Nervous System

Nervous Coordination

Do you know what the unique property of all living organisms is?

The living organisms possess the unique property of responding to the changes in the environment. This unique ability to respond the changes in the environment is called **irritability**.

Examples,

• When we touch an earthworm, it moves away.

• When a plant is placed in the shade, it grows towards the source of light.

• When a person sees a snake, he runs away from it.

In the first example, touch is a stimulus and moving away of earthworm is a response.

In the second example, source of light is a stimulus and growth of plant towards it is a response.

Similarly in the third example, a snake is a stimulus and running away from it is a response.

Thus, from the above examples, it is clear that all living organisms posses a special mechanism to identify and respond the changes in the environment (stimulus).

Do you know which organ systems have the ability to bring about this response? There are two special systems known as nervous system and endocrine system that help multicellular animals to control and coordinate various organ systems of the body and bring about the required response to the stimuli. The organisation of these systems and the way in which various living organisms receive stimuli differs from one organism to other.

Nervous system

In living organisms, there are three main constituents of nervous system and these are **receptors**, **effectors** and **conductors**.

Receptors– Receptors are the structures/organs that receive **stimulus** from the environment. **Stimulus** is defined as any change in the surrounding environment that would usually result in change in the activity of our body, for example when we touch a

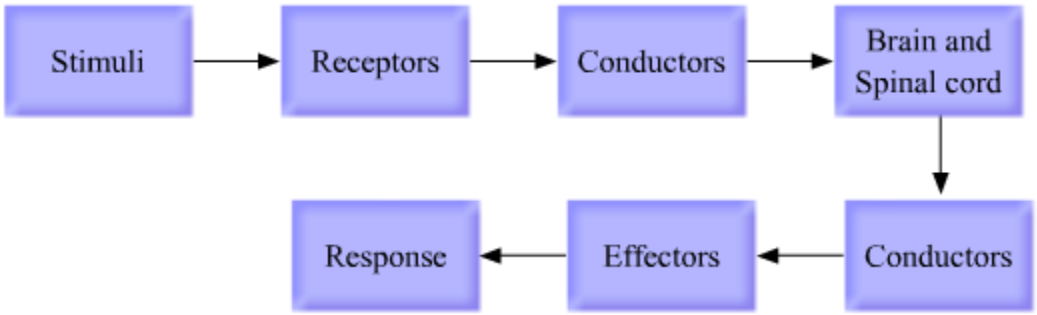
hot object, the heat acts as a stimulus. In higher animals, the sense organs act as receptors.

Effectors are the structures/ organs that show visible response to the stimulus. **Response** may be defined as the activity of our body which is shown in response to a stimulus. For example, on touching a hot object, we immediately withdraw our hand away from it.

This withdrawing of hand is the response to the stimulus, which is heat. In higher animals, muscles and glands act as effectors.

Conductors are the tissues that connect receptors and effectors and help in conduction of stimulus to the control centre of the body (brain in higher animals). In higher animals, conductors are nerves formed by nervous tissue/nerve cells (neurons).

They conduct the message to and fro in the form of impulses. **Impulse** is a wave of electrical disturbance that runs through the nerves.



Need of Nervous System

- It helps us in remembering and thinking, and making decisions.
- It keeps us informed about changes in our surrounding through sense organs.
- It controls the activities of voluntary muscles.
- It also regulates the involuntary activities of different muscles.

Neural Tissues

Nervous Tissues: Features

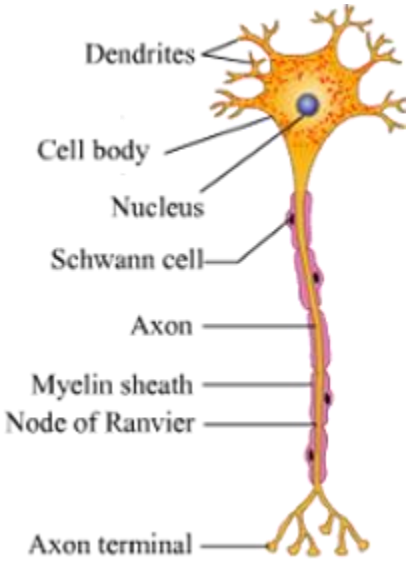
- Cells of the nervous tissues are highly specialized for becoming stimulated and then transmitting the **stimulus** very rapidly from one place to another within the body.
- The cells of these tissues are called **nerve cells or neurons**.
- They are present in the brain, spinal cord and nerves.
- The neurons act as postmen in the body, delivering messages accurately; the brain acts as the post office where all messages are collected, and which controls how the messages are delivered.

- Neurons are responsible for both collecting and delivering messages in our body.

  Function:

  The most important function of the nervous tissues is to control all the body activities by coordinating with the different body parts.

