Ratna Sagar

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Education, Our Mission

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Ratna Sagar
Education, Our Mission!

Revised and Updated

LIVING SCIENCE BIOLOGY

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10

EDUCATION, OUR MISSION

ICSE
Living Science
Biology

Class 10

Chapter 10 Nervous System

LEARNING OBJECTIVES

Major divisions of nervous system

- **Nerves**
- **Structure of a nerve cell (Neuron)**

Communication through the nerve – nerve impulse

- **Transmission of the nerve impulses**

Central nervous system

- **The human brain**
- **Spinal cord**

Reflex arc and reflex action

- **Components of a reflex arc**
- **Types of reflexes**

Peripheral nervous system

- **Somatic nervous system**
- **Autonomic nervous system**

What is nervous system?

The organ system in our body that brings about coordination and integration of body activities is the nervous system.

Major divisions of nervous system

The nervous system in human beings is divided into two main parts.

1. Central nervous system (CNS): It includes the brain and the spinal cord, and is the site of information processing in the nervous system.

2. Peripheral nervous system (PNS): It consists of nerves that emerge and enter into brain and spinal cord and runs between the central nervous system and different parts of the body. These nerves are divided into three groups – **sensory or afferent nerves** which transmit information to the CNS, **motor** or **efferent** nerves which carry messages from the CNS to the effector organ, and **mixed nerves**.

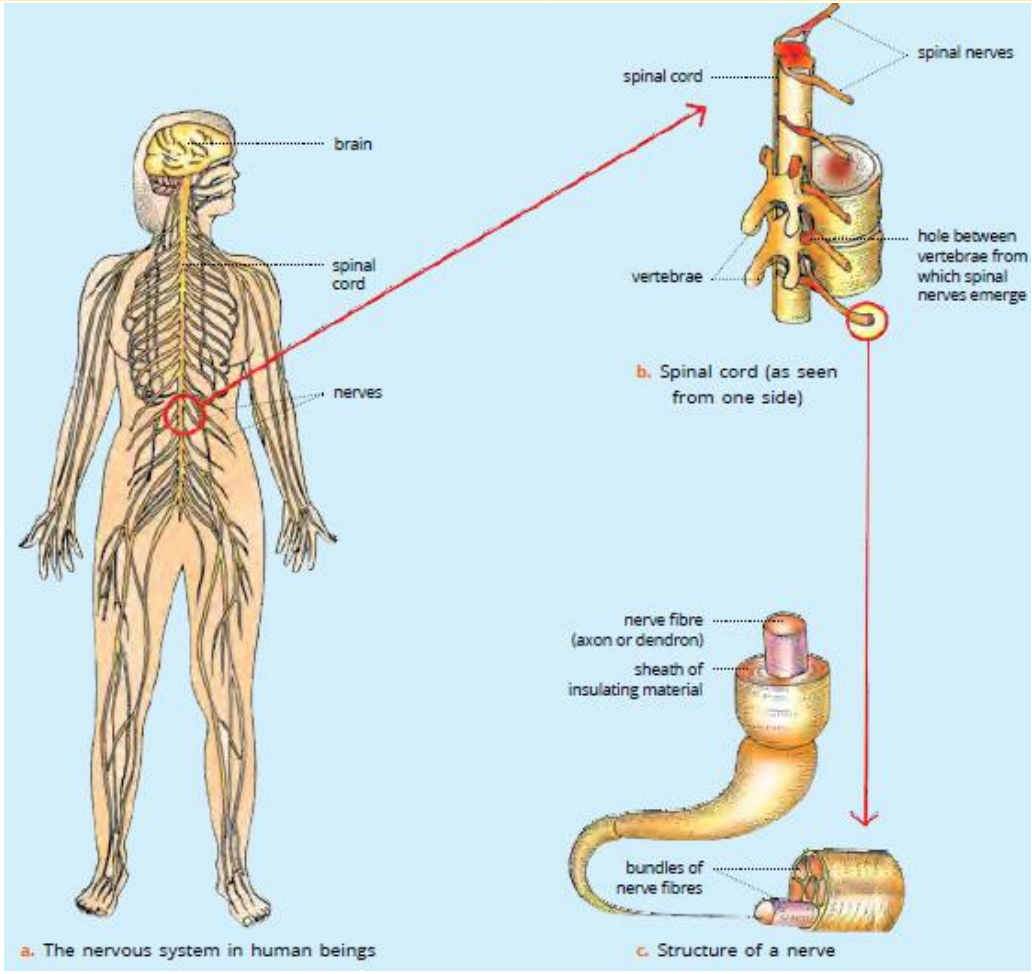
The PNS is further divided into two sub divisions:

1. The **somatic nervous system (SNS)** regulates voluntary activities and transmit messages to the skeletal muscles.

2. The **autonomic nervous system (ANS)** works independently to regulate involuntary activities. It consists of nerves and ganglia which connect the visceral organs like smooth muscles of heart, lungs, digestive tract and other internal organs and perform a variety of involuntary actions that are not under the control of our will. It has two components, viz. **sympathetic** and **parasympathetic**, which are antagonistic (opposite) to each other in their functions.

