

Organization of nervous system

■ DIVISIONS OF NERVOUS SYSTEM

Nervous system controls all the activities of the body. It is quicker than other control system in the body, namely endocrine system. Primarily, nervous system is divided into two parts:

1. Central nervous system
2. Peripheral nervous system.

■ CENTRAL NERVOUS SYSTEM

Central nervous system (CNS) includes brain and spinal cord. It is formed by neurons and supporting cells called neuroglia. Structures of brain and spinal cord are arranged in two layers, namely gray matter and white matter. Gray matter is formed by nerve cell bodies and the proximal parts of nerve fibers, arising from nerve cell body. White matter is formed by remaining parts of nerve fibers.

In brain, white matter is placed in the inner part and gray matter is placed in the outer part. In spinal cord, white matter is in the outer part and gray matter is in the inner part.

Brain is situated in the skull. It is continued as spinal cord in the vertebral canal through the foramen magnum of the skull bone. Brain and spinal cord are surrounded by three layers of meninges called the outer dura mater, middle arachnoid mater and inner pia mater.

The space between arachnoid mater and pia mater is known as subarachnoid space. This space is filled with a fluid called cerebrospinal fluid. Brain and spinal cord are actually suspended in the **cerebrospinal fluid**. Important parts of brain and segments of spinal cord are shown in Figure 133.1.

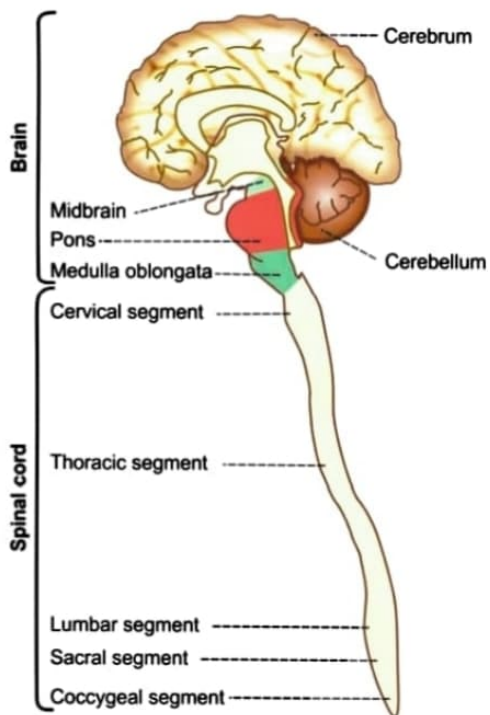


FIGURE 133.1: Parts of central nervous system

Parts of Brain

Brain consists of three major divisions:

1. Prosencephalon

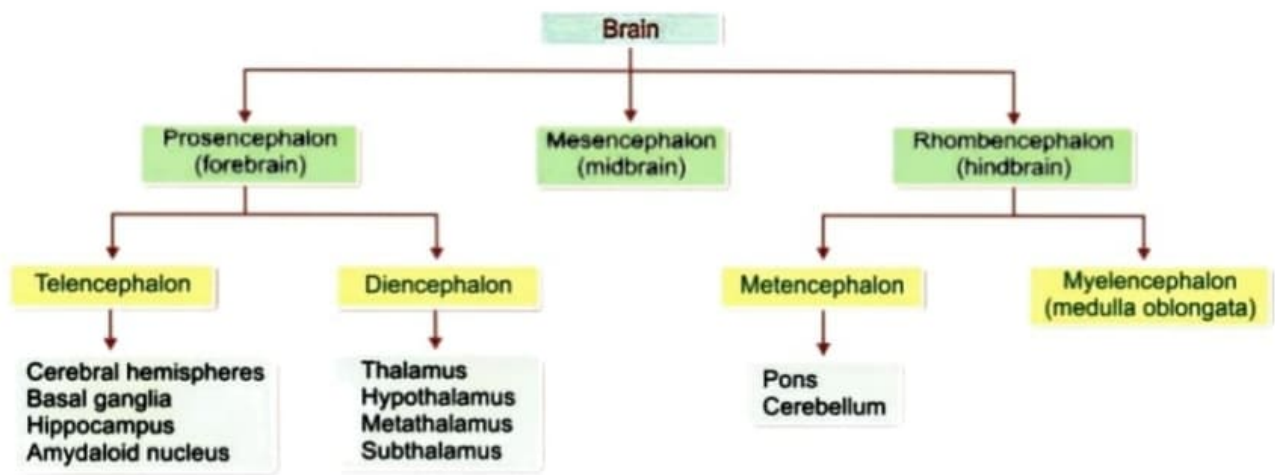


FIGURE 133.2: Parts of brain

2. Mesencephalon
3. Rhombencephalon

1. *Prosencephalon*

Prosencephalon is otherwise known as forebrain. It is further divided into two parts:

- i. Telencephalon, which includes cerebral hemispheres, basal ganglia, hippocampus and amygdaloid nucleus
- ii. Diencephalon, consisting of thalamus, hypothalamus, metathalamus and subthalamus.

