Reticular Formation

DEFINITION

Reticular formation is a diffused mass of neurons and nerve fibers, which form an ill-defined meshwork of reticulum in central portion of the brainstem.

SITUATION OF RETICULAR FORMATION

Reticular formation is situated in **brainstem.** It extends downwards into spinal cord and upwards up to thalamus and subthalamus.

ORGANIZATION OF RETICULAR FORMATION

Reticular formation is constituted by 5 groups of nuclei. All these nuclei are structurally and functionally distinct.

1. RAPHE GROUP

Raphe group of nuclei are situated along the midline of the brainstem forming a continuous column. Raphe nuclei secrete **serotonin** (5-hydroxytryptamine), which is an **inhibitory neurotransmitter.**

2. PARAMEDIAN GROUP

Paramedian group includes nucleus reticularis paramedianus and pontine reticulotegmental nucleus. These nuclei are concerned with **motor functions.**

3. LATERAL GROUP

Lateral group of nuclei are situated in the lateral one third of the tegmentum. It consists of nuclei with small (parvocellular) cells. Neurons of these nuclei receive sensory signals from the cranial nerves, cerebellum and spinal cord.

4. MEDIAL GROUP

Medial group of nuclei are situated in the medial two third of the tegmentum. It consists of nuclei with small cells and giant (gigantocellular) cells. Nuclei of this group form the major output of the reticular formation and send fibers to the hypothalamus, thalamus and spinal cord. These nuclei are associated with **motor functions.**

5. INTERMEDIATE GROUP

Intermediate group of nuclei are present only in the medulla. It is situated between the lateral and medial groups of nuclei. These nuclei are concerned with autonomic regulation of **respiration, heart rate** and **blood pressure.**

DIVISIONS OF RETICULAR FORMATION

Reticular formation is divided into three divisions based on the location in brainstem:

A. Medullary reticular formation
B. Pontine reticular formation
C. Midbrain reticular formation.

Each division of reticular formation has its own collection of nuclei.

NUCLEI OF MEDULLARY RETICULAR FORMATION

1. Lateral reticular nucleus
2. Ventral reticular nucleus
3. Dorsal reticular nucleus
4. Gigantocellular reticular nucleus
5. Paragigantocellular reticular nucleus
6. Paramedian reticular nucleus
7. Parvocellular reticular nucleus
8. Magnocellular reticular nucleus.

NUCLEI OF PONTINE RETICULAR FORMATION

1. Nucleus reticularis pontis oralis
2. Nucleus reticularis pontis caudalis
3. Locus ceruleus nucleus
4. Subceruleus reticular nucleus
5. Tegmenti pontis reticular nucleus
6. Pedunculopontine reticular nucleus
7. Nucleus reticular cuneiformis.

NUCLEI OF MIDBRAIN RETICULAR FORMATION

1. Red nucleus
2. Nucleus tegmental pedunculopontis
3. Nucleus reticular subcuneiformis.

CONNECTIONS OF RETICULAR FORMATION

AFFERENT CONNECTIONS

Reticular formation receives collaterals from almost all the ascending sensory pathways. It also receives fibers from different parts of the brain (Fig. 154.1):

1. Optic pathway
2. Olfactory pathway
3. Auditory pathway
4. Taste pathway
5. Spinal and trigeminal pathways carrying touch sensation
6. Pathways for pain, temperature, vibration and kinesthetic sensations
7. Cerebral cortex
8. Cerebellum
9. Corpus striatum
10. Thalamic nuclei.

EFFERENT CONNECTIONS

Reticular formation sends fibers to the following parts of central nervous system (Fig. 154.2):