Nerves

Nerves are composed of nerve fibres (axons) of separate neurons bundled together like the wires of a telephone cable enclosed by a tubular sheath. These nerve fibres or nerve cells are called **neurons** which form the basic unit of the nervous system. A neuron is the longest cell in the body. It receives information and transmits it from one part of the body to another part. Thus, neuron is the structural and functional unit of nervous system and highly specialized for responding to stimuli.



Structure of the human nervous system

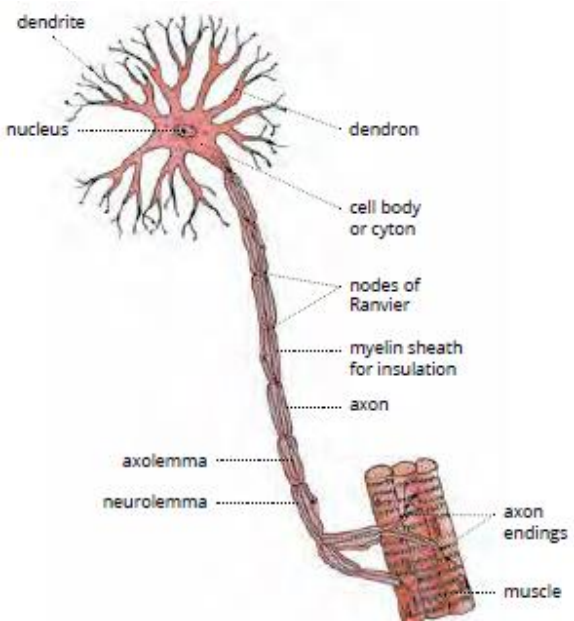
Types of nerves

There are three types of nerves depending upon the direction in which they transmit the impulse.

1. Sensory nerves: These are also called **afferent nerves**. These nerves contain sensory fibres which carry messages (impulse) from sensory receptors (in sense organs) towards the brain or spinal cord. **Example:** Optic nerve from eye leading to brain.

2. Motor nerves: These are also called **efferent nerves**. These nerves contain motor fibres which take messages away from the brain or spinal cord towards the effector organ (such as muscles and glands). **Example:** Nerves arising in brain and leading to the muscles of the eye balls for rotating it.

3. Mixed nerves: These nerves comprise of both sensory and motor nerve fibres. **Example:** Most cranial and spinal nerves are mixed nerves.



Structure of a nerve cell (Neuron)

Each nerve cell consists of three main parts:

1. Cell body: The **cell body** or **cyton** has a large, central nucleus surrounded by the granular cytoplasm. The cytoplasm contains **Nissl granules** and **neurofibrils**. It has all the cell organelles. There is no centrosome in cyton because the nerve cells have lost the ability to divide.

A nerve cell or neuron

2. Dendrites (*dendron:* tree)**:** These are short, threadlike branches which arise from the cell body. The dendrites conduct nerve impulse to cyton.

3. Axon: One of the branches (of dendrites) grows very large in comparison to others. This branch is called the **axon**. The axon is covered on the outside by three layers.

- **Axolemma** (the innermost layer)
- **Myelin sheath** or **medullary sheath** (the middle layer)
- **Neurolemma** (the outermost white insulating sheath)

There are three types of neurons:

1. Sensory neurons: These carry impulse from sense organs to the brain or spinal cord.

2. Motor neurons: These carry impulse from brain or spinal cord to effector organs (muscle or gland).

3. Association neuron: These interconnect sensory and motor neurons.

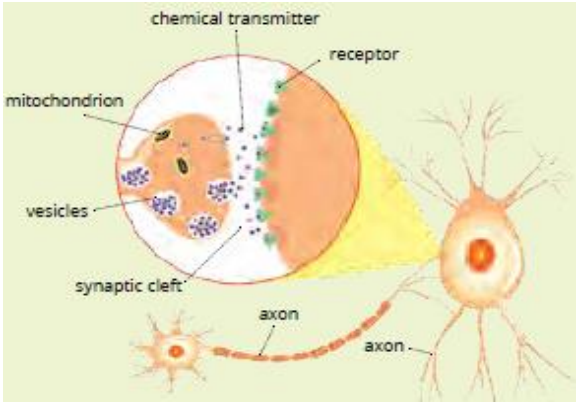
Synapse

The neurons are not attached to each other. There is a small gap between them. The fine gap or loose connection between the axon endings of one nerve cell and cyton or dendrite of the next nerve cell is called the **synapse**.

We can also say that the point of contact between two neurons is known as **synapse**. Signals travel from one neuron to another neuron across a junction called the synapse.

