Chapter - 26
Nervous System of Man

In all multicellular animals to experience stimulus received by receptive organs, transmit them in different body parts and implement responses from functional organs that controls the body by making sensation and co-ordination in all functions of different body parts is called **Nervous system.** The cells act in it is known as **Neurons**. It is also known as functional unit of nervous system. Dendrites of one cyton of a neuron are attached with axon of another neuron by specific joint, which is called synapsis.

Functions of nervous system

i. It coordinates and controls different activities of various organs of the body.

ii. It provides information to human about external environment through sensory organs. Means it receives information from external environment through stimuli.

iii. It also controls the voluntary muscular activities like running, speaking etc.

iv. It also regulates various involuntary activities like breathing, heart beat and movement of food in alimentary canal etc.

In this way nervous system coordinates our different body parts and functions as an overall unit.

Nervous system in animals

Various activities of animal body are controlled and coordinated by two systems- (a) Nervous system and (b) Endocrine system.

Main parts of the nervous system are : as follow -

I **Central Nervous System**– Under this system information is processed (receiving and action taken against it). This system is mainly includes Brain and spinal cord.

II **Peripheral Nervous system** – This system includes cranial nerves originated from brain and spinal nerves from spinal cord.

III **Autonomous Nervous system –**

I. Central Nervous System

(A) Brain –

The softest organ of human body is brain which is protected inside cranium of the skull. Three meninges or membranes are present on the brain which gives protection to it. (i) Outer one is hard **Duramater** (ii) A thin fragile web like middle membrane **Arachnoid** and (iii) highly vascular innermost **Piamater.**

(I) Duramater– It is outer most membrane. It is large and thick and made up of fibrous connective tissue and collagen fibres. It is attached with cranial bones and is non- elastic.

(ii) Arachnoid – It is middle layer. It is formed by soft collagen fibres and elastic fibres.

(iii) Piamater – This inner membrane is thin, soft and transparent. This membrane is adherent to the brain. A network of blood capillaries is spread in this cover by which brain and spinal cord receives oxygen and nutrition. Piamater hangs at two places in brain cavity as minute outgrowth. These are known as **Choroid plexus**.

Subdural cavity- It is the space between duramater and arachnoid.

Subarachnoid cavity – It is present between arachnoid and Piamater. Cerebrospinal fluid is filled in these cavities. It is alkaline fluid and protects brain from external shocks.

Cerebrospinal Fluid

It is lymph like fluid secreted by choroid plexus and come out as a filtrate from choroid plexus that is known as **cerebrospinal fluid**. In addition to protein, glucose, urea and chlorides in this fluid bicarbonates sulphate, phosphate, Potassium, Sodium, Calcium, creatinine and uric acid are also present in small amount. A healthy person has about 150 ml. This fluid flows from anterior to posterior side and travels through arachnoid cavity and finally enters back into blood through blood vessels of duramater.

Functions of cerebrospinal fluid -

(i) It protects brain and spinal cord from external shocks and also provides moisture to them.

(ii) It provides a medium for exchange of different nutrients between brain and blood. Along with it also provides medium for exchange of oxygen and carbon dioxide.

(iii) It protects brain and spinal cord from harmful pathogens and helps in diagnosis of various diseases related to brain. Meningitis is caused due to increased amount of cerebro spinal fluid

Structure of Brain

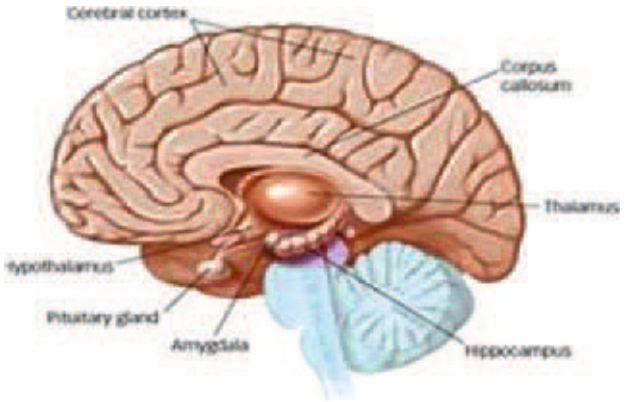

Fig. 26.1 Structure of Brain

Brain has three main parts (Fig. 26.1).

