

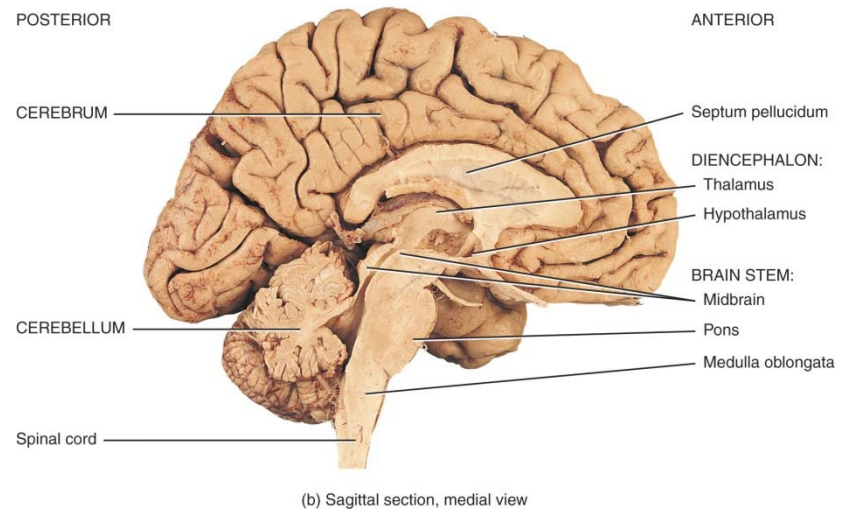
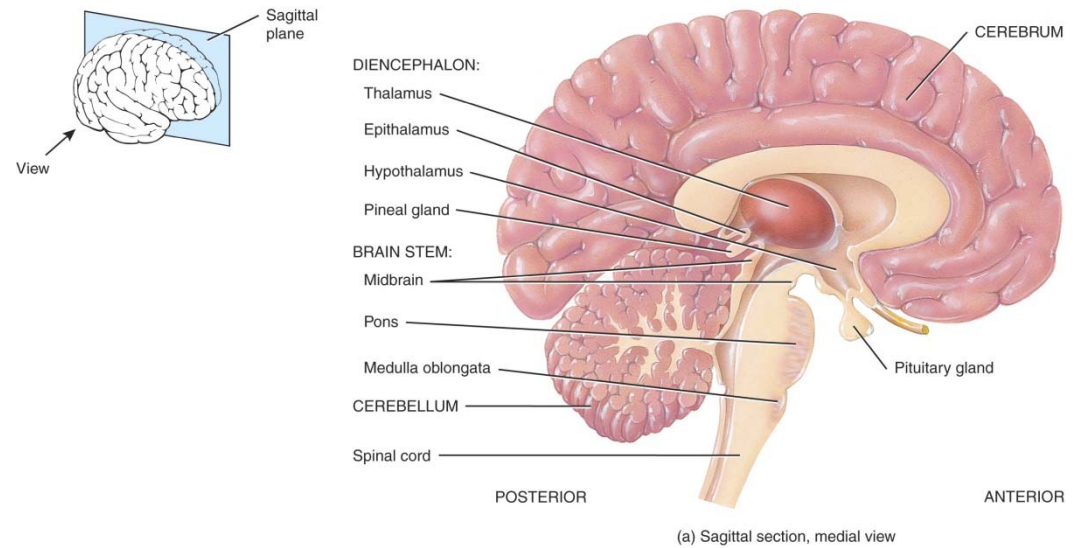
Brainstem & Diencephalon

Lecture Objectives

- Identify the gross features of the **brainstem**.
- Briefly describe the **internal structure** of the brainstem (ascending and descending pathways, sensory and motor cranial nuclei, substantia nigra, red nucleus, olivary nucleus and reticular formation).
- Describe the main connections of the sensory cranial nuclei.
- Describe the main connections of the motor cranial nuclei.
- Review the **blood supply** of the brainstem.
- Describe **lesions in the brainstem** such as medial medullary syndrome and lateral medullary syndrome.
- Describe the main connections of the substantia nigra and the red nucleus.
- Describe the main connections of **Reticular Formation** and correlate these connections with its main functions.
- Describe the anatomical features of the **diencephalon**; components, location and relations.

Principal Parts of the Brain

- Cerebrum
- Diencephalon
 - Thalamus, hypothalamus & epithalamus
- Cerebellum
- Brainstem
 - medulla, pons & midbrain

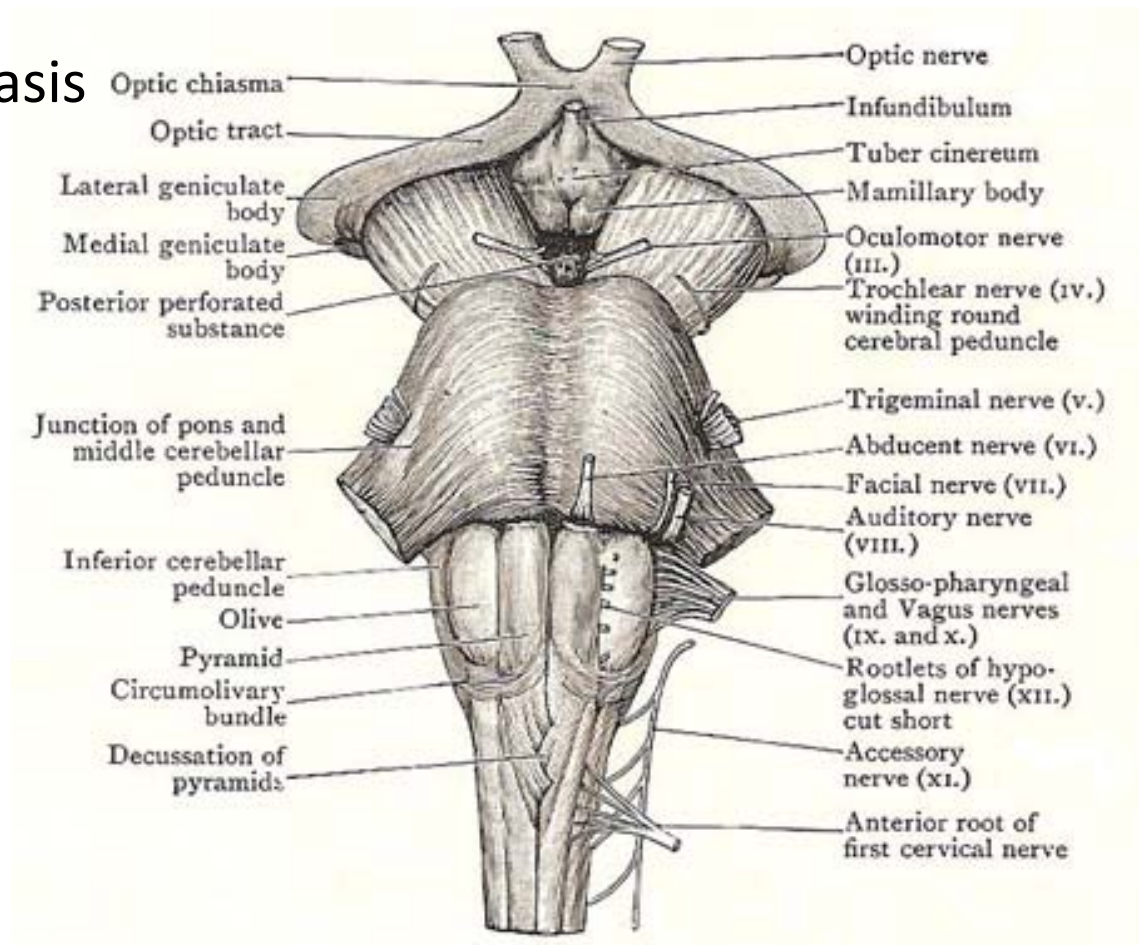


Brainstem Functions

- Ascending and descending tracts
- Reflex centers
 - Cardiovascular and respiratory centers
 - Coughing, sneezing, swallowing
- Nuclei of the cranial nerves
 - Motor and sensory
- Consciousness and arousal

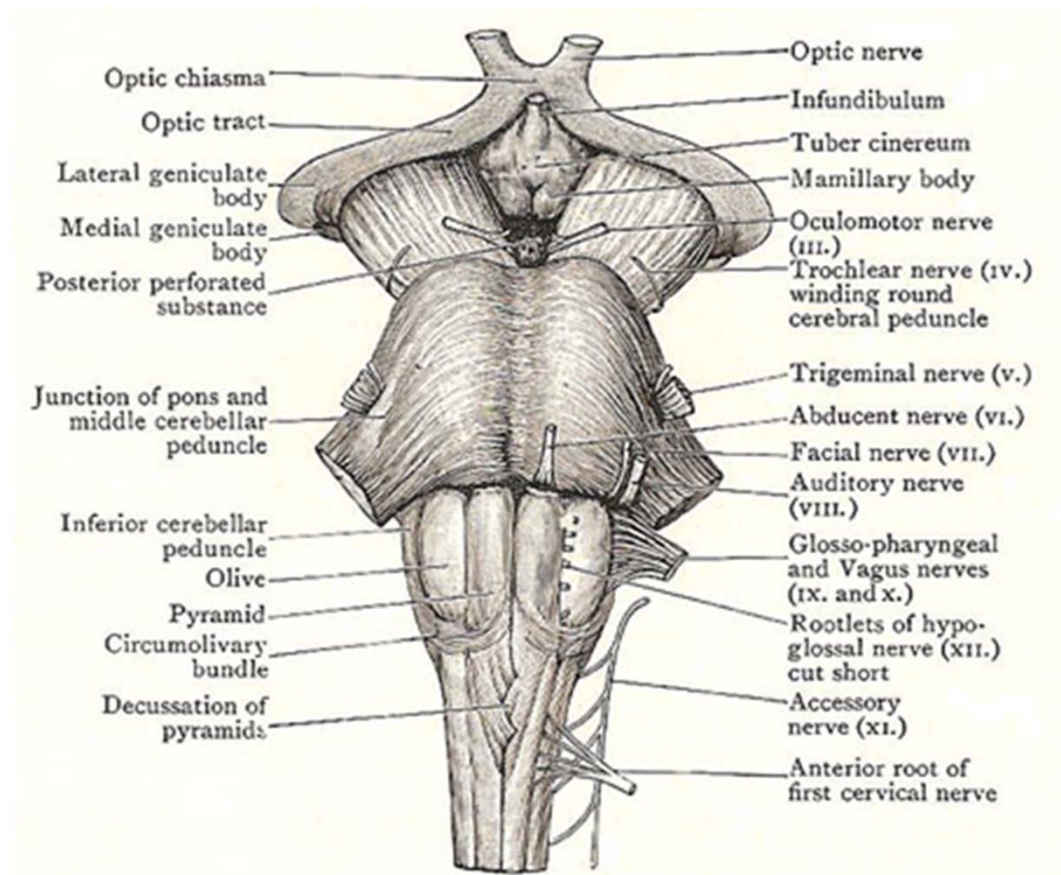
External Anatomy of Brainstem: Ventrally