What does a synapse do?

- ❖ Allows information to pass from one neuron to another.
- ❖ Ensures that the nerve impulse travels in one direction only.
- ❖ Allows the adjoining neuron to be excited or inhibited.
- ❖ Amplifies a signal (makes it stronger).
- ❖ Helps in information-processing by adding together the effects of all impulses received.
- ❖ Filters out low-levelled stimuli.



Structure of the synapse

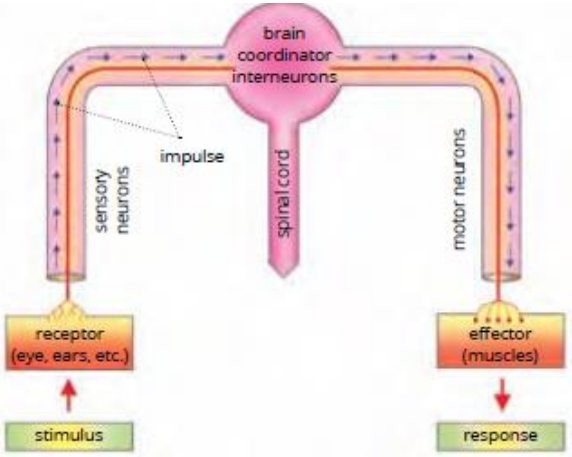
Communication through the nerve – nerve impulse

The nervous system receives a stimulus, through a receptor organ, integrates or coordinates it, and effects a response through the effector organ. Thus, a coordinated behaviour has six main components – stimulus, impulse, receptor, coordinator, effector, Components of coordinated behaviour and **response** .

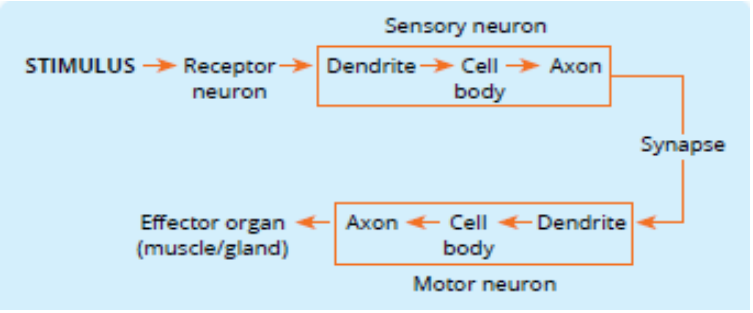
In such a coordinated behaviour, any stimulus of sound sight, smell, etc., is perceived by receptor organs like eyes, ears, skin, etc.

A **stimulus** is an agent or sudden (external or nternal) change that results in a change in activities of an organism. An **impulse** is a wave of chemical disturbance that travels through the nerve cell.

Receptors are sensory organs which receive stimulus and send wave in form of impulse towards CNS (coordinator).



Components of coordinated behaviour



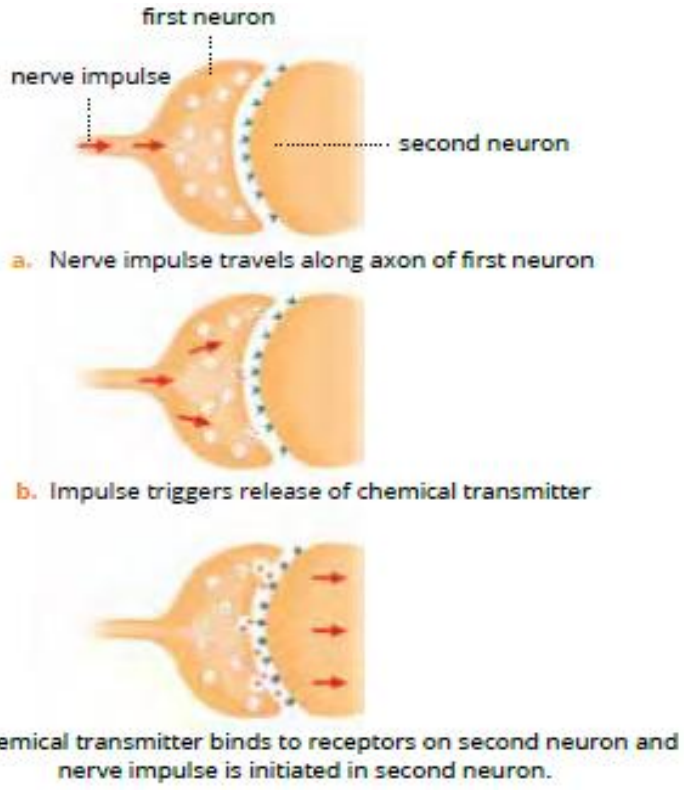
Flow chart showing direction of nerve impulse

Effectors are the muscles or organs which show response due to motor nerves. **Response** is a change that occurs in an organism due to stimulus. The brain and spinal cord are the **coordinators** which receive information in the form of messages called **nerve impulses**, from **receptor organs** via neurons.

