

Overview:

The brain and its essential parts are the most complex system ever known. With one trillion separate cells, each one in a continuous process of changing in response to chemical signals. From the moment of conception to the moment of death, the biology of the individual is changing. It is in this complexity that our species has found the capability to store the accumulated experience of thousands of generations to create human culture. Our language, religions, governments, childrearing practices, technologies, economies are all man made. All depend upon the remarkable capacity of the brain to make internal representations of the external world.

Biological Basis of Behavior

The physical structure of the body plays an important role in the behavior of an individual. The most important physical structure for psychologists is the nervous system. The nervous system carries orders from the brain and spinal cord to various glands and muscles; it also carries signals from stimuli receptors to the spinal cord and brain.

Nervous system

The nervous system is a complex combination of cells that allows an organism to gain information about what is going on inside and outside the body and to respond appropriately. It allows to learn and to act.

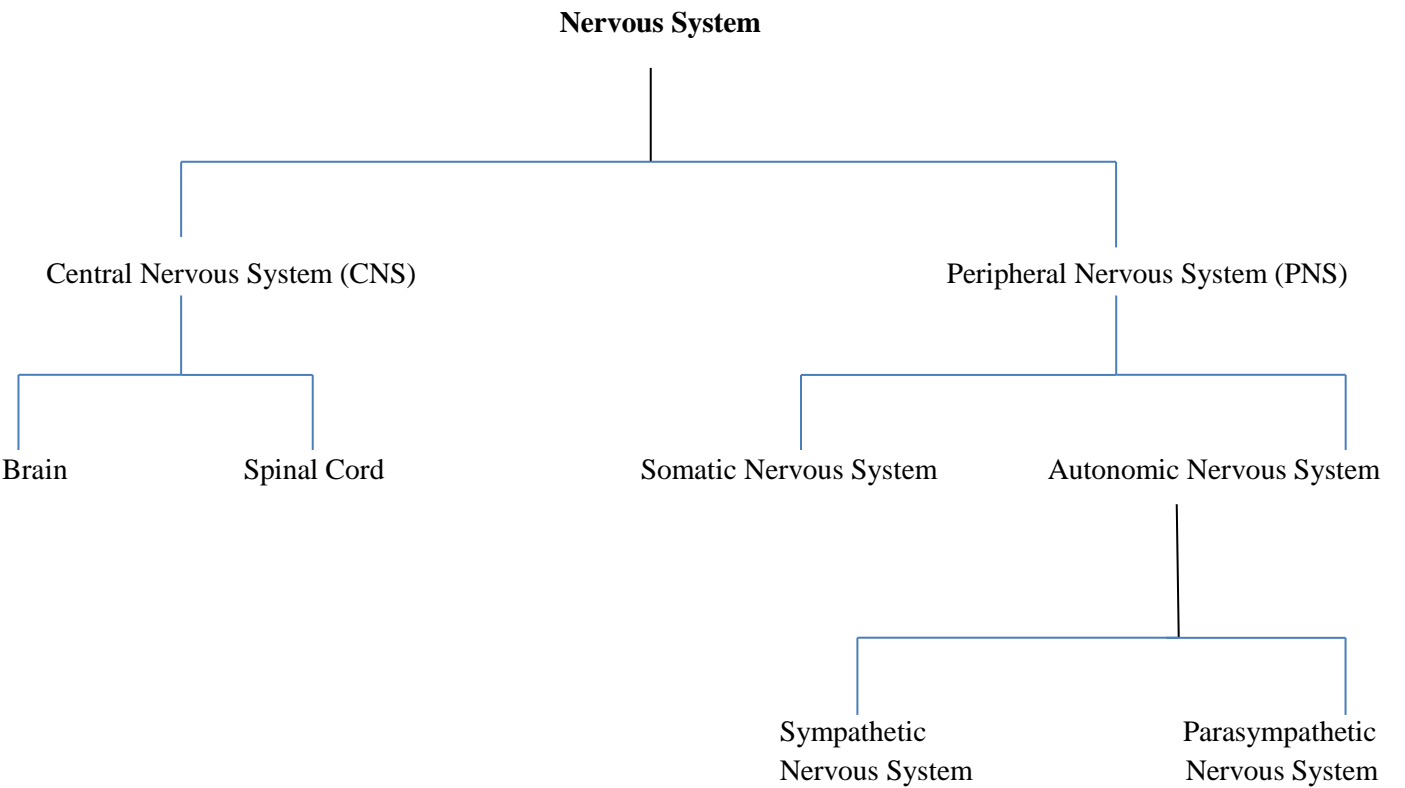
Many aspects of behavior and mental functioning cannot be fully understood without some knowledge of the underlying biological processes.

