

NERVOUS COORDINATION IN HUMANS

COMPETENCY: the learner should be able to appreciate that nerve impulses are electrical in nature, and are transmitted by specialized nerve cells whose structures differ to perform different roles in transmission.

LEARNING OUTCOMES: by the end of the chapter, the learner should be able to:

- ❖ Understand how the nervous system (brain, spinal cord and nerves) extend to all parts of the body and has sensory and motor functions.
- ❖ Identify the parts in the brain (cerebrum, cerebellum, medulla oblongata, pituitary gland and hypothalamus) and describe the role of the parts.
- ❖ Understand the concept of reflex action, identify the five components and explain their functions.
- ❖ Differentiate between voluntary and involuntary responses.
- ❖ Distinguish between substance/ drug abuse and abuse.
- ❖ Know the common substances and drugs abused in Uganda and understand the physiological, social and economic effects of substance and drug abuse.
- ❖ Understand how to control and avoid involvement in substance and drug abuse.

THE NERVOUS SYSTEM

This is a system of nerve cells and sensory organs that carry out coordination by transfer of impulses. It involves a network of message conducting cells called neuron cells connected to all body parts.

The nervous system is composed of

- ✓ Nerve cells/neurons
- ✓ Receptors
- ✓ Effectors.

KEY DEFINITIONS

A nerve cell; is the basic structural and functional unit of a nervous system along which nerve impulses are transmitted.

A receptor; is a sensitive cell, tissue or organ that receives a stimulus; converts it into nerve impulses and sends it to the central nervous system (brain or spinal cord). Examples of receptors include eyes, ears, nose, skin etc.

An effector; is a cell, tissue, organ/structure that receives impulses from the central nervous system and makes the necessary reaction/response. **For example**

EDUCATOR MARV

muscles and glands. **Response;** this is a change in activity of an organism in reaction to a stimulus e.g. withdraw of a hand from a hot object.

Central nervous system: this is the central part of the nervous system that consists of the brain and the spinal cord. It interprets and determines the nature of the response to the stimulus.

Peripheral Nervous system: This consists of spinal and cranial nerves which are either voluntary or involuntary nerves. The involuntary nerves form the autonomic nervous system

Autonomic nervous system

This consists of the sympathetic and parasympathetic nerves.

Functions of the nervous system

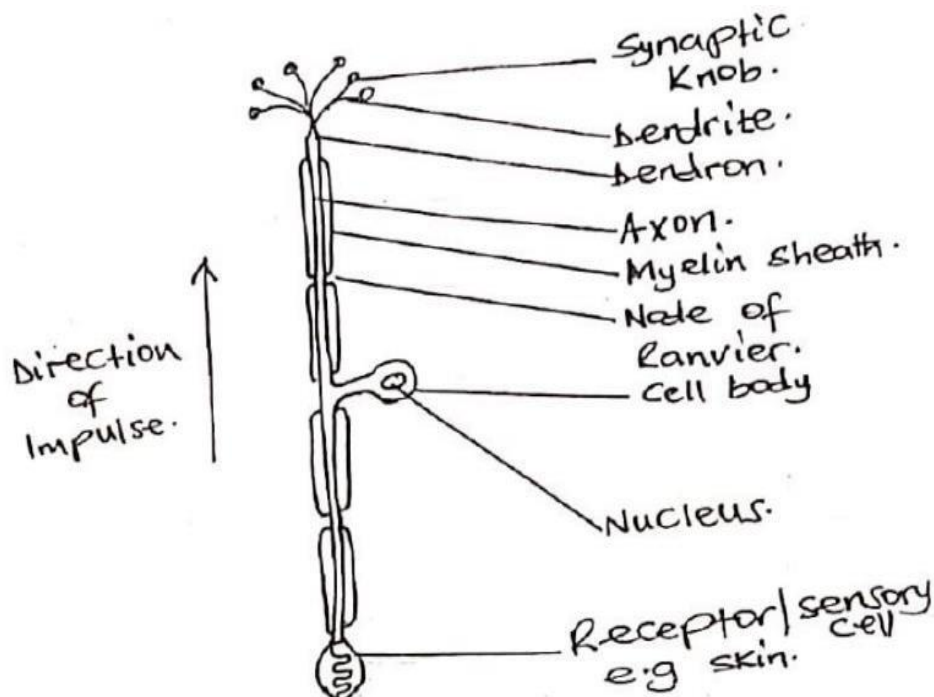
- ❖ It receives impulses from all sensory organs of the body.
- ❖ It stores information.
- ❖ It correlates various stimuli from different sensory organs.
- ❖ It sends messages to all parts of the body making the body function as a single entity.

