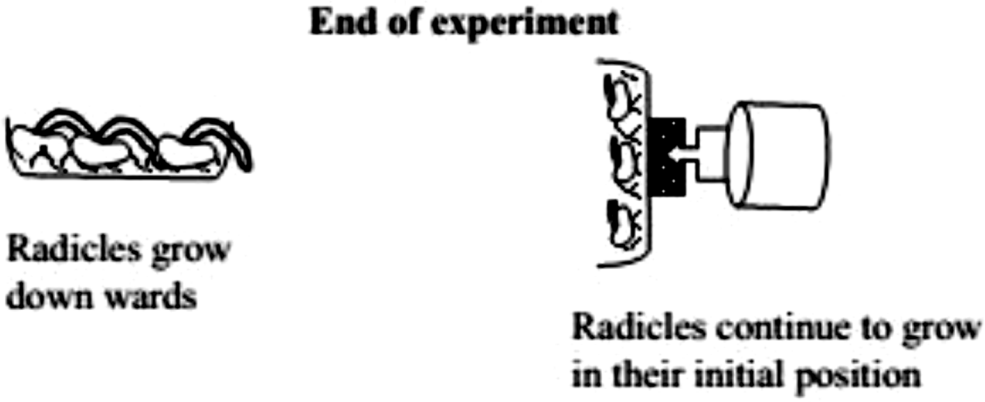
Cotton wool, seeds, petri dishes, water, clinostat, plasticin

Procedure

a) Place some seeds in two Petri dishes and cover them with moist cotton wool.
b) Leave the seeds for about 3 days to develop radicles.
c) Place one petri dish in plasticin perpendicular to the ground making the radicles horizontal to the surface.
d) Place another petri dish on a clinostat and make its radicles horizontal to the ground.
e) Start the clinostat to rotate such that all sides of the radicles receive the same gravitational pull.

Setup





Observations

The radicles in setup A bent downwards and those in B continued to grow horizontally.

Conclusion:

Roots are positively geotropic.

HYDROTROPISM

This is the growth movement of a plant and part in response to a unilateral source of water. The roots grow towards the source of water hence show positive hydrotropism. The shoots grow away from the source hence negatively hydrotropic.

EXPERIMENT TO SHOW HYDROTROPISM IN ROOTS

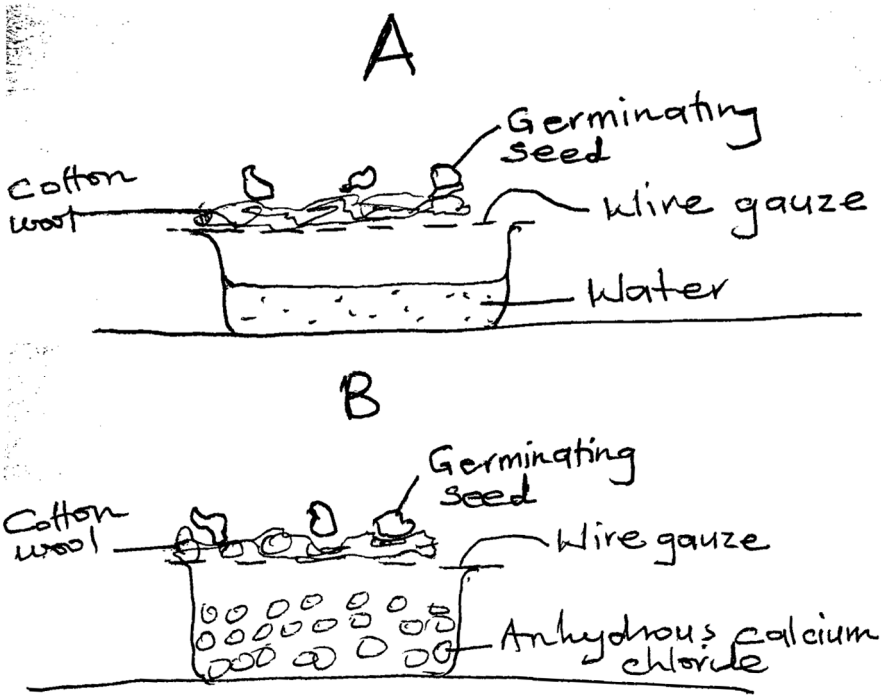
Materials

Wire gauze, water, seedlings, trough, and anhydrous calcium chloride.

Procedure:

a) Place wire gauze horizontally above a trough containing water.
b) Place moisture cotton wool on the trough leaving some spaces through which the radicle can pass.
c) Place germinating seedlings on cotton wool.
d) For the control set up a similar experiment but with a trough containing anhydrous calcium chloride instead of water.
e) Leave the experiment to run for 3 days.

Setup



Observation:

In A, the radicle grows towards water while in B, they curve away from dry air.

Conclusion:

Roots positively respond to water i.e. positively hydrotropic.

Explanation:

The calcium chloride absorbs moisture from the bottom of the trough. The upper part of the trough remains moist hence the radicle bends upwards towards the moisture.

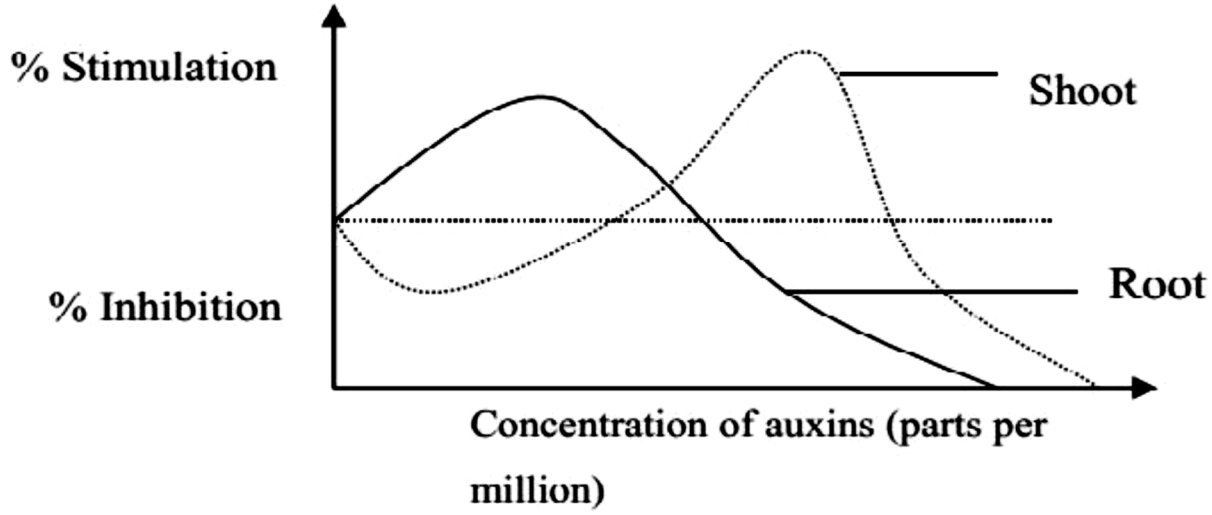
CONTROL OF RESPONSES IN PLANTS

Responses in plants are controlled by a group of plant hormones especially **auxins**. These auxins are produced at the root and shoot tip and are transported in the phloem together with manufactured food. Auxins **control responses** by **controlling growth through stimulation of cell elongation.** High auxins concentration stimulates faster growth in shoots and inhibits growth in roots.

Light affects the distribution of auxins. When the shoot tip is illuminated from one side, **auxins diffuse to the dark side** thereby **causing faster growth on the dark side** and the dark side becomes longer than the illuminated side. This causes the shoot to bend towards light.

Gravity also affects the distribution of auxins. If a seedling is lying horizontally, **more auxins will diffuse on the lower side of the root** and **shoot** due to **gravity**. In roots, the **high concentration of auxins inhibits growth** causing the lower side to grow slowly, while the upper side grows faster. This results in the roots bending towards gravity.

Graph showing the effect of auxins concentration on the growth of roots and shoots.



From the graph, it is noted that: when the concentration of auxins increases, growth in the shoot also increases to a maximum beyond which, further increase in auxins concentration inhibit growth in shoots. Growth response in the root decreases with increase in auxin concentration.

Importance of auxins

- Causes apical dominancy.
- Leads to parthenocarpy.
- Causes tropism.
- Fruit growth and development.
- Initiation of flowering.
- Root growth and development.