- Midbrain
 - Cerebral peduncles (basis pedunculi)
 - Interpeduncular fossa
- Pons
 - Basilar pons
 - Basilar sulcus
- Bulbopontine sulcus
- Medulla oblongata



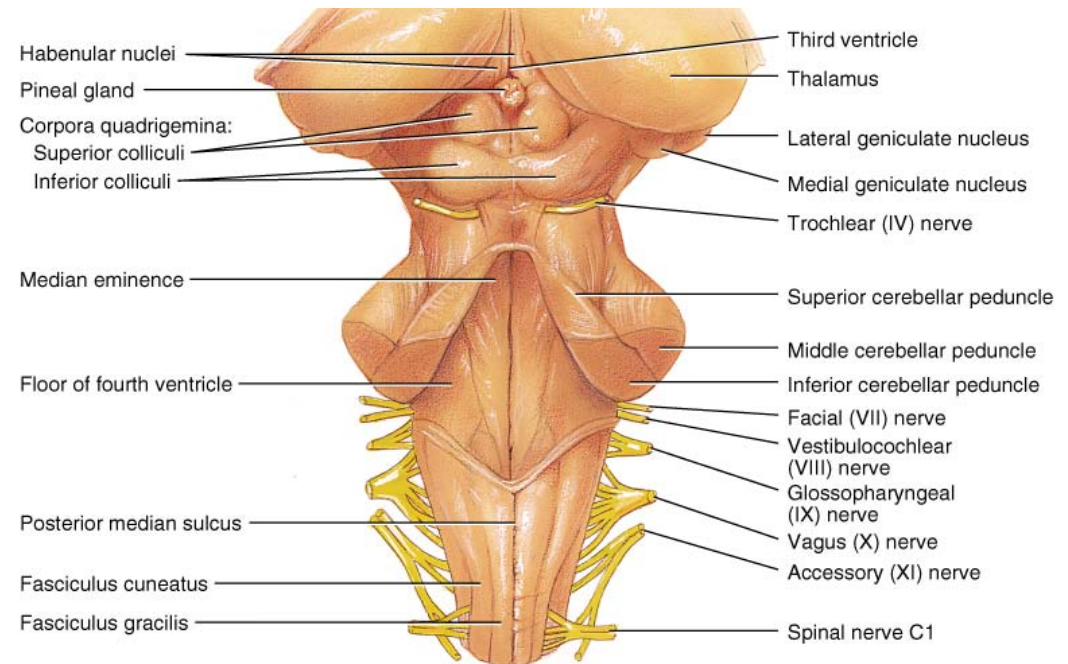
External Anatomy of Brainstem: Ventrally

- Bulbopontine sulcus
- Medulla oblongata
 - Ventral median fissure
 - Pyramids
 - Decussation of pyramids
 - Olives
 - Pre-olivary & post-olivary sulci
 - Inferior cerebellar peduncles



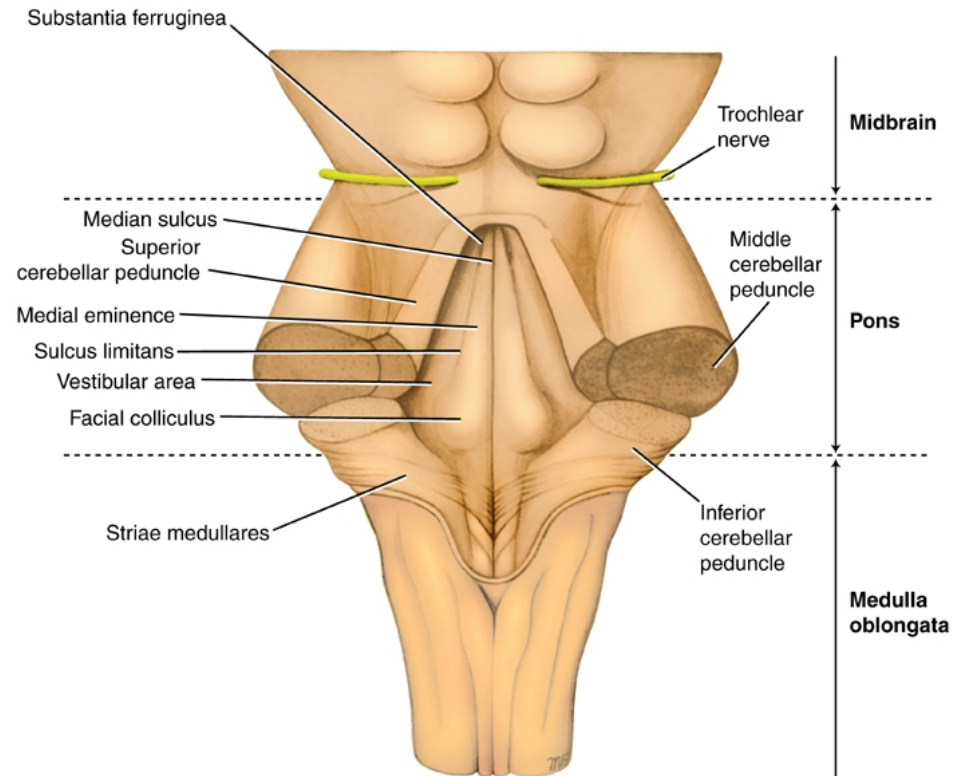
External Anatomy of Brainstem: Dorsally

- Corpora quadrigemini (midbrain)
 - Superior & inferior colliculi
- Cerebellar peduncles
 - Lateral walls of 4th ventricle
- Gracile & cuneate tubercles (closed surface of medulla)
 - Inferior to 4th ventricle
- Rhomboid fossa
 - Pontine part
 - Medullary part (open medulla)

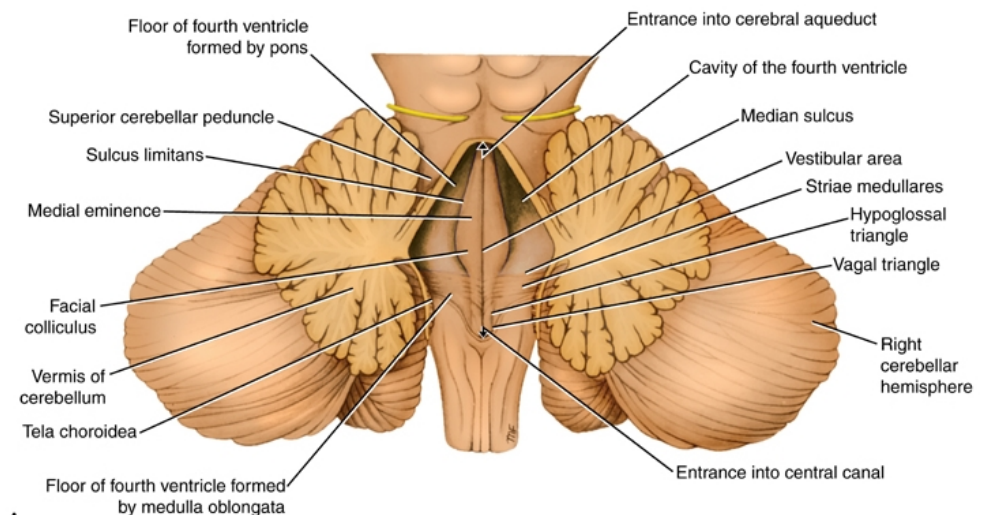


Rhomboid Fossa

- Posterior median sulcus
- Medial eminence (pons)
- Facial colliculus
 - Caudal part of the eminence
- Sulcus limitans
- Striae medullares
- Trigons
 - Vagal trigon (more lateral-inferior)
 - Hypoglossal trigon (more medial-superior)
- Vestibular areas
- Lateral points of the fossa
- Isthmus – superior constriction
- Obex – inferior narrowing