2. *Mesencephalon*

Mesencephalon is also known as midbrain.

3. *Rhombencephalon*

Rhombencephalon or hindbrain is subdivided into two portions:

- i. Metencephalon, formed by pons and cerebellum
- ii. Myelencephalon or medulla oblongata (Fig. 133.2).

Midbrain, pons and medulla oblongata are together called the brainstem.

CENTRAL NERVOUS SYSTEM

The part of the nervous system which occupies the central axis of the body is called central nervous system (CNS). It comprises the *brain* and the *spinal cord*.

A. THE BRAIN

It weighs about 1.5 kg in adults and comprises all the structures which are intracranial i.e. located within a hard bony skull. It is divided into 3 parts: *fore brain*, *mid brain* and *hind brain*. The brain also contains 4 interconnected cavities, the *cerebral ventricles*, that contain cerebrospinal fluid (CSF).

1. Fore brain: It is subdivided into: *telencephalon* and *diencephalon* (Fig. 11.1.1).

(i) **Telencephalon** – it consists of the two *cerebral hemispheres* (or *cerebrum*) and their interconnections.

(a) The hemispheres, although separated by a longitudinal division, are connected to each other by bundles of nerve fibers known as *commissures*, the *corpus callosum* being the largest.

(b) The cortex of each hemisphere is divided into 4 lobes, the *frontal*, *parietal*, *occipital* and *temporal* (Fig. 11.1.2).

(c) The *cerebral cortex*, an area of grey matter, about 3 mm thick, is highly folded. This increases the area available for cortical neurons without increasing appreciably the volume of the brain.

(d) The *subcortical nuclei* form other areas of grey matter that lie deep within the cerebral hemispheres. Predominant among them are the *basal ganglia*.

(ii) **Diencephalon** – its upper 2/3rd comprises *thalamus* and lower 1/3rd comprises *hypothalamus* which connects with the *pituitary complex*. The thalamus is a large cluster of nuclei that serves as a synaptic relay station.

2. Mid brain or Mesencephalon: It is divided into two parts by *Aqueduct of Sylvius* (duct which connects the IIIrd ventricle in the midbrain, with the IVth ventricle in the pons and medulla) into:

(i) Ventral part called *cerebral peduncle*, chiefly of white matter, uniting the pons with the thalamic region of the cerebrum. It comprises the *tegmentum*, *substantia nigra* and *basis peduncle*; and

(ii) Dorsal part, called *tectum* which constitutes two elevations, *superior and inferior colliculi*.

3. **Hind brain or Rhombencephalon.** It comprises *pons*, *medulla oblongata* and *cerebellum*.

Important Note

An area of brain that includes both grey and white matter is the **Limbic System**. It is formed by an interconnected group of brain structures, including portions of frontal and temporal lobes, thalamus, hypothalamus, as well as the pathways that connect them (page 1051).

Important Points

1. The mid brain, pons and medulla together constitute the **brain stem**. All cranial nerves are situated in the brain stem. For example:
 - (i) in the mid brain – III and IV nerves,
 - (ii) in the pons – V, VI, VII and VIII nerves, and
 - (iii) in the medulla – IX, X, XI and XII nerves.
2. The **cerebellum** is connected by three large bundles of nerve fibers, the *cerebellar peduncles* with the dorsal side of the brain stem:
 - (i) via *superior cerebellar peduncle* with the mid brain,
 - (ii) via *middle cerebellar peduncle* with the pons, and
 - (iii) via *inferior cerebellar peduncle* with the medulla.
3. Running through the core of the brain stem and consisting largely of neuron cell bodies (*i.e.* grey matter), is the **reticular formation** (page 981).

B. THE SPINAL CORD

1. The spinal cord is a long (approx. 45-50 cm in length), narrow (about 2 cm in diameter) cylindrical structure. It lies outside the skull beginning from its base at the foramen magnum to terminate at the lower border of 1st lumbar vertebra. Below the 1st lumbar vertebra the spinal cord contains the lumbar and sacral roots in bands, known as the *cauda equina* (or horse tail).