TYPES OF NERVE CELLS

1. SENSORY NEURONS OR AFFERENT NEURONS

These receive impulses from receptors and transmit them to the central nervous system. A sensory neuron has a single elongated dendrite called a **Dendron**.

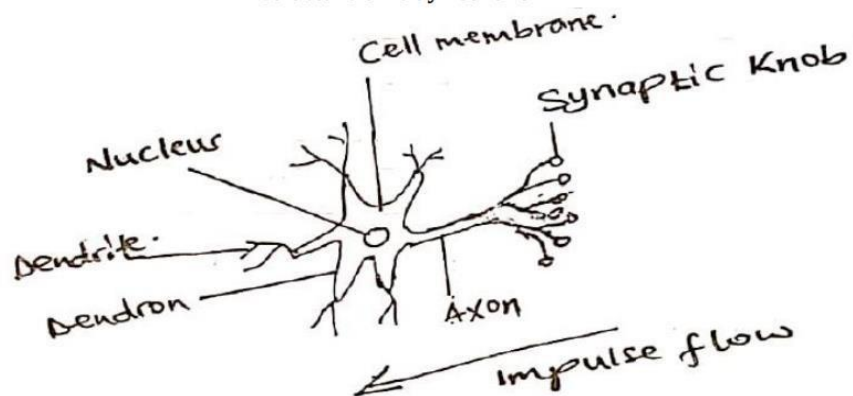
STRUCTURE OF A SENSORY NEURON



RELAY/INTERMEDIATE/ASSOCIATIVE/INTERCALARY NEURONS

These conduct impulses within the central nervous system linking sensory neurons to the motor neurons. They are located in the central nervous system between sensory and motor neurons.