Our nervous system, sense organs, muscles and glands enable us to be aware of and to adjust to our environment. Our perception of events depends on how our sense organs detect stimuli and how our brain interprets information coming from the senses.

Much of our behavior is motivated by our basic needs. Our ability to use language, thinking and problem solving depends on a complex brain structure. The human nervous system provides for the flexible functioning of a biological organism that faces constant challenges from an ever changing environment.

The system that controls and regulates the structure and function of the brain, spinal cord, nerves, and the nerve cells; it maintains coordination between the nervous system and the rest of the bodily systems.

- It is responsible for the internal communication system that ensures the integrated functioning of the various systems.
- Nerve impulse is an electrical impulse that travels along the nerves at a speed of around 400km/ hour.
- Brain cells never re grow; once destroyed or dead, they can not be replaced.
- Nerve fibers are very thin and fine in size.



**All parts of nervous system are interrelated for discussion purposes it can be separated into following divisions and subdivisions.**

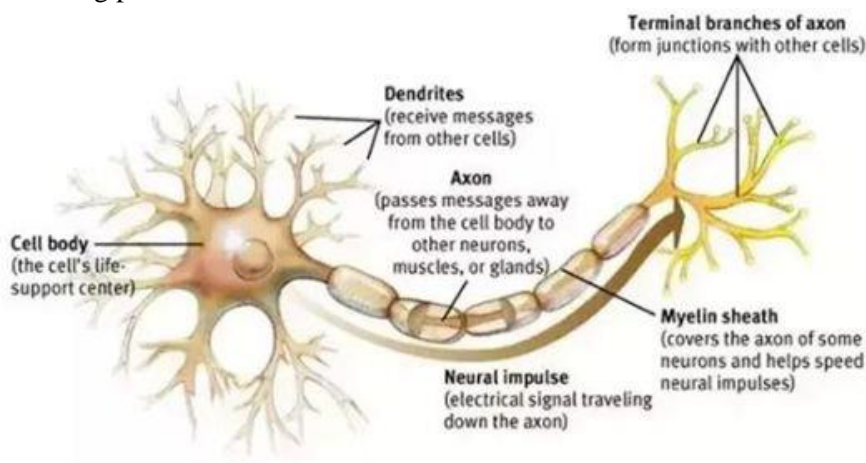
## **The Neuron**

Neurons are microscopically small cells that exist throughout our nervous system by the billion. They are tiny in the complex. All behaviors begin with the action of neurons. A neuron is a cell specialized to receive process and transmit information to other cells within the body.

Neurons have the basic building blocks of the nervous system. They are in shape, size, chemical composition and function. Neuron gathers information from one and transmits signals to the other.

## **Structures of Neurons**

A typical neuron has following parts



## **Dendrites**

It is derived from Greek word meaning tree. Dendrites are the branch like extensions from a neuron's cell body where most neural impulses are received. In a mature neuron there may be thousands of dendrites.

## **Cell Body**

All neurons are certain to have a cell body or soma. It contains the nucleus of the cell which contains the genetic information that keep cell functioning. With nucleus it contains the **cytoplasm** that sustains the cells life. The soma combines and averages all the information coming in from its dendrites and passes it to an extended fiber, the axon.

## **Soma**

The cell body containing the cytoplasm and the nucleus of the cell; cytoplasm keeps it alive. Soma often circular in shape furnishes the cell with nutrients and manufactures chemicals used in transmitting information.

## **Axon**

It is a long tail like extension of a neuron. It carries an impulse away from the cell body toward the synapse. Axons take the signal from soma and conduct it along its length. This length varies; it can be more than three feet in the spinal cord and less than a millimeter in brain.

## **Myelin Sheath**

It is a white fatty covering found on some axons that serves to insulate and protect them while increasing the speed of impulse.