1. Fore brain–

It is mainly formed by two parts **cerebrum** and **Diencephalon**. It forms important part of brain which is about 2/3 part of complete brain.

(a) Cerebrum – It is the most developed and largest part of fore brain. It is divided into two parts (Right and Left) which are known as cerebral hemisphere. Both these hemispheres are connected by thick band of transverse nerve fibres called corpus calosum. It is much folded due to presence of ridges and grooves on its outer surface. Left hemisphere of cerebrum controls right portion of body and right hemisphere control left portion of body. Cerebrum looks as an oval shaped structure from upper side. In middle of it a line like fissure is present which separates both hemispheres. Each hemisphere is internally hollow and two areas (one inner and other outer) are present in its wall. Its outer area (cerebral cortex) has cyton of nerve cells and due to grey in colour, it is called **Grey matter**. Inner area is made of white axon fibres and that is called **white matter**

Olfactory lobe - Two lobes are found at the anterior side of cerebral hemisphere which is known as olfactory lobes. These lobes helps in sense of smell.

Functions of Cerebrum –

(i) It performs the mental work i.e. thinking, reasoning, planning and memorizing etc.

(ii) It receives and analyses information from sense organs i.e. eyes, ears and nose etc. It also take action on this information.

(iii) It initiates contraction of voluntary muscles and controls them.

(b) Diencephalon – It is located behind and below the cerebrum and situated between cerebral hemisphere and mesencephalon. Its cavity is called as diocoel. Roof of diencephalon forms a folded structure called as anterior choroid plexus. It is extremely sensitive. Thalamus and Hypo-thalamus are its two parts.

(I) Thalamus – It is oval shaped lobe, formed by grey matter which is located below to cerebrum. It serves the transmission of those sensory impulses (e.g. pain and comfort)

which go to cerebrum.

(ii) **Hypothalamus -** It is located at the base of the cerebrum and below thalamus. It controls induced behavior like hunger and thirst and eroticism. It also controls the hormone secreted by pituitary gland. Hypothalamus also controls body temperature. Along with this, it is also regulatory center regarding the amount of fluid within body and also controls blood pressure.

(2) Mid Brain

It is middle part of the brain. It is also known as mesencephalon. Its two main parts are as follow-

(a) **Corpora Quadrigemina-** Two inferior and two superior optic lobes are found in mid brain of human. These are found attached by tectum on dorsal surface of mid brain. These are collectively known as Corpora Quadrigemina. These receive stimuli related with vision and hearing.

(b) **Cerebral peduncle**– These are found in front of mid brain. These are also known as cruracerebri. It is a bundle made up of fibres which joins cerebral cortex with spinal cord and other parts of the brain.

(3) Hind Brain –

It is posterior or last part of the brain. It is mainly consists of three parts.

(a) Cerebellum- It is comparatively small part of brain which lies below the base of cerebrum. Its dorsal surface is more developed. It has many grooves instead of folds. Its cortical part is also made of grey matter. It has two main functions.

(i) To maintain body balance

(ii) To maintain coordination in muscular activities

(b) Pons Varolli – It lies just above medulla oblongata and below cerebral peduncle. It joins both two lobes of cerebellum. It also joins other parts of the brain. It is formed by white matter. It has pneumotaxic center for regulation of respiratory ventilation. It also acts as mediator controller in chewing activity, salivation and hearing, secretion of tears and moment of eye balls.

(c) Medulla Oblongata– It is the last part of the brain. It is triangular in shape and located between pons and spinal cord and attached with spinal cord. Its cavity is known as Meta-coel. Its functions are as follow-

1. It is center for breathing, coughing, swallowing etc.

2. It controls heart beats, blood pressure, and peristaltic movements of alimentary canal and other various involuntary activities.

B. Spinal Cord

Spinal cord extends from medulla oblongata of brainstem to whole length of vertebral column passing through central canal of vertebrae. It also contains three same meninges or membranes as present on brain and the same cerebrospinal fluid is also filled in their spaces.

