Brainstem

■ INTRODUCTION

Brainstem is the part of brain formed by medulla oblongata, pons and midbrain. Brainstem contains ascending and descending tracts between brain and spinal cord. It also contains many centers for regulation of vital functions in the body.

■ MEDULLA OBLONGATA

Medulla oblongata or medulla is the lowermost part of brain. It is situated below pons and is continued downwards as spinal cord. Medulla forms the main pathway for ascending and descending tracts of the spinal cord. It also has many important centers which control the vital functions.

1. *Respiratory Centers*

Dorsal and ventral group of neurons form the medullary respiratory centers, which maintain normal rhythmic respiration.

2. *Vasomotor Center*

Vasomotor center controls blood pressure and heart rate.

3. *Deglutition Center*

Deglutition center regulates the pharyngeal and esophageal stages of deglutition.

4. *Vomiting Center*

Vomiting center induces vomiting during irritation or inflammation of gastrointestinal (GI) tract.

5. *Superior and Inferior Salivatory Nuclei*

Salivatory nuclei control the secretion of **saliva.**

6. *Cranial Nerve Nuclei*

Nuclei of 12th, 11th, 10th and some nuclei of 8th and 5th cranial nerves are located in the medulla oblongata. 12th cranial (hypoglossal) nerve controls the movements of **tongue.** 11th cranial (accessory) nerve controls the movements of **shoulder** and 10th cranial (vagus) nerve controls almost all the **vital functions** in the body, viz. cardiovascular system, respiratory system, GI system, etc. 8th cranial nerve (the cochlear division of this nerve), which has the relay in medulla oblongata, is concerned with the auditory function.

7. *Vestibular Nuclei*

Vestibular nuclei contain the second order neurons of vestibular nerve. There are four vestibular nuclei, situated in the rostral part of medulla and caudal part of pons, namely superior, medial, lateral and inferior vestibular nuclei. Medial and inferior vestibular nuclei extend into medulla.

All the medullary centers and nuclei of cranial nerves are controlled by higher centers, situated in cerebral cortex and hypothalamus.

■ PONS

Pons forms a bridge between medulla and midbrain.

Functions of Pons

1. Axons of pontine nuclei join to form the middle cerebellar peduncle or the brachium pontis. Pons forms the pathway that connects cerebellum with cerebral cortex.
2. Pyramidal tracts pass through the pons
3. Medial lemniscus is joined by the fibers of 10th, 9th, 7th and 5th cranial nerves in pons
4. Nuclei of 8th, 7th, 6th and 5th cranial nerves are located in pons
5. Pons contains the pneumotaxic and apneustic centers for regulation of respiration
6. It also contains the vestibular nuclei, which are already mentioned in medulla oblongata.

■ MIDBRAIN

Midbrain lies between pons and diencephalon. It consists of two parts:

A. Tectum
B. Cerebral peduncles.

■ TECTUM

Tectum is formed by two structures:

1. Superior colliculus
2. Inferior colliculus.

1. *Superior Colliculus*

Superior colliculus is a small structure and is an important center for reflexes. Through tectospinal tract, superior colliculus controls the **movements** of the eyes, head, trunk and limbs, in response to visual impulses. Efferent fibers from superior colliculus going to the nucleus of III cranial (oculomotor) nerve cause constriction of pupil during light reflex. Thus, it forms the center for **light reflex.** Superior colliculus also receives afferents from optic tract, which helps in the integration of **optical and postural reflexes.**

2. *Inferior Colliculus*

Inferior colliculus consists of single layer of neurons to which the lateral lemniscus (auditory fibers) synapses. Inferior colliculus is the center for auditory reflexes. Stimulation of this also produces reflex vocalization.

■ CEREBRAL PEDUNCLES

Cerebral peduncles include:

1. Basis pedunculi
2. Substantia nigra
3. Tegmentum, which includes red nucleus.

1. *Basis Pedunculus*

Basis pedunculus consists of pyramidal tract fibers in the middle, temporopontine fibers laterally and frontopontine fibers medially.

2. *Substantia Nigra*

Substantia nigra is situated below the red nucleus. Substantia nigra is considered as one of the components of basal ganglia (Chapter 151).