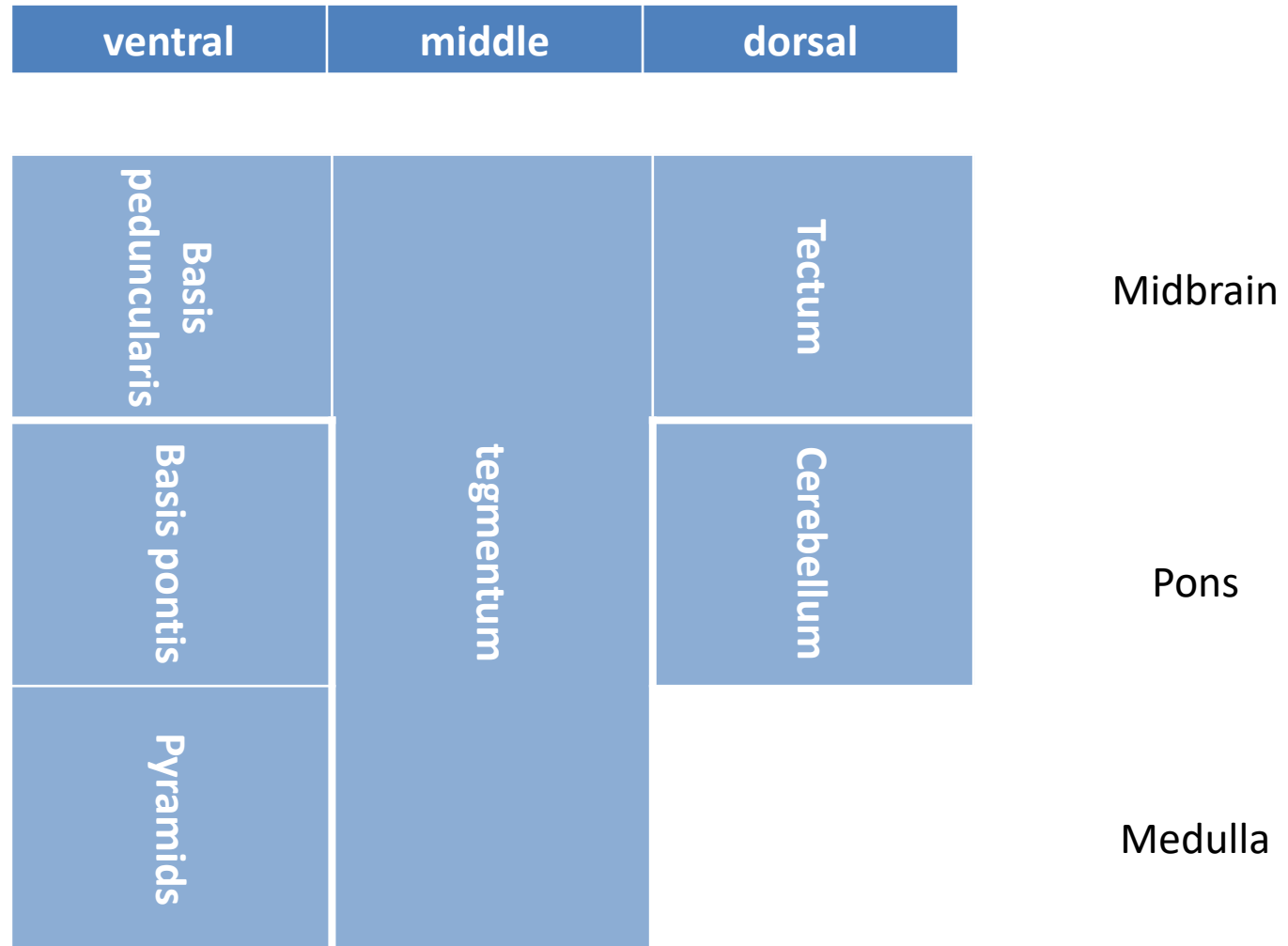
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Brainstem Structure



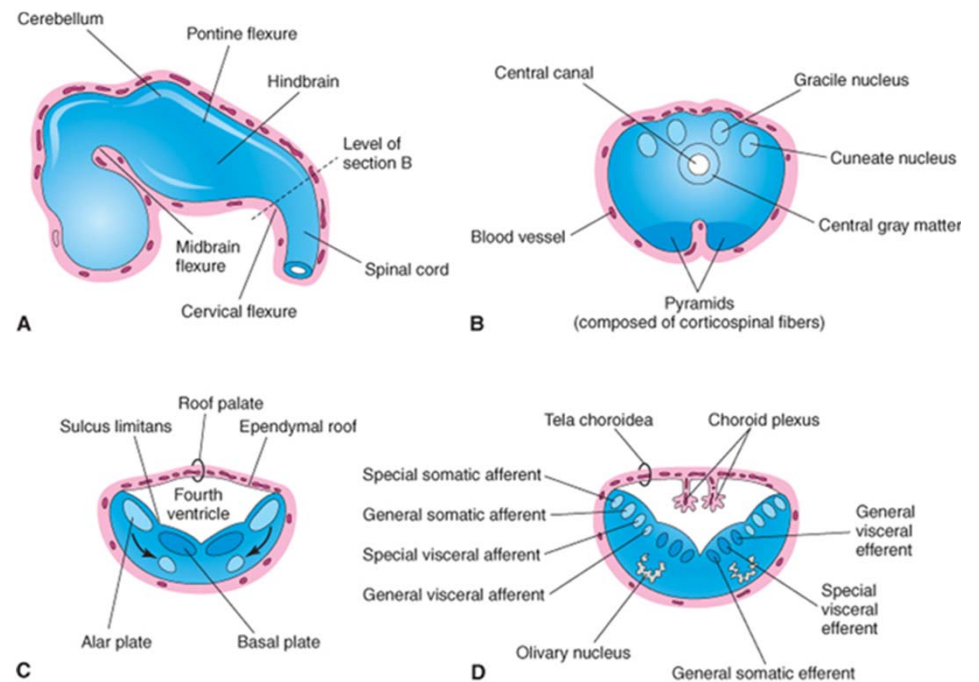
Functional Distribution of Brainstem Nuclei

