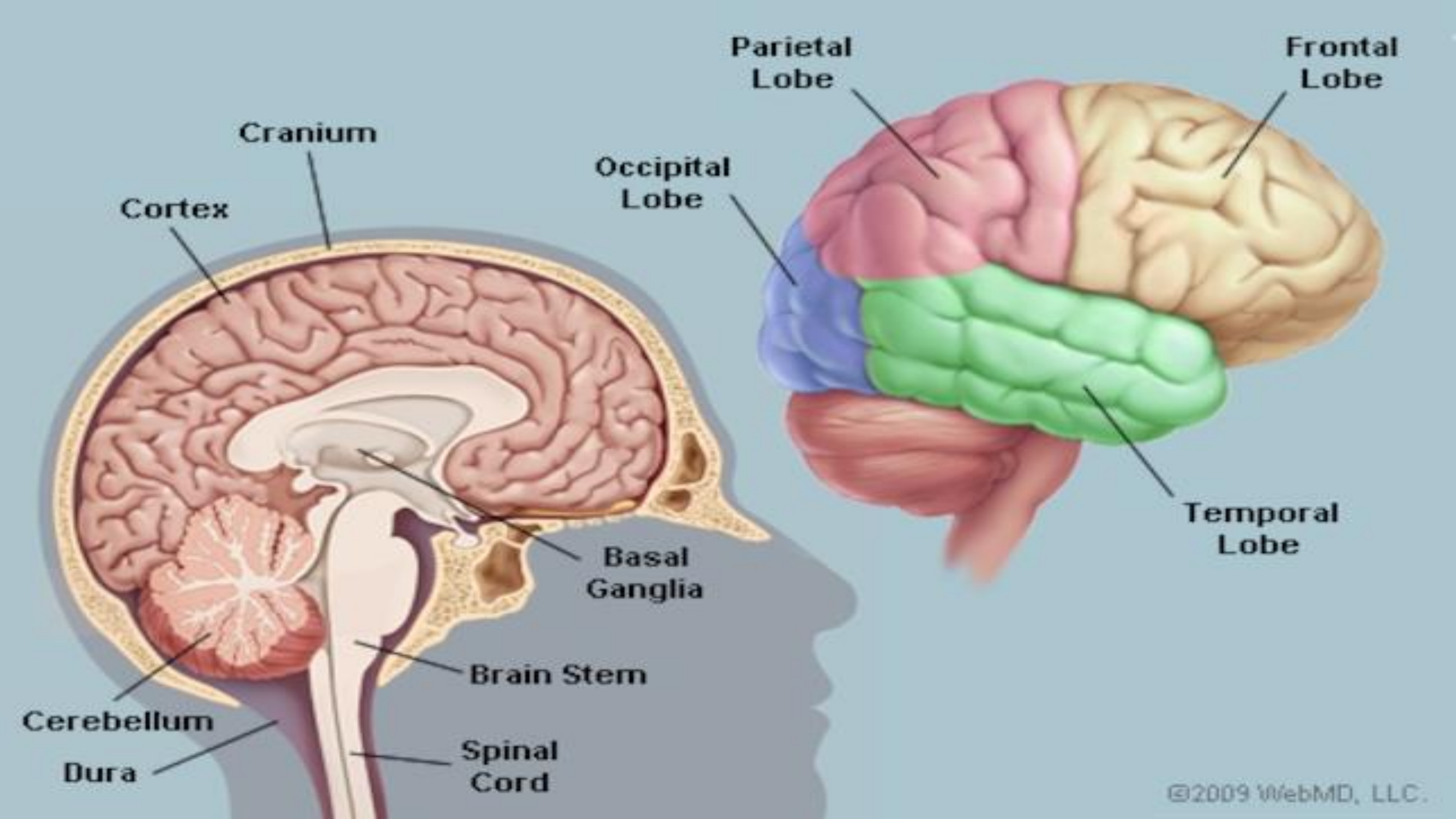
- In primates, the cerebral cortex is divisible into **four lobes, frontal, parietal, occipital and temporal.**
- The two cerebral cortices are connected by transverse myelinated fibres known as the **corpus callosum.**
- Each hemisphere has got specific activities not completely duplicated in the other half.
- Motor activity in the humans is dominated by one of the cerebral hemispheres.
- The ability of one hemisphere to control movement, reducing that burden for the other half is called as **cerebral dominance.**


Parietal Lobe
Frontal Lobe
Cranium
Occipital Lobe
Cortex
Basal Ganglia
Temporal Lobe
Brain Stem
Cerebellum
Spinal Cord
Dura
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Brain

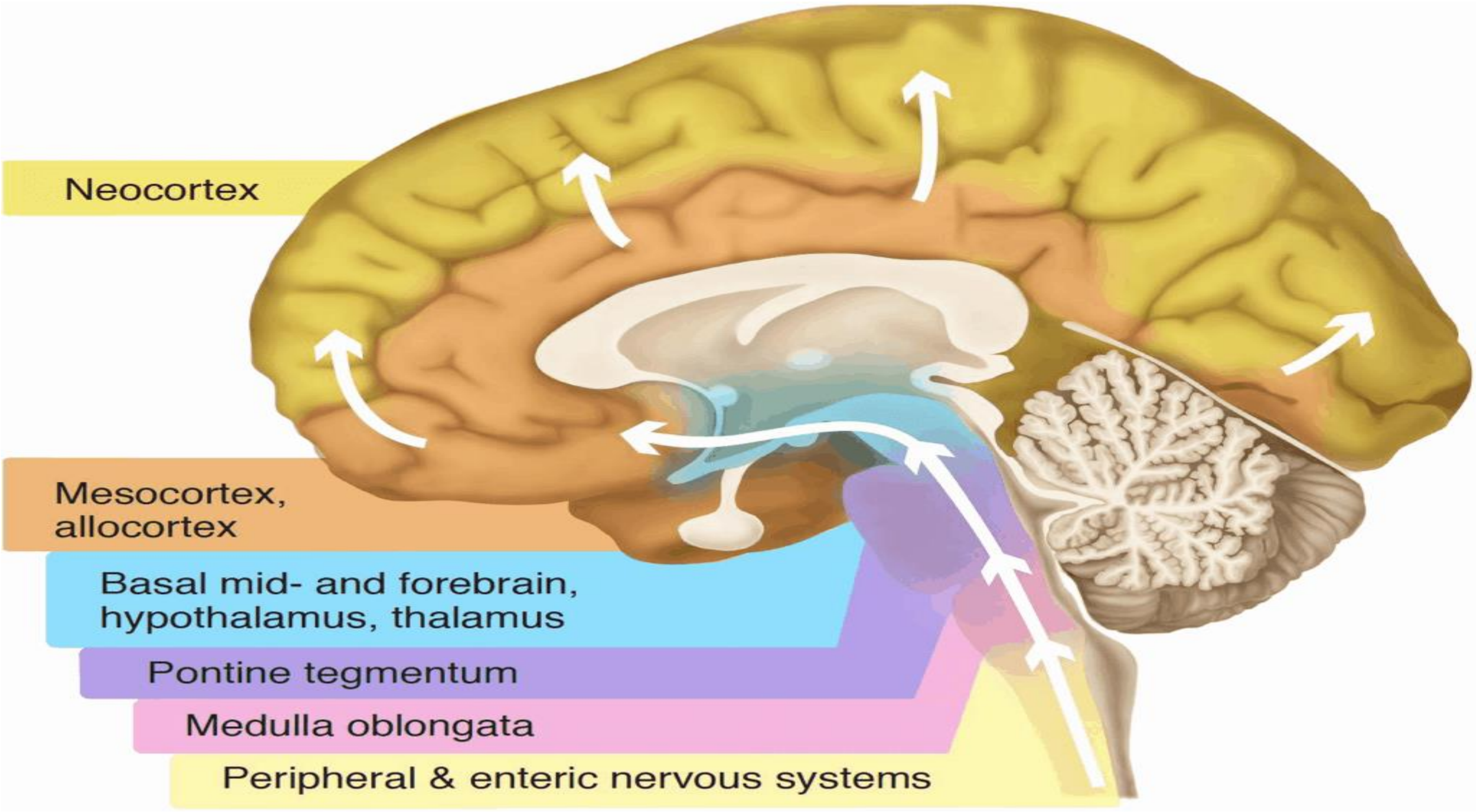
- The forebrain (**proscephalon**)
  - **Telencephalon** (two cerebral hemispheres)
  - **Diencephalon** or interbrain
    - Epithalamus
    - Thalamus
    - Subthalamus
    - Hypothalamus
    - posterior pituitary and pineal gland.
- The midbrain or **mesencephalon**
- Hindbrain or **rhombencephalon** comprising pons, medulla and cerebellum