PLANT GROWTH SUBSTANCES

1. Indole Acetic Acid (IAA)

It is a naturally occurring growth substance in higher plants. It influences cell elongation and root initiation. It has a powerful effect on growth. It also brings about development of parthenocarpic fruits. It also checks formation of branches from side buds. If IAA is applied to the cut end of the main stem, the side buds don't develop into branches.

2. Gibberellins

They are produced by plants in varying amounts in seeds and young plants. If a solution of gibberellins is sprayed on a plant, it increases the water absorbing capacity of the cells. Gibberellins also contribute to flowering and growth of fruits.

EXPERIMENTS TO SHOW THAT AUXINS ARE RESPONSIBLE FOR GROWTH

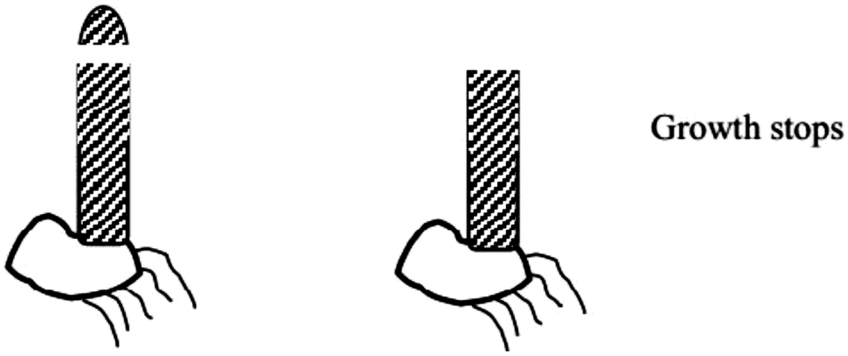
Materials

Coleoptiles (plant seedling) and razor blade

Procedure

Using a razor blade, cut off the tip of the coleoptile and leave it to stand for 3-6 days.

Setup



Observations

Growth stops taking place.

Explanation

The coleoptile tip produces new cells by cell division and it also produces a growth-promoting chemical. When the tip is cut off, growth stops.

Assignment

Describe an experiment to show the effect of indole acetic acid (IAA) on a decapitated coleoptile tips.

TACTIC RESPONSE (TAXIS)

This is the movement of whole organism or cell from one place to another in response to a directional stimulus. It is a positive tactic response when the whole organism moves towards the stimulus and negative tactic when the organism moves away from the stimulus.

Types of taxis

1. Phototaxis in response to light.
2. Chemotaxis in response to chemicals.
3. Thigmotaxis in response to touch.
4. Geotaxis in response to gravity.

Examples of taxis

1. Unicellular organisms e.g. Euglena swim towards light hence positively tactic (phototactic).
2. Earth worms, wood lice and cockroaches move away from light hence negative phototactic.
3. Sperms swim towards the chemical produced by the ovum hence positively chemotactic.
4. White blood cell moves towards harmful bacteria in the body hence positively chemotactic.

NASTIC RESPONSE (NASTIC)

This is the movement of a plant part in response to a non-directional stimulus or it is a response in which plants are not related to the direction of stimulus but to its intensity. Nastic response is named depending on the type of stimulus i.e.

- Photonasty if the stimulus is light.
- Hydronasty if the stimulus is water.
- Thigmonastic if the stimulus is touch.
- Lastic movements do not involve growth.

Characteristics of nastic responses

1. It involves changes of turgidity of plant cells.
2. It is a rapid response.
3. It occurs in any part of a plant.
4. The response is not related to the direction of the stimulus.
5. It is induced by non-directional stimulus.

Examples of nastic response

1. Opening and closing of flowers in response to light e.g. morning glory.
2. Sudden closer of leaf lets of *mimosa pudica* in response to touch.
3. Closures of leaves of insectivorous plants e.g. butterwalt and pitcher plant where the insect lands on the leaf. Such plants are found in nitrogen deficient soil.

Similarities between nastic and tropic movement

1. Both are brought about by external stimulus.
2. Both occur in plants
3. Both involves movement of plant parts.

Differences between tropism and nastic responses

Nastic response	Tropism
Does not depend on the direction of the stimulus.	It depends on the direction of the stimulus
It occurs in any part of the plant.	It occurs in growing tips of plants
It does not involve auxins	It involves auxins
Are usually faster	Are usually slower
It involves growth and turgor changes	It involves growth only.

CONTROL OF RESPONSES IN MAMMALS

Coordination in mammals can be divided into two

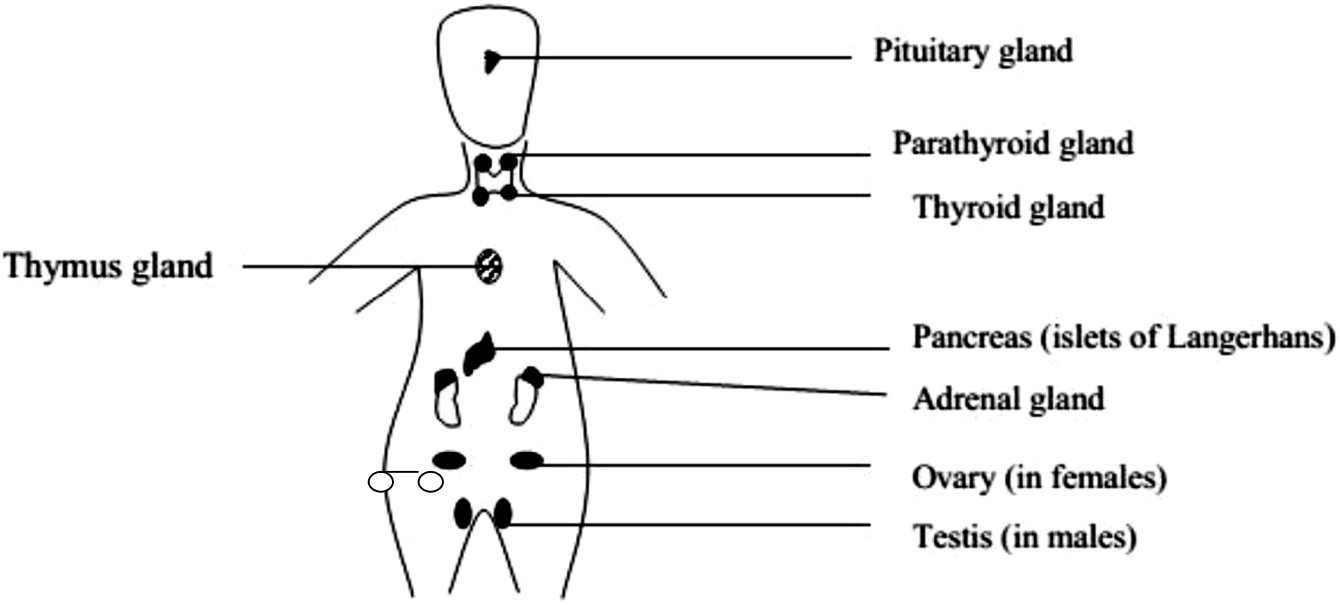
1. **THE ENDOCRINE SYSTEM**

   This is a system of ductless glands in which hormones are produced. The release of their secretion is stimulated by either the central nervous system or a hormone from another gland. A hormone is an organic substance which is produced in small quantities and transported by blood to target organs where it exerts its effects.

2. **EXOCRINE GLANDS**

   These are glands which have ducts through which their secretions are transported together with the nervous system, the endocrine system is very important for the integration of body functions and coordination.

STRUCTURE OF HUMAN BODY SHOWINING LOCATION OF DIFFERENT GLANDS



Summary of glands and their secretions

Gland	Secretions
Salivary gland	Saliva containing enzymes
Tear gland	Tear
Mammary gland	Milk
Sweat gland	Sweat
Gastric gland	Gastric juice containing enzymes
Pituitary gland	Oxytocin, prolactin, ADH, TSH, ACTH, FSH, LH, growth hormone
Thyroid gland	Thyroxine
Parathyroid	Parathormone
Pancreas	Enzymes, insulin, glucagon
Gastric wall	Gastrin
Adrenal gland	Adrenaline, cortisol, sex corticoids
Testis	testosterone
Ovary	Oestrogen, progesterone
Duodenum wall	Secretin

DIFFERENCES BETWEEN ENDOCRINE AND EXOCRINE GLANDS

ENDOCRINE GLAND	EXOCRINE GLAND
It releases its secretion into the blood stream	It releases its secretion into a duct
It does not have a duct	It has a duct
The secretion is a hormone	The secretion is an enzyme, milk, sweat, but not a hormone
It is found far from the target	It is found near the target

HORMONES

This is a substance that is secreted by an endocrine gland. Hormones regulate physiological processes like growth, metabolism, and blood sugar level regulation.
The hormone diffuses from the endocrine gland into the blood stream, which transports it to the target. Generally, the point of secretion and target of a hormone are in different parts of the body, e.g. vasopressin is secreted by the pituitary gland in the head region, but its target is the nephron in the abdominal region.