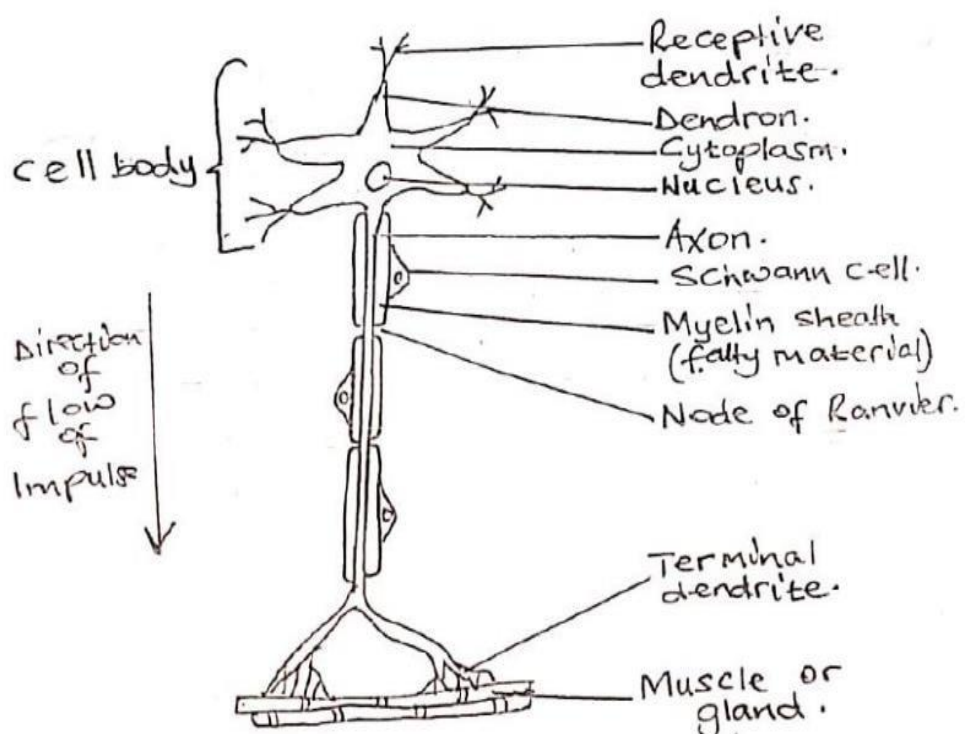
STRUCTURE OF A RELAY NEURON



MOTOR OR EFFERENT NEURONS

These receive impulses from the central nervous system and transmit them to the effectors. They have short dendrites with a cell body at one end of a long axon.

THE STRUCTURE OF A MOTOR NEURON



FUNCTIONS OF THE DIFFERENT PARTS OF THE NEURON

(i) Dendrites and dendrones;

- ✓ Are extensions of the cell body.
- ✓ They link one nerve cell to another via small gaps called **synapses**.
- ✓ Receptive dendrites of a motor neuron receive impulses from relay neuron and send them to the cell body
- ✓ The terminal dendrites of motor nerve send impulses to the effector (muscle).

(ii) Cell body

Contains cytoplasm in which cell reactions occur like respiration that releases energy used to transmit impulses.

Has nucleus that controls cell activities.

(iii) Axon

- This is a cytoplasmic extension running from the cell body.
- It carries impulses from the cell body to an effector/brain. It contains cytoplasm called **axoplasm**.

(iv) Schwann cell;

Produces myelin sheath.

(v) Myelin sheath; fatty material.

It is made of fats. It insulates the axon and speeds up the transmission of nerve impulses.

(vi) Synaptic knob

It contains chemicals called **neurotransmitter substances**; which when released are used to transmit a nerve impulse across a synapse from one nerve cell to another.

A synapse is a microscopic gap between 2 nerve cells or between a nerve cell and an effector; through which transmission of an impulse occurs neurotransmitter substance released from the synaptic knob.

Thus, the dendrite endings of one nerve cell don't touch those of another but there is a gap called **synapse**.

Synapse ensures that impulses flow in only one direction.

EDUCATOR MARV

(vii) **Node of Ranvier:** It is a small gap between adjacent myelin sheaths.

It also speeds up transmission of nerve impulses.

BRAIN CHECK

Compare;

Motor with relay neurons

Sensory and relay neurons.

Sensory and motor neurons.

Comparison between motor and sensory neurones

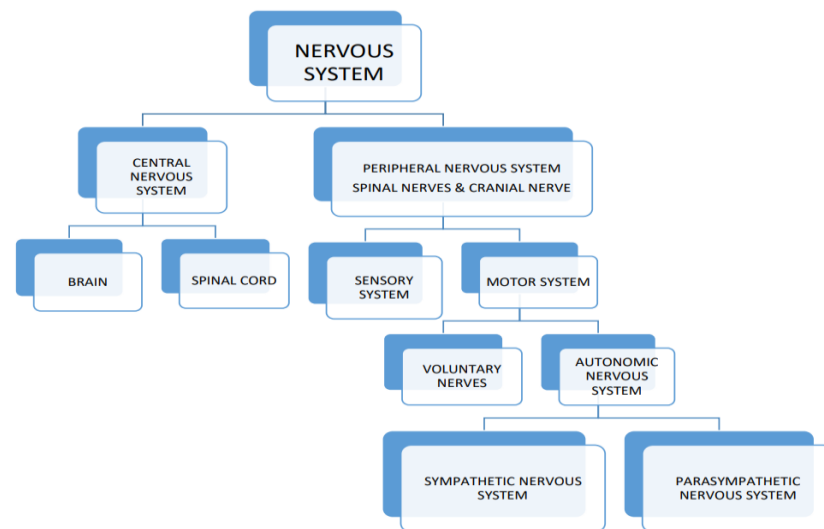
Similarities:

1. They both transmit impulses.
2. They both have a nucleus.
3. They both have an axon,
4. Both have dendrites
5. Both have cytoplasm in their cell bodies.
6. In both impulses move in one direction.