- **Diencephalon**
- The diencephalon is located at the base of the brain. It contains the:
- Thalamus
- Subthalamus
- Epithalamus
- Hypothalamus
- The thalamus acts as a kind of relay station for signals coming into the brain. It's also involved in alertness, pain sensations, and attention.
- The epithalamus serves as a connection between the limbic system and other parts of the brain. The limbic system is a part of the brain that's involved with emotion.
- The hypothalamus processes information that comes from the autonomic nervous system. Its role includes **controlling eating, sleeping, and sexual behavior.**
- Some specific actions the hypothalamus is responsible for include:
  - maintaining daily physiological cycles, such as the sleep-wake cycle
  - controlling appetite
  - regulating body temperature
  - controlling the production and release of hormones

CEREBRAL CORTEX

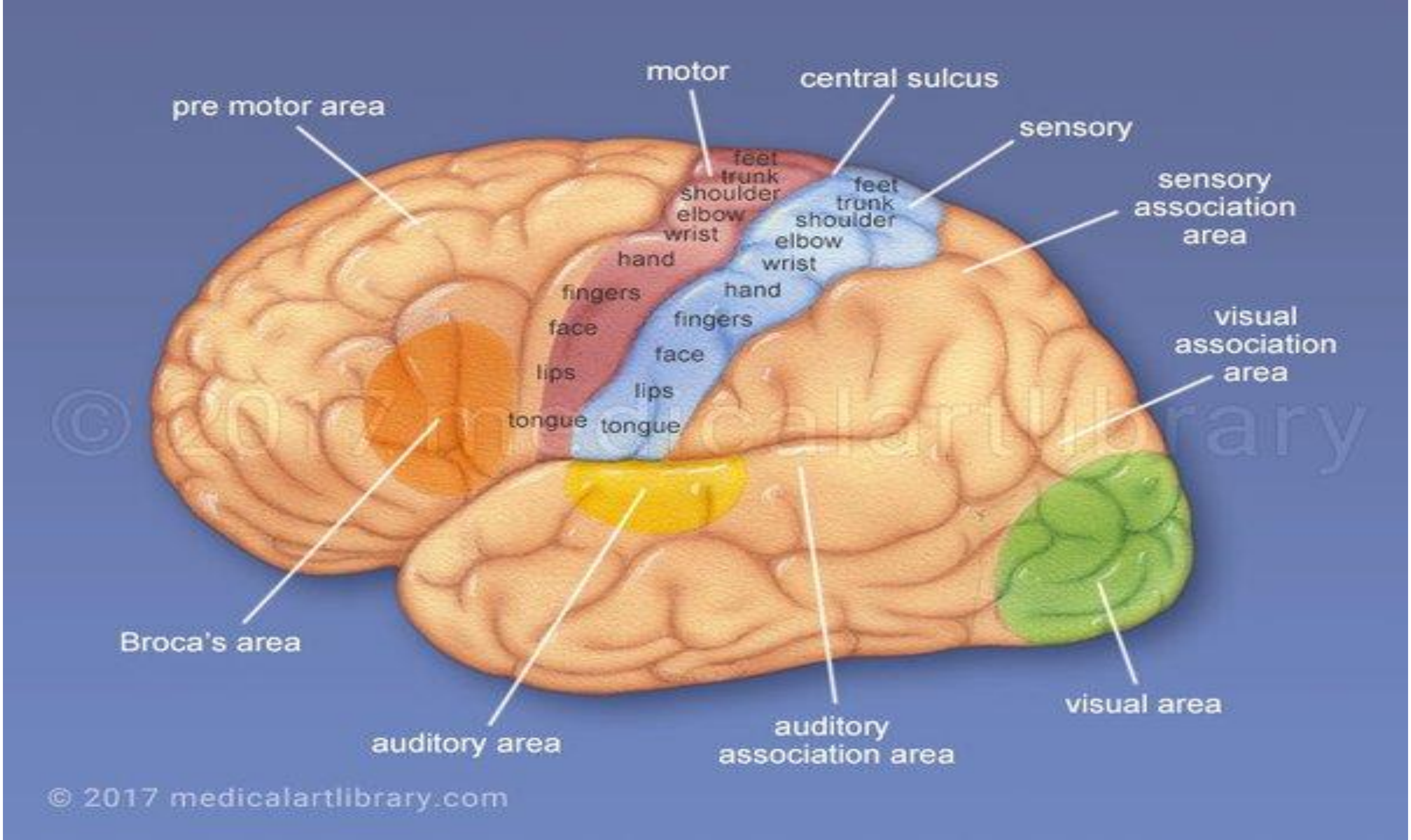
- The cerebral hemisphere is the predominant portion of the brain.
- Each **cerebral hemisphere** (as also cerebellar hemisphere) is composed of
- (1) a covering of **gray matter** (cortex or pallium) made up of nerve cell bodies, dendrites, axon terminals and glial cells
- (2) a central mass of **white matter** consisting of mainly myelinated processes of many neurons and some important nuclei like the **basal ganglia** (mass of gray matter).
- The cortex is the highest integration centre in the somatic nervous system that *regulates complex skeletal muscle movements* and most of its functions are under voluntary control. It acts as a **centre for consciousness, abstraction of ideas, vocalization and storage of experience.**
- The bilaterally situated cerebral cortex of telencephalon is divided into
  - A primary olfactory portion called the **allocortex** *(*also known as **rhinencephalon***)*
  - A non-olfactory portion called the **neocortex.**
- In mammals the **allocortex is often called as the limbic system**. In other vertebrates like reptiles, birds and amphibians, the neocortex is absent or poorly developed.
- Allocortex regulates emotions.