The information flows to the **effector organs**, i.e. muscles, which contract or relax or secrete substances to show response

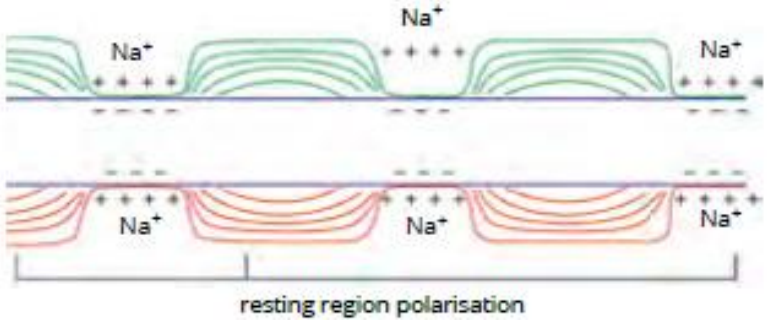
Transmission of the nerve impulses

Nerve impulses pass along a neuron in one direction only. At one end, the neuron is connected to a sensory receptor that receives the stimulus and converts it into electrochemical waves which are carried by the neuron. The fibre at this stage is said to be **excited**.



At resting state – Polarised state

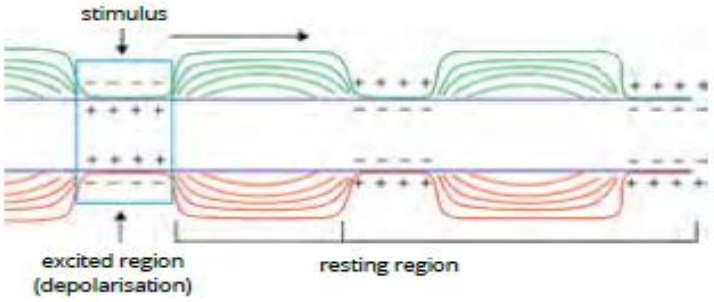
At normal (resting) state, the outer side of nerve fibres carry more positive (+) charge due to more Na^+ ions outside the axon membrane. This is called **polarised state.**

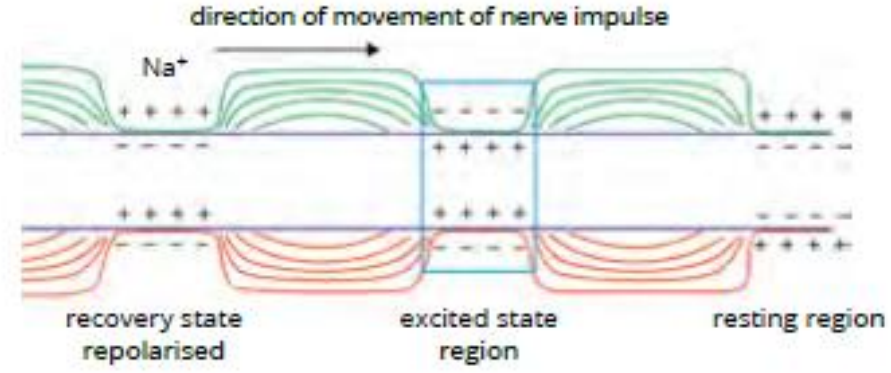


At stimulated (excited) state – Depolarisation

On receipt of a stimulus, the axon membrane at the place of stimulus becomes more permeable to Na^+ ions and as a result, the Na^+ move inside causing loss of polarity, i.e. **depolarisation**.

This region, thus, becomes **excited region**. This region of depolarisation moves forward to next area which in turn becomes depolarized.





Returning to normal state – Repolarisation

The previous area (which has received stimulus) becomes repolarised due to active transport of Na^+ ions outside.

This transport is achieved by **sodium pump** for which energy in the form of ATP is required. Thus, conduction of nerve impulse is a wave of depolarisation followed by repolarisation.

Central nervous system

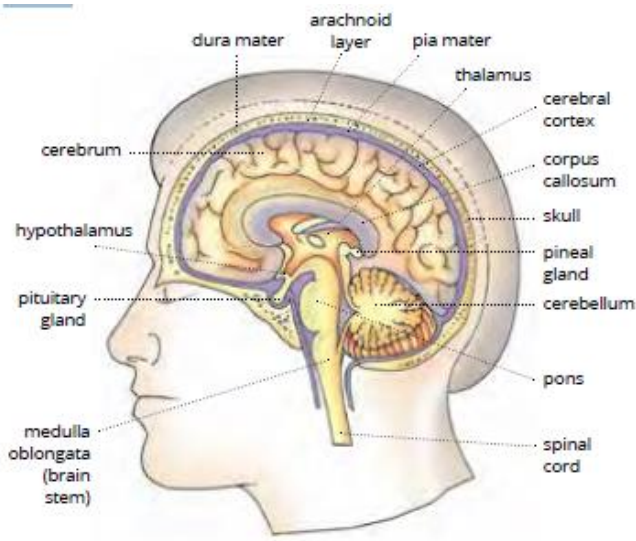
The central nervous system consists of the brain and the spinal cord.