3. *Tegmentum*

Tegmentum lies dorsal to substantia nigra and is actually the upward continuation of the reticular formation in pons. Tegmentum comprises three decussations and red nucleus.

Decussations in tegmentum

i. **Superior cerebellar peduncle,** which is formed by fibers between cerebellum and other parts of CNS. These fibers are predominantly efferent fibers from dentate nucleus of cerebellum; few fibers are from other cerebellar nuclei such as nucleus globosus and nucleus emboliformis.
ii. **Forel decussation,** which is due to the crossing of rubrospinal tracts from either side
iii. **Meynert decussation,** which is due to the crossing of medial longitudinal bundle that is formed by efferent fibers of 3rd, 4th and 6th cranial nerves.

Red Nucleus

Red nucleus is a large oval or round mass of gray matter, extending between the superior colliculus and hypothalamus.

Parts of red nucleus

Red nucleus has two parts:

1. **Nucleus magnocellularis,** which is formed by large cells. Fibers from this form the rubrospinal and rubrobulbar tracts.

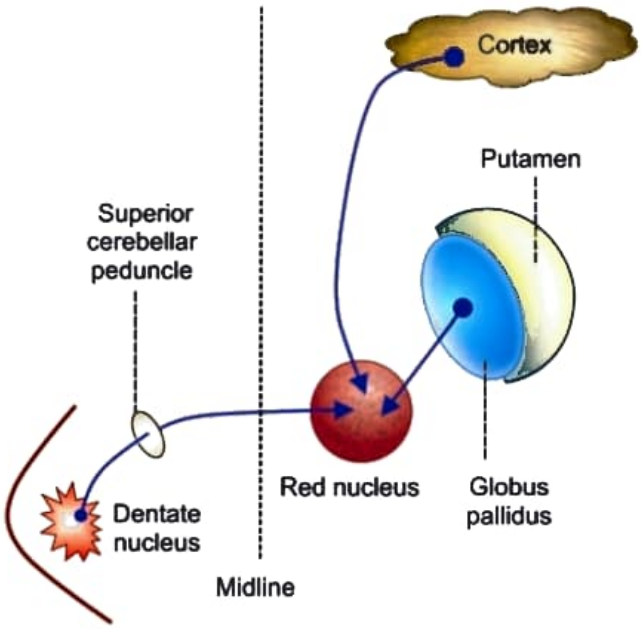

FIGURE 146.1: Afferent connections of red nucleus

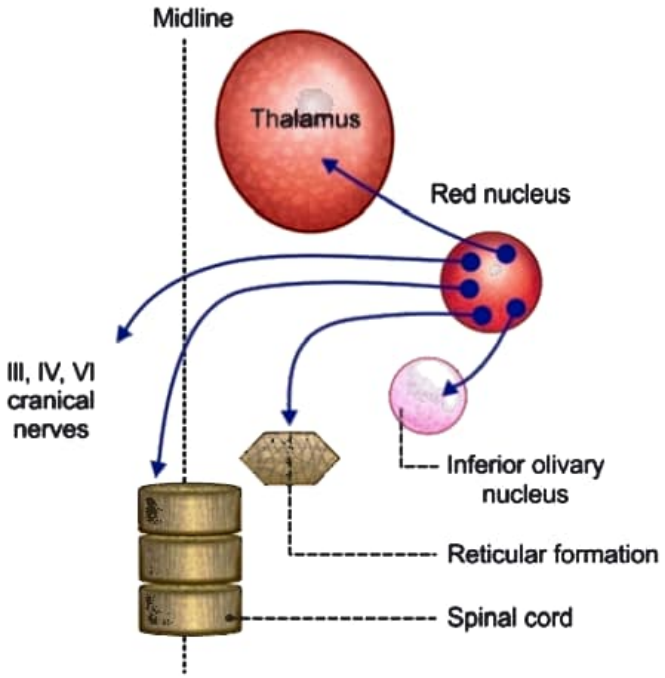

FIGURE 146.2: Efferent connections of red nucleus

2. **Nucleus parvocellularis,** which is formed by smaller cells. Fibers from this form mainly the rubroreticular tract.