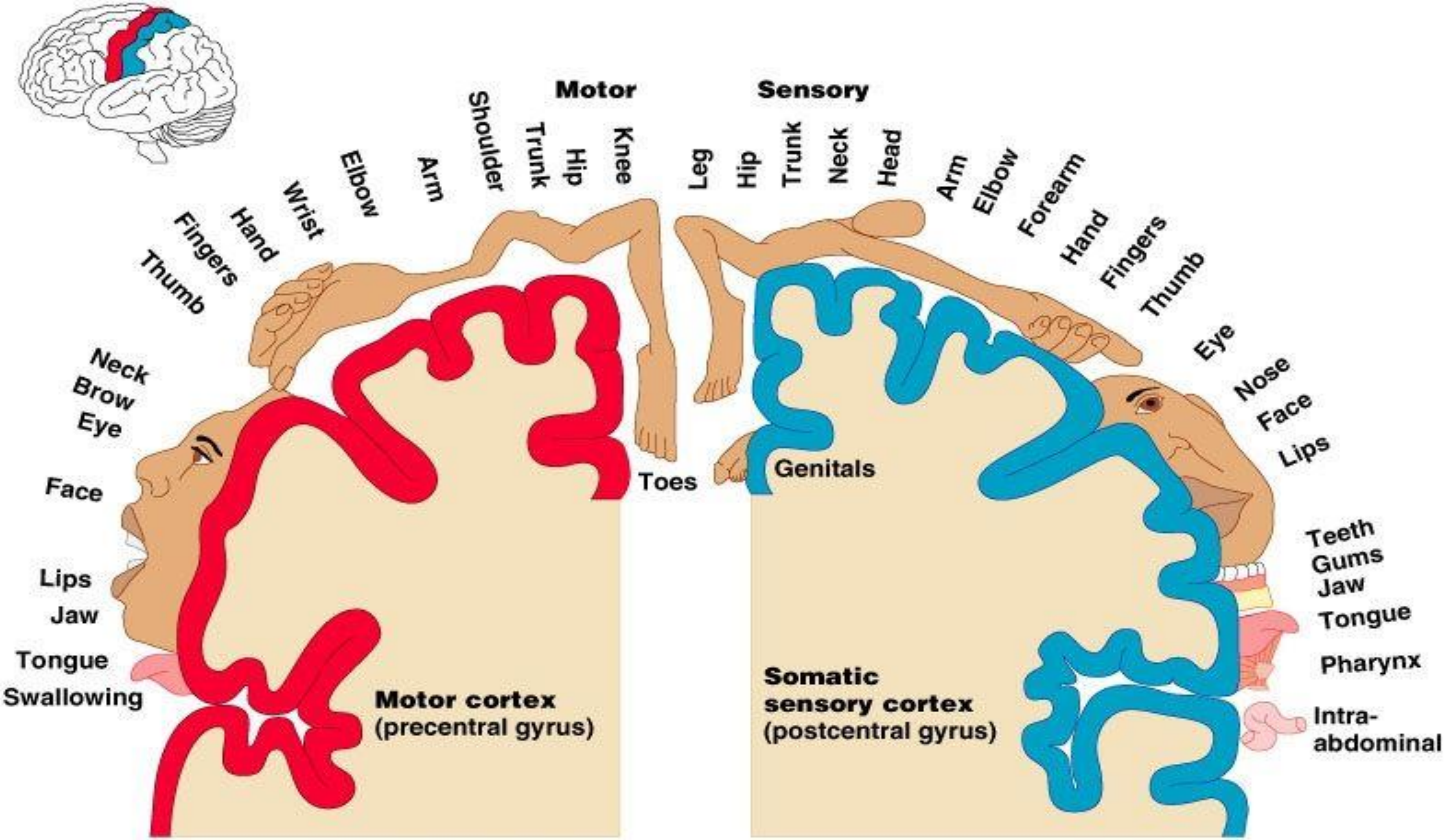
Allocortex V/S Neocortex

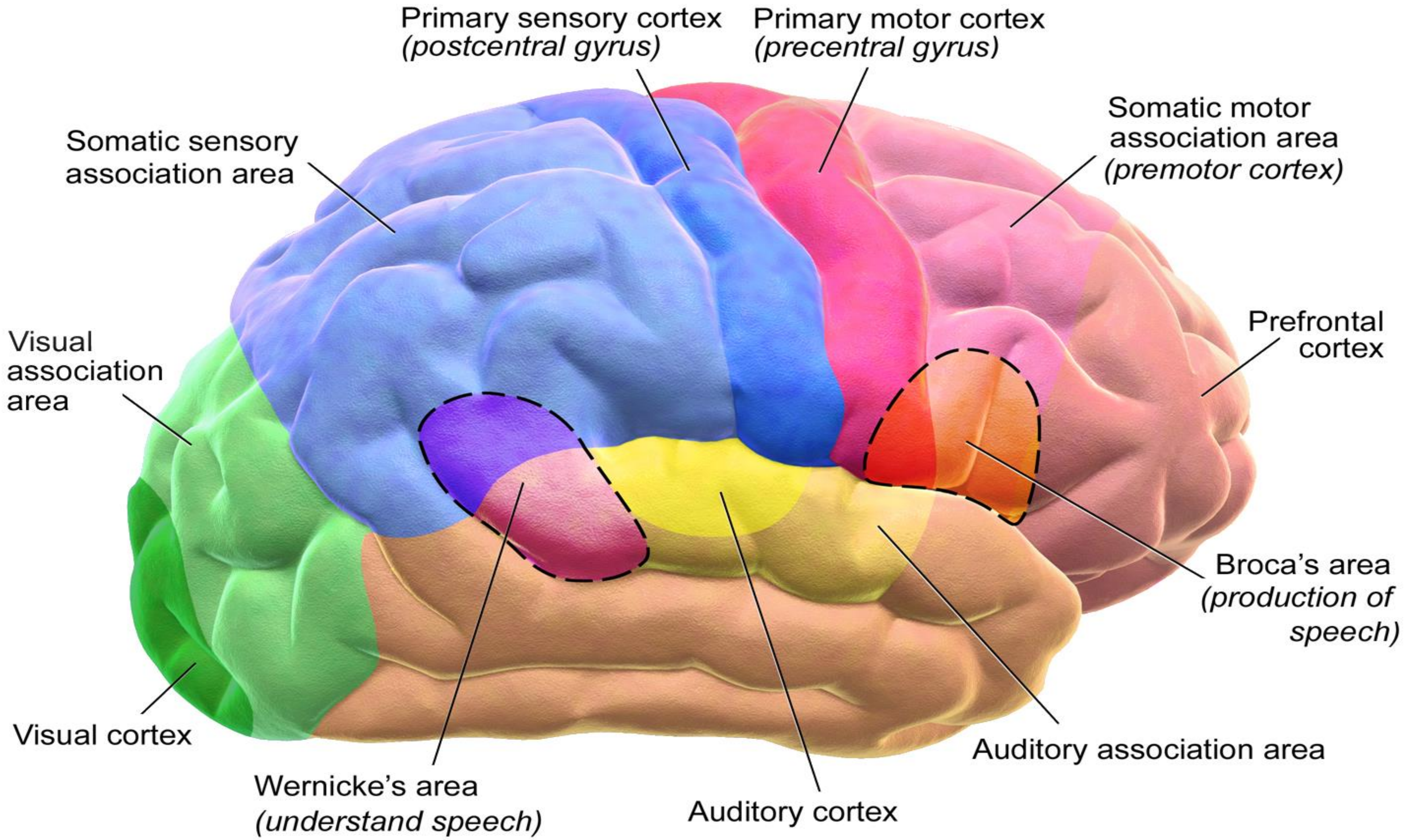


CEREBRAL CORTEX IN POSTURE AND MOVEMENT

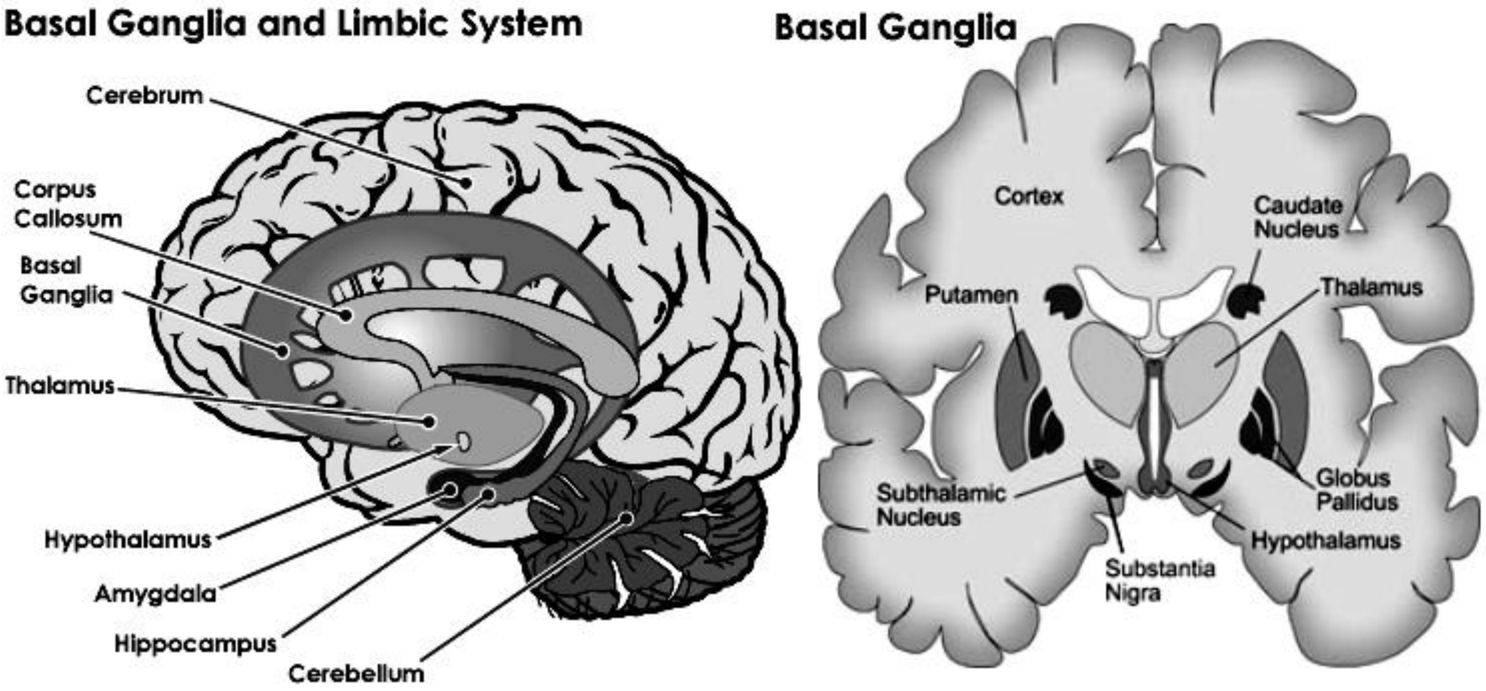
- Regions of the cortex are specialised and distinct parts have specific actions.
- The motor cortex is located in the **frontal lobes** and receives sensory signals from the somatosensory cortex to initiate the motor activities.
- The motor cortex comprises three functional areas –
  - **primary motor cortex**,
  - **premotor area**
  - **supplemental motor area**
- The primary motor cortex has topographical representation of different muscle areas of the body. In pigs and horses, lips and nose are represented in large areas of cortex; legs and feet have little representation. In humans, face and limbs are represented by extensively large areas. Stimulation of this area produces discrete movements.
- The **premotor area is concerned with complex movement patterns** – position of shoulder to keep the legs to perform specific tasks. Most often the premotor area sends its signals through the basal ganglia and thalamus back to primary motor area to elicit complex patterns of movements.
- The **supplemental motor areas are involved in eliciting bilateral activities** like lifting of weight with both hands simultaneously.


motor
central sulcus
pre motor area
sensory
sensory association area
feet
trunk
shoulder
elbow
wrist
hand
fingers
face
lips
tongue
feet
trunk
shoulder
elbow
wrist
hand
fingers
face
lips
tongue
visual association area
Broca's area
visual area
auditory area
auditory association area


Motor
Sensory
Thumb
Fingers
Hand
Wrist
Elbow
Arm
Shoulder
Trunk
Hip
Knee
Neck
Brow
Eye
Face
Lips
Jaw
Tongue
Swallowing
Toes
Motor cortex
(precentral gyrus)
Leg
Hip
Trunk
Neck
Head
Arm
Elbow
Forearm
Hand
Fingers
Thumb
Eye
Nose
Face
Lips
Genitals
Teeth
Gums
Jaw
Tongue
Pharynx
Intra-
abdominal
Somatic
sensory cortex
(postcentral gyrus)


Primary sensory cortex
(postcentral gyrus)
Primary motor cortex
(precentral gyrus)
Somatic sensory
association area
Somatic motor
association area
(premotor cortex)
Visual
association