➤ Midline

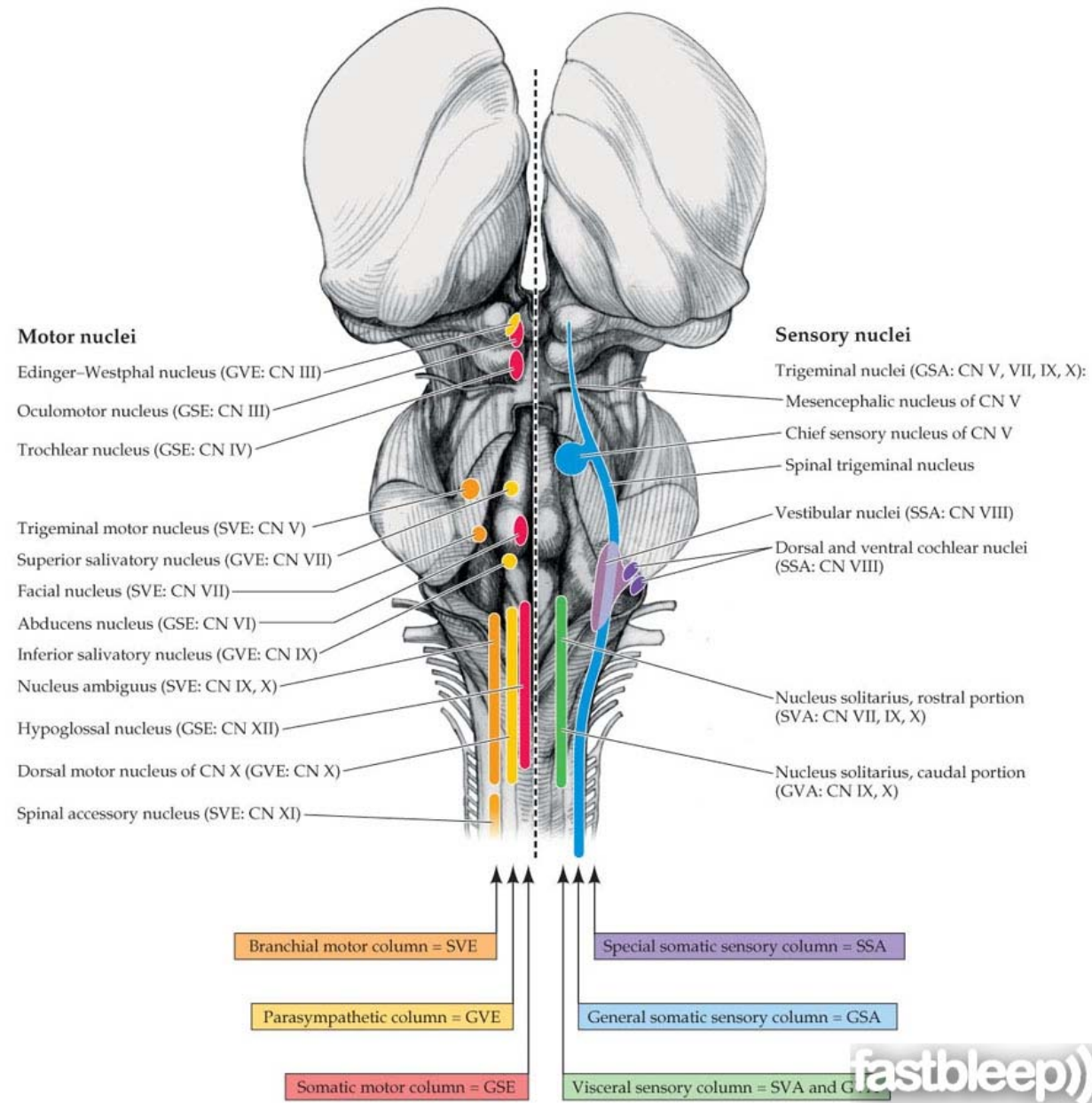
- GSE – III, IV, VI, XII
- SVE – V, VII, IX, X, XI
- GVE – III, VII, IX, X

➤ Sulcus limitans

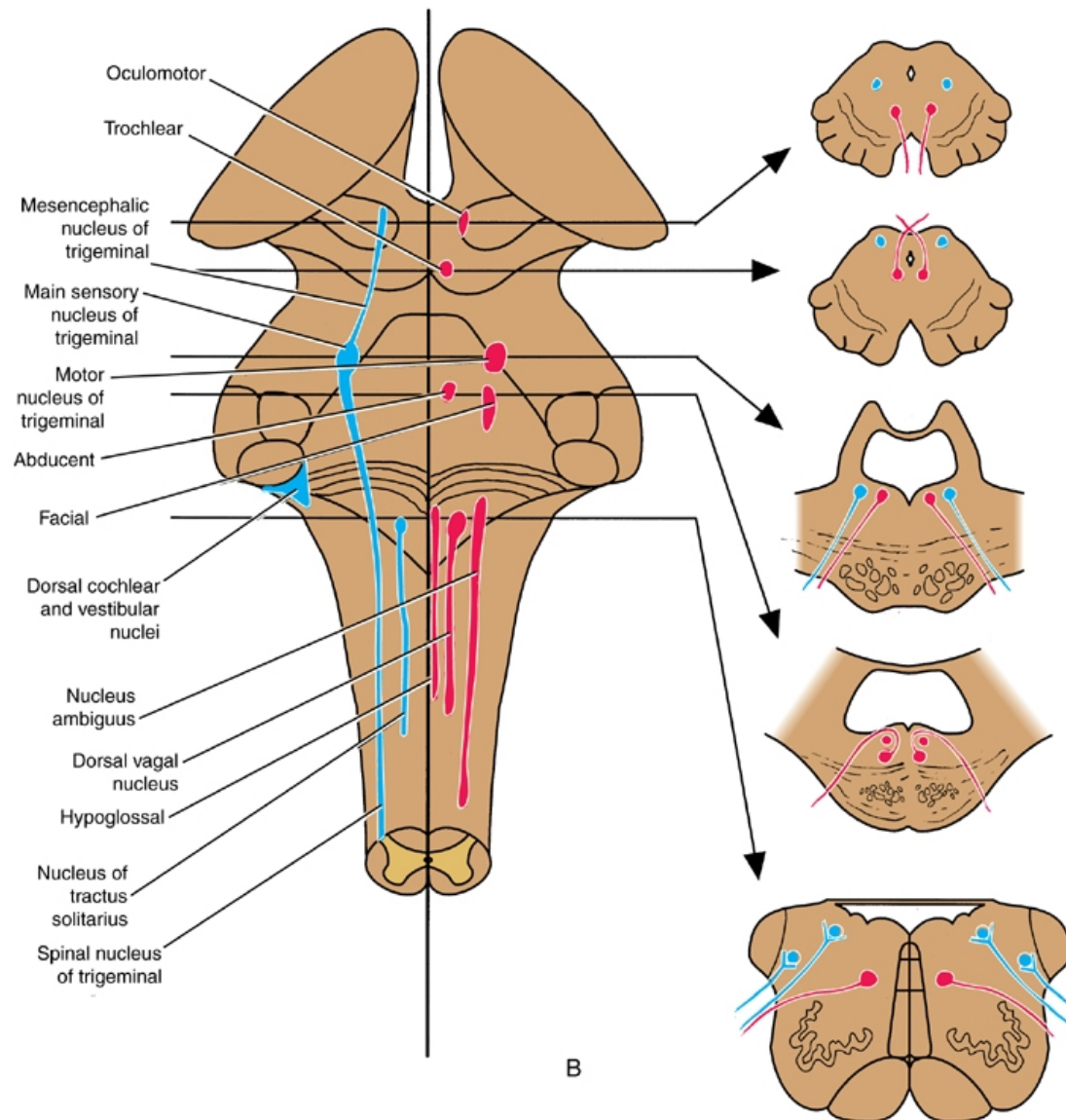
- GVA – n. of tractus solitarius
- SVA – n. of tractus solitarius
- GSA – V sensory nuclei
- SSA – vestibular & cochlear



Brainstem Nuclei

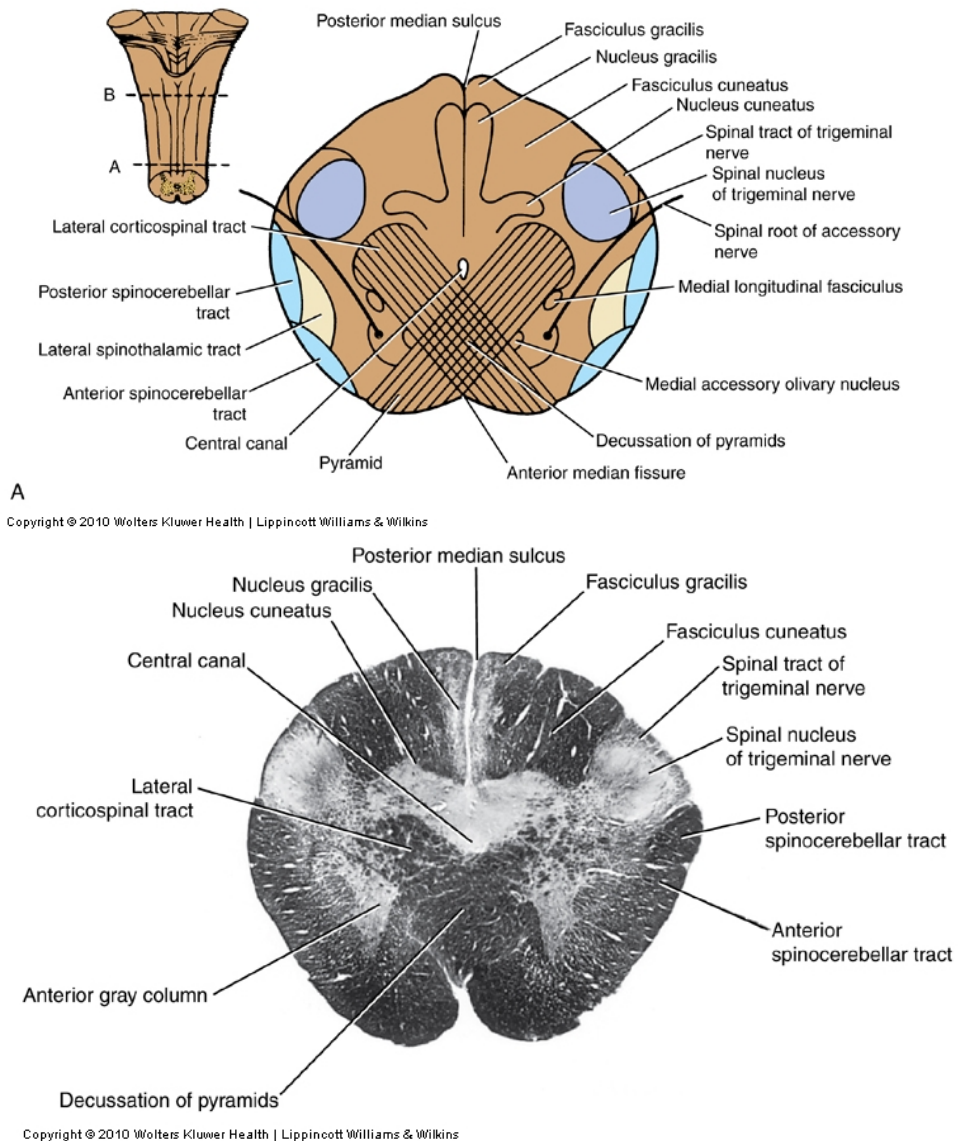


Brainstem Nuclei



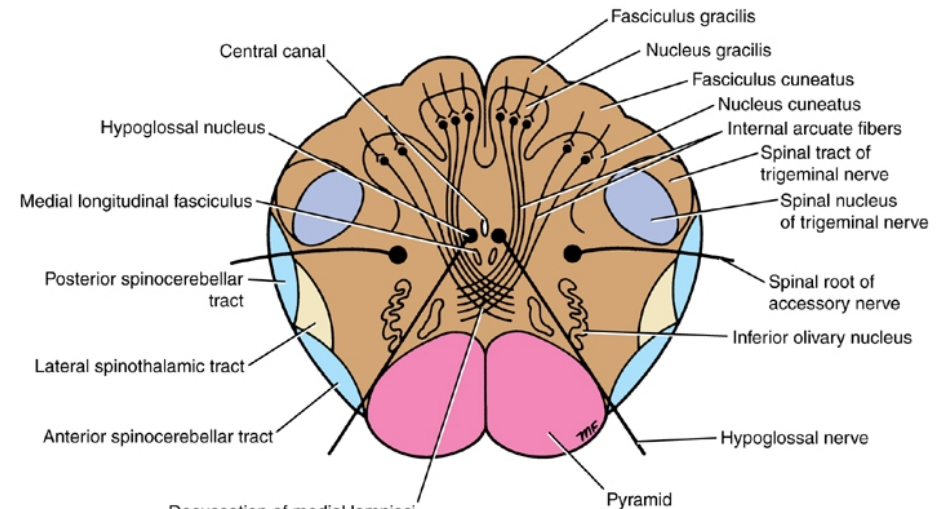
Internal Structures of Medulla

- Level of pyramidal decussation (closed part)
 - Cranial nerve nuclei
 - Spinal tract & nucleus of trigeminal nerve
 - Motor pathways
 - Pyramids
 - Decussation of pyramids
 - Somatosensory pathways
 - Nucleus gracilis & cuneatus
 - Fasciculus gracilis & cuneatus