Differences:

Motor neurone	Sensory neurone
i) Has a longer axon	Has a shorter axon
ii) It has a cell body at the terminal end of the axon	Has a cell body located on the axon branch.
iii) It has a short dendrite	It has a long Dendron
iv) It carries impulses from the central nervous system to the effectors	It carries impulses from the receptors to the central nervous system.
v) It has several dendrites	It has one Dendron

COMPONENTS OF THE NERVOUS SYSTEM

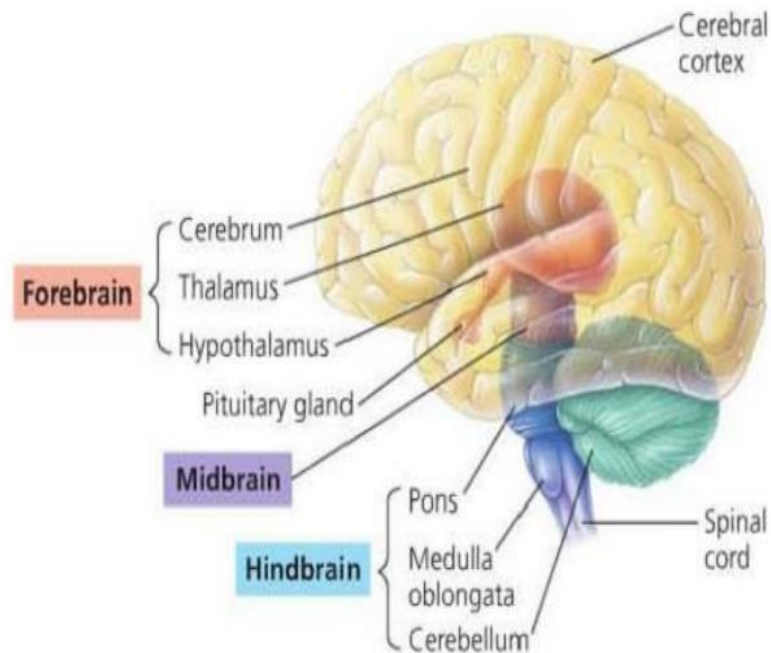


THE CENTRAL NERVOUS SYSTEM

This is made up of the brain and spinal cord.

The brain is covered and protected externally by the **skull (cranium)** and internally by membranes called **meninges**. It is made up of three distinct areas namely the **forebrain**, **midbrain** and hind brain.

THE BRAIN



EDUCATOR MARV

1. THE FORE BRAIN

It consists of the:

The cerebrum (cerebral hemisphere):

It consists of right and left cerebral hemispheres which are interconnected by the **corpus callosum**.

It is covered by a thin layer of cerebral cortex.

The right hemisphere sends and receives impulses from the left side of the body while the left hemisphere receives impulses from the right side of the body.

It coordinates **learning, memory, reasoning, conscience and personality**. It is responsible for intelligence. (Sensing, thinking and imagining).

2. THE MID BRAIN

The thalamus

It transmits impulses of sensations received from sense organs like eyes, ears and skin to the cerebral cortex of the cerebrum.

Hypothalamus:

It is found below the thalamus and controls activities of the pituitary gland.

It controls body temperature, carbon dioxide levels in blood, appetite, sleep, hunger, sex drive etc.

It produces hormones like Oxytocin and ADH that are stored in the pituitary gland.

It also coordinates and controls the autonomic nervous system.

The autonomic nervous system is a control system that acts largely **unconsciously** and **regulates bodily functions**, such as the **heart rate, digestion, respiratory rate, pupillary response, urination, and sexual arousal**.

This system is the primary mechanism in control of the **fight-or-flight** response.

Pituitary gland: it secretes a number of hormones like the thyroid stimulating hormone, follicle stimulating hormone, luteinizing hormone etc.

Optic lobes: are paired lobes which interpret sight.

3. HIND BRAIN

It is made up of:

Cerebellum: It is responsible for maintenance of balance, posture and muscular coordination (locomotion). It receives impulses from skeletal muscles. It is the one affected in drunkards.