## **Synapse** (*Connection between nerve cells*)

There is a gap between the end of each neuron and the start of the next. This junction is known as synapse, to bridge the gap and get the neural message across to the next neuron in line electrical conduction in the axon is changed to chemical transmission. When a neural impulse travels down the axon and arrives at the axon terminals, it triggers the secretion of a chemical called a neurotransmitter. The neurotransmitter substance travels across the synaptic gap and stimulate the next neuron.

**Synaptic Transmission:** the procedure through which information is relayed from one neuron to another across the synaptic gap.

Neurons communicate with one another at junctions called synapses. At a synapse, one neuron sends a message to a target neuron another cell.

Most synapses are chemical; these synapses communicate using chemical messengers. Other synapses are electrical; in these synapses, ions flow directly between cells.

At a chemical synapse, an action potential triggers the presynaptic neuron to release neurotransmitters.

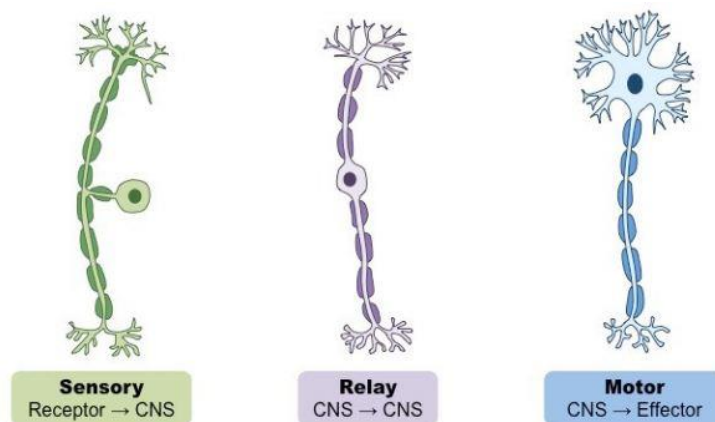
**Neurotransmitters:** The post synaptic neuron is stimulated by the chemical messages released from neurons; they cross the synapse from one neuron to another.

### Neurotransmitters and Their Role

- **Acetylcholine:** Learning, Memory and Muscle control
- **Dopamine:** Motor activity, Coordination, Emotion and Memory
- **Epinephrine:** Emotion, Stress
- **GABA (Gamma-Amino Butyric Acid):** Anxiety, Arousal, Learning
- **Serotonin:** Sensory Processing,
- **Glutamate:** Anxiety, Mood

### Types of neurons

- **Sensory Neurons (afferent):** they carry messages toward the Central Nervous System from the sensory receptor cells.
- **Motor Neurons (efferent):** they carry messages away from the Central Nervous System toward the muscles and glands.
- **Inter-Neurons:** they relay messages from sensory neurons to other inter-neurons and/or to motor neurons. Sensory neurons rarely communicate directly with motor neurons. Between them is, usually a third category of neurons called interneurons. Interneurons are in billions and found only in brain and spinal cord.



### Main Parts of the Nervous System

- **The Peripheral Nervous System**
- **The Central Nervous System**

### Peripheral Nervous System

The central nervous system is isolated from any direct contact with the outside world. Peripheral nervous system is the network of sensory and motor neurons between the central nervous system and the surface of the body.

- The peripheral nerves located throughout the body, have two types.
  - Some carry information from each of the sensory receptors as in the eyes, ears, skin and so on to the brain.
  - Some carry messages from the brain and spinal cord to the muscles and glands.

The central and peripheral nervous system are continually communicating with each other.

## Somatic Nervous System

- This system is under voluntary control. It controls the skeletal muscles of the body.

## Autonomic Nervous System

- This nervous system controls the nerves of the inner organs of the body on which humans have no conscious control. This includes the heartbeat, digestion, breathing (except conscious breathing) etc.
- The nerves of the autonomic nervous system circulate the smooth involuntary muscles of the (internal organs) and glands and cause them to function and secrete their enzymes etc. Autonomic Nervous System has two parts:
  1. **The sympathetic nervous system**
  2. **The parasympathetic nervous system**

### The sympathetic nervous system

The sympathetic nervous system (SNS) is part of the autonomic nervous system (ANS), which also includes the parasympathetic nervous system (PNS). The sympathetic nervous system activates what is often termed the fight or flight response.

This part of ANS arouses us for defensive action fight or flight.

If something alarms, endangers, excites, or enrages a person, the sympathetic nervous system accelerates heart beat, slows digestion, raises the sugar level in blood, dilates the arteries and cools the body through perspiration; makes one alert and ready for action.