area
Prefrontal
cortex
Broca's area
(production of
speech)
Visual cortex
Auditory association area
Wernicke's area
(understand speech)
Auditory cortex

Basal ganglia



BASAL GANGLIA

- In mammals it acts as **accessory motor system**. While in birds this acts as a part of the motor cortex in which the motor cortex is poorly developed.
- It is located beneath the cerebral cortex and consists of complex structure and includes **corpus striatum** (striated body) consisting of caudate nucleus and putamen, **globus pallidus** (pallidum), **subthalamic nucleus** and **substantia nigra.**
- The globus pallidus and putamen collectively form a structure, the **lenticular nucleus.**
- The nuclei of basal ganglia are interconnected – substantia nigra with striatum, caudate and putamen with globus, globus pallidus with subthalamic nucleus.
- The basal ganglia send output fibres from globus to **thalamus (inhibitory)** and to **cortex (excitatory).**
- It receives inputs from the somatosensory, motor and supplementary areas of the cerebral cortex and cooperates with these areas performing complex patterns of motor activity; e.g. shooting a ball through a hole, bowling a cricket ball etc – i.e. any skilled movement performed subconsciously.

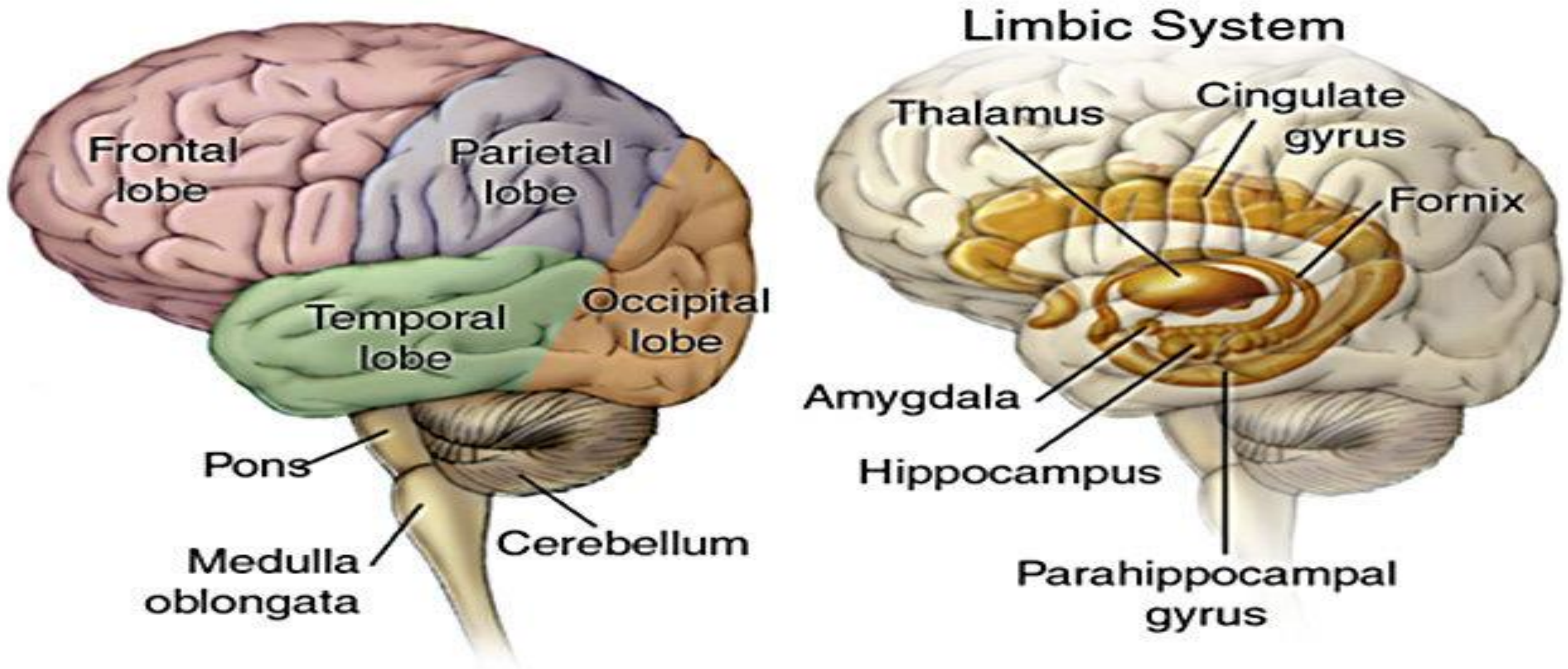
- The basal ganglia is also involved in cognitive control of motor activity (cognition – thinking process of the brain; most of the motor actions are due to thoughts generated in the mind).
- E.g. a predator lion approaching a prey like deer produces instantaneous and automatic reactions in deer involving turning away from the lion, beginning to run and evading and escaping from the lion. This cognitive control of the motor activity determines subconsciously and instantly the pattern of movement to achieve the complex activity.
- General effects of diffuse basal ganglia excitation is to inhibit the muscle tone throughout the body, which results from inhibitory signals transmitted from ganglia to BSRF.
- Conditions such as **Parkinson’s disease and Huntington’s chorea** in human beings are related to malfunctioning of basal ganglia.