Medulla oblongata: It controls involuntary actions in the body like yawning, vomiting, blinking of eyes etc. Injury to this region leads to instant death.

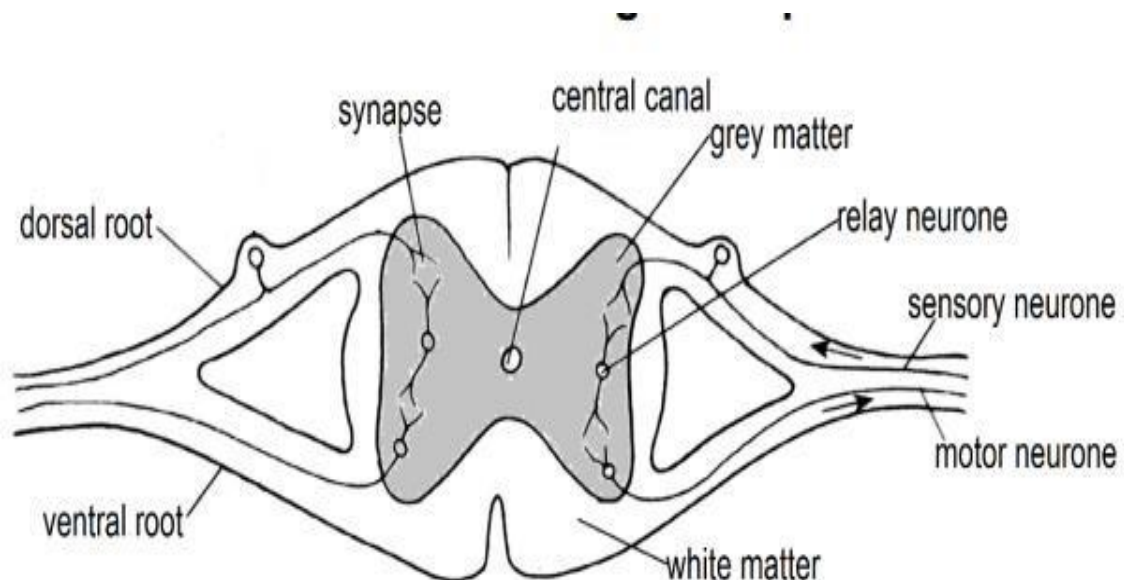
FUNCTIONS OF THE BRAIN

- ✓ It receives impulses from all receptors and sends back impulses to the effectors.
- ✓ It integrates and coordinates all activities in the body such that the body works efficiently.
- ✓ It stores information.
- ✓ It is involved in cranial reflex actions but it does not initiate them.

THE SPINAL CORD

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

TRANSVERSE SECTION THROUGH THE SPINAL CORD



FUNCTIONS OF THE SPINAL CORD

- ❖ It connects the peripheral nervous system to the brain.
- ❖ It is a center for simple spinal reflex actions.
- ❖ Receives impulses from receptors.
- ❖ Interprets messages especially in reflex arc.
- ❖ Sends impulses to the effectors.

THE PERIPHERAL NERVOUS SYSTEM

It is made up of **neurons** that link the **brain** and **spinal cord** to **muscles** and **organs such as the eyes and ears**.

It is divided into **autonomic nervous system** and **somatic nervous system**.

The autonomic nervous system is responsible for the **involuntary** control of internal organs, blood vessels, smooth muscles and cardiac muscles.

The somatic nervous system is responsible for the **voluntary** control of skin, bones, joints and skeletal muscles.

VOLUNTARY AND INVOLUNTARY ACTIONS

VOLUNTARY ACTIONS

These are initiated consciously under the direct control of the brain i.e. they are actions one does at will e.g. **dancing, laughing, stealing**, etc.

These actions are performed consciously by an animal.

In such actions the animal chooses to do or not to do something.

INVOLUNTARY ACTIONS

These are actions that occur without conscious thoughts e.g. **breathing**, yawning, blinking of eyes etc.

They are rapid autonomous actions that occur without the conscious thoughts of the animal.