Its outer membrane is Duramater, middle membrane is arachnoid and internal membrane is Piamater. The space between durameter and arachnoid is called subdural cavity. The space between arachnoid and piamater is called subarachnoid cavity. The cerebrospinal fluid in filled is both these cavities.

In this way the distribution of grey matter and white matter is just reverse in the spinal cord means white matter is on outside and grey matter found inside.

Grey matter looks like butterfly shaped in cross section of spinal cord. It forms two dorsal horns on dorsal surface and two ventral horns on ventral surface which are made from nerve fibres. Two grooves are present on dorsal and ventral surface of spinal cord which is known as dorsal fissure and ventral fissure. Sensory fiber of nerve enters in spinal cord through dorsal fissure or dorsal horn and motor nerve enters from ventral fissure or ventral horn. At the roof of dorsal surface there is a swelling which is called dorsal root ganglion. There are 31 pairs of spinal nerves.

General structure of spinal cord shown in

Table 26.1 Description of Cranial Nerves

S. N.	Name	Nature	Origin	Function
1	Olfactory Nerve	Sensory	Olfactory mucous membrane	Smell
2	Optic Nerve	Sensory	Retina of Eye	For Vision
3	Occulomotor Nerve	Motor	From four muscles of eye ball and Lacrimal gland	Movement of eye ball and contraction of pupil
4	Trochlear Nerve	Motor driver	From superior oblique muscles of eye ball	Movement of eye ball
5	Trigeminal Nerve	Mixed	From Mucous membrane, Skin, face and muscles of lips	Muscular movement and cutaneous sensations
6	Abducens Nerve	Driver	Posterior rectus eye muscle	Movement of eye ball
7	Facial Nerve	Mixed	From Taste gland, Salivary gland, Face and neck,	Movement, saliva secretion and taste
8	Auditory Nerve	Sensory	Internal ear	Hearing and balancing the body.
9	Glossopharyngeal	Mixed	Muscles of pharynx, tongue and salivary glands	Taste, swallowing and saliva secretion
10	Vagus Nerve	Mixed	From Heart, Pharynx, stomach trachea, alimentary canal and blood vessels	Control of visceral organs activities
11	Spinal Accessory Nerve	Motor	From Neck and shoulders muscles	Movement of muscles.
12	Hypoglossal Nerve	Motor	From muscle of tongue	Movement of tongue

figure is just like shown in transverse section. This figure shows that how spinal nerves are originated from it (Fig. 26.2).

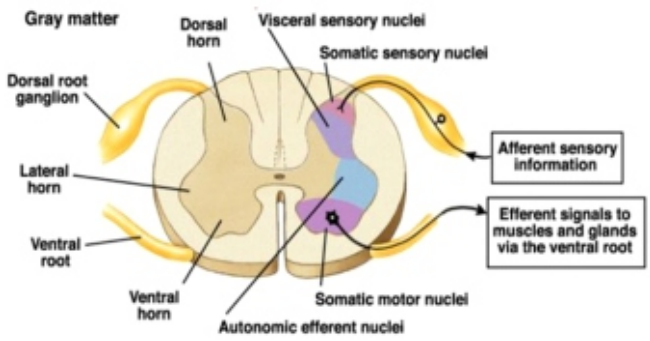

Fig. 26.2 Structure of spinal cord

Functions of spinal cord –

1. To carry reflexes down ward the neck.
2. To carry sensory impulses from skin and muscles to brain.
3. To carry responses from brain to body and hands and legs.
4. It acts as centre of spinal reflex.
5. It helps in all functions of brain.
6. The cerebrospinal fluid filled in it protects spinal cord from external shocks.
7. It maintains proper pressure on brain and movement of different substances.
8. It controls and coordinates involuntary activities.

II. Peripheral Nervous System

Peripheral nervous system includes all those nerves which arise from brain and spinal cord. The nerves arise from brain are known as cranial nerves and the nerves from spinal cord are known as spinal nerves.

(a) Cranial nerves– There are 12 pairs of cranial nerves in human. They arise from brain. The types of these nerves are different due to their functions i.e. these nerves are sensory, motor and Mixed. Their name, functions and nature are mentioned (Table 26.1).