THE PROPERTIES OF A HORMONE

1. A hormone is steroid or protein in nature
2. A hormone regulates physiological processes by stimulating or inhibiting the activity of target organs.
3. It is effective in a small quantity.
4. Its effect is wide spread
5. It is altered or destroyed immediately after performing its role
6. It is secreted directly into the blood stream
7. It is synthesized by an endocrine gland
8. It is secreted in response to a stimulus
9. Its gland and target are in separate and distant parts of the body

DIFFERENCES BETWEEN A HORMONE AND AN ENZYME

HORMONE	ENZYME
It is secreted by an endocrine gland	It is secreted by an exocrine gland
It is discharged into the blood stream	It is discharged into the duct
It stimulates or inhibits target structures	It controls and speeds up chemical reactions
It is steroid or protein in nature	It is protein in nature
It is altered or destroyed after action	It is not altered or destroyed after action
Its gland and target are in distant parts of the body	Its gland and target are in close parts of the body

A TABLE SHOWING THE HORMONES PRODUCED BY THE ENDOCRINE SYSTEM AND THEIR EFFECTS

Glands	Hormone produced	Effects/ functions
Anterior pituitary gland	Thyroid stimulating hormone (TSH)	• It stimulates the thyroid gland to produce the thyroxine hormones
	Follicle stimulating hormone. (FSH)	• It stimulates egg development in the females and sperm development in the males. • Stimulates the ovaries to produce oestrogen • Stimulates release of progesterone by the ovary • Stimulates testosterone secretion in testes
	Luteinizing hormone (LH)	• It causes ovulation in the females, • It causes conversion of the graafian follicle into corpus luteum in ovaries. • It stimulates testosterone secretion in the testes
	Growth hormone (GH)	• It stimulates growth especially bones, excess in children results into gigantism and under secretion in children results into stunted growth (dwarfism)
	Andrenocoticotrophic hormone (ACTH)	• It causes the adreno cortex to produce/secrete its hormones. • Stimulates lipid breakdown and release of fatty acids from fat cells
Posterior pituitary gland	Anti-diuretic hormone(A.D.H) vasopressin	• It causes reabsorption of water in the kidney nephrons. i.e. osmoregulation • Under secretion results in diabetes insipidus
	Oxytocin	• It brings about parturition (contraction of the uterus during birth)

		• Stimulates milk flow from the mammary glands
Thyroid gland (neck region)	Thyroxine	• Controls metabolic activity, raises body metabolic rate (BMR) • Excess results into an increased metabolic rate which leads to protrusion of eye balls. Under secretion leads to goitre.
Parathyroid gland.	Parathyroid hormone	• It increases iron calcium absorption
Stomach	gastrin	• Stimulates secretion of gastric juice
Duodenum	Secretin	• Controls secretion of bile and pancreatic juices
Pancreas (Islets of langerhans)	Insulin	• It controls the balance of sugar in blood by converting glucose to glycogen in case there is an excess. • Under secretion results into diabetes mellitus.
	Glucagon	• It converts glycogen in to glucose
Adrenal gland	Adrenalin	• For flight and fight actions, by increasing heart rate and metabolic rate.
Ovary (lower abdomen)	Oestrogen hormone	• It brings about healing and repair of the uterus wall after menstruation. • It brings about development of female reproductive organs. • It brings about development of secondary sexual characteristics. • Deficiency causes delay in the development of secondary sexual characteristics.
	Progesterone	• It promotes proliferation of uterus wall • Controls the menstrual cycle • It maintains pregnancy.
Testis (produced from scrotum)	Testosterone (male sex hormone)	• Development of male sexual characters • Deficiency causes delay in the development of secondary characters.

NB. Pituitary gland is the master gland.

THE EFFECT OF ADRENALINE

It prepares the body for emergency, danger and stress conditions such as fear, anxiety, shock in the following ways;

1. It increases the rate of metabolism. This generates more energy.
2. The rate of heart beat increases. This ensures fast distribution of glucose and oxygen to the respiring cells.

3. The breathing rate increases. This allows inhalation of more oxygen and exhalation of carbon dioxide
4. The bronchioles relax. This ensures that more oxygen inflates the alveoli
5. It changes glycogen to glucose. The glucose is broken down to produce energy.
6. The rate of respiration increases to produce more energy
7. Blood is diverted to the vital organs to distribute oxygen and glucose
8. The pupil dilates so that more light enters
9. It inhibits peristalsis and digestion. This reduces appetite and causes gastric upsets
10. It prevents contraction of the bladder
11. The hair rises to an upright position
12. It can cause shivering and development of goose flesh
13. It causes an increase in body temperature and sweating
14. It increases mental awareness and reduces the sensory threshold.

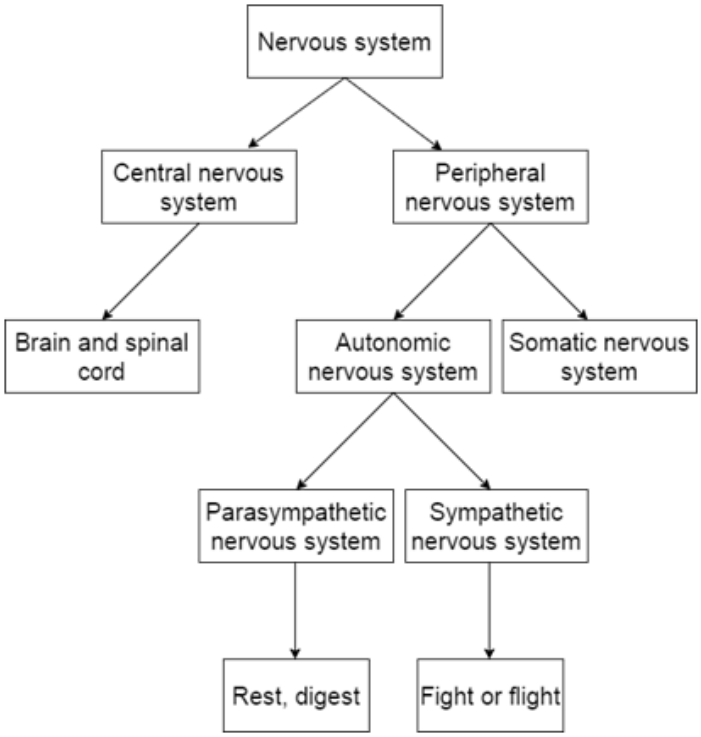
THE NERVOUS SYSTEM

The nervous system acts as a system of coordination within the the body of an organism.

There are three **specific** components of the nervous system namely;

1. **Receptors** [sensory cells]; these are cells or organs that receive stimuli like smell; touch; taste, sight, etc.
   Examples of sense organs include eye, nose, skin, ear, tongue.
   The Receptors must produce a message called an impulse on receiving the stimulus.
2. **Neurons (nerve cells).** These are the functional units of the nervous system. Their function is to transmit information to and away the central Nervous system.
3. **Effectors**; these are cells or structures which perform a particular function in response to impulse reaching them. The effectors are either muscles which contract or glands which secrete useful substances.

ORGANISATION OF THE NERVOUS SYSTEM



The function of the central nervous system is to coordinate and regulate various activities of the different body parts.