  Neurons



  The fundamental unit of the nervous system is the nerve cell. Let us learn more about it.

- **A neuron** consists of a **cell body** and an **axon**.
- The cell body or cyton contains a nucleus and cytoplasm.
- The axon elongates from the cell body and branches into many dendrites.
- Several nerve fibres with connective tissues form a **nerve.**

  Dendrite:It receives information from the axon of an adjacent neuron and conducts it toward the cell body.

  Axon: It conducts messages away from the cell body.

  Cell body: It contains a nucleus, mitochondria and other organelles. It is concerned with the maintenance and growth of the cell.

  Whiz Kid

Glial cells are non-conducting supportive cells of the nervous system. They provide nutritional support and insulation to the neurons present in the central and autonomous nervous systems.

There is an insulated sheath that surrounds the axon of a neuron. This is called myelin sheath. It consists of fat-containing cells called **Schwann cells** and helps in the fast transmission of nerve impulses.

The myelin sheath is not continuous over the axon and has some gaps exposing the axon. A gap between two adjacent myelin sheaths is called **node of Ranvier**.

Parts of a Neuron

Did You Know?

- An individual nerve cell may be up to a metre long.
- Signals are transmitted through a neuron at a velocity of 1.2 miles/hour to 250 miles/hour.
- There are as many neurons in the human brain as there are stars in the Milky Way, i.e., around hundred billion.
- The number of ways in which information travels in the human brain is greater than the number of stars in the universe

Solved Examples

Easy

Example 1:

Where is the nucleus located in a neuron—in the axon, cyton or dendrite?

Solution:

In a nerve cell, the nucleus is located in cytoplasm of the cell body or cyton. Cell organelles like mitochondria and Golgi bodies are also present in the cytoplasm.

Hard

Example 2:

How are two neurons connected to each other?

Solution:

The axon endings of one nerve cell are loosely placed on the cell body or cyton of another nerve cell, thereby forming a loose connection called **synapse**. Electric signals are transmitted from one neuron to the next across such synapses through the release of chemicals called **neurotransmitters**.

A released neurotransmitter crosses a synapse and starts a similar electrical impulse in the dendrite of the adjacent neuron. In this way, impulses are transmitted from one neuron to another and, ultimately, to the brain.

Nerves

A nerve is made up of a bundle of axons/nerve fibres which are enclosed in a tubular medullary sheath. This sheath prevents the mixing of impulses in the adjacent fibres.

They are of three types:

Sensory nerves: They bring impulses from the sense organs to the brain or the spinal cord, for example, auditory nerve of the ear.

Motor nerves: They carry impulses from brain/spinal cord to the muscles or glands, for example, nerves to the muscle of eyes.

Mixed nerves: They carry both sensory and motor signals.

Human Brain - Structure and Function

The body performs various activities. **All these activities are controlled by the brain. How does the brain control all activities? Are there any divisions in the brain, which take over the control of different activities?**

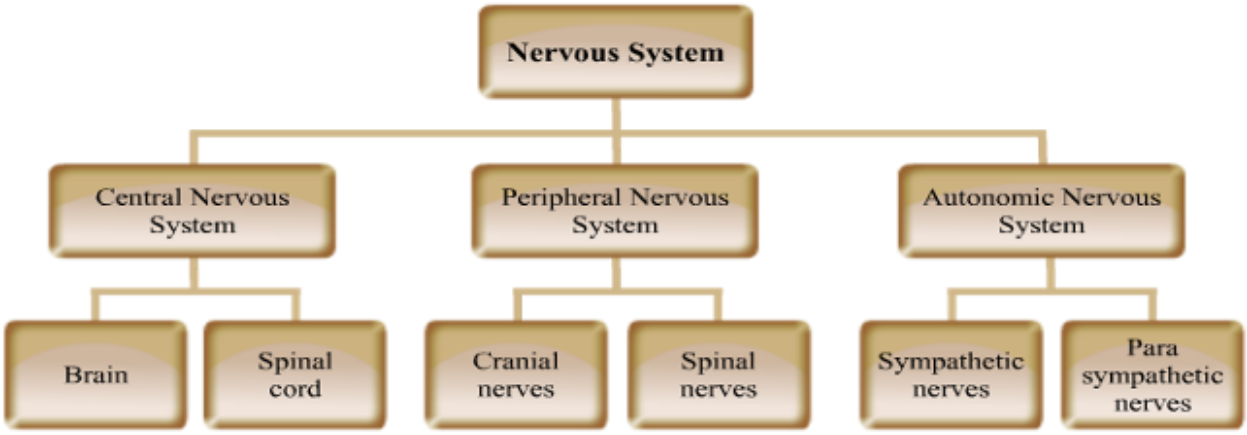
Do you know which organs make up the nervous system?