(b) Spinal nerves – These nerves arise from spinal cord. Human has 31 pairs of it. Extending from back portion of medulla oblongata to lumbar region. They swell from lumber region and emerge nerves for hands and legs. In human each spinal nerve comes out from inter vertebral spaces between two vertebrae of vertebral column. This spinal nerve emerges from dorsal rootand forms a ganglion. The nerves emerging from dorsal rootis sensory type and nerve emerging from ventral root is of motor type. By these two qualities spinal nerves are mixed in nature (Table 26.2)

Table 26.2 Description of spinal nerves present in human

S.No.	Name of nerves	Number	Location
1	Cervical spinal nerves	8 pairs	From first vertebra to below the cervical vertebra.
2	Thoracic spinal nerves	12 pairs	Below both sides of each thoracic vertebra.
3	Lumber spinal nerves	5 pairs	Below both sides of each lumber vertebra
4	Sacral spinal nerve	5 pairs	Near both sides of sacral vertebra
5	Coccygeal spinal nerve	1 pair	Near both sides between coccygeal and sacral vertebra.

III. Autonomous Nervous System

It was discovered by Langley. It is completely motor and uncontrolled. It provides nerves to involuntary muscles and glands. It is formed of ganglions and chain of one pair of nerves which is located on both lateral sides of spinal cord. This system is mainly a motor system, which controls involuntary activities of visceral organs. It has two main parts (a) **Sympathetic nervous system** (b) **Para sympathetic nervous system** (Fig. 26.3)