1. Cerebral cortex
2. Diencephalon: Thalamus, hypothalamus and subthalamus

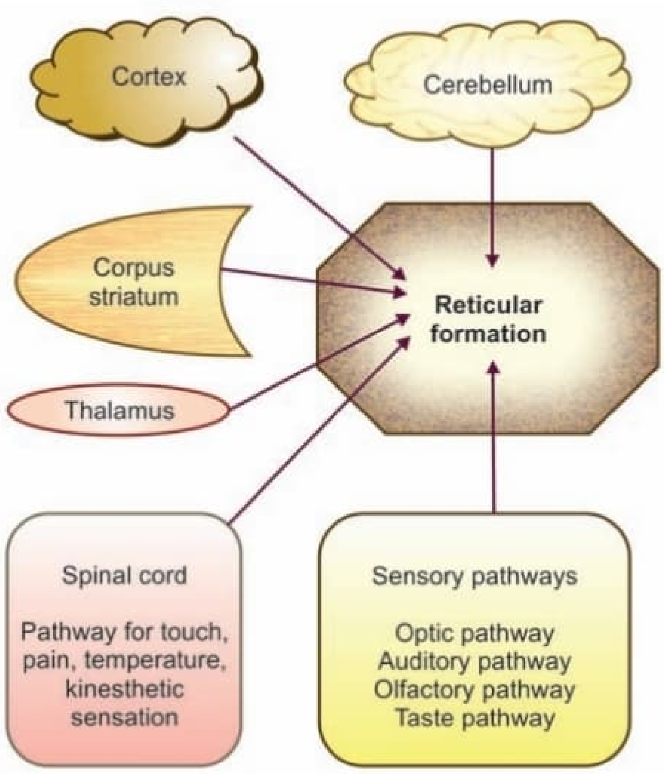

FIGURE 154.1: Afferent connections of reticular formation

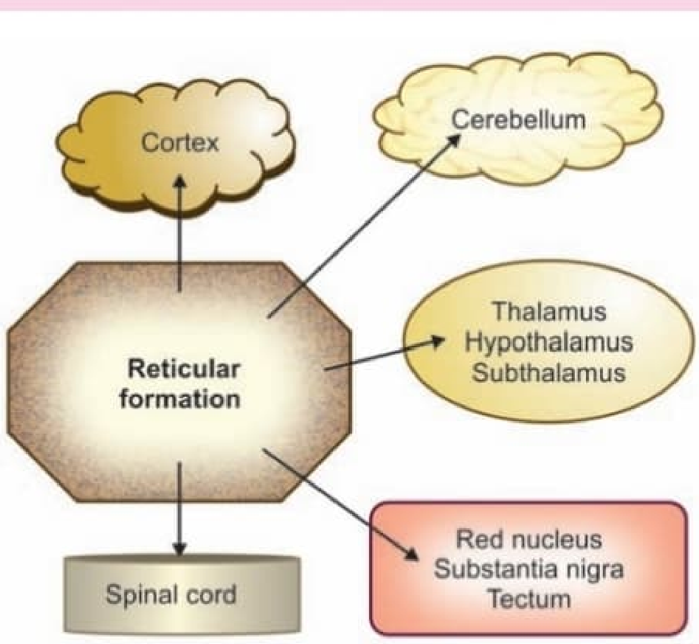

FIGURE 154.2: Efferent connections of reticular formation

3. Midbrain: Red nucleus, tectum and substantia nigra
4. Cerebellum
5. Spinal cord.

FUNCTIONS OF RETICULAR FORMATION

Based on functions, reticular formation along with its connections is divided into two systems:

A. Ascending reticular activating system
B. Descending reticular system.

ASCENDING RETICULAR ACTIVATING SYSTEM

Ascending reticular activating system **(ARAS)** begins in lower part of brainstem, extends upwards through pons, midbrain, thalamus and finally projects throughout the cerebral cortex. It projects into cerebral cortex in two ways:

1. Via subthalamus
2. Via thalamus.

The ARAS receives fibers from the sensory pathways via long ascending spinal tracts (Fig. 154.3).

Functions of ARAS

1. The ARAS is concerned with **arousal** phenomenon, **alertness,** maintenance of **attention** and **wakefulness.** Hence, it is called ascending reticular activating system. Stimulation of midbrain reticular formation produces wakefulness by **generalized activation** of entire brain including cerebral cortex, thalamus, basal ganglia and brainstem.

   Any type of sensory impulses such as impulses of proprioception, pain, auditory, visual, taste and olfactory sensations cause sudden activation of the ARAS producing arousal phenomenon in animals and human beings. Even the impulses of visceral sensations activate this system. Sympathetic stimulation and adrenaline cause arousal by affecting midbrain.
2. The ARAS also causes **emotional reactions**
3. The ARAS plays an important role in regulating the **learning processes** and the development of **conditioned reflexes.**

Mechanism of Action of ARAS

Impulses of all the sensations reach cerebral cortex through two channels:

1. Classical sensory pathways
2. Ascending reticular activating system.

1. *Classical or specific sensory pathways*

Classical sensory pathways are the pathways, which transmit the sensory impulses from receptors to cerebral cortex via thalamus. Some of the pathways carry impulses of a particular sensation only. For example, auditory stimulus transmitted by auditory pathway reaches the auditory cortex via thalamus and causes perception of sound. Such classical sensory pathways are called specific sensory pathways.