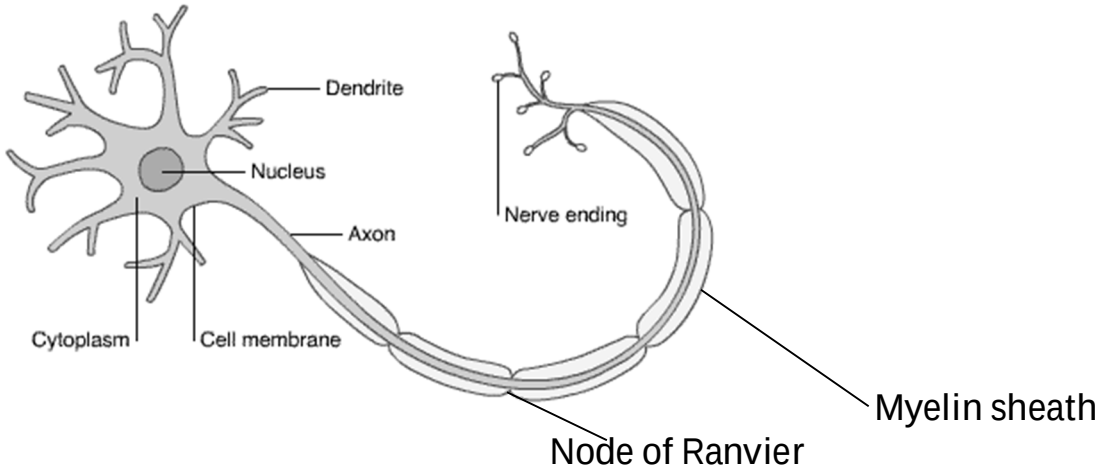
The peripheral nervous system is divided into
1. Voluntary which is responsible for the movement of the skeletal muscles
2. Autonomic (involuntary) nervous system. This is responsible for the involuntary movements in the body like breathing; heart beat; movement of food along the gut.

Types of neurons

There are three types of neurons

NEURONE	STIMULATED BY	TRANSMITS IMPULSES TO	STRUCTURE
1. Sensory/ Afferent	Receptor	Relay neurone	Cell body in root cell ganglion
2. Relay/ intermediate/ Associate	Sensory neurone	Motor neurone	No axon
3. Motor/effector	Relay neurone	Gland, muscle (effector organ)	Schwann cells

PARTS OF A NEVRONE



The three types of neurons vary in structure however they share a number of structural features and this include;

1. **Cell body**: This consists of dens e cytoplasm surrounding a prominent nucleus. It is where energy required to transmit the impulse is produced and the nucleus controls all the other activities within the neurone. In motor neurons, the cell body is found at end of the axon and it branches into dendrones which also branch into dendrites.
2. **Myelin sheath:** This is a fatty material that surrounds the axon. It is produced by Schwann cells. The myelin sheath insulates and protects the axon and also aids the transmission of impulses. It is broken at various points called Nodes of Ranvier and this increases the rate at which the impulse is transmitted.

3. **Dendrites:** These provide connection inform of a synapse with other neurones to effect communication. They are delicate hair like out growths which are in close contact with other neurons or with stimulus receptor cells.
4. **The axon**: This is along cytoplasmic extension running from the cell body. Inside the axon is exoplasm which contains ions that facilitate transmission of impulses. In motor and sensory nerves, it is usually covered with myelin sheath.
5. **Node of Ranvier**: It speeds up the transmission of impulses.

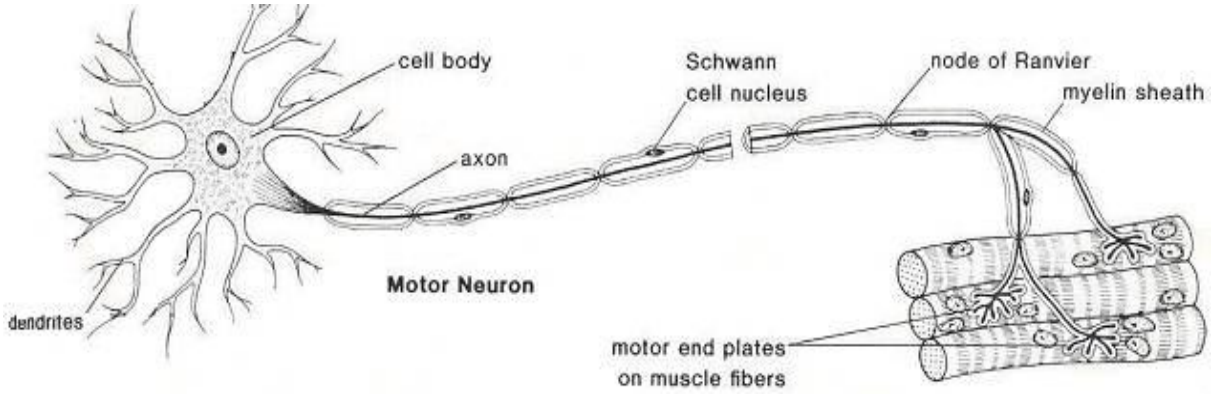
DIFFERENCES BETWEEN A MOTOR NEURONE AND A **SENSORY NEURONE**

MOTOR NEURONE	SENSORY NEURONE
Relays impulses from the central nervous system to effectors	Relays impulses from a receptor to the central nervous system.
Has long axon	has a short axon
Has a short dendrones	has only one dendrite which is long
Cell body is in the terminal end of the axon	Cell body is between the axon and the much-elongated dendrite.
Terminal dendrites connect with muscles and effectors	Terminal dendrites connect with the intermediate neurone

THE SIMILARITY BETWEEN THE STRUCTURE OF THE SENSORY AND MOTOR NEURONE

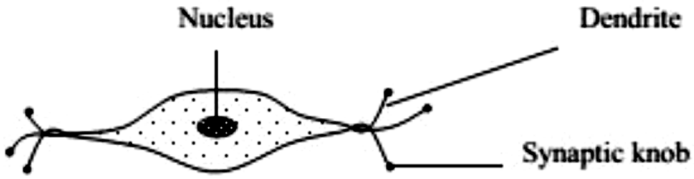
1. The nerve fibre has a fluid called axoplasm
2. They have one axon
3. The axon may be myelinated
4. The axon has branches called terminal dendrites
5. The terminal dendrites have synaptic knobs
6. They have one cell body
7. Each dendron has branches called receptive dendrites.

Motor neurone



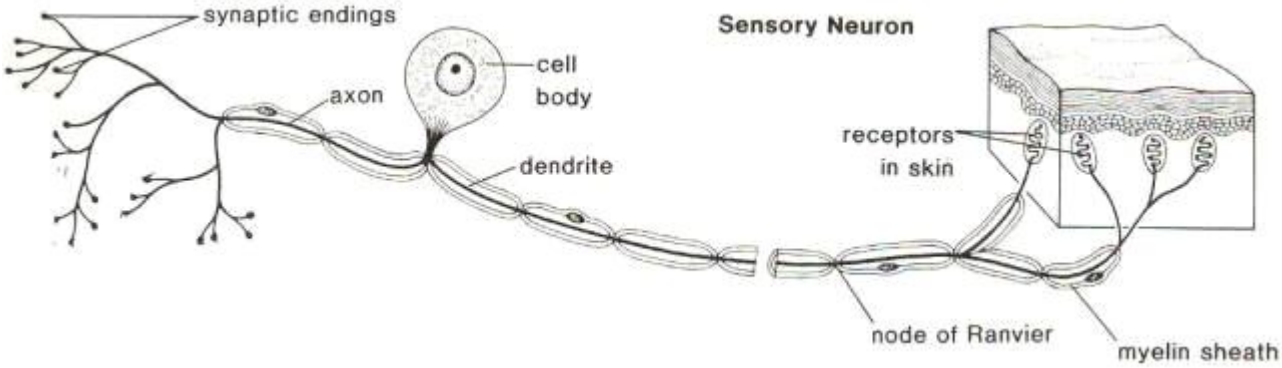
Intermediate neurone

This is the neurone that transmits an impulse from the sensory to the motor neurone. It is found in the central nervous system. It is the area where information is interpreted.



Sensory neurone

This is a nerve cell that transmits impulses from the receptor to the central nervous system. The axon is short. The dendron is long. The centron is between the axon and Dendron, i.e. the centron is on a branch from the axon. The axon ends in small branches called terminal dendrites, which have synaptic knobs. The dendron has branches called receptive dendrites, i.e. nerve endings. In some cases, the dendron and axon are myelinated, i.e. they have a white fatty material called myelin. The nerve fibre contains a fluid called axoplasm.