The human brain

The human brain is a highly developed organ and is situated in the **cranium** (brain box) of the skull. In an adult, it weighs about 1200–1400 g, about 2% of body weight.

Covering of brain (Meninges)

Brain is covered on the outside by three membranes called **meninges** (*singular*: menix). **Meninges are protective coverings of the brain** that consist of three layers



1. The outer tough, protective layer **dura mater** is formed of fibrous tissue.

2. The middle **arachnoid layer** is a delicate membrane which gives web-like cushion.

3. The inner thin, transparent and highly vascular layer is the **pia mater**. It is richly supplied by blood.

Parts of the brain

The human brain is divisible into three major parts: 1. Forebrain 2. Midbrain 3. Hindbrain

Fore brain: It is the anterior region of the brain. It has following parts:

1. Cerebrum (seat of intelligence, memory, consciousness and voluntary action)

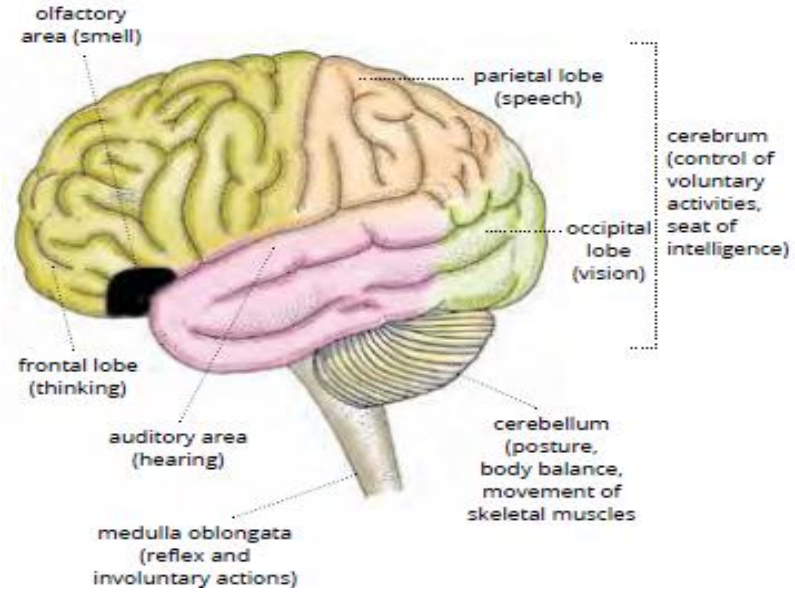
2. Diencephalon (thalamus, hypothalamus, pineal gland)

1. Cerebrum

The cerebrum is the main part of forebrain.

❖ Cerebrum is the largest and the most prominent part of the brain. It is divided into two halves – the right and left **cerebral hemispheres**.

❖ The two hemispheres are connected by a thick band of nerve fibres called **corpus callosum**. Corpus callosum helps in the transfer of information from one hemisphere to another.



Different regions of the cerebrum are associated with different functions

Functions of cerebrum

❖ Because of highly developed grey matter the cerebrum governs mental abilities like **thinking**, **reasoning**, **learning**, **memory** and **intelligence**.

❖ It also controls all voluntary functions; **willpower**, **emotions** and **speech**.

❖ It enables us to observe things around us through sense organs.

❖ It also controls feelings of **love**, **admiration** and **hatred**. Overall the cerebrum is the seat of intelligence, memory and will power.

2. Diencephalon

The **diencephalon** mainly consists of the **pineal gland**, **pituitary gland**, **thalamus** and **hypothalamus**. It encloses a cavity called the **third ventricle**. The **thalamus** is a relay station for sensory impulses going to the cerebrum. The **hypothalamus** is situated at the floor of the brain and helps in thermoregulation.

Functions of diencephalon

The diencephalon contains reflex centres for muscular and glandular activities. It also has centres of emotions,hunger and thirst. It also helps in controlling the body temperature (thermoregulation) and water–salt balance in the body (osmoregulation).

Midbrain: It is a thick-walled structure and is a smaller portion of the brain. The midbrain or **mesencephalon** connects the anterior region of the brain to the posterior region and therefore all nerve fibres pass through this region. On the dorsal side of the midbrain lie optic lobes which control vision.

Hindbrain: The hindbrain has three main parts.
1. Cerebellum **2.** Pons **3.** Medulla oblonga

1. Cerebellum (Little brain)

❖ The **cerebellum** is situated in the dorsal region of the hindbrain. Cerebellum is a much smaller area and is located at the base under the large cerebrum.