Connections of red nucleus

Afferent connections: Red nucleus receives fibers from:

1. Nucleus parvocellularis, which receives fibers from motor cortex (area 6) – corticorubral fibers (Fig. 146.1)
2. Nucleus magnocellularis, which receives fibers from motor cortex (area 6) – pallidorubral fibers
3. Nucleusmagnocellularis, whichreceives fibers from dentate nucleus (of opposite side) – cerebellorubral or dentatorubral tract.

Efferent connections: Red nucleus sends efferent fibers to various parts of brain and spinal cord:

1. Rubrospinal tract to spinal cord (Fig. 146.2)
2. Rubrobulbar tract to medulla
3. Rubroreticular fibers to reticular formation
4. Rubrothalamic tract to lateral ventral nucleus of thalamus
5. Rubro-olivary tract to inferior olivary nucleus
6. Fibers to nuclei of 3rd, 4th and 6th cranial nerves.

Functions of red nucleus

1. *Control of muscle tone:* Because of its connections with cerebellum, vestibular apparatus and skeletal muscle, the red nucleus plays an important role in facilitating the muscle tone.
2. *Control of complex muscular movements:* Red nucleus controls the complex muscular movements. It plays an important role in the integration of various impulses received from many important areas of brain.
3. *Control of righting reflexes:* Red nucleus is the center for all righting reflexes except optical righting reflexes (Chapter 157).
4. *Control of movements of eyeball:* Through its efferent connections with nuclei of 3rd, 4th and 6th cranial nerves, red nucleus plays an important role in the control of ocular movements (Chapter 165).
5. *Control of skilled movements:* Red nucleus plays an important role in controlling the skilled muscular movements by its connections with spinal cord and cerebral cortex.

Internal Capsule

■ DEFINITION

Internal capsule is the broad and compact band of afferent and efferent fibers connecting cerebral cortex with brainstem and spinal cord. Cerebral cortex is connected with brainstem and spinal cord by both afferent and efferent fibers. Fibers arising from different parts of cerebral cortex descend down into white matter of cerebral hemispheres in the form of radiating mass of fibers called corona radiata. While passing down towards the brainstem, corona radiata converges in the form of internal capsule.

Fibers from spinal cord and brainstem reach cerebral cortex in the same route. A large portion of internal capsule is formed by thalamic radiation.

■ SITUATION

Internal capsule is situated in between thalamus and caudate nucleus on the medial side and lenticular nucleus on the lateral side.

■ DIVISIONS

Internal capsule has two limbs, the anterior and posterior limbs. In between these two limbs, lies the genu of internal capsule. Distal end of posterior limb is continued as the caudal portion of internal capsule (Fig. 148.1). Nerve fibers of each division are given in Table 148.1.

■ ANTERIOR LIMB

Anterior limb of internal capsule is short and lies between lenticular and caudate nuclei.

■ POSTERIOR LIMB

Posterior limb is long and situated between thalamus and lenticular nucleus.

■ GENU

Genu is situated between the anterior and the posterior limbs.

■ CAUDAL PORTION

Caudal portion is otherwise known as **retrolenticular portion** of internal capsule.

■ APPLIED PHYSIOLOGY – EFFECT OF LESIONS OF INTERNAL CAPSULE

Lesion of internal capsule is caused by thrombosis or hemorrhage in branches of middle cerebral arteries.