Let us explore.

The nervous system is divided into - **central nervous system (CNS) and peripheral nervous system (PNS)**. The **CNS** consists of the brain and spinal chord while the **PNS** consists of the nerves that connect the central nervous system to different parts of the body.

The central nervous system receives information from all parts of the body and also sends information to the muscles. Communication between the **CNS** and body parts is facilitated by the nerves of **PNS**.

The important components of nervous system are:



Components of human nervous system

The Central Nervous System

The central nervous system consists of the brain and the spinal cord. The brain is enclosed in a bony box called the **cranium** and spinal cord is protected by **vertebral column.**

The brain and spinal cord are externally covered by protective covering called **meninges**. It is made up of three layers namely **duramater** (outer layer), **arachnoid** (middle layer), **piamater** (inner layer).

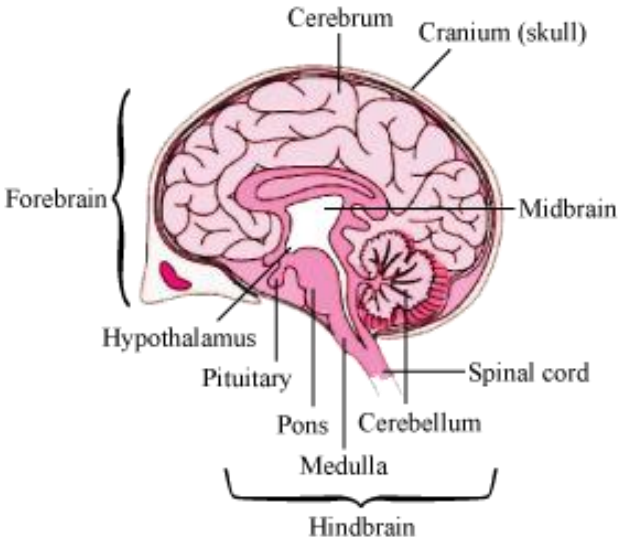
The space between meninges is filled by a watery fluid called **cerebro-spinal fluid (CSF)**. This fluid flows from the brain to spinal cord and then back to brain. It acts as a shock absorber and protects brain form injuries. It also provides nutrients to the cells in brain and spinal cord.

Human Brain

The brain is the main coordinating centre of the body. It is a part of the nervous system, which controls and monitors every organ of the body. The weight of the brain of an adult is about 1400 grams.

Different regions of the brain

The brain is divisible into three main regions—forebrain, midbrain, and hindbrain.



Forebrain

It is the main thinking part of the brain. It consists of the cerebrum, thalamus and hypothalamus. The forebrain has sensory regions, which receive sensory impulses from various receptors. It also has motor regions, which control the movement of various muscles such as leg muscles.

There are separate areas in the forebrain specialized for hearing, smelling, seeing, general sensations such as pain, touch, taste, etc.

Cerebrum: The cerebrum is the largest part of the brain and constitutes four-fifth of its weight. It is divided by a deep cleft into two equal parts called left and right cerebral hemispheres.

Cerebrum has two regions, an **outer cortex** and **inner medulla**. The inner cortex is made up of cytons (nerve cell body) that give it a greyish appearance, so it is also called as **grey matter**.

The medulla is composed of nerve fibres (axons and dendrites) that give it an opaque white appearance due to presence of myelin sheath covering, so is also called a **white matter**.

The cortex is provided with ridges called convolutions that increase the surface area of the cerebrum. The well developed cortex is responsible for the high degree of intelligence of the humans.

The information obtained through sense organs is stored in the cerebrum and used when needed. This ability to store information helps in retaining the memory.

A certain part of the cerebrum primarily controls intelligence, learning, memory, emotions, consciousness, thinking, and the ability to articulate speech. The forebrain is also known as the main thinking part of the brain.

In cerebrum, the nerves that come from the right side of the body are connected to the left side of cerebral hemisphere and the nerves that come from the left side of the body are connected to the right side of the cerebral hemisphere.

Therefore, organs of the right side of the body are controlled by left hemisphere and organs of the left side are controlled by the right hemisphere. Thus, injury in the left side of cerebral hemisphere results in the paralysis of organs on right side of the body and vice-versa.

Dienchephlon

It is the part of the forebrain located below the cerebrum. It includes both thalamus and hypothalamus.

Thalamus is situated between cerebral cortex and mid brain. It receives the nerve impulse form sense organs and transmits them to the upper region. It coordinates the sensory and motor signaling.

The **hypothalamus** contains many areas that control the body temperature, urge for eating and drinking, etc. Some regions of the cerebrum along with hypothalamus are involved in the regulation of sexual behaviour and expression of emotional reactions such as excitement, pleasure, fear, etc.