❖ There are no convolutions, but many furrows.

❖ It has an outer cortex made of **grey matter** and an inner section consisting of **white matter**.

Functions of cerebellum

It maintains **body balance** and controls **muscular activities**. It makes the **body movements** smooth, steady and coordinated. It regulates and coordinates **contraction of skeletal muscles**.

2. Pons

Pons forms the part of the brain stem at the floor of hindbrain. It is a bridge of transverse nerve tracts extending from the cerebrum to the cerebellum. It also connects the forebrain to the spinal cord.

3. Medulla oblongata

The **medulla oblongata** is the third main part of the **hindbrain**. It is the lowermost part of the brain located at the base of the skull. It is continued as spinal cord in posterior region.

Functions of medulla oblongata

It contains vital reflex centres, such as cardiac centre, respiratory centre and centres for swallowing, sneezing and coughing. Thus, it controls involuntary functions of the body like heartbeat, swallowing and breathing.

Spinal cord

The **spinal cord** is a cylindrical, long cord which arises from the medulla oblongata and runs along the vertebral column. It passes through the neural canal of the vertebral column. Like the brain, it is also protected by the three meninges, cerebrospinal fluid and a cushion of adipose tissue.

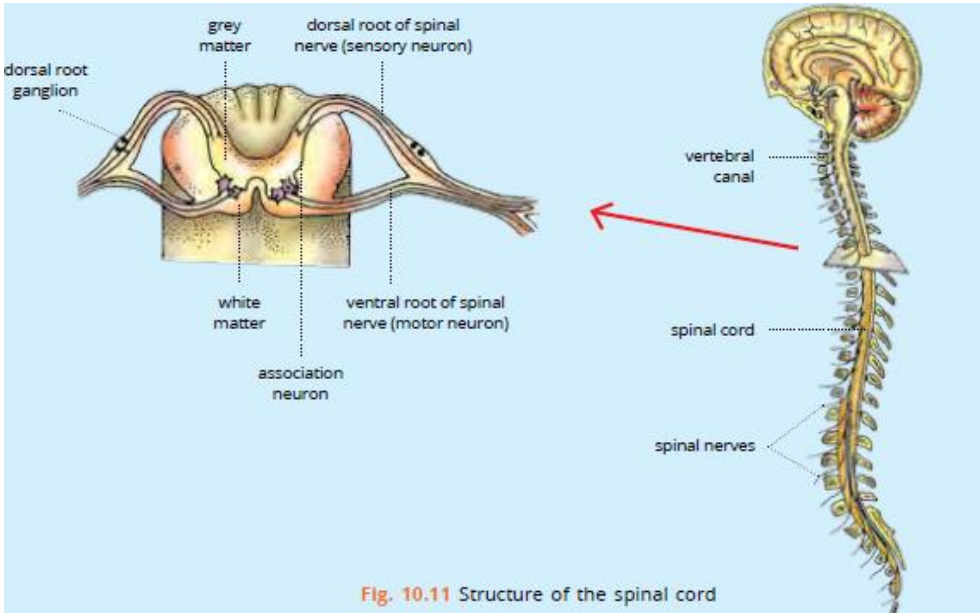


Fig. 10.11 Structure of the spinal cord

In the peripheral part, axons are concentrated and this area is called the **white matter.** On each side of the spinal cord there are two horns, the **dorsal horn** and the **ventral horn**. The dorsal root ganglion contains the cell bodies of sensory neuron. A nerve joined to the dorsal horn or dorsal root ganglion picks up sensations from various organs. It is called the **sensory nerve**.

The ventral root ganglion of spinal cord contains the cell bodies of motor neuron. That is, from the ventral horn or ventral root ganglion arises the **motor nerve** which takes the messages from the spinal cord to the organs concerned.

Functions of the spinal cord

- It is the centre for reflex actions.
- The spinal cord conducts reflexes below the neck.
- It conducts sensory impulses from skin and muscles to the brain.
- It conducts motor responses from brain to the muscles of trunk and limbs.

Reflex arc and reflex action

There are certain body responses which are immediate and do not require any processing by the brain. These responses or actions are controlled by the spinal cord. These are called **reflex actions**.

A reflex action may be defined as a spontaneous, automatic and mechanical response to a stimulus controlled by the spinal cord without the involvement of the brain. The pathway followed by sensory and motor nerves in a reflex action is called the **reflex arc.**

Components of a reflex arc

A reflex arc has four main components.

1. Receptor or sensory organ to perceive the stimulus.
2. Sensory or afferent nerve which carries the message from receptor to the spinal cord.
3. Relay or association neurons of the spinal cord which transmit impulses from the afferent (sensory) neurons to the efferent (motor) neurons.
4. Motor or efferent nerve which carries the message from the spinal cord to the muscles or glands.