THE DIFFERENCE BETWEEN THE FUNCTIONS OF THE SENSORY AND MOTOR NEURONE

SENSORY NEURONE	MOTOR NEURONE
It transmits the impulse from the receptor to the central nervous system	It transmits the impulse from the central nervous system to the effector
The impulse is transmitted to the cell body by one long dendron	The impulse is transmitted to the cell body by many short dendrons
The terminal dendrites transmit the impulse to the intermediate or motor neurone	Terminal dendrites transmit the impulse to the effector
The receptive dendrites receive the impulse from a receptor	The receptive dendrites receive the impulse from a relay or sensory neurone
The impulse is transmitted from the cell body by a short axon	The impulse is transmitted from the cell body by a long axon
The transmission of the impulse is by myelinated or un myelinated dendron	The transmission of the impulse is by un myelinated dendrons

The similarity between the function of the sensory and motor neurone

1. They transmit an impulse
2. The impulse is transmitted to the cell body by a dendron
3. The impulse is transmitted from the cell body by an axon

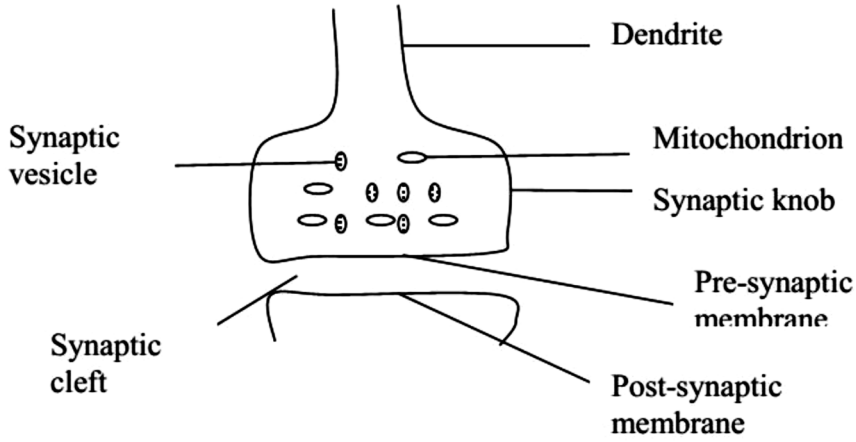
The transmission of the impulse is through a myelinated or un myelinated axon

FACTORS AFFECTING THE SPEED OF IMPULSE TRANSMISSION ALONG THE NEVRONES

1. Presence of myelin sheath impulse transmission is faster in myelinated axon /neurons than in non –myelinated neurons.
2. Diameter of the axon.
   Larger neurones transmit impulses faster than narrow axons.

SYNAPSE

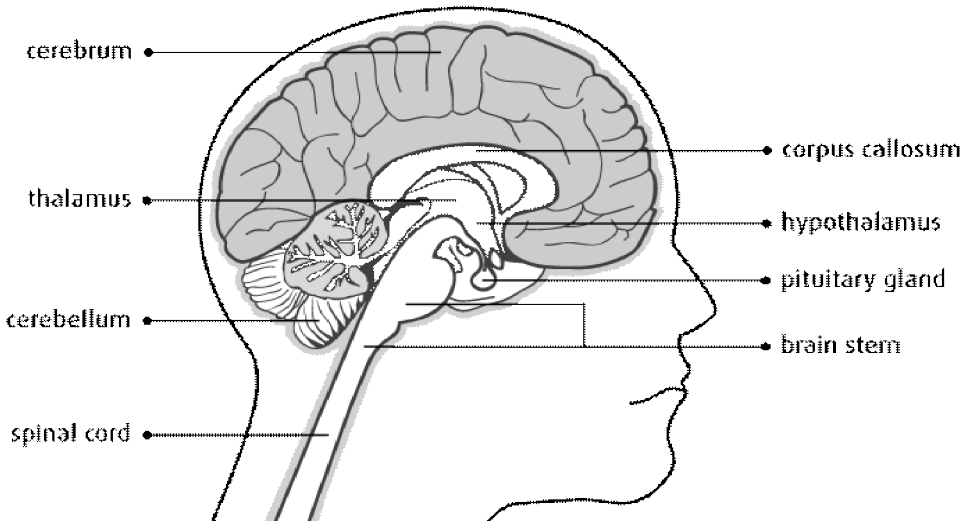
A synapse is a specific functional point that links one neurone to another or it is a means by which a nervous impulse is passed from one neurone to another.



IMPULSE TRANSMISSION ACROSS A SYNAPSE

When a stimulus reaches the receptors, it generates an impulse which passes to the cell body of the sensory neurone. The impulse then goes through the axon to the dendrite then to the dendrite of another neurone across the synapse. An impulse in one axon triggers release of a transmitter substance (acetylcholine) into the synaptic gap. The transmitter substance stimulates the adjacent neurone to form an impulse and so the stimulus is passed on. The transmitter substance is then destroyed and is resynthesized to carry more impulses. This ensures that an impulse travel only in one direction.

THE STRUCTURE OF THE BRAIN



THE CENTRAL NERVOUS SYSTEM

THE BRAIN;

It is protected by three main structures.

1. The skull (cranium) - which protects it externally.
2. The meninges – these are membranes which protect it internally.
3. Cerebral –spinal fluid, this is a shock absorber and it also provides nourishment to the brain.

GENERAL FUNCTIONS OF THE BRAIN

a) It receives impulses from sensory organs and sends them to the respective organs for proper functioning of the body (relay centre).
b) It makes decisions based on inherited characteristics or past experiences so as to modify behaviour.
c) It helps the muscular body balance.
d) It co-ordinates the vital body processes like regulation of body temperature, breathing, heartbeat etc.

The brain is divided into three major regions, that is;

1. Fore brain.
2. Mid brain
3. Hind brain

1. The fore brain

It consists of:

(i) The cerebrum (cerebral hemisphere)

This is the largest part of the brain. It is made up of 2 hemispheres i.e. the left and the right cerebral hemispheres. The right hemisphere controls the activities of the left side of the body while the left hemisphere controls the activities of the right side of the body. The 2 hemispheres are joined by a fibre known as ***corpus collosum.***

Functions of cerebrum

1. It controls all voluntary activities
2. It is a centre of memory and reasoning.
3. It receives impulses from the sense organ of smell, touch, sight, taste and sound.

(ii) The olfactory lobes:

These are paired lobes located ventrally at the base of the cerebrum. They are small in size. They receive impulses from the olfactory nerves bringing about the sense of smell.

2. The mid brain

It consists of:

(i) Thalamus

It integrates sensory impulses from the eyes, skin and ear and sends them to the cerebral cortex of the cerebrum. It also directs impulses from all parts of the body to particular areas of the brain.

(ii) Hypothalamus

It is a centre of many activities. It is below the thalamus. It controls involuntary activities e.g. water and salt balance (osmoregulation). Controls body temperature, carbon dioxide, levels in blood, appetite, sleep, hunger, wakefulness, sex drive and produces hormones e.g. oxytocin and ADH which are stored in the pituitary gland.

iii) Pituitary gland

It secretes a number of hormones like the thyroid stimulating hormone, FSH, LH, ADH, etc. which control various activities. It also controls other endocrine glands in the body thus called the ***master gland.***

iv) Optic lobes

These are paired lobes. Their main function is to interpret sight.

3. Hind brain

It is made up of:

(i) Cerebellum

This is concerned with maintenance of balance, locomotion and posture. It receives impulses from the skeletal muscles.