### The parasympathetic nervous system

**When the stressful situation subsides, parasympathetic nervous system begins its activity.**

- It produces an effect opposite to that of sympathetic nervous system.
- It conserves energy by decreasing heart beat, lowering blood pressure, lowering blood sugar and so on.
- In daily life situations, both sympathetic and parasympathetic systems work together to keep us in steady internal state maintaining the homeostasis.

The parasympathetic nervous system is one of two divisions of the autonomic nervous system. Sometimes called the rest and digest system, the parasympathetic system conserves energy as it slows the heart rate, increases intestinal and gland activity, and relaxes muscles in the gastrointestinal tract.

## The Central Nervous System

The central nervous system consists of the **brain** and **spinal cord**. It is referred to as "central" because it combines information from the entire body and coordinates activity across the whole organism.

### The Brain (The center of the nervous system)

- The vital organ that is responsible for the functions of seeing, hearing, smelling, tasting, thinking, feeling, remembering, speaking, dreaming, information processing, and a lot more.
- The regulator of basic survival functions such as breathing, resting and feeding.
- It is responsible for abstract level functions such as decision making, foresight, and problem solving.
- The spinal cord is an information highway connecting the PNS to the brain.
- Information travels from the brain by way of spinal cord.
- The brain is the most complex organ in the body and uses 20 percent of the total oxygen we breathe in.
- The brain consists of an estimated 100 billion neurons, with each connected to thousands more.

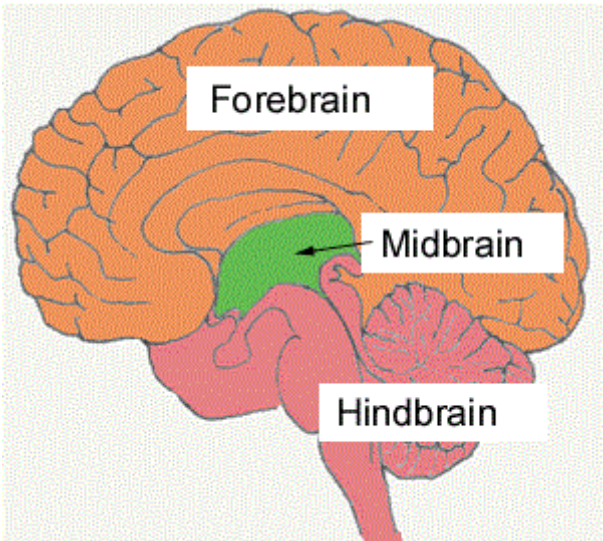
### Functions of the Various Structures of the Brain

- • Regulation of the internal systems
- • Reproduction
- • Sensation
- • Motion (movement control)
- • Adaptation to the varying environmental demands

Structure of Brain

- The deeply grooved structure lies safely and securely in our skull.
- The average adult human brain weighs 1.3 to 1.4 kg (approx. 3 pounds).
- If you look at it from the outside the brain is pinkish gray in color; soft and mottled.
- The brain contains billions of nerve cells (neurons) and trillions of "support cells".

Major Divisions of the Brain



There are three major divisions of the brain. They are the forebrain, the midbrain, and the hindbrain.

- 1- The **forebrain** is responsible for a number of functions related to thinking, perceiving, and evaluating sensory information.
- 2- The **midbrain**, connects the hindbrain and the forebrain. It is associated with motor functions and auditory and visual responses.
- 3- The **hindbrain** is associated with balance and equilibrium and the coordination of movement along with autonomic functions like our breathing and our heart rate.

1. Fore Brain

- Cerebrum
- Thalamus
- Hypothalamus
- Limbic system

2. Mid Brain

- Tectum
- Tegmentum
- Reticular formation
- Substantia nigra

3. Hind Brain

- Cerebellum
- Pons
- Medulla oblongata

Cerebrum (Fore Brain)

- Largest part of the human brain, associated with higher brain functions such as thought and action.
- Occupies 2/3 of the brain’s total mass
- Consists of two symmetrical halves or hemispheres; The right cerebral hemisphere controls the left side of the body and vice versa.
- The hemispheres are connected by Corpus Callosum, a thick mass of nerve fibers.
- Cerebrum regulates the brain’s higher cognitive and emotional functions.