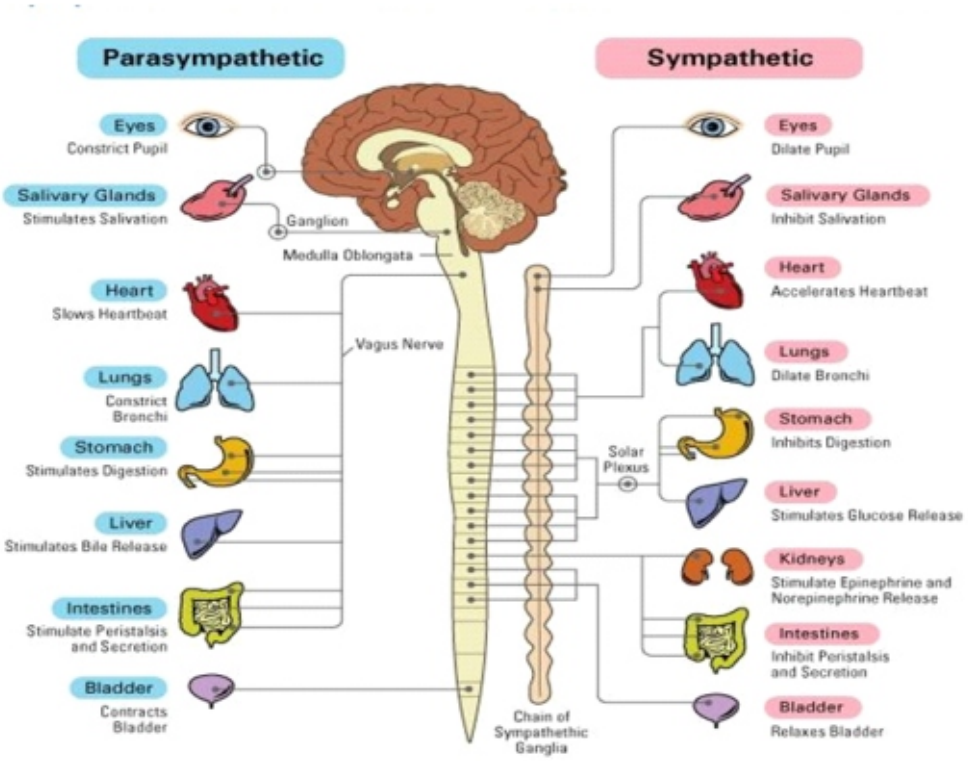

Fig. 26.3 Stucture of Sympathetic and Parasympathetic nervous system

Table 26.3 Effects of Autonomous Nervous System

S. No.	Sympathetic Nervous system	Parasympathetic Nervous system
1	Increases heart beat	Decreases heart beat
2	Increases secretion of adrenal gland	Decreasessecretion of adrenal gland
3	Pupil dilates	Constriction of pupil
4	Increases secretion of sweat	Decreases secretion of sweat
5	Excites arrector pili muscle	Relaxes arrectorpili muscles
6	Increases blood pressure	Decreases blood pressure
7	Constrict peripheral blood vessel (skin vessels) but dilates those blood vessels supplying blood to organs connected to emergency like heart, lungs, brain etc.	Dilates peripheral blood vessels but constricts other to reduce blood supply.
8	Relaxes urinary bladder	Contracts urinary bladder
9	Increases secretion of lacrimal glands.	Decreases secretionof lacrimal glands.
10	Increases sugar level in blood	Decreases sugar level in blood
11	Decreases secretion of salivary glands	Increases secretion of salivary glands
12	Decreases peristalsis of alimentary canal	Increases peristalsis of alimentary canal
13	Decreases secretion of digestive glands	Increases secretion of digestive glands
14	Contracts sphincter of anus	Relaxes sphincter of anus

Sympathetic nervous system prepares the body to face emergency condition and Para sympathetic nervous system establishes in normal condition after the end of emergency. Both these system work reversely. Both these system have opposite functions and proper controlling on all activities of the body. The opposite effects of two sub-divisions of autonomous nervous system on different organs is tabulated (Table 26.3).

Autonomous nervous system is too much affected by emotions like sadness, anger, fear, sexual stimulation etc.

Reflex action

Automatic, rapid and involuntary response caused by any stimulus in body is known as reflex action. For example -

- By touching your hand to hot giddle or pointed thorn withdraws your hand quickly.
- Only by observing or smelling of any known tasty food water (saliva) secretes in mouth.

Reflex action is of two types – (i) Simple or Unconditional and (ii) Acquired / Conditional.

(i) Simple or Unconditional Reflex Action

Simple / Unconditional reflex actions are innate or natural that does not need any previous information and they are not controlled by brain. Such type of reflex action is known as simple / unconditional reflex reactions.

- **Closing of eyelid immediately –** Something seems to coming immediately towards eye.
- **Coughing –** swallowed food enter in trachea instead of food pipe.
- Constriction of eye pupil in strong light
- Tickles the leg of sleeping person leg pulled immediately

(ii) Acquired Reflex Action

These are also known as conditional reflex

action. Animal learns them by experience and training. First of all Russian Bio physiologist Ivan Petrovich Pavlov demonstrated it on a hungry dog. In this experiment he gave bread to the dog after ringing bell then saw salivation. This activity was done repeatedly for many days. After this he observed that saliva secreted in dog's mouth by just ringing the bell not given bread. In this example, actually the brain keeps remember the actual taste of food and works accordingly in unconscious state. The reason of it was development of conditional reflex action in dog. Some other examples of these reflex actions are following –

- Suddenly pull breaks when anybody to get ahead of your car or bicycle.
- Lace-up- shoes even talking to someone.
- Dogs run away when you just bent yourself like you are picking up a stone to pelt.
- You stand up as soon as teacher enters in the class.

Mechanism of Reflex – Action-

Fibres of spinal cord and motor fiber of ventral root play special role in it. For example- pin picked on the skin stimulate sensation present in it. They transmit sensation to dendrites of related somatic sensory fibers. Here these fibres transmit impulses to the neuron cells present in the dorsal ganglia of spinal nerve. Terminal node of these calls sends impulses to dendrites of nearest motor nerves. Here sensory induction becomes motor impulse. Axons of motor cells are fibres of ventral root. They carry these impulses to legs, where muscle contract which trigger limbs.

These actions are very fast. The pathway started from sensory organs to motor to impulse path is known as reflex arch. The nerves (sensory- motor carrier) involve in whole activity and responses by them are known as reflex action.