(ii) Medulla oblongata

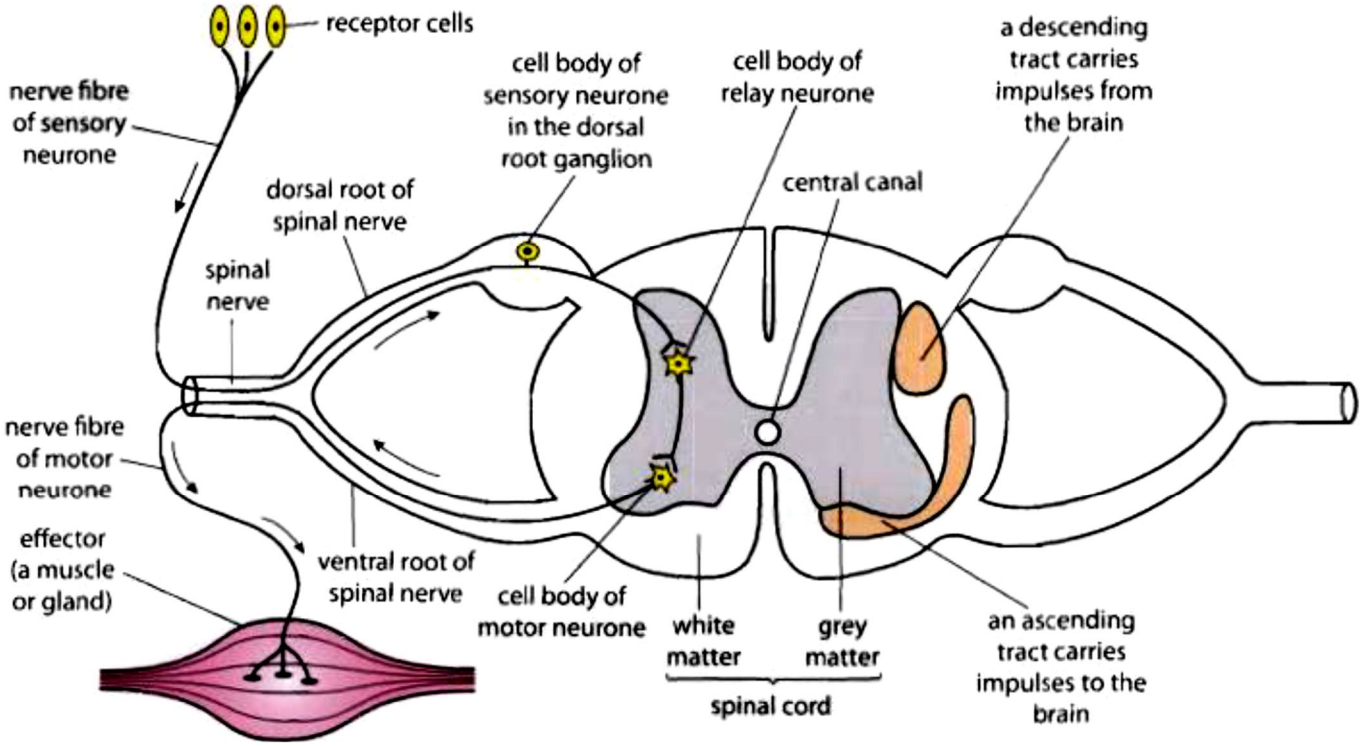
This controls involuntary actions like yawning, vomiting, blinking of the eye, etc. any injury to this region leads to instant death.

THE SPINAL CORD

This is part of the central nervous system that runs from the brain to the tail through and covered by the vertebral column.

Functions of the spinal cord

1. It connects the peripheral nervous system to the brain.
2. It is a centre for simple spinal reflex actions
3. Receives impulses from receptors
4. Interprets messages especially in reflex arc
5. Sends impulses to the receptors.



This is the posterior extension on the brain. It is protected by the vertebra column. It has two major regions i.e;

1. The grey matter and
2. The white matter.

The grey matter is centrally located and it consists of large numbers of cell bodies and their dendrites. The grey matter surrounds a small canal which contains the cerebral spinal fluid that supplies food to the cells. The white matter surrounds the grey matter and consists of myelinated axons that conduct impulses to and from the brain. Spinal nerves; these are groups of axons that enter or leave the spinal cord at intervals. Each has a separate dorsal and ventral root

REFLEX ACTIONS (INVOLUNTRARY)

This is a sudden, automatic and uncontrolled response of parts of the body to a stimulus e.g. knee jerk, withdrawal of a hand from a hot object, blinking due to an approaching object, sneezing, constriction and dilation of the pupil due to changes in light intensity

REFLEX ARC;

This is described as the path taken by a nerve impulse in a reflex action. The route that is followed by impulses during a reflex action is called **reflex arc**. A reflex action moves in the following direction;

1. A receptor is stimulated and an impulse travel along a sensory nerve fibre to the spinal cord
2. The impulse is picked up by an intermediate neurone within the CNS
3. The intermediate nerve fibre transmits the impulse to a motor nerve fibre which is connected to an effector.
4. The effectors which could be muscles or glands respond to the stimuli appropriately

Spinal reflex, this is a reflex action which involves the spinal cord. It usually occurs in actions which occur below the head i.e. Knee jerk, peristalsis,

Cranial reflex; this is a reflex action which occurs in the region of a head and it involves the brain e.g. salivation, blinking.

Characteristics of reflex actions

a) They occur rapidly.
b) They occur spontaneously and take a short time.
c) They are coordinated either by brain or spinal cord
d) They are not learned but inborn.

CONDITIONED REFLEX ACTIONS

This is a reflex action triggered by a certain stimulus which the animals learn to associate with a different stimulus. Conditioned reflex is a learned response an organism develops after practice when an ineffective stimulus is introduced. It was observed by Pavlov that the sight, smell, taste of meat caused hungry dog to salivate. He later introduced another stimulus which was the ringing of the bell before introducing the meat. After many presentations, he found out on ringing the bell alone, the dog could be induced to salivate. The dogs were therefore conditioned to the sound of the bell. When he rang the bell without food for some time, the dogs later stopped salivating. Most cases of simple learning are forms of conditioned reflexes e.g. learning ride a bicycle, a child learning to walk, learning to cook food etc.

VOLUNTARY ACTIONS;

These are actions done consciously by an animal i.e. one is aware of them. They are initiated by the cerebral cortex of the brain e.g. singing, slapping, walking, and eating.

DIFFERENCES BETWEEN VOLUNTARY ACTIONS AND INVOLUNTARY ACTIONS

VOLUNTARY ACTIONS	REFLEX ACTIONS
They don't occur spontaneously	occurs spontaneously after receiving a stimulus
They do not occur very rapidly	Occur very rapidly
Many neurons are involved	Only three types of neurons are involved.
They are mediated by pathways in the cerebral cortex of the brain	Are mediated by pathways either in the brain or spinal cord.
Responses to stimulus are always Varying according to conditions	Responses to stimulus are normally the same.

AUTONOMIC NERVOUS SYSTEM

This is part of the nervous system that controls involuntary activities such as blinking. It is made up of two parts i.e.

1. parasympathetic system and
2. Sympathetic.

The sympathetic system is important especially during emergency situations. it brings about responses associated with fight or flight.

The parasympathetic nervous system controls internal responses associated with a relaxed state. These often cause antagonistic effects in the organs e.g. the heartbeat may be accelerated by the sympathetic system while the parasympathetic system slows it down.

DIFFERENCES BETWEEN THE NERVOUS CORDINATION AND HORMONAL CORDINATION

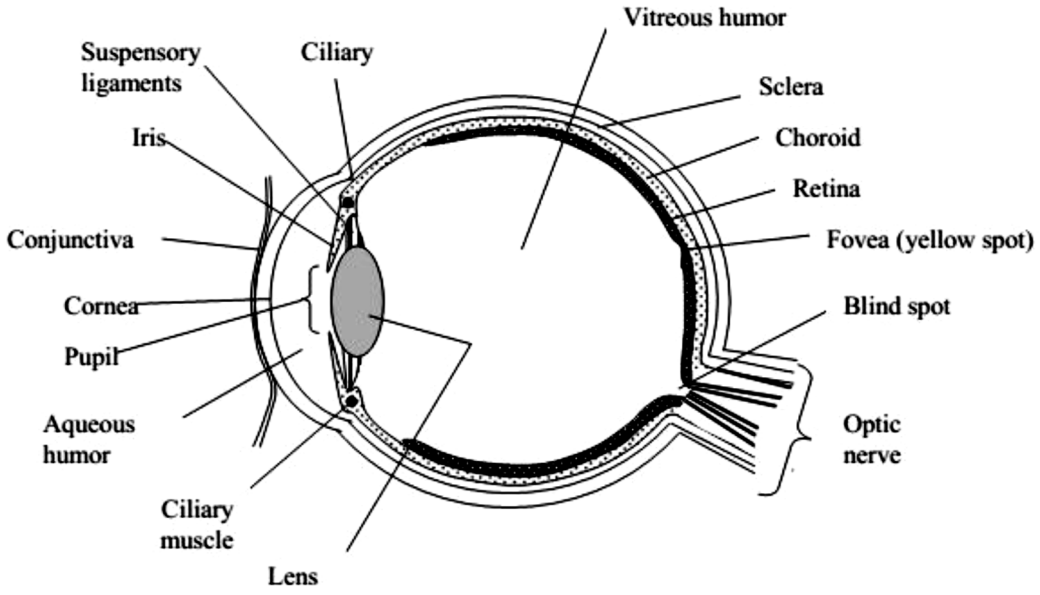
THE NERVOUS CORDINATION	HORMONAL CORDINATION
Massage is electrical.	Message is chemical
The message travels in nerve cells and neurones.	The massage travels in blood
There is quick transmission	Slow transmission
Response lasts for a short time	Response lasts for a long time.
Controlled by the brain and the spinal cord.	Most are controlled by pituitary gland in the brain
Response is usually in one part of the body.	Response usually in many parts of the body

DIFFERENCES BETWEEN TROPISMS AND REFLEX ACTIONS

TROPISMS	REFLEX ACTION
Involve growth movements that occur in plants.	Involve muscular movements that occur in animals.
There is unequal growth and this result into bending.	Involve contraction of muscles which can be reversed.
Occur only in growing regions.	Continues throughout life in all parts of the body.
They are usually slow	They are usually fast.