- In birds, the basal ganglia perform all the motor functions, even the voluntary movements.
- In dog and cats, decortication removes only the discrete type of motor functions but does not affect the ability to walk, eat, and fight.
- **The neurotransmitters** of the basal ganglia are dopamine, GABA, acetylcholine, serotonin, encephalins and several other transmitters. Glutamate is the excitatory and GABA, dopamine and serotonin are inhibitory transmitters.

LIMBIC SYSTEM AND HYPOTHALAMUS

- LIMBIC SYSTEM:
- The limbic system is a set of brain structures that include the hippocampus, amygdala, septum, anterior thalamic nuclei, and limbic cortex (**cingulate, pyriform cortex and hippocampus**), which controls a variety of functions like emotion, behavior, long term memory, and olfaction
- The limbic system functions in
- a) behavioural inhibition i.e. failure to respond or act
- b) approach or avoidance behaviour
- c) fight or flight behaviour

Anatomy of the Brain



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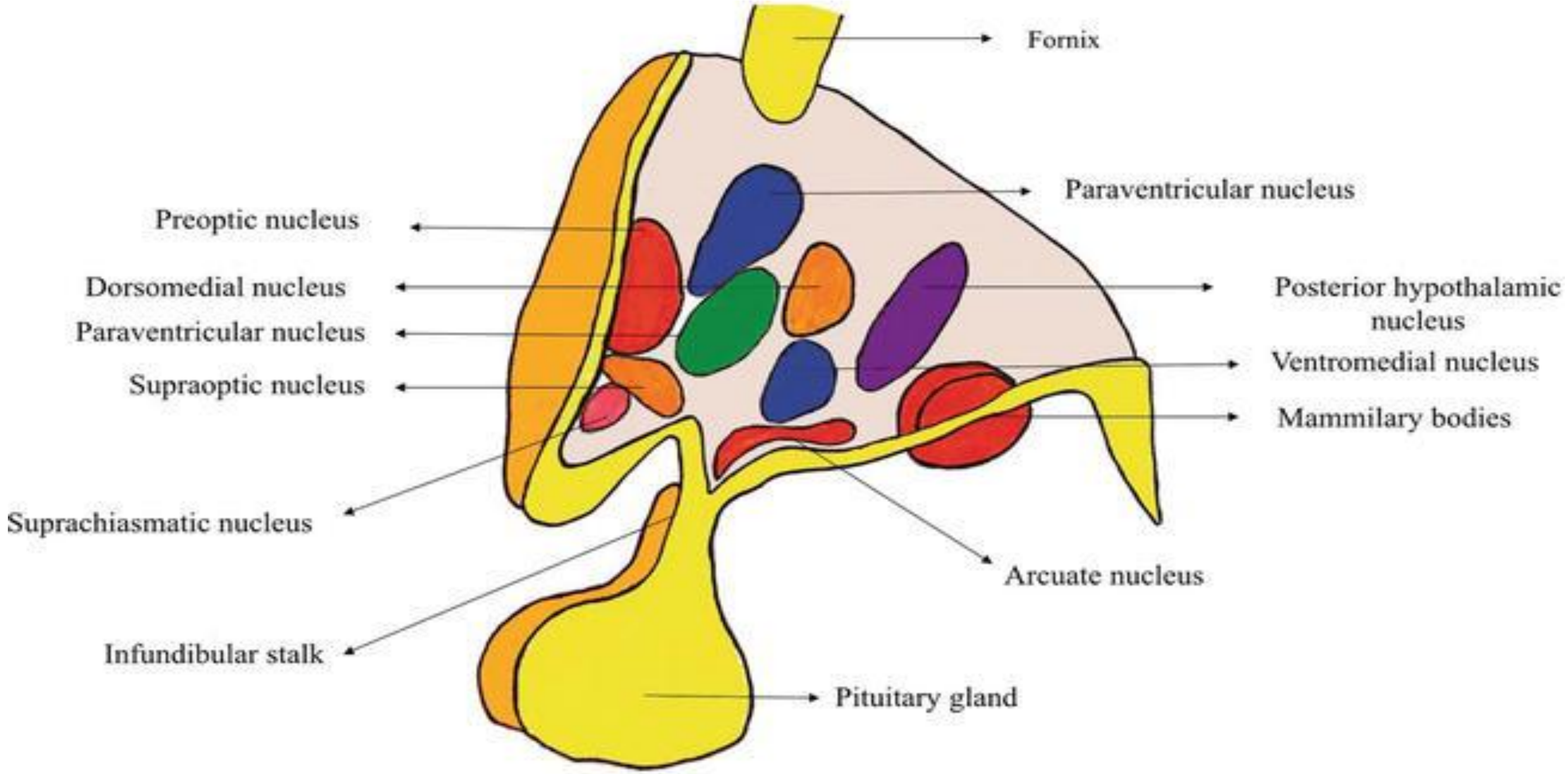
- The limbic system is involved in evaluation of sensory input in terms of emotional impact and producing appropriate motor response.
- **The major part of limbic system is hypothalamus** which is primarily considered as ***"visceral brain"*** and its functions are expressed by visceral motor activity.
- Hypothalamus acts as a principal motor output pathway of the limbic system and controls the vegetative functions of the body- **thirst, hunger and many of the emotional behaviours**.
- It regulates the cortical functions through the activation and inactivation of the brain stem reticular formation.

- The septal area occupies a central position within the limbic system and plays a key role in the integration of many afferent signals into organised efferent information which are then distributed to the limbic system, and thus controls the **autonomic, endocrine and somatic activity.**
- Hippocampus alters the ongoing autonomic and somatic activity and plays an important role in regulating the emotional behaviour.
- Formation and recall of *memory require the function of* **amygdala and hippocampus.**
- The hippocampus is involved in consolidation of memory; it allows an animal to know where it is in space and to learn relevant features associated with space.