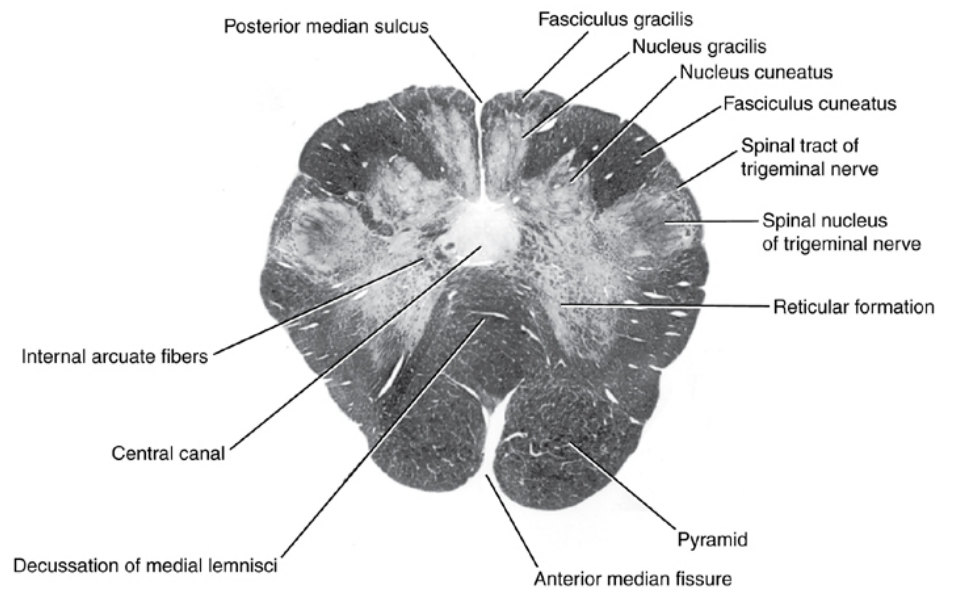


Internal Structures of Medulla

- Level of internal arcuate fibers (closed part)
 - Cranial nerve nuclei
 - Spinal tract & nucleus of trigeminal nerve
 - Motor pathways
 - Pyramids
 - Somatosensory pathways
 - Fasciculus gracilis & cuneatus
 - Nucleus gracilis & cuneatus
 - Internal arcuate fibers
 - Decussation



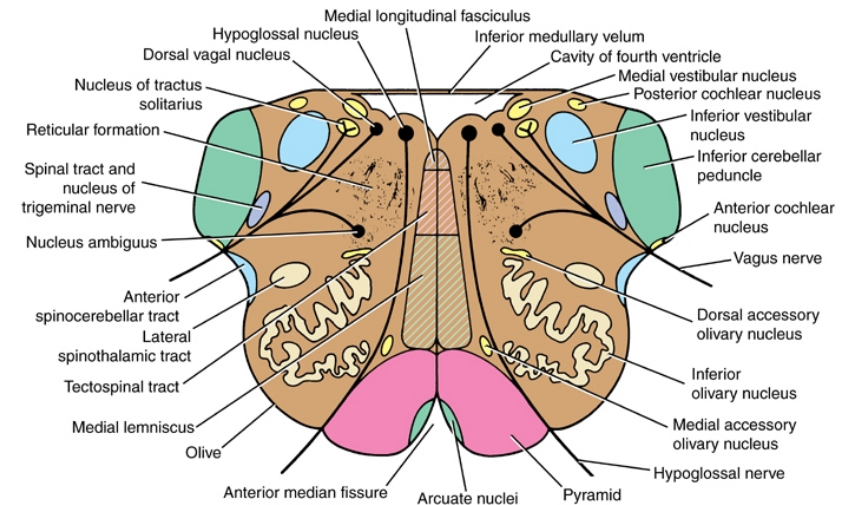
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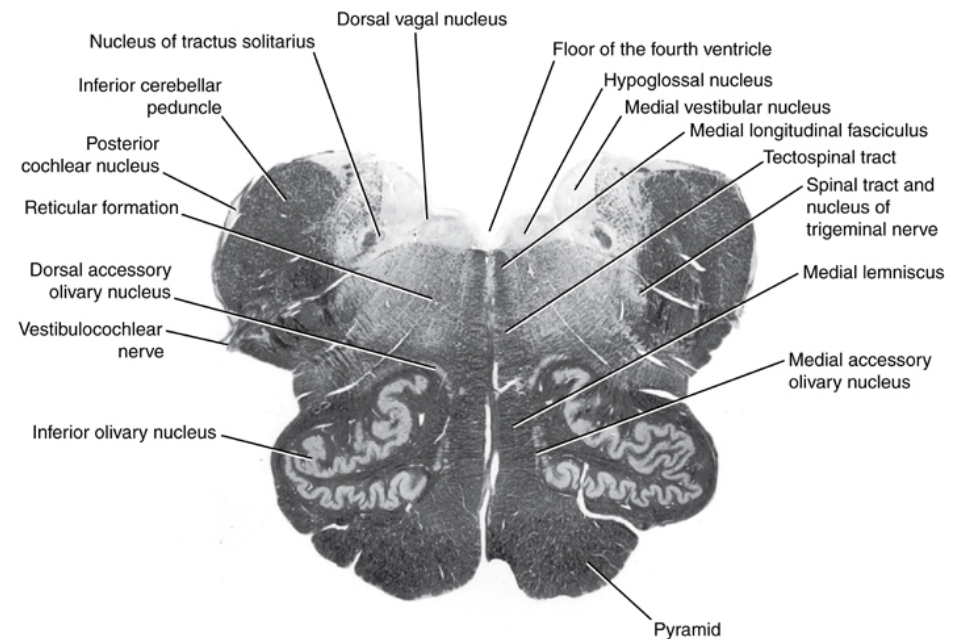
Internal Structures of Medulla

- Level of olivary nucleus (open part)
 - Cranial nerve nuclei
 - Hypoglossal nucleus
 - Dorsal vagal nucleus
 - Vestibular nuclei
 - Nucleus of tractus solitarius
 - Spinal tract & nucleus of trigeminal nerve
 - Motor pathways
 - Pyramid
 - Olivary nucleus
 - Inferior cerebellar peduncle
 - Somatosensory pathways
 - Medial lemniscus



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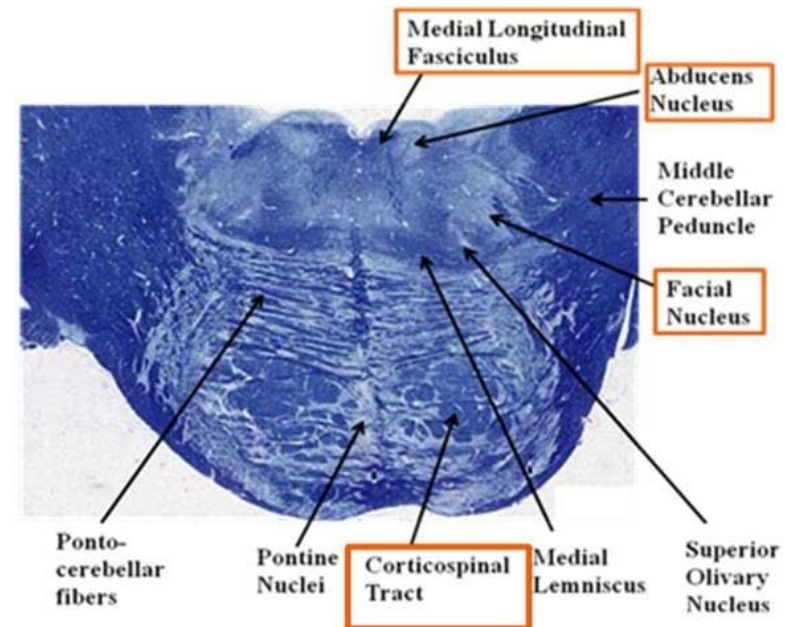
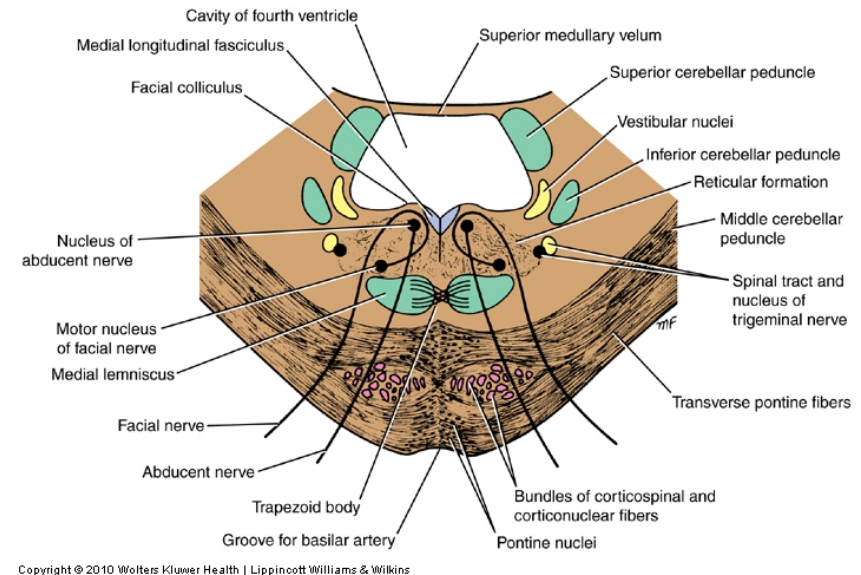
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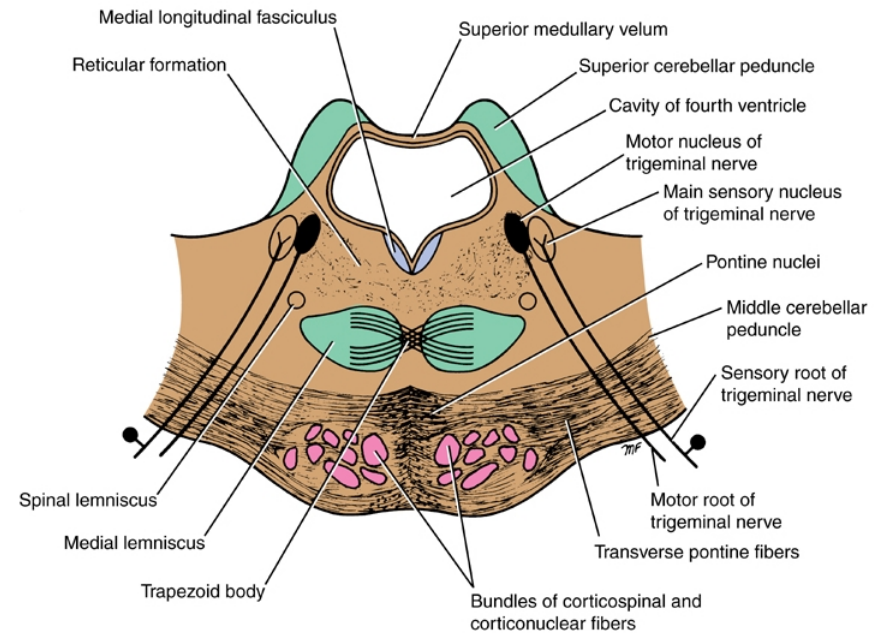
Internal Structures of the Pons