SENSE ORGANS

1. THE MAMMALIAN EYE



THE SCLERA (**WHITE OF EYE**); It is a tough, non-elastic protective outermost coat /layer around the eye. It continues as a cornea.
THE CORNEA; being a denser medium than air, light entering is refracted inwards towards the pupil and the lens (rays begin to converge).
THE CHOROID; It's a layer of tissue lining the interior of the sclera.
It contains a network of blood capillaries providing food and oxygen to the eye.
It deeply pigmented (black) reducing the reflection of light with the eye.

THE AQUEOUS AND VITREOUS HUNOUR; these are solutions of salts, sugars and proteins in water. Aqueous humour is quite fluid and vitreous jelly like;

- They help to refract light and produce an image on the retina.
- Their pressure outwards on the sclera maintains the shape of the eye.
- The crystalline Len, the cornea and conjunctiva absorb their food and oxygen from the aqueous humours.

THE LENS; the cornea and crystalline lens refract light so producing an image on the retina.
SUSPENSORY LIGANENTS; they hold the lens in position and attach it to the hairy body.
CILIARY BODY; it contains ciliary muscles which help in focusing or accommodation. (curvature of lens is altered which alters the focal length so enabling clear images of objects at varying distances to be formed on retina).
IRIS; in its centre is a pupil. The contraction or relaxation of opposing muscles fibres in the iris increases or decreases the size of the pupil, so controlling the intensity of light entering the iris contains blood vessels and pigment layers that determine the eye colour.

THE RETINA; this is a layer that contains light sensitive cells. It is on the retina that images are formed.
There are two light-sensitive cells in the retina

1. Rods. These are sensitive to different shades of light but not colour. . The rods are more responsive to light of low intensity.
2. Cones. Are sensitive to colour but do not respond in dim light. This why at dusk we can no longer distinguish between colours but see objects as shades of grey

THE BLIND SPOT; region where the nerve fibres leave the eye to enter the optic nerve, there are no light-sensitive cells.
THE FOVEA OR YELLOW SPOT; it gives most accurate interpretation of an image (for colour). It contains only cones and has greatest concentration of sensory cells**.**
THE RECTUS MUSCLE; it attaches the eyeball to the orbit (depression in the skull) and all allows it to move within the orbit.
THE CONJUNTIVA; it covers the exposed part of the eyeball.
It also forms a continuous layer with the skin of eyelids which protect the eyeball and control the amount of light entering the eye. It is kept moist by a solution from the tear gland.

IMAGE FORMATION IN THE BRAIN

Light rays from the object are refracted into the retina by the cornea, lens; aqueous and vitreous humour until they are focused in the retina. Impulses are then sent to the brain through the optic nerve for interpretation. The image formed on the retina is diminished, inverted and real, however the brain interprets the image to give an impression of an upright image of the right size and colour but then also judges the distance of the object from the eye.

ACCOMODATION

This refers to the change in the shape of the lens in order to focus images onto the retina. Rays from a distant object would be focused at a point behind the retina if the lens were not adjusted appropriately. This is made possible by adjusting the size and shape of the lens by the ciliary muscles and also the suspensory ligament.

Far objects

Parallel light rays are refracted by the cornea. The ciliary muscles in the ciliary body relax. The suspensory ligaments straighten/tighten; the lens becomes thin and less convex. Light rays are then focused onto the retina.

Near objects

The diverging light rays are refracted by the cornea. The ciliary muscles in the ciliary body contract. The suspensory ligaments relax and hence sluken. The lens thus becomes thicker and more convex. Light rays are focused into the retina.

Dark and light vision

The eye is also adapted to see both in dim light by varying the amount of light entering it. This is done by varying the size of the pupil so that it is wide to allow in more light when it is dim and is narrow to allow in little light in bright light. These adjustments are done by a set of antagonistic muscles in the iris.

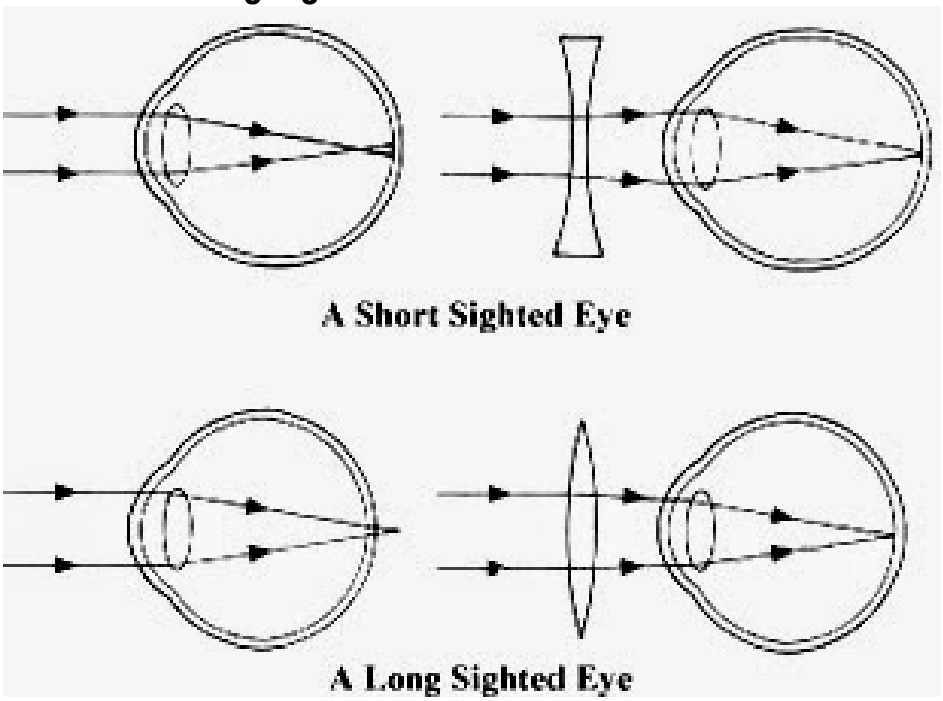
DEFECTS OF THE EYE

These occur when the eye can no longer focus light on the retina unless assisted by some external lenses.

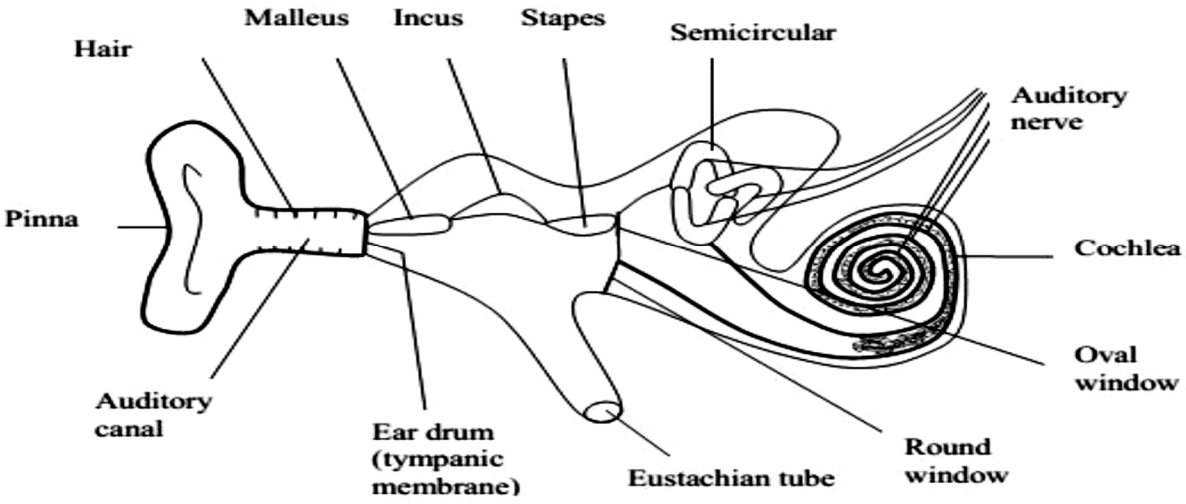
1. **Short sightedness (myopia)**
   A short sighted person cannot focus distant objects properly. Light rays from a distant object fall at a point in front of a retina forming a blurred image. This may be due to the eyeball being too long.
   The defect can be corrected by using spectacles with concave
2. **Long sightedness (hypermetropia**)
   A long-sighted person cannot focus near objects properly. Light rays from the object fall at a point behind the retina. This occurs when the eyeball is too short.
   This defect can be corrected by using spectacles with convex lenses which make the light rays converge before they reach the eye
3. **Astigmatism (presbyopia)**
   This refers to a condition in which the cornea or the lens is unevenly curved, so that light rays passing through them are bent at different angles. This leads to poor

formation of images in the retina. It is a characteristic of old age. It can be corrected by wearing spectacles with special cylindrical lenses.