HYPOTHALAMUS

- It forms that portion of the rhinencephalon (limbic system) that is closely related to the behaviour.
- The hypothalamus includes optic chiasma, tuber cinerium, mamilary bodies, median eminence, infundibulum and neurohypophysis and consists of many nuclei.
- The hypothalamus contribute to ***rage behaviour*, affects emotions like fear response, arousal, exploration and orientation.**
- The hypothalamus and its related structures control many internal conditions of the body such as body temperature, osmolality of the body fluids, the drive to eat and drink etc known as ***"the vegetative functions of the body".***
- Hypothalamus sends output signals downward through the brainstem reticular formation of mesencephalon, pons and the medulla as autonomic outflow, upward to the areas of the anterior thalamus and limbic cortex and into the infundibulum of hypothalamus to control secretions of pituitary glands.


Fornix
Paraventricular nucleus
Preoptic nucleus
Dorsomedial nucleus
Paraventricular nucleus
Supraoptic nucleus
Posterior hypothalamic nucleus
Ventromedial nucleus
Mammilary bodies
Suprachiasmatic nucleus
Arcuate nucleus
Infundibular stalk
Pituitary gland

Functions of Hypothalamus

- Cardio vascular regulation:
- Regulation of body temperature:
- Regulation of body water:
- Hyperosmolality of the body fluid stimulates the thirst centre in the lateral hypothalamus. Regulation of uterine contraction and milk ejection:
- Neuroendocrine reflex stimulation of paraventricular nuclei, (entry of foetus into the birth canal stimulates sensory nerves, which passes via the spinal cord to hypothalamus and releases oxytocin) causes increased uterine contraction.
- Tactile stimulation of udder sends sensory impulses to hypothalamus causing release of oxytocin, which aids milk ejection by stimulating the contraction of the myoepithelial cells surrounding the alveoli of the mammary gland.
- Regulation of food intake:

- The lateral hypothalamic area is referred as **feeding centre**.
- *Sleep and wakefulness*
- *Reproductive functions*:
- **Median eminence** of the hypothalamus releases GnRH in a pulsatile manner, which regulates the FSH and LH release from the pituitary gland.

- **Brain stem**
- The brain stem is located in front of the cerebellum and connects to the spinal cord. It's responsible for passing messages to various parts of the body and the cerebral cortex. It consists of three major parts:
- **Midbrain.** The midbrain helps control eye movement, processes visual and auditory information, regulates motor movements, and is involved in arousal and wakefulness.
- **Pons.** This is the largest part of the brain stem. It's located below the midbrain. It's a group of nerves that help connect different parts of the brain. The pons also contains the start of some of the cranial nerves. These nerves are involved in facial movements and transmitting sensory information, as well as breathing.
- **Medulla oblongata.** The medulla oblongata is the lowest part of the brain. It acts as the connection between the brain stem and spinal cord. It also acts as the control center for the function of the heart and lungs. It helps regulate many important functions, including **motor and sensory functions, breathing, sneezing, and swallowing.**

Functions of Brain stem: It is involved in

- Control of respiratory, cardiovascular system and partial control of G. I. tract functions
- equilibrium
- eye movements
- stereotyped movements of the body (forward extension and flexion, turning or rotatory movements of body) and reflex activities
- It is a pathway for signals from higher neural centres

CEREBELLUM

- Cerebellum is not necessary for sensations or initiation of movement, but it plays a crucial role in coordination of movements initiated from other parts of the brain.
- Cerebellum (little brain) is the silent area of the brain
- It is located immediately dorsal to pons and medulla and caudal to cerebral hemispheres.
- Deep fissures divide it into three lobes –
  - **Archicerebellum**
  - **Paleocerebellum**, (anterior lobe or spinocerebellum)
  - **Neocerebellum**, (cerebrocerebellum). Neocerebellum is a laterally protruding structure.
- Cerebellum is attached to brainstem by three cerebellar peduncles
  - Brachium conjunctivum (rostral) to mesencephalon and thalamus,
  - Brachium pontis (middle) to pons
  - The restiform body (caudal) to medulla and the spinal cord.

- The cerebellum consists of an outer layer of gray matter called the cerebellar cortex and inner white matter consisting of axons from and to cortex and from four pairs of cerebellar nuclei located within the white matter. The cerebellar cortex consists of three layers
  - The outermost is the molecular layer composed of **granule cell axons, stellate and basket cells**
  - Middle layer is **purkinje cell layer consisting of purkinje neurons**
  - **The innermost layer is the granular cell layer. The Golgi neurons are the large stellate cells located in the granule cell layer.**
- The cells of the cerebellar cortex (the granule cells, Golgi neurons, stellate cells and purkinje cells) only the **granule cells are the excitatory neurons** and all others are inhibitory neurons which utilises GABA as neurotransmitter.

Functions of cerebellum:

- The typical function of the cerebellum is to help provide rapid *turn-on* signals for the agonist muscles and simultaneous *turn-off* signals for the antagonist muscles at the beginning of a movement and at the termination of movement helps to contribute *turn-off* signals to agonist and *turn-on* signals to antagonists.
- *Archicerebellum* or *vestibulocerebellum* receives afferents from the vestibular system and projects its efferents primarily back to the vestibular nuclei and reticular formation of the medulla and helps to control the balance between agonist and antagonist muscle contractions of spine, hip and shoulders during rapid changes in body position.
- *Paleocerebellum*, or *spinocerebellum:* When a movement is actively taking place, paleocerebellum makes appropriate adjustments and controls the execution of movement and muscle tone i.e. it coordinates skilled voluntary movements.
- The paleocerebellum receives information from the cerebral cortex and red nucleus about the intended sequential plan of movement. It also receives information from muscle spindles, vestibular and visual systems and other sensory receptors about the movement in the body that is actually being performed.
- When the intended movement and the actual movement are not the same, the cerebellum sends corrective output signals to the motor cortex and red nucleus to carry out the intended movement (*error-correction function*).
- For e.g. if a cat's brain intends to move its head to food in a dish, but sensory receptors inform the cerebellum that the pathway its head is moving will cause the mouth to miss the dish, the cerebellum makes appropriate adjustment commands to the motor cortex and red nucleus, which in turn corrects the head's pathway.

- Cerebellum is important in the planning and execution of ballistic movements i.e. many *preplanned rapid movements* of the body without any feedback information to the cerebellum or from the cerebellum to the motor cortex to set a motion to go to a specific distance and then to stop. E.g. riding a bicycle–after learning the motor skill of riding, a person can ride on a bicycle concentrating on any other thing, while cerebellum co-ordinates the motor pattern of riding the cycle.
- In cerebellar diseases, an appropriate adjustment to the intended movement and actual movement is not made and this results in movement disorders.
- The part of the body moving to perform a specific function will oscillate back and forth past its intended point several cycles before it finally fixes the part on its mark. This is called **action tremo***r* or *intention tremor* and the tremor becomes worse when the animal is moving especially near the end of the movement. Affected animals walk in an uncoordinated fashion called ***ataxia*.**
- The cerebellum modulates the reflex activities of the muscle, and thus controls the *muscle tone*. The fastigial nucleus relays the paleocerebellar cortex activity to lateral vestibular nucleus where it inhibits the activity of the lateral vestibular nucleus.
- Removal of paleocerebellum enhances the excitatory lateral vestibular nucleus activity upon the alpha motor neuron of spinal cord and causes ***a-rigidity*** in antigravity muscles.