Spinal Cord Reflex Arch– The path way taken by impulse generated at the time of reflex action by neuron is known as reflex arch (Fig. 26.4). Main organs of this pathway are-

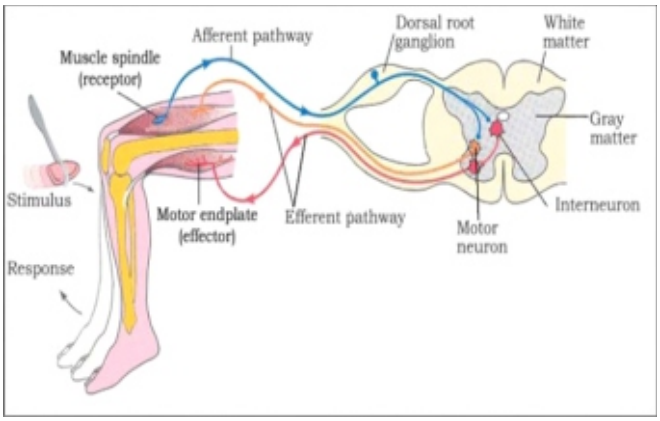

Fig. 26.4 Reflex arc

(a) Sensory organ - These are receptors found on animal's body which are stimulated by receiving stimulations from external or internal environment. It includes five receptors eye, nose, ear, skin and tongue.

(b) Sensory cell – Sensory cells carry impulses from sensory organs to spinal cord.

(c) Nerve centre of spinal cord– Centre of actions.

(d) Motor nerve– The function of transmission and carry impulse.

(e) Effective organs – These organs complete their response to impulses received through motor nerve. Generally theses are muscles and glands. There are so many examples of reflex actions i.e. when we put our hand in boiling water, hand removes immediately even without knowing that it is hot. It is later known that water was hot. In this process sensations of pain are received by many pairs of receptors present in skin and impulses are sent to spinal cord through dorsal sensory root. With the help of motor neuron it enters into spinal cord at sensory synapse and transmitted to muscles by motor neurons. After this process muscle contracts and this process takes mili second. One nerve fibre carries this impulse to brain from spinal cord. This is the time period when we feel pain.

Important points

1. Nervous system is divided into two parts (i) central nervous system (ii) Peripheral nervous system.
2. Central nervous system consists of brain and spinal cord.
3. Peripheral nervous system is formed bycranial and spinal nerves and autonomous nervous system.
4. Structure of spinal cord is formed of grey and white matter. It has a central cavity.
5. Nervous system is formed by of nerve cells, nerve fibres and neuroglia.
6. Nature of nerves is sensory, motor and mixed type.
7. 12 pairs of cranial nerves are found in human.
8. 31 pairs of spinal nerves are found in human.
9. Autonomous nervous system has two parts (i) sympathetic and (ii) Para sympathetic
10. Spinal cord's function is to control reflex action.
11. Peripheral nervous system is formed from cranial nerves.
12. Cerebrum is the largest part of brain and this is the centre of intelligence.

Practice Questions

Multiple Choice Questions

1. What is the unit of nervous system?
   (a) Nephron (b) Neuron
   (c) Brain (d) Spinal cord
2. Temperature controlling centre in the brain of man is –
   (a) Pituitary gland (b) Diencephalon
   (c) Hypothalamus (d) None of above
3. A function of parasympathetic nervous system is –
   (a) Dilation of pupil of eye
   (b) Secretion of sugar in liver
   (c) Increase heart beat
   (d) Stimulate sensation of saliva
4. The Scientist worked on conditioned reflex action is –
   (a) Mendel (b) Pavlov
   (c) Darwin (d) Ian Wilmut
5. Number of cranial nerves in human are –
   (a) 10 pairs (b) 10
   (c) 12 pairs (d) 12

Very Short Answer Questions

1. What the cavities of brain are called?
2. How many numbers of cranial nerves are found in mammals?
3. Which is the longest cell?

Short Answer Questions

1. Which are two parts of autonomous nervous system?
2. Why this name is givento peripheral nervous system?
3. Mention one function of each of the following.
   I. Cerebrum
   ii. Cerebellum
   iii. Medulla oblongata
   iv. Hypothalamus
4. Mention the name of main parts of the brain.
5. Mention the name of the fluid filled in the cavities of brain

Essay Type Questions

1. Explain with labelled diagram of transverse section of spinal coral and simple neural circuit of reflex action related to it.
2. Describe structure of human brain with diagram.
3. Describe the Cranial nerves of mammals.
4. Describe reflex actions.
5. Describe spinal nerves in detail.

Answer Key-

1. (b) 2. (c) 3. (d) 4. (b) 5. (c)