Midbrain

It is the small region of the brain that connects cerebrum with the hind brain . It has regions that are concerned with the sense of sight and hearing. Some regions of the midbrain transmit motor impulses to the limbs.

Hindbrain

It consists of three parts namely **pons varoli, cerebellum** and **medulla oblongata**.

Pons varoli consists of the nerve fibres that connect various portions like cerebrum, cerebellum and medulla oblongata of the brain. It has the control centers for facial expression, respiration and mastication etc. Among the twelve pairs of cranial nerves, four pairs originate from the pons varoli.

The **cerebellum**, which is a part of the hindbrain, is responsible for maintaining the posture and equilibrium of the body. It also coordinates the contraction of voluntary muscles, according to the directions of the cerebrum.

Medulla is the posterior most part of the brain and is connected to the spinal cord. Most involuntary actions such as heart beat, blood pressure, movement of food in the alimentary canal, salivation, etc. are controlled by the medulla of the hindbrain.

Spinal Cord

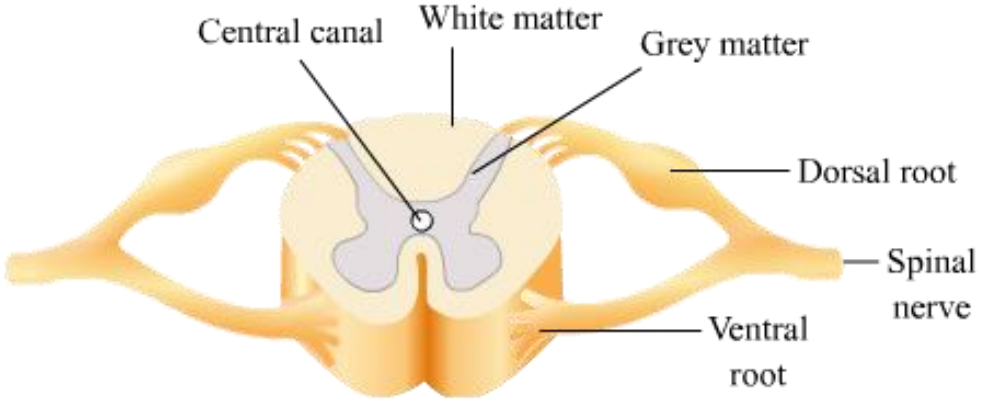
It is the continuation of the medulla oblongata and runs through the vertebral column. The spinal cord is made up of two similar halves fused together to form a central canal containing the cerebrospinal fluid.

The outer portion of the spinal cord is known as the **white matter**, which consists of nerve fibres and the inner portion contains the cell bodies of neurons and is known as the **grey matter**.

There are thirty one pairs of spinal nerves that arise from the spinal cord. These nerves are divided into branches that reach to several parts of the body like, heart, lungs, stomach, urinary bladder, sex organs etc.

The movement of limbs in the body are controlled by the spinal cord through reflex actions.

The spinal cord tapers at the end at the last vertebrae where from a collection of nerve roots originate, which are horsetail-like in appearance and hence called the **cauda equina.**



Cross section of spinal cord

Protection to the brain and spinal cord

The brain, being an important organ, requires protection. Therefore, it is enclosed in a bony box called the **cranium**. The brain inside the brain box is also surrounded by a fluid-like material, which acts as shock absorber and thus, provides further protection to the brain. Spinal cord is protected by a bony, vertical rod with several curves called the **vertebral column**.

Do You Know?

The brain transmits messages at a rate of 240 miles per hour!

There are 10 million nerve cells in our brain.

The brain uses more than 25% of the oxygen used by the human body!

As compared to other animals, the ant has the largest brain in relation to its body.

Peripheral Nervous System

It consists of the nerves arising from the brain and the spinal cord, which links the CNS to the rest of the body. It consists of two types of nerves.

- **Cranial nerves:** There are 12 pairs of cranial nerves and they emerge from the brain and reach the organs in the head region.
- **Spinal nerves:** There are 31 pairs of spinal nerves that emerge from the spinal cord and reach various parts of the body.

Messages are transferred from the brain to the spinal cord and then to the rest of the body and similarly messages from the rest of the body reach the spinal cord from where they are transferred to the brain. The spinal cord also controls all reflex actions.

Autonomic Nervous System

The autonomic nervous system helps to carry out the orders of the medulla, which controls the vital body functions.

It consists of two networks:

- **Sympathetic system**: The sympathetic nerves lead to all vital internal organs and glands. They regulate the actions of smooth muscles such as that of the stomach, intestine, and the heart.
- **Parasympathetic system**: This system is made up of the vagus and the pelvic nerves.

The sympathetic system speeds up the body functions and prepares the body for combat and escapes while the parasympathetic system counteracts to that of the sympathetic system and slows down the body functions.