Neocerebellum

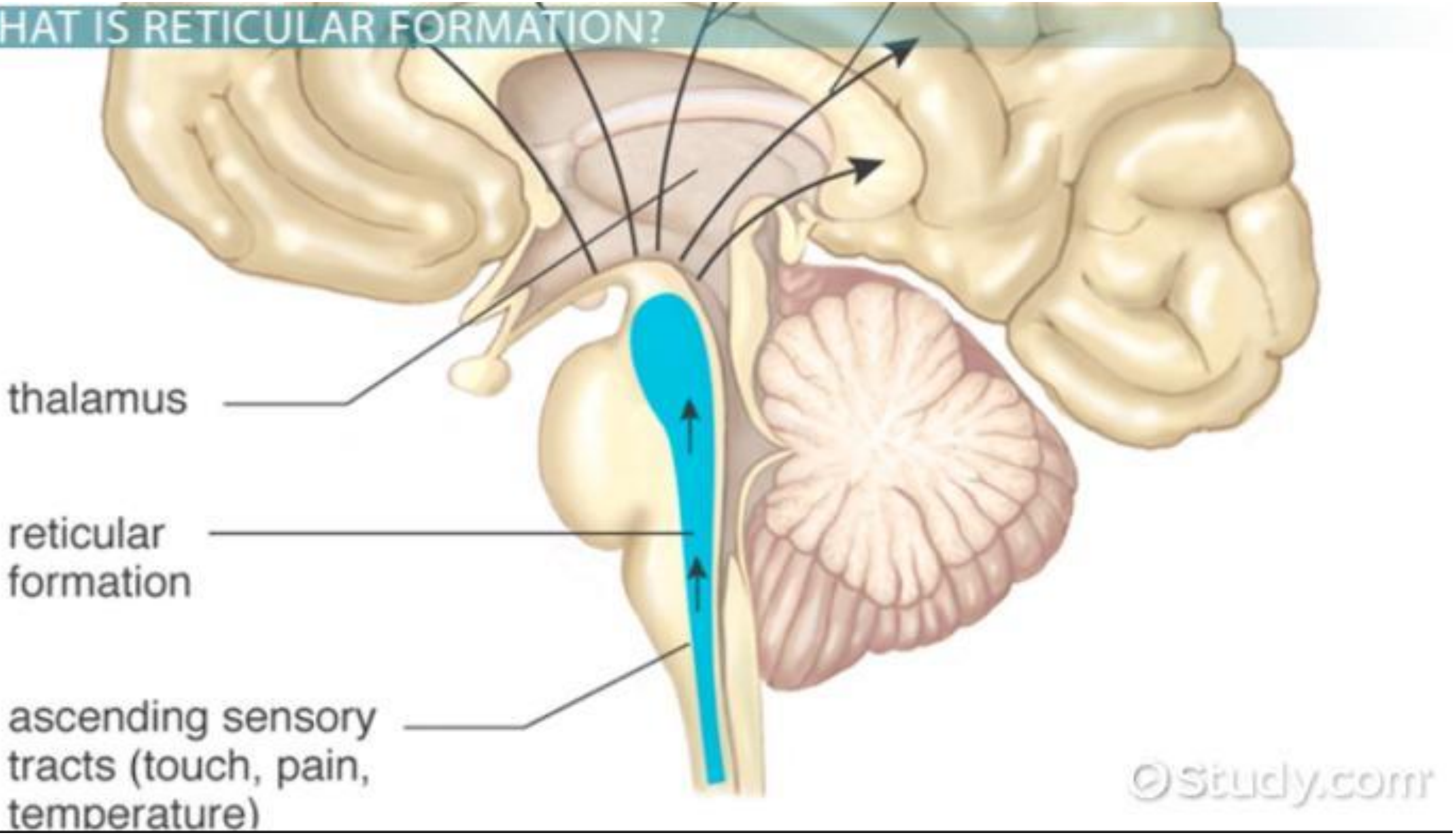
- Neocerebellum, or cerebro-cerebellum receives inputs exclusively from premotor and somato-sensory cerebral cortex through corticopontine cerebellar system and sends their output signals to premotor cerebral cortex through the thalamus.
- The neocerebellum plays an important role in planning and timing of sequential movements.
- Cerebellum is considered to be a modulator of motor activity and coordinates movements.

CONSCIOUSNESS AND AWAKE STATE

- When an animal is aware of its environment, it is consciousness
- increased level of consciousness is arousal
- focusing on some aspect of environment is attention

- **Brain Stem Reticular Formation** (BSRF) **is a neuronal network extending the length of the medulla, pons, midbrain and projects into thalamus and hypothalamus. Caudally it is continuous with the interneurons of the spinal cord.**
  - The efferent fibres of the reticular formation are organised into *ascending and descending reticular formation*.
  - The ascending reticular formation projects into other areas of brain, including brain stem, cerebrum and cerebellum.
  - The descending reticular formation projects into the spinal cord.

WHAT IS RETICULAR FORMATION?



- **The BSRF regulates the sensory, motor and the endocrine functions.**
- The brainstem reticular formation receives sensory input signals from all sensory systems–somesthetic, vestibular, visual, auditory, gustatory and olfactory sensory systems, through spinoreticular tract and also from the vestibular nuclei, cerebellum and basal ganglia and motor area of the cerebral cortex.
- BSRF integrates sensory information within the CNS and controls the activities of both the motor neurons of skeletal muscles and the autonomic neurons (cardiovascular, respiratory and the G.I. tracts).
- **The BSRF plays a key role in somatic and visceral motor control.**

Ascending reticular formation:

- It alters the consciousness through the sensory inputs from the auditory, visual, olfactory, tactile, pain and proprioceptive sensory systems. It regulates the neuronal activity within the brain and contributes to **wakefulness.**
- It controls the activity of the cerebral cortex, hippocampus, basal ganglia and cerebellum which is referred to as ***behavioural arousal*.**

Descending reticular formation:

- It influences the motor activities such as flexor and extensor reflexes and decrebrate rigidity.
- It alters the activity of the alpha and gamma motor systems through reticulospinal tract.
- It also contains centres that inhibit spinal motor neurons.
- The reticular formation contains the centres that promote wakefulness (midbrain RAS).
- Through pontine raphe nuclei it promotes sleep.
- **Other functions of BSRF are - respiratory control, cardiovascular, micturition, emesis, rumination, deglutition, mastication control etc.**

Reticular Excitatory Area

- Nerve signals from the brainstem reticular system activate the cerebral cortex.
- The level of activity of the brain is controlled by an excitatory area located in the reticular substance of the pons and mescencephalon which is known as **bulboreticular facilitatory area (reticular activating system –RAS)**.
- The areas that constitute the RAS are
  - **Midbrain reticular formation**
  - **Mesencephalon**
  - **Thalamic intralaminar nucleus**
  - **Dorsal hypothalamus**
  - **Tegmentum**

Functions of RAS

- Regulating Sleep-Wake Transitions: The main function of the RAS is to modify and potentiate thalamic and cortical function to promote wakefulness.
- The physiological change from a state of deep sleep to wakefulness is reversible and mediated by the RAS.
- Inhibitory influence from the brain is active at sleep onset, coming from the preoptic area (POA) of the hypothalamus.
- During sleep, neurons in the RAS will have a much lower activity; conversely, they will have a higher activity level during the awake state.
- Attention: The reticular activating system also helps mediate transitions from relaxed wakefulness to periods of high attention.

Role of peripheral sensory signals

- The levels of activity of the excitatory area in the brainstem and therefore the level of activity of entire brain is determined by sensory signals that enter the brain from the periphery (pain signals strongly excite the brain).
- Feedback signals from the cerebral cortex also enter the bulboreticular excitatory area. Thus at any time when the cerebral cortex is activated by "thought process" or "memory process", signals are sent from cortex to brain stem excitatory area which in turn sends still more excitatory signals to cortex. This *positive feedback* leads to an ***awake-state*** of mind.