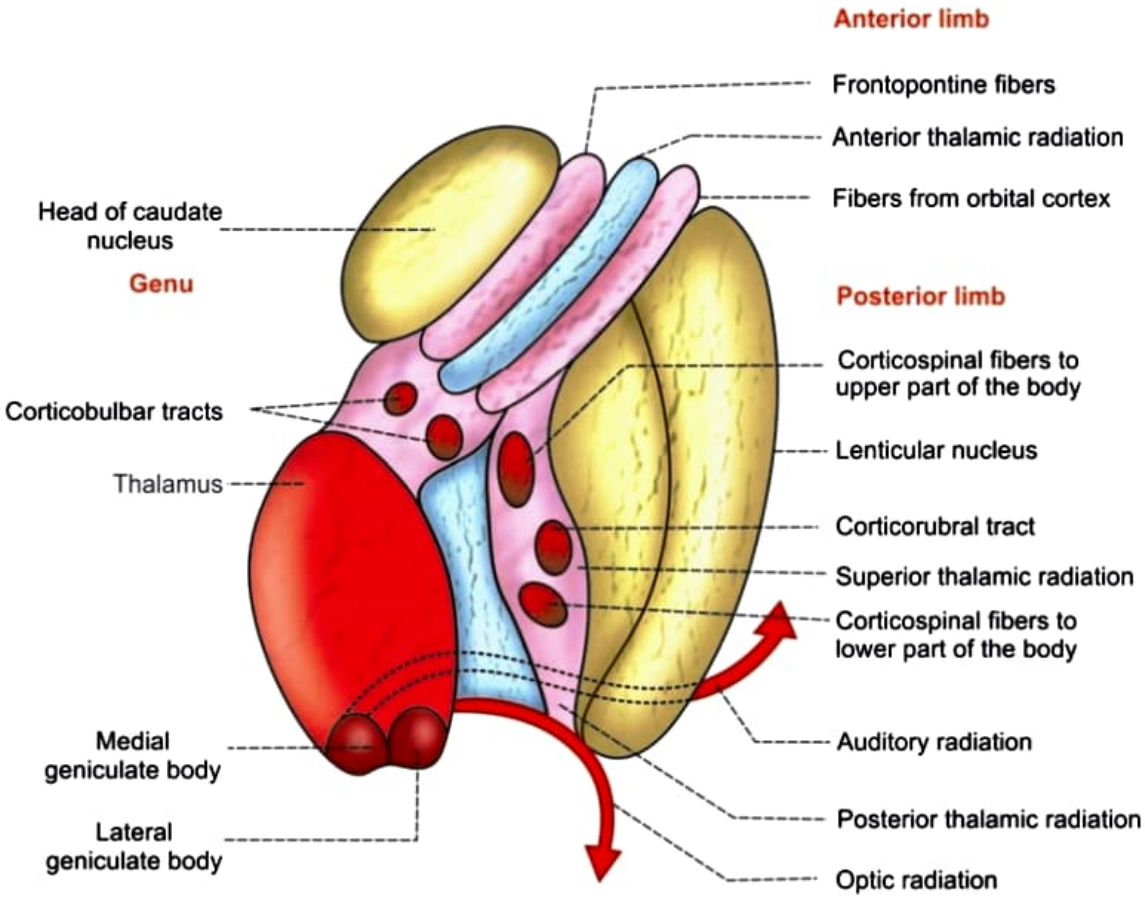

FIGURE 148.1: Components of internal capsule. Pink = Descending fibers, Blue = Ascending fibers.

The effects of lesion depend upon the part of internal capsule involved.

TABLE 148.1: Fibers of internal capsule

Division	Nerve fibers present
1. Anterior limb	1. Anterior thalamic radiation 2. Prefrontal corticopontine (frontopontine) tract 3. Fibers from orbital cortex to hypothalamus
2. Posterior limb	1. Corticospinal tracts 2. Superior thalamic radiation 3. Frontal corticopontine tract
3. Genu	Corticobulbar tract
4. Caudal portion	Posterior thalamic radiation

■ IN ANTERIOR LIMB

Anterior limb contains thalamocortical and frontopontine fibers. Lesion in this limb causes widespread **disability** in the body. Both motor and sensory functions are lost.

■ IN POSTERIOR LIMB

Lesion in posterior limb affects the sensory fibers (thalamocortical fibers). So, it causes:

1. Contralateral **hemianesthesia** (loss of sensation in opposite side of the body)
2. Contralateral **hemihyperesthesia** (abnormal sensation in opposite side of the body)
3. **Hemiplegia** (paralysis of upper and lower limbs in one side of the body).

Hemianesthesia and hemiparesthesia occur because of lesion of superior thalamic radiation. Hemiplegia is due to injury of corticospinal tracts.

■ IN GENU

Lesion in genu causes alteration in **motor activities** in opposite side due to damage of corticobulbar fibers.

■ IN CAUDAL PORTION

Lesion in this portion of internal capsule causes contralateral **hemianesthesia.** It also produces **hemianopia** and **deafness,** because of the involvement of the auditory and visual fibers.