Reflexes

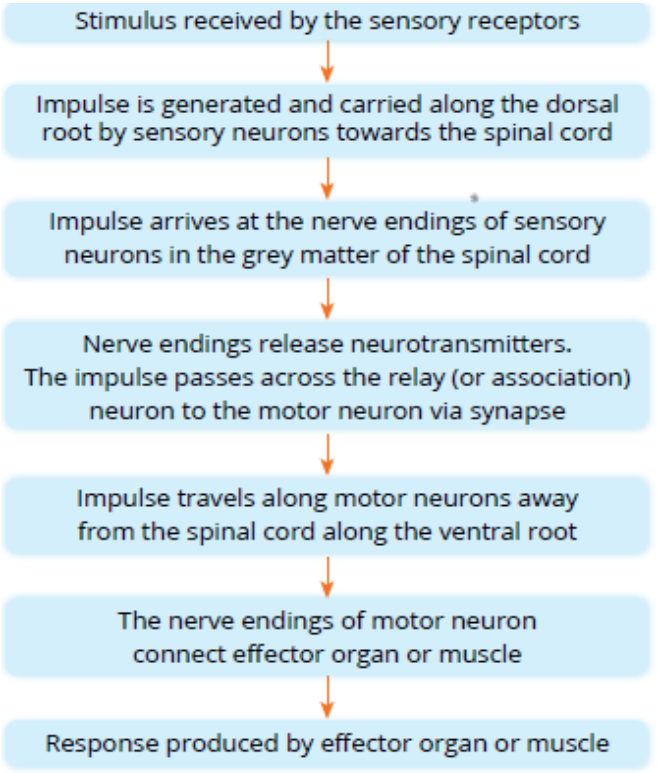
There are mainly two types of actions – voluntary actions and involuntary actions.
Voluntary actions are those actions which are performed consciously. **Involuntary actions** are those actions which occur unknowingly without our will. All involuntary actions are reflexes and involve some kind of sensory stimulation.

Types of reflexes

There are two types of reflexes:**1.** Simple or natural reflexes **2.** Conditioned or acquired reflexes

Notes: **Differences between voluntary and involuntary actions are given in Table 10.3.**

Sequence of events in a reflex arc



Types of reflexes

There are two types of reflexes:

1. **Simple or natural reflexes** are those reflexes which do not require any previous learning experience. Such reflexes are inborn and inherited from parents.
2. **Conditioned or acquired reflexes** are those which develop due to some previous experience or training. The conditioned reflexes are not inborn and result due to some learning in one's lifetime.

Peripheral nervous system

The **peripheral nervous system** (PNS) comprises the nerves that connect the central nervous system with different parts of the body.

Peripheral nervous system is divided into two subdivisions – **somatic nervous system** and **autonomic nervous system**.

1. Somatic nervous system

The somatic nervous system includes both motor neurons and sensory neurons. The fibres of motor and sensory neurons are bundled together into nerves, which are of two types.

❖ **Cranial nerves** connected directly to the brain, such as the optic nerve (for eye), auditory nerve (for ears), mixed nerves (for face), etc.