Sleep

- It is a state of reversible unconsciousness and relative immobility of an animal.
- Sleep is necessary for good health and animals deprived of sleep become ill, irritable and engage in vicious fights and their immune function is altered.
- Sleep centres are located in the **pons and medulla** and it is called as ***raphe nuclei***. The nerve fibres of this area secrete serotonin. These nuclei send fibres to reticular formation, upward to thalamus, neocortex, hypothalamus and many areas of the limbic cortex. Fibres extend downward to spinal cord where they inhibit the incoming pain signals. The raphe nuclei provide inhibitory signals to the RAS and thereby induce sleep.
- Based upon the period of rest and activity, the animals may be classified as
- **Monophasic animals***:* Have prolonged period of rest during night and are active during daytime (man, birds).
- **Polyphasic animals**: Show several alternate periods of rest and activity (wild animals)
- **Intermediate type**: Has alternate periods of rest and activity during daytime followed by brief period of rest at night (domestic animals).
- In mammals living in sea, like whales and seals and some birds exhibit ***unihemispheric sleep*** i.e. the right hemisphere is awake while the left sleeps and vice-versa.

- **Slow wave sleep or Deactivated Sleep:**

It is referred to as deep, restful, dreamless or the normal sleep, which is associated with decrease in both peripheral vascular tone and other visceral functions of the body. It causes 10 to 30% reduction in the heart rate, blood pressure, respiratory rate, basal metabolic rate and the body temperature. There is increased threshold to sensory stimulation and relative muscular inactivity.

The deactivated sleep is characterised by **delta waves** in EEG.

- **Paradoxical sleep, Desynchronised sleep, REM sleep or Activated Sleep:**

This sleep is associated with dreaming in humans. It seems animals do dream; e.g. sleeping dogs often pedal their feet and sometimes bark. In a normal night of sleep, bouts of REM sleep lasting for 5 to 30 minutes appear about 90 minutes apart.

Theories of sleep

- Many theories are proposed to explain sleep but no one seems sufficient.
- The earlier theory of sleep was a reduction in the activity of the RAS as an important predisposing cause of sleep but this was found to be not completely true.
- The current belief is that sleep is promoted by active inhibitory process. Stimulation of raphe nuclei of the lower pons and medulla produces a natural sleep and serotonin is involved as neurotransmitter.
- Reduction in the proprioceptive impulse transmission to the higher cerebral centres due to fatigue of the neuromuscular mechanism.
- Fatigued animals may accumulate some sleep-inducing substances (e.g. *muramyl peptide*, a low molecular weight substance), which are metabolic end products and they can promote sleep.
- Stimulation of *diffuse thalamic nuclei*, *suprachiasma* region of the hypothalamus and nucleus *tractus solitarius*releases acetylcholine, which induces sleep.
- The principle value of sleep is to restore natural balances among the neuronal centres.

Beta waves (very low amplitude-2-20µV, high frequency; 13 to 30 waves/sec)	During state of alertness. They are the fastest [EEG] waves and signal an active cortex and an intense state of attention. Irregular register (unsynchronized).
Alpha waves (low amplitude-5-100µV, 8 to 13 waves/sec)	During awake and relaxed state, with closed eyes. Neurons are firing at different times. Regular register (synchronized).
Theta waves (low-medium amplitude-5-100µV, spike-like waves; 4-8 waves/sec)	During sleepy, already sleeping, or in a sleep transition. It can be observed in from the hippocampus. Theta rhythm is also observed in REM sleep. Because the hippocampus is involved in memory processing, the presence of theta rhythm during REM sleep in that region of the brain might be related to memory activity.
Delta waves (high amplitude -20-40µV, low frequency; 0.5 - 4 waves/sec)	During deep asleep. Neurons, which are not engaged in the processing of information, are firing all at the same time. Therefore, the activity is synchronized. Waves are large and slow.
REM 60 to 70 waves/sec	Maximal retraction of the pupil and nictating membrane follow the volleys of ocular movements

Electroencephalogram (EEG)

- Electrical recordings from the surface of the brain or from the outer surface of the head result in continuous electrical activity. The undulations of the recorded electrical potentials are called as *brain waves*.
- EEG waves are about 0–200mV and have frequency ranging from 1 in few sec to 50 per sec
- There are four types of brain waves called as *beta, alpha, theta* and *delta* waves.
- These waves *arise when millions of neurons in the brain are activated simultaneously*.
- Alpha waves disappear during sleep.
- β-waves occur during activation of the CNS (alert wakefulness) or during tension.
- Theta waves occur during emotional stress and disappointment.
- δ waves are seen during deep sleep and in some brain disorders.

PINEAL GLAND

- It is the main translator of photoperiodic effect in animals.
- The pineal gland produces a hormone, **melatonin in response to darkness.**
- Light passes from the retina to supra chiasmatic nucleus of the hypothalamus and to superior cervical ganglia from where it passes to pineal gland.
- **The melatonin inhibits gonadal activity.**
- **Cat and horses are positively affected with increasing light period and goat and sheep are positively affected by decreasing photoperiod.**
- Thus the pineal gland acts to relay light-dark information to the hypothalamus and regulates seasonal breeding in animals.

Neurohormonal Control of Brain Activity

- In addition to neural control, excitatory or inhibitory hormones also participate to regulate the brain activity. This includes (1) norepinephrine system (2) dopamine system (3) serotonin system. Norepinephrine is excitatory, serotonin is inhibitory and dopamine is both excitatory and inhibitory depending on the area involved.
- ***Locus ceruleus*** located between pons and medulla secretes norepinephrine which excites the brain to increased activity.
- **substantia nigra of basal ganglia secret** secrets dopamine, it acts as inhibitory transmitter (destruction of this area leads to Parkinson's disease).
- **Raphe nuclei** located in pons and medulla secretes serotonin and it is involved in promoting normal sleep.

MEMORY

- It is the recollections of previous thoughts or experiences.
- Memory is the basis for higher mental functions and is required for learning and adaptive functions.
- Memories are stored in the brain by changing the basic sensitivity of synaptic transmission between neurons as a result of previous neural activity. The new or facilitated pathways causing the memory are called as memory traces.
- Memory can be classified into
- ***Short-term memory:*** it is the memory that lasts for a few seconds to few minutes (remembering a telephone number) and it may involve reverberating circuits in neurons or presynaptic facilitation or inhibition.
- ***Intermediate long-term memory***: it lasts for days to weeks and then fade away unless activated sufficiently to become permanent
- ***Long-term memory***: it lasts for years even up to the lifetime. It results from structural changes at the synapses – increase in vesicle release sites for transmitter release, increase in number of vesicles released, increase in number of presynaptic terminals, changes in dendritic spines etc.

Mechanisms of memory

- The molecular mechanism of long-term memory is that a stimulus to the neuron causes a neurotransmitter, for e.g. serotonin, to bind to a receptor.
- This results in an increase in cyclic- AMP, which in turn activates protein kinase C.
- The **protein kinase C** translocates to the nucleus
- Where it phosphorylates *cAMP response element binding protein* (CREB).
- CREB is a transcription factor that acts on DNA to activate genes for protein synthesis
- These proteins form new synaptic connection which are the basis of long-term memory

conditioned reflexes

- Salivary and the gastric secretions produced in response to food is a natural and inborn reflex. The sight or the smell of the food forms the natural stimulus, which causes the **natural conditioned response** in the form of salivary or gastric secretions.
- If the animal is fed in association with the bell sound or music (neutral stimuli) and this practice is frequently repeated, it causes conditioned salivary secretion to the bell sound or music even in the absence of food. This type of response is referred to as **artificial conditioned reflexes.**