- Caudal part
 - Cranial nerve nuclei
 - Nucleus of abducent nerve
 - Motor nucleus of facial nerve
 - Motor pathways
 - Somatosensory pathways
 - Medial lemniscus

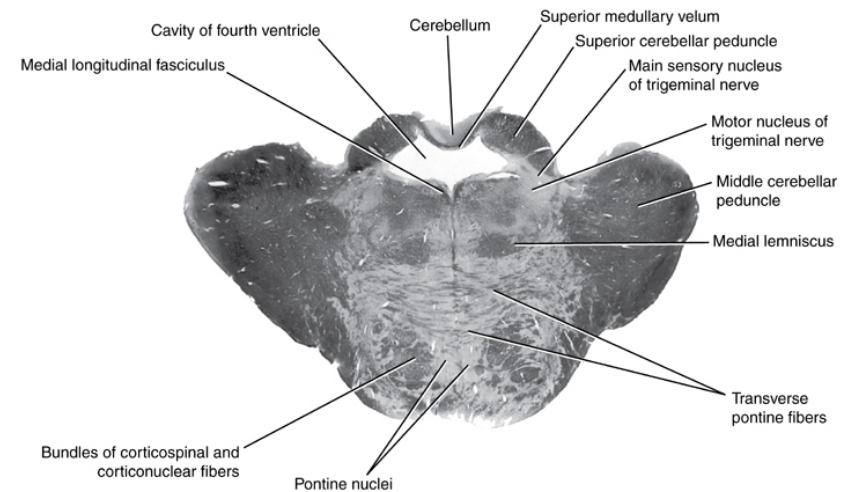


Internal Structures of the Pons

- Cranial part
 - Cranial nerve nuclei
 - Motor nucleus of trigeminal nerve
 - Main sensory nucleus of trigeminal
 - Motor pathways
 - Middle & superior cerebellar peduncles
 - Pontine nuclei
 - Corticospinal fibers
 - Somatosensory pathways
 - Medial lemniscus



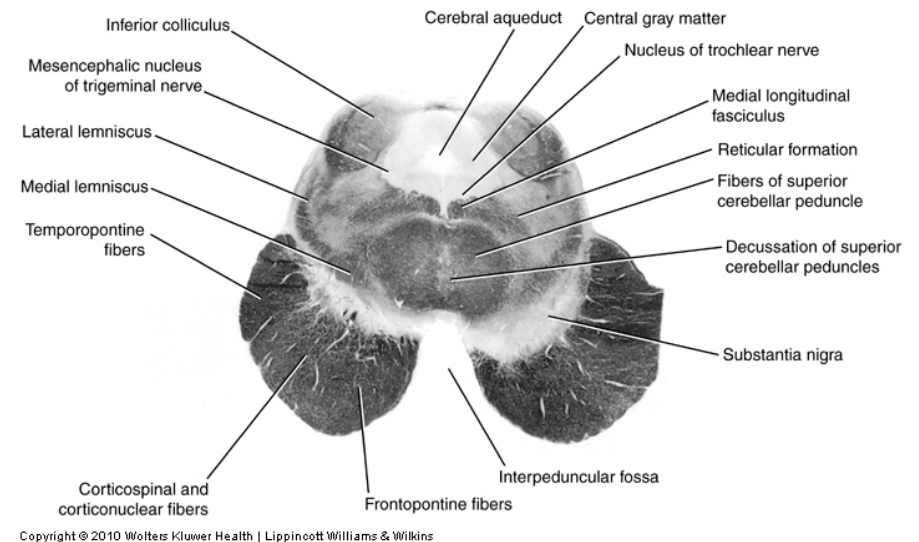
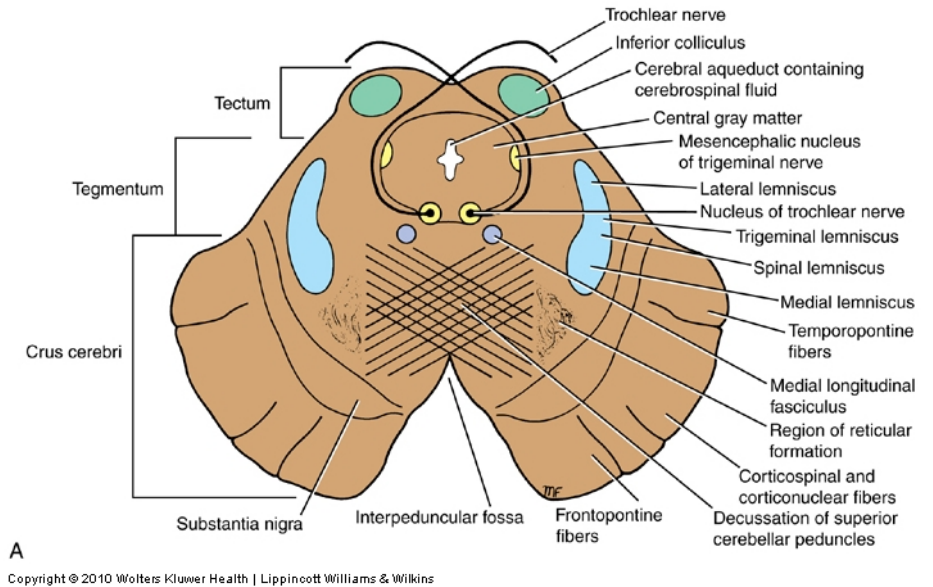
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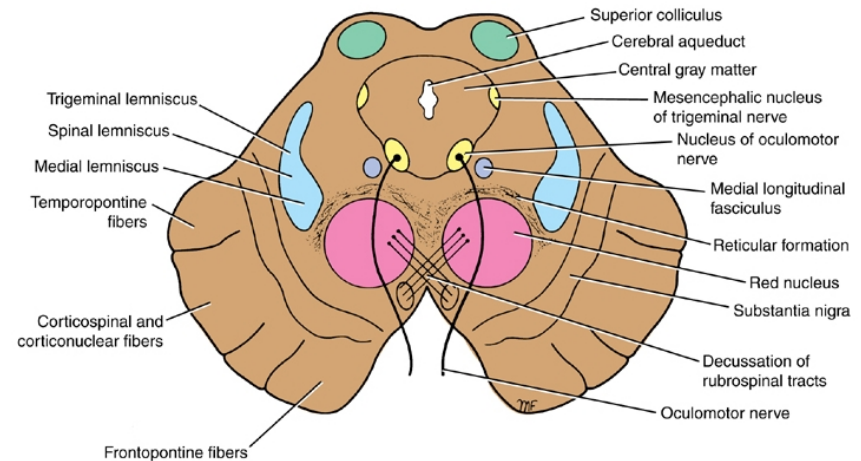
Internal Structures of the Midbrain

- Level of inferior colliculi
 - Cranial nerve nuclei
 - Nucleus of trochlear nerve
 - Mesencephalic nucleus of trigeminal nerve
 - Motor pathways
 - Inferior colliculi
 - Decussation of superior cerebellar peduncles
 - Substantia nigra
 - Crus cerebri
 - Somatosensory pathways
 - Medial lemniscus



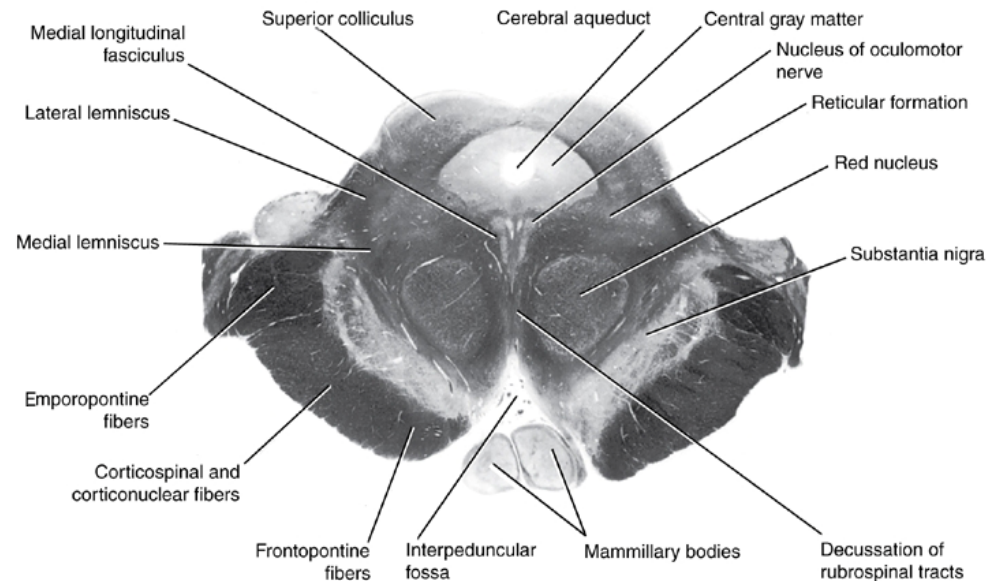
Internal Structures of the Midbrain

- Level of the superior colliculi
 - Cranial nerve nuclei
 - Nucleus of oculomotor nerve
 - Motor pathways
 - Superior colliculi
 - Red nucleus
 - Substantia nigra
 - Crus cerebri
 - Somatosensory pathways
 - Medial lemniscus