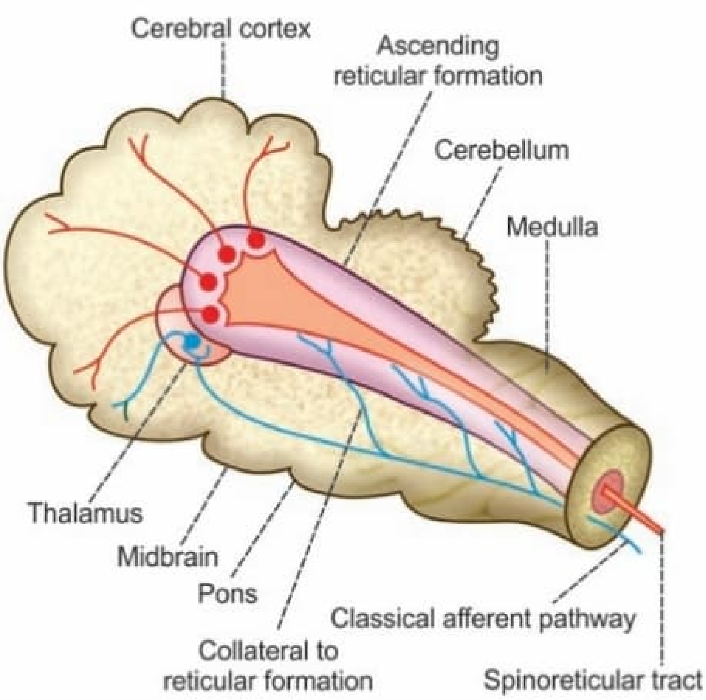

FIGURE 154.3: Ascending reticular formation

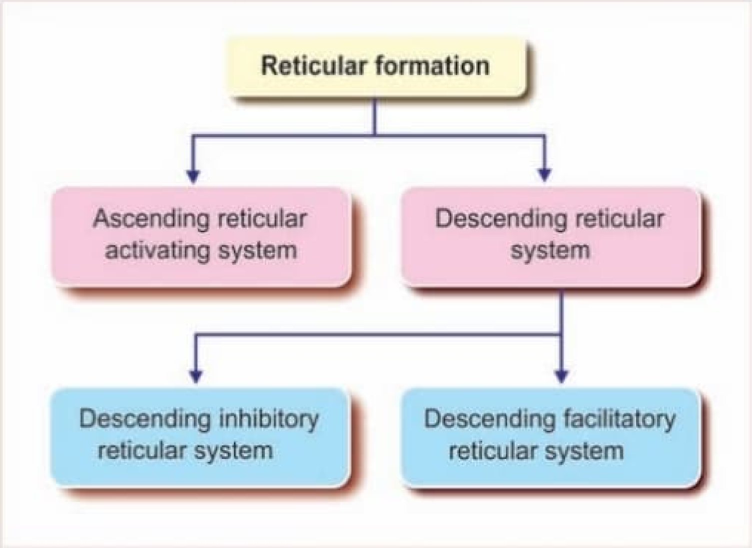

FIGURE 154.4: Functional divisions of reticular formation

2. *Ascending reticular activating system or non-specific sensory pathway*

All the sensory pathways send collaterals to ARAS, which is a multisynaptic relay system. These collaterals project in diffused areas of ARAS. So, the sensory impulses transmitted via the collaterals reach different parts of ARAS. It also receives afferents from spinal cord directly in the form of spinoreticular tract. ARAS in turn sends the impulses to almost all the areas of cerebral cortex and other parts of brain. Hence, this pathway is called the non-specific sensory pathway.

Non-specific projection of ARAS into the cortex is responsible for the arousal, alertness and wakefulness. Sensory impulses transmitted directly to cortex via classical pathway causes perception of only the particular sensation. Whereas, the impulses transmitted to cortex via ARAS do not cause the perception of any particular sensation, but cause the generalized activation of almost all the areas of cerebral cortex and other parts of brain. This leads to reactions of arousal, alertness and wakefulness.

The ARAS is in turn controlled by the feedback signals from cerebral cortex. Also, an inhibitory system controls the activities of ARAS. Inhibitory system involves posterior hypothalamus, intralaminar and anterior thalamic nuclei and medullary area at the level of tractus solitarius.

Tumor or lesion in ARAS leads to **sleeping sickness** or **coma.** The impact of head injury on ARAS also causes coma.

■ DESCENDING RETICULAR SYSTEM

Descending reticular system includes reticular formation in brainstem, reticulospinal tract and reticular formation in spiral cord.

It modifies the activities of spinal motor neurons. Functionally, descending reticular system is divided into two subdivisions (Fig. 154.4):

1. Descending facilitatory reticular system
2. Descending inhibitory reticular system.

Descending Facilitatory Reticular System

Descending facilitatory reticular system is present in upper and lateral reticular formation. Its functions are:

i. *Facilitation of somatomotor activities*

a. Descending facilitatory reticular system maintains muscle tone by exciting the gamma motor neurons in spinal cord; stimulation of this area causes increased muscle tone
b. It facilitates the movements of the body. Stimulation of this part of reticular system causes exaggerated movements.
c. It plays a role in wakefulness and alertness by activating the ARAS.

ii. *Facilitation of vegetative functions*

Descending facilitatory reticular system is the center for facilitation of the autonomic functions such as cardiac function, blood pressure, respiration, gastrointestinal function and body temperature.

Descending Inhibitory Reticular System

Descending inhibitory reticular system is located in a small area in lower and medial reticular formation. Its functions are:

i. *Control of somatomotor activities*

a. Descending inhibitory reticular system plays an important role in the control of muscle tone. By receiving signals from basal ganglia, it inhibits the gamma motor neurons of spinal cord and decreases muscle tone. Stimulation of this area causes decreased muscle tone.

b. It is responsible for smoothness and accuracy of voluntary movements. It controls the muscular activity by inhibiting the motor neurons of spinal cord.

c. It also controls the reflex movements.

ii. *Control of vegetative functions*

Descending inhibitory reticular system is the center for inhibition of several autonomic functions such as cardiac function, blood pressure, respiration, gastrointestinal function and body temperature.