DIFFERENCES BETWEEN VOLUNTARY AND INVOLUNTARY ACTIONS

Voluntary actions	Involuntary actions
Result from decision making and free will.	Do not involve thoughts, decision making and not done at will.
Controlled by the cerebrum	Controlled by medulla oblongata
They take time since they involve thinking.	They are fast since they do not involve thinking.
The same stimulus may bring different responses e.g. hunger can evoke eating or crying in children.	The same stimulus brings about the same response time and again.

THE REFLEX ACTION

A reflex action is a rapid automatic (involuntary) response to a particular stimulus.

Reflex actions take place without the awareness of the individual and are not initiated by the brain.

A reflex action occurs as a result of impulses travelling along neurons in a path called a **reflex arc**.

A reflex action can either be **simple reflex or conditioned reflex**.

SIMPLE REFLEX ACTION

This is an involuntary quick response to a stimulus without conscious thoughts.

It is also known as an **instinctive reflex** which does not have to be learnt.

They include **sneezing, coughing, salivating, the knee jerk and removal of a hand from a hot flame**.

For instance: when one steps on a sharp object, the knee jerk enables the removal of the foot thus avoiding further injury.

CHARACTERISTICS OF A SIMPLE REFLEX ACTION

- ❖ It occurs rapidly i.e. the action occurs very fast.
- ❖ It is inborn (innate) but not learnt.
- ❖ It is coordinated by either the brain or spinal cord but usually initiated by spinal cord.

EDUCATOR MARV

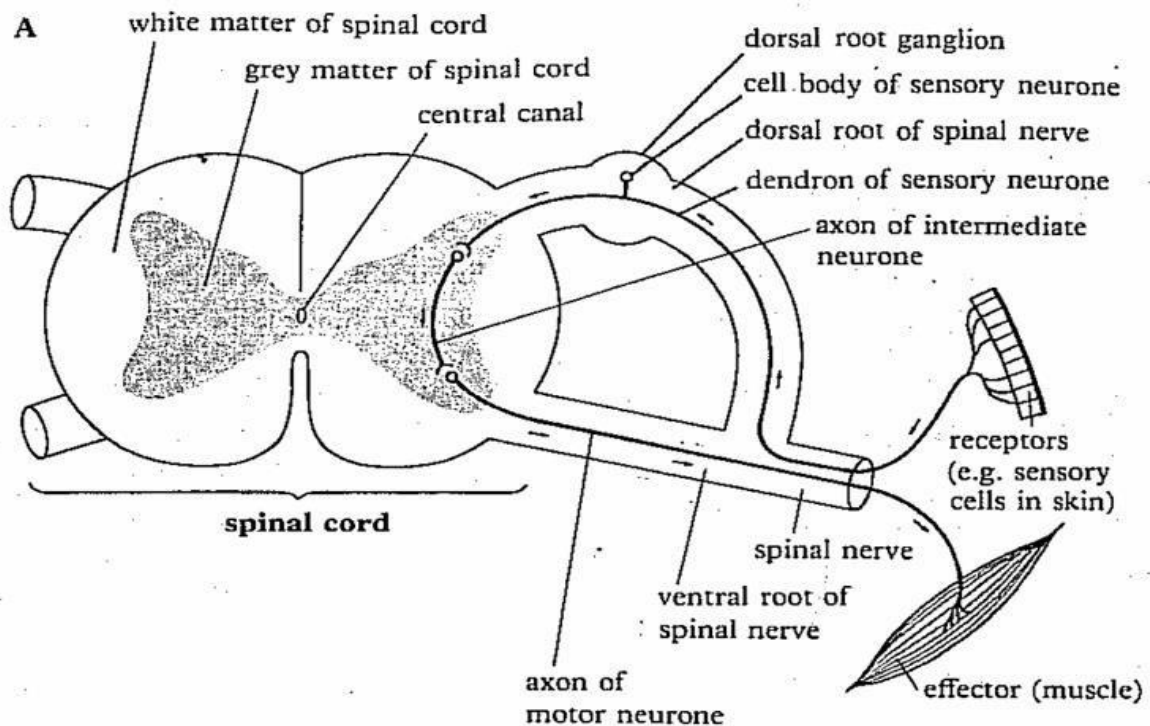
- ❖ It occurs without one's will.
- ❖ It is a repeated response to a similar stimulus.
- ❖ Three neurons are involved i.e sensory, relay and motor neurons.