Thalamus (Fore Brain)

- The pair of egg-shaped structures located at the top of the brainstem.
- Incoming sensory information is channeled to the appropriate area of the cerebral cortex by thalamus, so that it is processed there.
- Thalamus acts like a relay station of the brain’s sensory switchboard; it directs messages to the sensory receiving areas in the cortex and transmits replies to the cerebellum and medulla.
- It receives information from the sensory neurons and routes it to the higher brain regions that
- deal with vision, audition, taste and touch.

Hypothalamus (Fore Brain)

- One of the smallest structures in the brain.
- The neural structure laying below (hypo) the thalamus; Composed of several nuclei. Small bundles of neurons that regulate physiological processes involved in motivated behavior e.g. hunger, thirst, regulation of body temperature.
- Hypothalamus acts as the body’s Thermostat.
- Helps govern the endocrine system via the pituitary gland.
- Is linked to emotions.

## Homeostasis

- Hypothalamus maintains the body's internal equilibrium e.g. looking for food when energy levels are low, causing constriction of the blood vessels when body temperature falls.

## Limbic System (Fore Brain)

- Evolutionarily the structure of limbic system is rather old.
- The limbic system, often referred to as the "emotional brain", is found buried within the cerebrum.
- At the border of the brainstem and cerebral hemispheres it is a doughnut-shaped system of neural structures; associated with emotions e.g. fear and aggression, and drives like hunger and sex; regulates body temperature, blood sugar level and blood pressure.

## Structures within the Limbic System (Fore Brain)

### Hippocampus

- The hippocampus is the part of the limbic system that is important for memory and learning.

### Amygdala

- Two almond-shaped neural clusters in the limbic system that are linked with emotions.
- They are related with aggression and fear.

### Hypothalamus (Described above)

## 2. Mid Brain

### Tectum (Mid Brain)

- The **tectum** (Latin: roof) also **tectum** mesencephali, or midbrain **tectum** is the dorsal region or roof of the midbrain. The position of the **tectum** is contrasted with the tegmentum, which refers to the region ventral (in front of) to the ventricular system, or floor of the midbrain.
- **Tectum** plays a central role in the network that interfaces between sensory stimuli and behavioral motor patterns. Situated dorsally in the midbrain

### Tegmentum (Mid Brain)

- The red nucleus is responsible for controlling basic body and limb movements. The reticular formation controls arousal and self-consciousness.

### Reticular Formation (Mid Brain)

- The reticular formation is a region running through the middle of the hindbrain and into the midbrain.
- A thick network of nerve cells.
- It keeps the brain alert even during sleep.
- It makes the cerebral cortex attend to new stimulation by arousing it.
- Long fibrous tracts of reticular formation run into the thalamus.
- Needed for arousal from sleep & to maintain consciousness.
- Serious damage to reticular formation may result into a coma.

### Substantia Nigra (Mid Brain)

- The area of the brain that sends signals down the spinal cord to control the muscles of the body. Dopamine, the main neurotransmitter, is made by the cells of the substantia nigra.

## 3. Hind Brain

### Cerebellum (Hind Brain)

- Cerebellum" comes from the Latin word for "little brain". The cerebellum is located behind the brain stem.
- Cerebellum is somehow similar to the cerebral cortex: the cerebellum is divided into hemispheres and has a cortex that surrounds these hemispheres.
- It carries 10% of the weight of the brain.
- It contains as many neurons in the brain.
- Its function is to coordinate body movements i.e. coordination, maintenance of posture & balance.
- Damage to cerebellum results into jerky and uncoordinated body movements.

**Pons** = Latin word for bridge (Hind Brain)

- Bridge connecting spinal cord with brain and parts of brain with each other.
- The pons seems to serve as a relay station carrying signals from various parts of the cerebral cortex to the cerebellum.
- Nerve impulses coming from the eyes, ears and touch receptors are sent on the cerebellum.
- The pons also participates in the reflexes that regulate breathing.
- It has parts that are important for the level of consciousness and for sleep.