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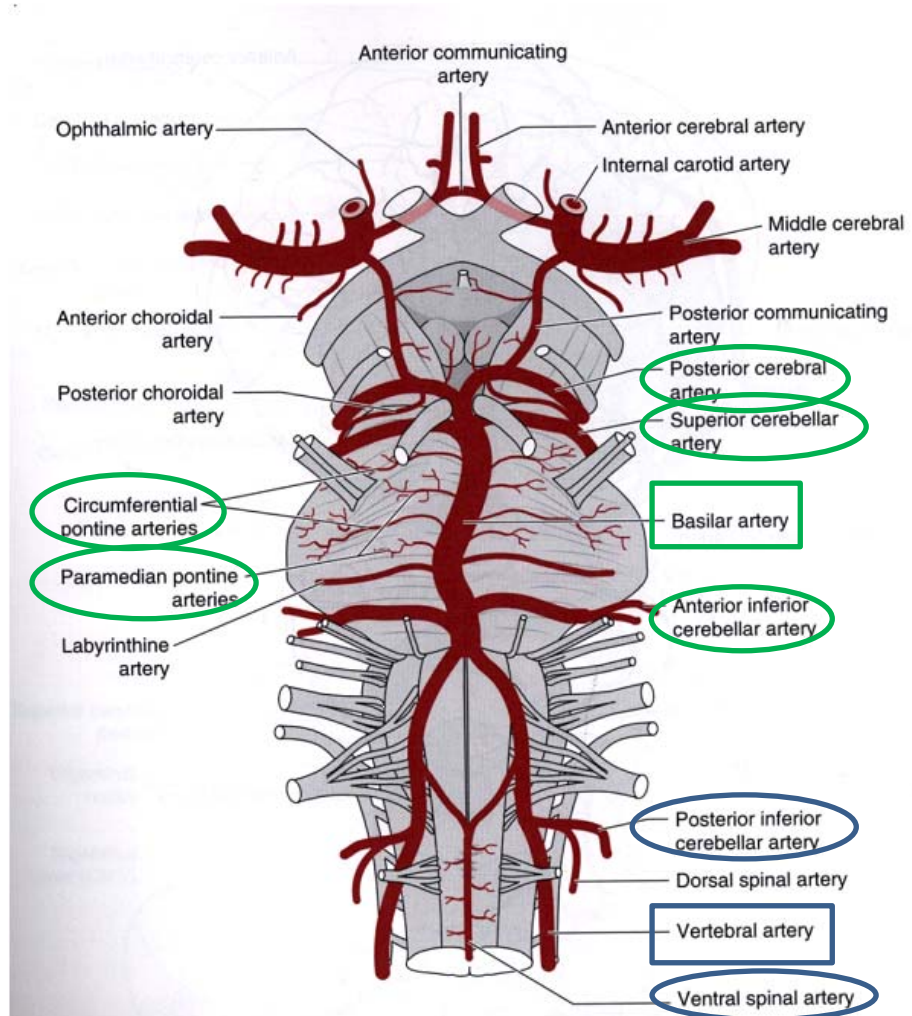
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Spinal cord & Brainstem Labeled Sections: External Link

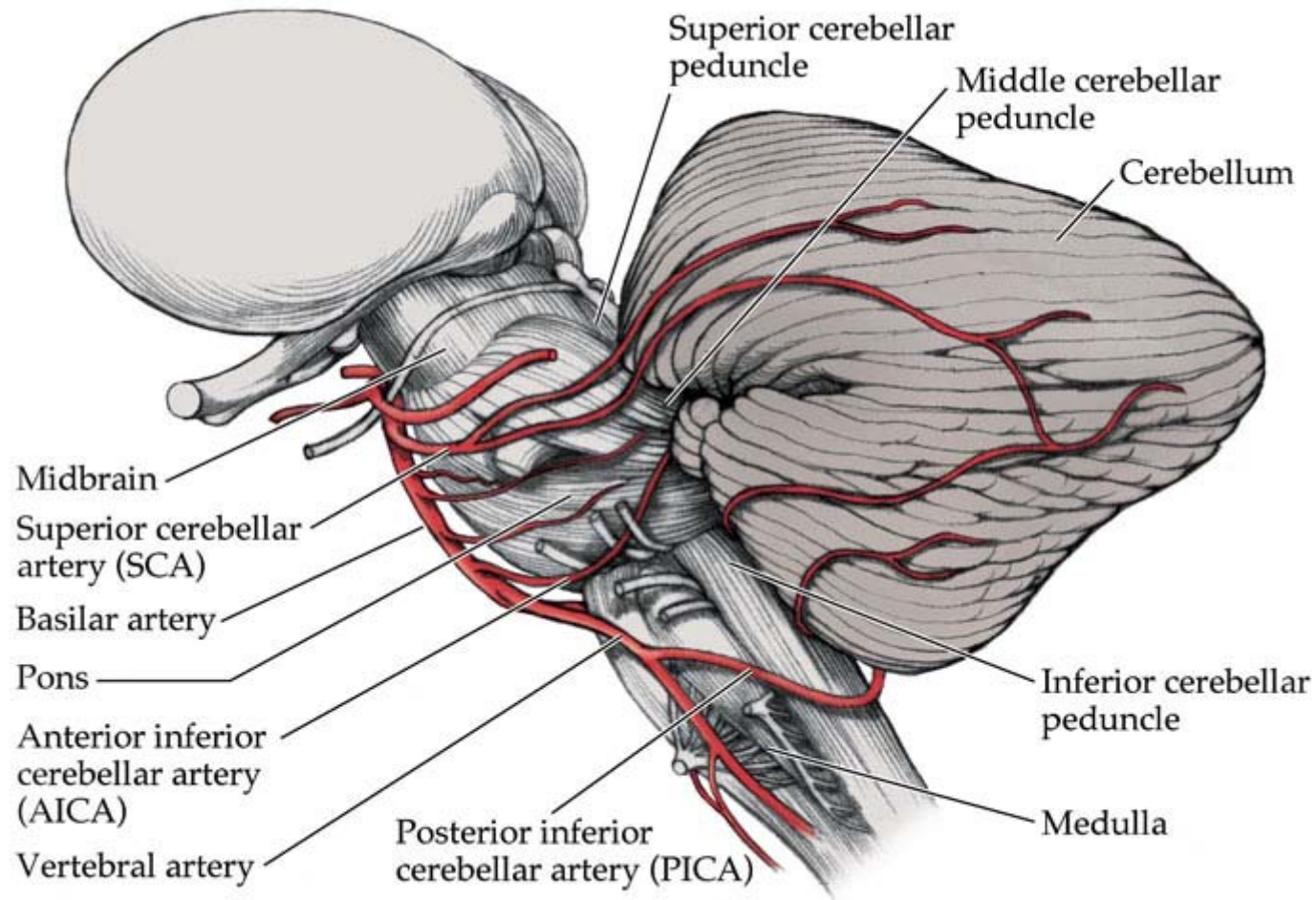
- <http://www.bellarmino.edu/faculty/mwiegand/atlas/cover.html>

Blood Supply to Brainstem

- Blood supply to BS is from posterior circulation
- Vertebral a.
 - Anterior spinal a.
 - PICA
- Basilar a.
 - AICA
 - Paramedian branches
 - Circumferential branches
 - Short & long
 - SCA
 - PCA