EXAMPLES OF SIMPLE REFLEX ACTIONS

Simple reflex action	stimulus	Importance
Knee jerk	Touch on tendon of the knee	Prevents damage of the lower leg
Withdrawal of hand	Hot objects	Prevents burning of hand
Blinking	Foreign particles on the cornea	Protects the eye from physical injury
salivation	Sight or sight of food	Prepares the individual for softening and lubrication of food, easing swallowing.
Constriction of the pupil of eye.	Bright light	Prevents excess entry of light into the eye, which can damage the cells in the retina.
Sneezing	Dust getting into nose	Releases and expels dust containing germs e.g bacteria
Secretion of tears	Onion peels	Irritating chemicals that can damage the eyes are washed away by tears.

DESCRIPTION OF THE REFLEX ARC

Reflex arc is a route or nervous pathway taken by the nerve impulses in a reflex action.

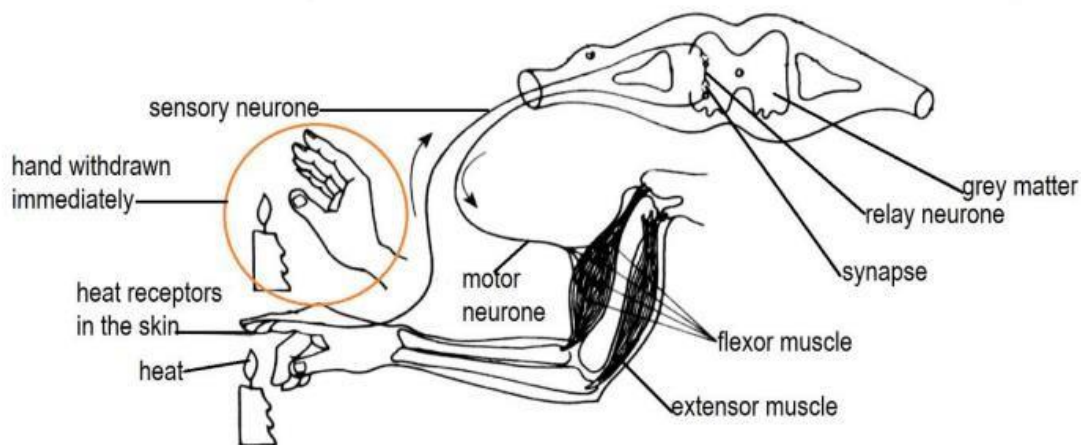


EDUCATOR MARV

The stimulus is perceived by the **receptors**, which change it into nervous impulse (**transduction**).

- ❖ The impulse travels along the sensory neuron to the spinal cord.
- ❖ In the **grey matter** of the spinal cord, the sensory neuron makes synaptic connections to the relay neuron and impulses move from the sensory neuron to the relay neuron across synapses.
- ❖ The relay neuron in turn transmits the impulse to the motor neuron across a synapse.
- ❖ The impulse then moves from the spinal cord to the effector muscles through the motor neuron.
- ❖ The impulse causes the muscles to contract or relax depending on the stimulus.

Reflex arc of a hand being withdrawn from a hot flame



HOW A HAND IS WITHDRAWN FROM A HOT OBJECT

(AN EXAMPLE OF A SIMPLE REFLEX ACTION)

- ❖ When one accidentally touches a hot object using a finger, the heat receptors in the finger receive the stimulus and change it into nervous impulses that travel along the sensory neuron to the spinal cord and then cross the synapse.
- ❖ The impulse is then handed over to the relay neuron in the spinal cord (grey matter) and then cross another synapse.
- ❖ The relay neuron in turn hands over the impulse to the motor neuron.
- ❖ The motor neuron then carries the impulse from the spinal cord to the effector muscles of the hand.
- ❖ This causes the muscles to contract and the hand is removed from the hot

EDUCATOR MARV

object.