Correction of short and long sightedness



2. THE EAR



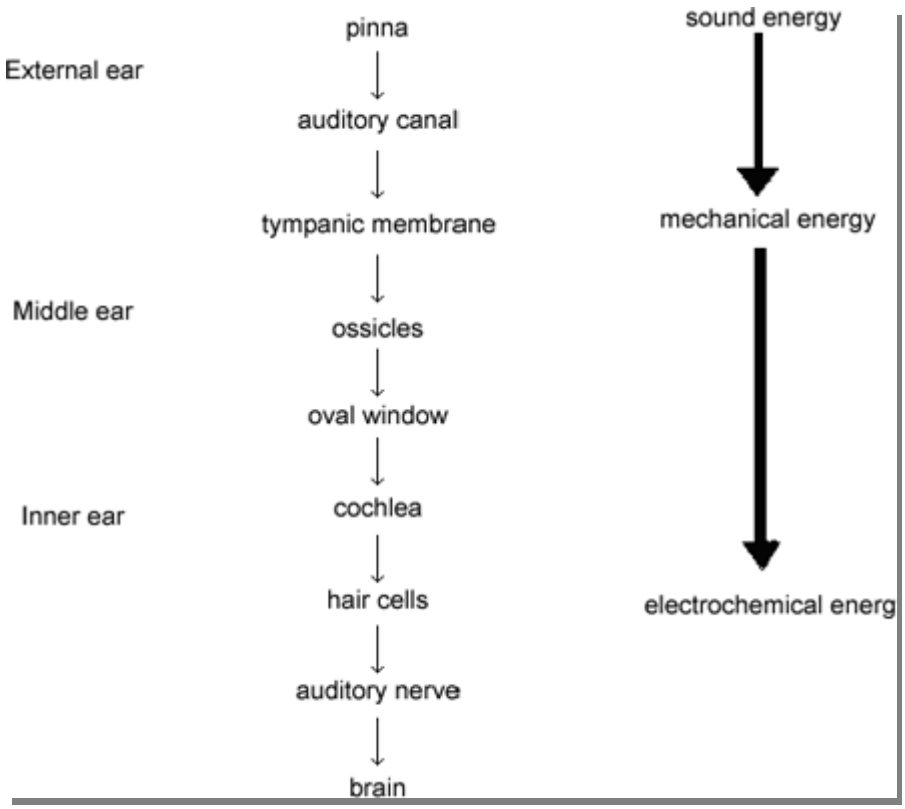
PARTS OF THE EAR

Structure	Description of Anatomy	Functions
Pinna	large fleshy external part of the ear	• collects sound and channels it into the ear • detects the direction of sound
Auditory canal	Narrow canal, air filled and has hairs	• passage of sound waves • prevents easy entry of foreign bodies and dust
Tympanic membrane	the eardrum - a membrane that stretches across the ear canal	• Vibrates when sound waves reaches it and transfers mechanical energy into the middle ear
Ear ossicles	Three tiny bones, the hammer (malleus), anvil (incus) and stirrup (stapes)	• amplify the vibrations from the tympanic membrane
Oval window	region that links the ossicles of the middle ear with the cochlea in the inner ear	• picks up the vibrations from the ossicles and passes them onto the fluid in the cochlea
Round window	membrane between cochlea and middle ear	• bulges outward to allow pressure differences in the cochlea
cochlea	circular fluid filled chamber	• changes mechanical energy into electrochemical
Organ of Corti	A structure within the cochlea	• location of the hair cells that transfer vibrations into electrochemical signals
Auditory nerve	The nerve that travels from the ear to the brain	• Transmits electrochemical signals to the brain
Eustachian tube	Narrow open and air filled	• Connects the mid ear to the roof of the mouth/buccal cavity • Equalizes pressure on either side of the ear drum

Process of hearing

The **pinna** collects the sound waves which are concentrated along the **auditory canal** to the ear drum. The **ear drum** then vibrates and the vibrations are picked by the ear ossicles which transmit the waves to the **oval window**. The oval window **amplifies** the vibrations and passes them to the **fluid** in the **cochlea**. The cochlea **vibrates stimulating the hair cells which then move up** and **down**. At this stage impulses are produced electrochemical signals and sent to auditory nerves which transmit the impulses to the brain where they are interpreted as sound.

Summary of the path taken by the sound waves



Balancing

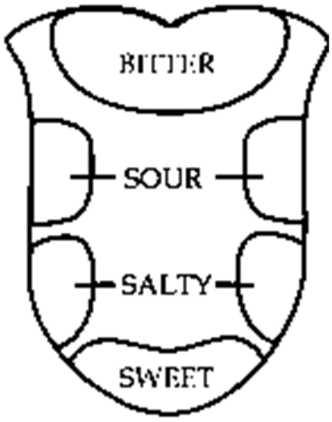
Body balancing refers to the ability of the body to remain stable when subjected to certain forces of decentralisation. The senses of balance is carried out by the semi circular canals. The sensitivity results from many different stimuli perceived by by different receptors e.g

- Eyes supply information about the position and body movement.
- Mechanoreceptors detect changes in pressure and strecthing in muscles

The semicircular canals contain a fluid called endolymph that flows when the head is moved, and sensory cells are embedded in a gelatinous mass containing calcium carbonate called otoliths. These form the capula.

3. TONQUE

The tonque contains sensory cells grouped together in taste buds. Each taste bud consists of elongated cells embeded on the sides of the papillae. The sensory cells, also called gustatory cells have hair like processes projecting above the surface of the papillae. Sensory nerve fibres connecting the cells to the brain are found at the base of the cells. There are four basic taste stimuli that human tonque is capable of detecting.



4. NOSE

This is the sense organ for smell or olfactory. Smell occurs as a result of chemicals in air dissolving in the moist linings of the nasal cavity. The dissolved substance stimulates the chemo receptors in the nose to generate impulses which are carried to the brain by olfactory nerves for interpretation as odour.

5. SKIN

This is an important sense organ because it enables the body to feel

- Touch
- Pressure
- Temperature changes
- Pain

STUDY QUESTIONS

1. A child heard a dog barking; got frightened and ran. Describe how the events occurred.

2. State the similarities and differences between the following
(a) Voluntary and reflex actions
(b) Conditioned reflexes and reflex actions
(c) Hormones and enzymes
(d) Sensory and motor neurons
(e) Tropisms and reflex actions
(f) Nervous and endocrine system
(g) Exocrine and endocrine glands

3. Describe what happens to the nervous system during
(i) a pupil reflex.
(ii) the knee jerk.

4. (a) state the causes of long sightedness and short sightedness
(b) Draw a diagram to show the structure involved in a spinal reflex
(c) Draw a diagram to show how the eye defects in 4 (b) above can be corrected.

5. (a) draw a diagram to show the structure involved in a spinal reflex
(b) What happens to your body when you sit on a sharp pin?

6. (a) describe the adaptation of the human eye
(b) How is an image formed on the retina?
(c) Describe the various causes of deafness

7. State the functions of the major parts of the brain.

8. A boy moved out of the classroom to see a distant aeroplane. Describe the adjustments in his eye.

9. Describe an experiment to show that plant shoots are positively phototrophic.