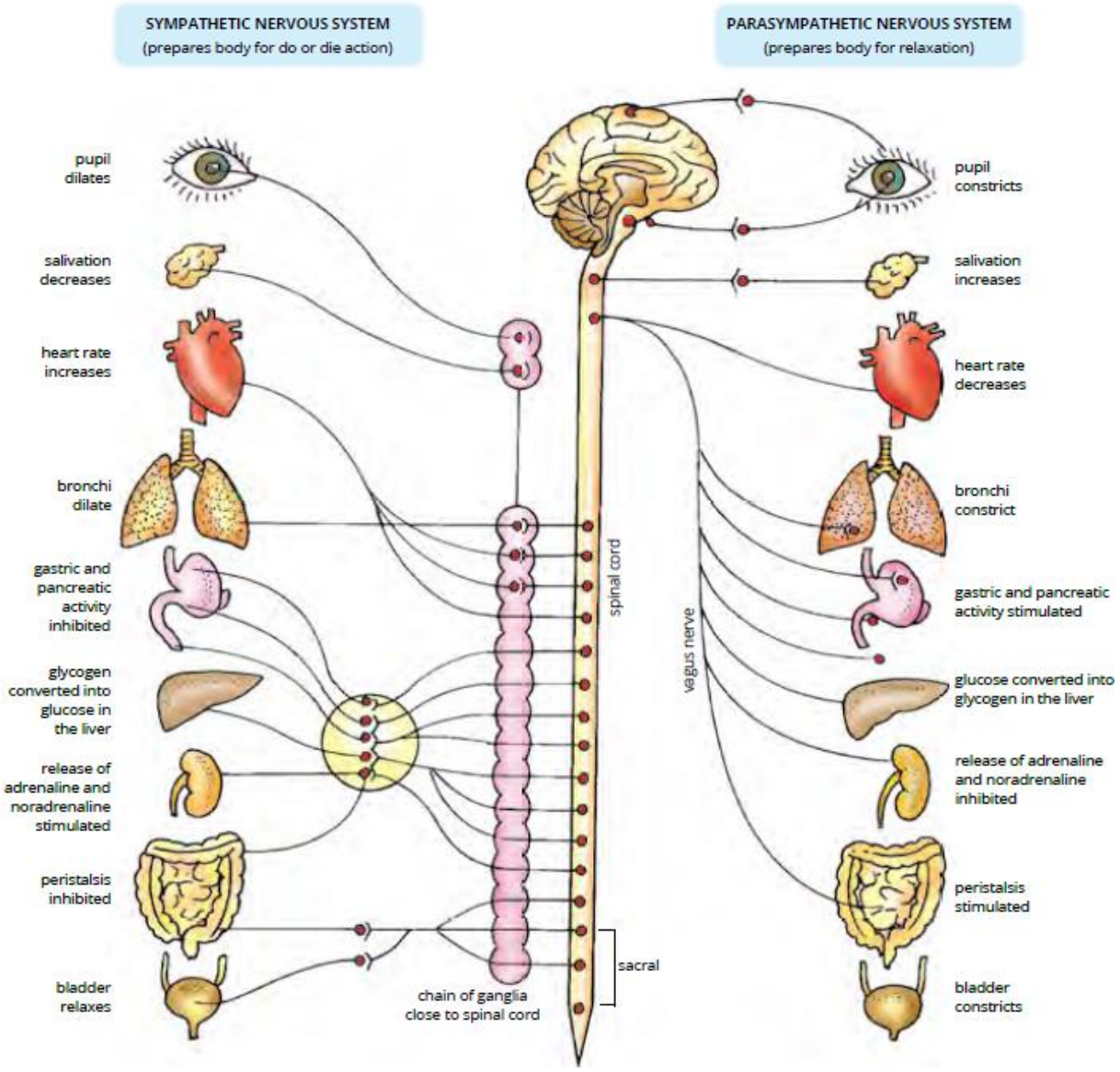
There are **12 pairs** of cranial nerves.

❖**Spinal nerves** emerg from spinal cord. There are **31 pairs** of spinal nerves. **Every spinal nerve is a mixed nerve** having both sensory and motor nerves.

2. Autonomic nervous system

The **autonomic nervous system (ANS)** includes a chain of 22 pairs of ganglia which lie close to the spinal cord and are associated with the organs they control. ANS is primarily a motor system consisting of neurons that control the functioning of many organs such as Heart muscles, Glands, Smooth muscles (muscles of blood vessels, digestive, respiratory and reproductive tracts).

The effect of the two systems is antagonistic. In general, the sympathetic system stimulates a particular function and prepares the body for violent actions against unusual emergency conditions, while the parasympathetic system has inhibitory or calming down effect, i.e. it re-establishes normal conditions after the violent action is over.



Autonomic nervous system showing sympathetic and parasympathetic divisions

SUMMARY...

❖ The nervous system in humans is divided into two parts: central nervous system and peripheral nervous system.

❖ The central nervous system includes the brain and the spinal cord, and is the site of information processing in the nervous system.

❖ The peripheral nervous system consists of nerves that runs between central nervous system and different parts of the body.

❖ The structural and functional unit of the nervous system is a highly specialized cell called the nerve cell or the neuron. Each neuron has three principal parts – the cell body or cyton, the axon and dendrites.

❖ Nerves can be sensory, motor or mixed.

❖ The nervous system receives a stimulus through a receptor organ, integrates or coordinates it, and effects a response through the effector organ.

❖ The human brain has three main divisions – the forebrain comprising of cerebrum and diencephalon,the midbrain and the hindbrain comprising of cerebellum, pons and medulla oblongata.

❖ Cerebrum is the largest and the most prominent part of the brain. It has ridges and grooves (gyri and sulci) which increase surface area for nerve cells. The outer cortex of cerebrum contains grey matter. Cerebrum governs mental abilities like thinking, reasoning, learning, memorizing, intelligence, will and emotions.

❖ Cerebellum is the smaller part located at the base under the large cerebrum. It maintains body balance and controls postures and coordinates muscular activities.

❖ Medulla oblongata is the lowermost part of the brain located at the base of the skull. It contains vital reflex centres and controls the activities of the internal organs.

❖ The spinal cord is a long cord which arises from the medulla oblongata and runs along the vertebral column.

❖ Reflex action is a spontaneous, automatic and mechanical response to a stimulus controlled by the spinal cord without the involvement of the brain.

❖ Sympathetic and parasympathetic nervous systems are antagonistic (opposite to each other) in their functions.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