2. A **cross-section** of the spinal cord shows the following structures:

(i) A prominent fissure anteriorly, called *anterior median fissure* and a less prominent fissure (or septum) posteriorly, called *posterior median fissure* (or septum); between these fissures lies the *central canal*.

(ii) The grey matter consisting of nerve cells forms an H-shaped figure long

(iv) The **dorsal or posterior horn** receives the fibers of the posterior roots which are *purely sensory* in function. Their cell bodies are found in the dorsal (posterior) root ganglion which is a swelling on the posterior root. These ganglion cells are bipolar, their axons connect both with peripheral structures and with structures in the dorsal horn.

(v) Surrounding the grey matter is the white matter, consisting of large numbers of ascending and descending axons cut across. The white matter is divided into three *white columns* (or funiculi):

(a) *anterior white column*, lying between the anterior median fissure and the anterior roots;

(b) *lateral white column*, lying between the anterior and posterior roots; and

- (c) *dorsal white column*, lying between the posterior roots and the posterior median fissure.
- (vi) The sensory and motor fibers join to form a *mixed nerve* which comes out from the vertebral canal as a *peripheral spinal nerve* via the intervertebral foramen.

Important Notes

1. In the brain stem and the spinal cord white matter surrounds the grey matter and consists mostly of myelinated nerve fibers; whereas in the cerebrum and cerebellum, grey matter surrounds the white matter and consists mainly of nerve cells and neuroglia.
2. The fatty 'myelin' in myelinated nerve fibers gives a white appearance to the white matter whereas the cell bodies of neurons provide the grey matter, a grey (ash colour) appearance.

A. THE SOMATIC NERVOUS SYSTEM

It is made up of all the nerve fibers going from the CNS to the skeletal muscles cells. It comprises the *spinal* and *cranial* nerves.

1. **The spinal nerves:** There are 31 pairs of the spinal nerves. Each pair is attached to the spinal cord by two roots viz. dorsal root and ventral root. These include:
 - (a) 8 pairs of *cervical* nerves,
 - (b) 12 pairs of *thoracic* nerves,
 - (c) 5 pairs of *lumbar* nerves,
 - (d) 5 pairs of *sacral* nerves, and
 - (e) 1 pair of *coccygeal* nerve.
2. **The cranial nerves:** These nerves have their cell bodies in the brain. There are 12 pairs of the cranial nerves. Some are *afferent (sensory)*, some are *efferent (motor)* and those containing both of these components are called *mixed* nerves (Table 11.1.1).

PERIPHERAL NERVOUS SYSTEM

This is the part of nervous system which lies outside the CNS. It consists of the nerves extending from the brain and spinal cord out to all parts of the body. It is divided into: *somatic* and *autonomic* nervous system.

Name	Fiber types	Principal function
I. Olfactory nerve	Afferent	Olfaction (smell)
II. Optic nerve	Afferent	Vision
III. Oculomotor nerve	Mixed	Innervate extrinsic muscles that move the eyeball and intrinsic muscles that constrict pupil and alter lens shape for accommodation. Bring sensation from proprioceptors in eye muscles.
	(i) Efferent	
IV. Trochlear nerve	Mixed	Innervate extrinsic muscles that move the eyeball. Bring sensation from proprioceptors in eye muscles.
	(i) Efferent	
V. Trigeminal nerve	Mixed	Innervate muscles of mastication. Bring sensations from receptors in skin and skeletal muscles of face, nose, and mouth and from teeth sockets.
	(i) Efferent	
VI. Abducens nerve	Mixed	Innervate extrinsic muscles that move the eyeball. Bring sensations from proprioceptors in eye muscles.
	(i) Efferent	
VII. Facial nerve	Mixed	Innervate skeletal muscles of facial expression and swallowing; also innervate nose, palate, lacrimal and salivary glands. Bring taste sensation from anterior 2/3rd of the tongue.
	(i) Efferent	
VIII. Vestibulocochlear nerve	Mixed	Audition (hearing), and maintenance of balance and equilibrium.
	(ii) Afferent	
IX. Glossopharyngeal nerve	Mixed	Innervate muscles involved in swallowing and parotid salivary gland. Bring taste from posterior 1/3rd of the tongue.
	(i) Efferent	
X. Vagus nerve	Mixed	Innervate muscles of heart, pharynx, larynx and GIT; and glands of thorax and abdomen. Bring information from receptors in thorax and abdomen.
	(i) Efferent	
XI. Spinal accessory nerve	Mixed	Innervate neck muscles (sternomastoid and trapezius).
	(ii) Afferent	
XII. Hypoglossal nerve	Efferent	Innervate muscles of the tongue.