**Medulla/ Medulla Oblongata** (Hind Brain)

- Located at the top of the spinal cord and continuous with it.
- Lower part of the brainstem that helps to control autonomic functions
- Damage to Medulla can be fatal as it is the center responsible for vital functions i.e., respiration, heart beat, and blood pressure.
- Contains ascending & descending tracts that communicate between the spinal cord & various parts of the brain.
- At medulla, nerves ascending from the body and descending from the brain cross over; hence the left side of the body is connected to the right side of the brain and vice versa. **Contains 3 vital centers:**

**Cardio inhibitory center:** regulates heart rate.

**Respiratory center:** regulates the basic rhythm of breathing.

**Vasomotor center:** regulates the diameter of blood vessels.

## Functions of Brain areas

The brain contains various structures that have a multitude of functions. Below is a list of major structures of the brain and some of their functions.

### Basal Ganglia

Involved in cognition and voluntary movement

Diseases related to damages of this area are Parkinson's and Huntington's

**Parkinson's** disease is a progressive nervous system disorder that affects movement.

chorea, is an inherited disorder that results in the death of brain cells. The earliest symptoms are often subtle problems with mood or mental abilities.

### Brainstem

Relays information between the peripheral nerves and spinal cord to the upper parts of the brain

Consists of the midbrain, medulla oblongata, and the pons

### Cerebral Cortex

- Coming from the Latin word for "bark", cortex means covering, or sheath; the cortex is a sheet of tissue making up the outer layer of the brain.
- It is the body's ultimate control and information-processing center
- Outer portion (1.5mm to 5mm) of the cerebrum
- Receives and processes sensory information

### Olfactory Bulb

Bulb-shaped end of the olfactory lobe, Involved in the sense of smell

### Pineal Gland

Endocrine gland involved in biological rhythms, Secretes the hormone melatonin

### Pituitary Gland

Endocrine gland involved in homeostasis, Regulates other endocrine glands

### Wernicke's Area

Region of the brain where spoken language is understood

### Broca's Area

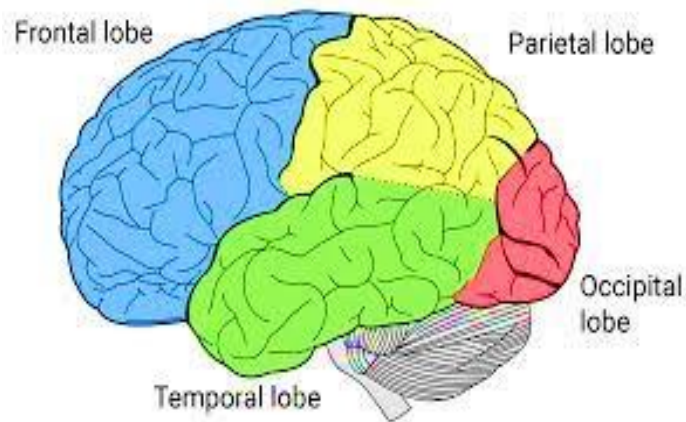
Speech production



## Cerebral Lobes

- **Frontal lobe**
- **Parietal lobe**
- **Temporal lobe**
- **Occipital lobe**

Each lobe controls a different range of activities.



1. The **frontal lobes** are associated with higher cognition, voluntary movements, and language. (Broca's Area).
2. The **parietal lobes** are associated with processing sensory information.
3. The **temporal lobes** are associated with hearing and interpreting sounds as well as the formation of memories.
4. The **occipital lobes** are associated with visual processes.

## The Spinal Cord

The spinal cord connects to the brain via the brain stem and then runs down through the spinal canal, located inside the vertebrae. The spinal cord carries information from various parts of the body to and from the brain. In the case of some reflex movements, responses are controlled by spinal pathways without involvement from the brain.

- Continuation of the Medulla Oblongata.
- The spinal cord is about 45 cm long in men and 43 cm long in women and weighs about 35-40 grams.
- The vertebral column (back bone), encapsulating the spinal cord, is about 70 cm long comprising vertebrae in the vertebral column.
- The spinal cord is much shorter than the vertebral column.
- Signals arising in the motor areas of the brain travel back down the cord and leave in the motor neurons.
- The spinal cord also acts as a minor coordinating center responsible for some simple reflexes like the withdrawal reflex.

**Reflex** - rapid (and unconscious) response to changes in the internal or external environment, needed to maintain homeostasis

**Reflex arc:** the neural pathway over which impulses travel during a reflex. The components of a reflex arc include:

- **Receptor** - responds to the stimulus
- **Afferent pathway** – sensory
- **Central Nervous System**