❖ At the same time, the original message is sent to the brain which then interprets it as pain or heat.

Note; these processes occur rapidly in the body without the awareness of the individual.

THE KNEE JERK REFLEX

- ❖ When the knee is tapped, the receptors in the knee detect the stimulus.
- ❖ The stimulus is converted into electrical messages (impulses).
- ❖ These impulses are transmitted by the sensory neuron to the spinal cord.
- ❖ In the spinal cord the sensory neuron transmits the impulses to the relay neuron across a synapse.
- ❖ The relay neuron relays the impulses to the motor neuron across a synapse.
- ❖ The motor neuron transmits the impulses to the effectors.
- ❖ The effectors bring about the response.

THE IMPORTANCE OF SIMPLE REFLEX ACTIONS

- ❖ They help animals to avoid danger
- ❖ They control activities in the body, which we do not have conscious control over.
- ❖ They form a basis of some animals' behavior, e.g. amoeba.

ASSIGNMENT

Using Biology reference material or the internet, research and read about conditioned reflex actions e.g. Ivan Pavlov's experiment on the dog.

Similarities between the nervous and endocrine system

- ✓ Both affected by nature of stimulus
- ✓ Both cause a response
- ✓ Both result co-ordination in the body
- ✓ Both involve chemical transmission of messages
- ✓ Responses in both are both physiological and physical

Nervous system	Endocrine system
Nerve impulses are both electrical and chemical	Messages are only chemical
Responses are fast.	Responses are slow
Responses are shorter lived	Most responses occur over a longer time
Impulses are transmitted along nerve fibres	Hormones are carried in blood
This effect is more localized (specific)	Effect is wide spread in the whole body
Stimulus arises from any part of the body where sensory receptors are located.	Stimulus arises from specific organs and tissues only e.g. endocrine glands.

DRUG/SUBSTANCE USE AND DRUG ABUSE

Drug use refers to the act of consuming drugs or substances typically for recreation or medicinal purposes. It can be responsible, controlled and even beneficial in certain cases.

Drug abuse or substance abuse refers to the misuse, over use and excessive consumption of drugs leading to negative consequences on the physical, mental and social wellbeing of the person.

It is associated with loss of control, impaired judgment and decline in mental and physical health.

Common drugs include; **alcohol, cigarettes, marijuana, kuber, khat, shisha, and petrol/glue, cocaine/coke, heroin**

CAUSES OF DRUG AND SUBSTANCE ABUSE

- ❖ Peer pressure
- ❖ Mental health disorders such as anxiety, depression etc.
- ❖ Low self esteem
- ❖ Lack of parental guidance and supervision

PHYSIOLOGICAL EFFECTS OF DRUG ABUSE

- ❖ Nausea and abdominal pain, which can also lead to changes in appetite and weight loss
- ❖ Increased strain on the liver, which puts the person at risk of significant liver damage or liver failure
- ❖ Seizures
- ❖ Stroke
- ❖ Mental confusion
- ❖ Brain damage
- ❖ Lung disease
- ❖ Weakened immune system increasing risk of illness and infection
- ❖ Heart conditions.

SOCIAL AND ECONOMIC EFFECTS OF DRUG ABUSE

- ❖ Users become paranoid about their relationships e.g thinking their friends are turning against them.
- ❖ Become aggressive and violent towards people.
- ❖ Family conflicts that might include physical, mental abuse and neglect.
- ❖ Unemployment.
- ❖ Increased likelihood of emotional and mental disorders (like anxiety and depression)
- ❖ Sexually transmitted diseases, due to unprotected sex
- ❖ Unplanned pregnancies.

EDUCATOR MARV

Prevention, control of substance and drug abuse

- ❖ Providing moral support and counselling.
- ❖ Effectively deal with any kind of temptations and peer pressure
- ❖ Create awareness about the side effects and consequences of the addiction
- ❖ Avoid addiction to all these drugs
- ❖ Treatment of the people who are already addicted
- ❖ Build habits to stay busy.
- ❖ Practice positive self-talk.