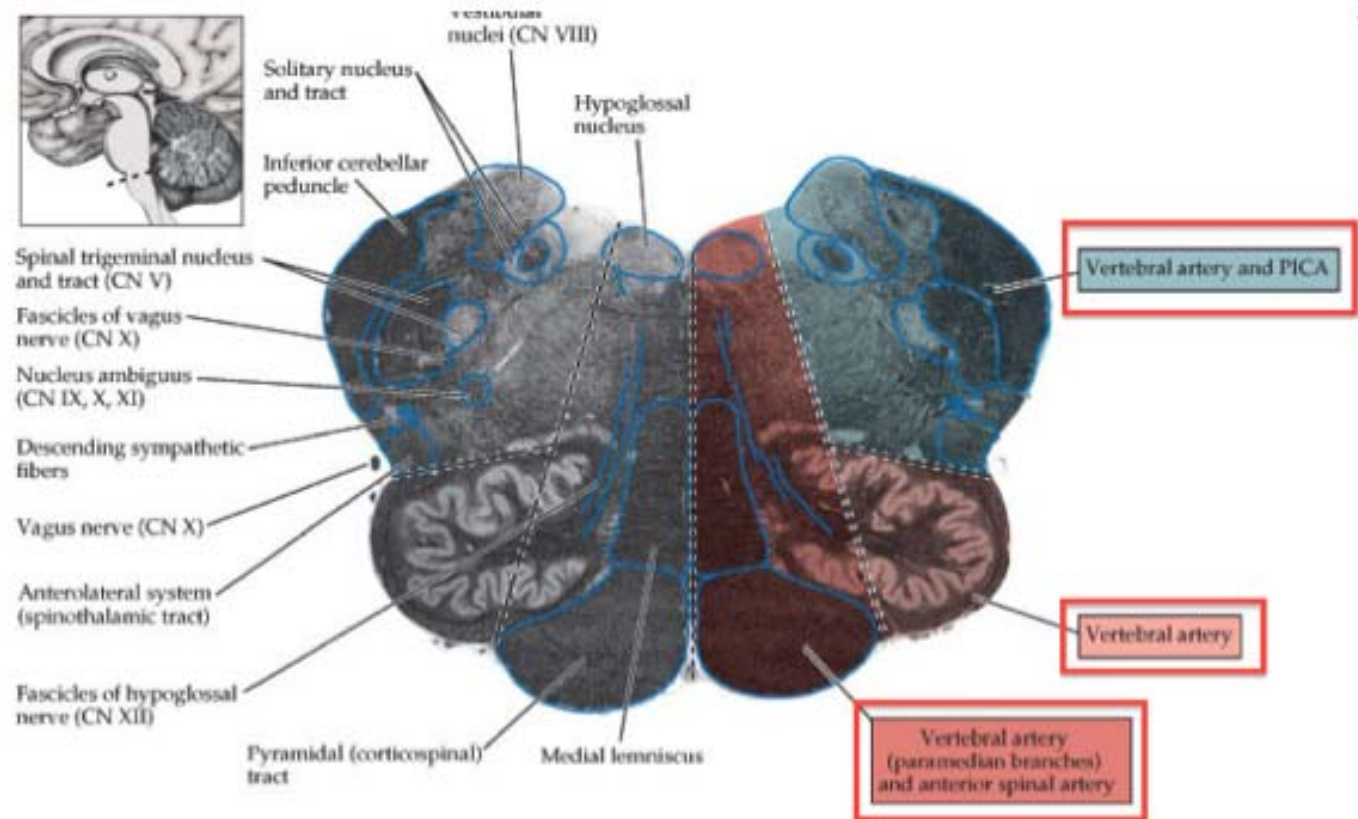


Blood Supply to Brainstem



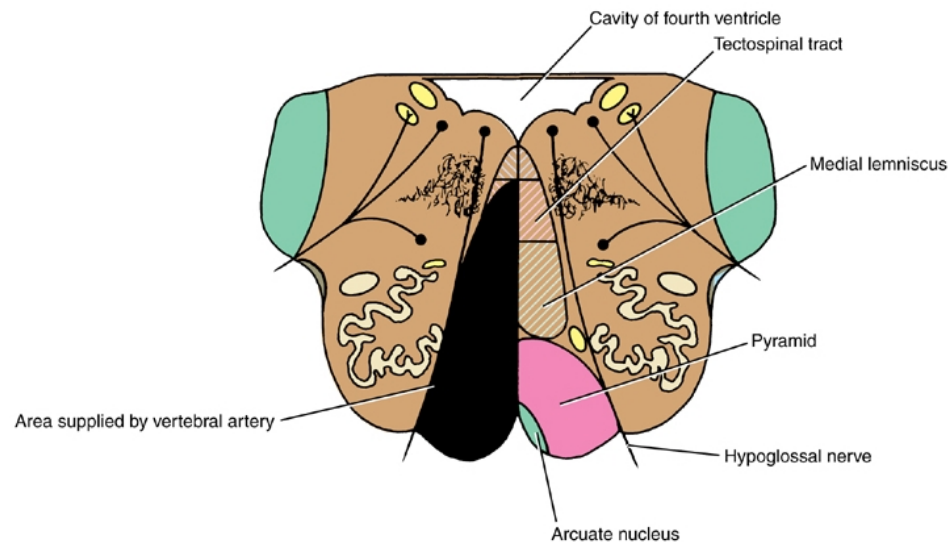
Blood Supply: Medulla

- Anterior spinal a.
- Vertebral a.
- PICA



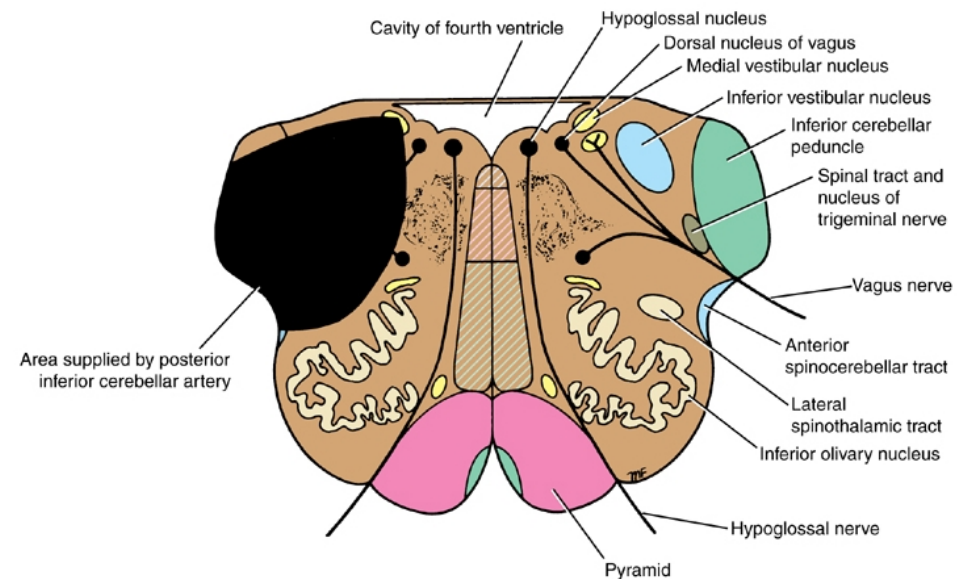
Medullary Lesions

Medial medullary syndrome



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Lateral medullary (Wallenberg) syndrome



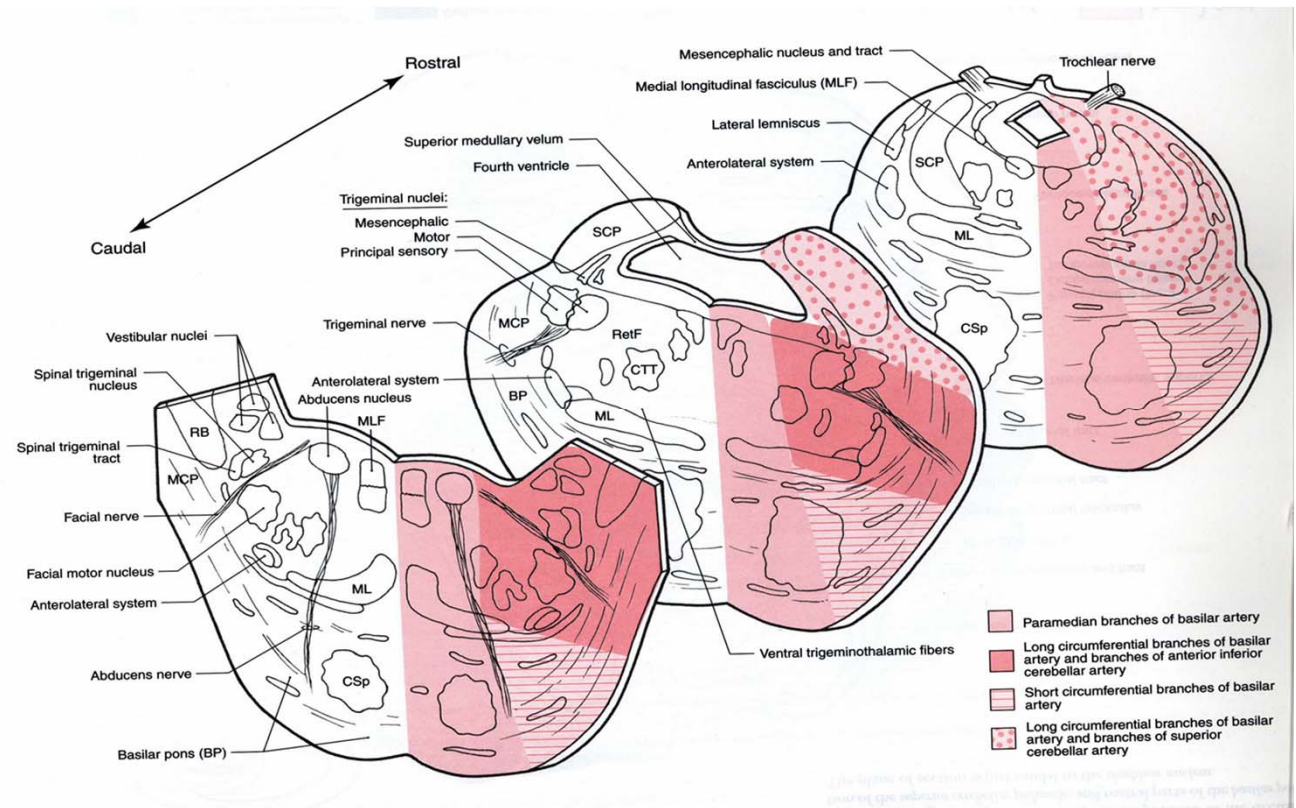
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Table 1. Patient's signs and symptoms comparing with known neurovascular syndromes.

	Patient's signs/symptoms	Afected structure
Medial medullary syndrome	Hemiplegia sparing the face	Pyramidal tract
	Loss of tactile and proprioceptive sensitivity	Medial lemniscus
	Ataxia with a tendency to fall towards the lesion (ipsilateral)	Uncertain: can involve restiform body, cerebellar hemispheres, olivocerebellar fibers and spinocerebellar tracts
Lateral medullary syndrome	Vertigo, nausea and vomiting	Vestibular nucleus and its connections
	Dysphagia, hoarseness, loss of vomiting reflex, bradycardia	Cranial nerves IX and X
	Ipsilateral loss of pain and temperature sensitivity, sometimes involving the face	Spinothalamic tract

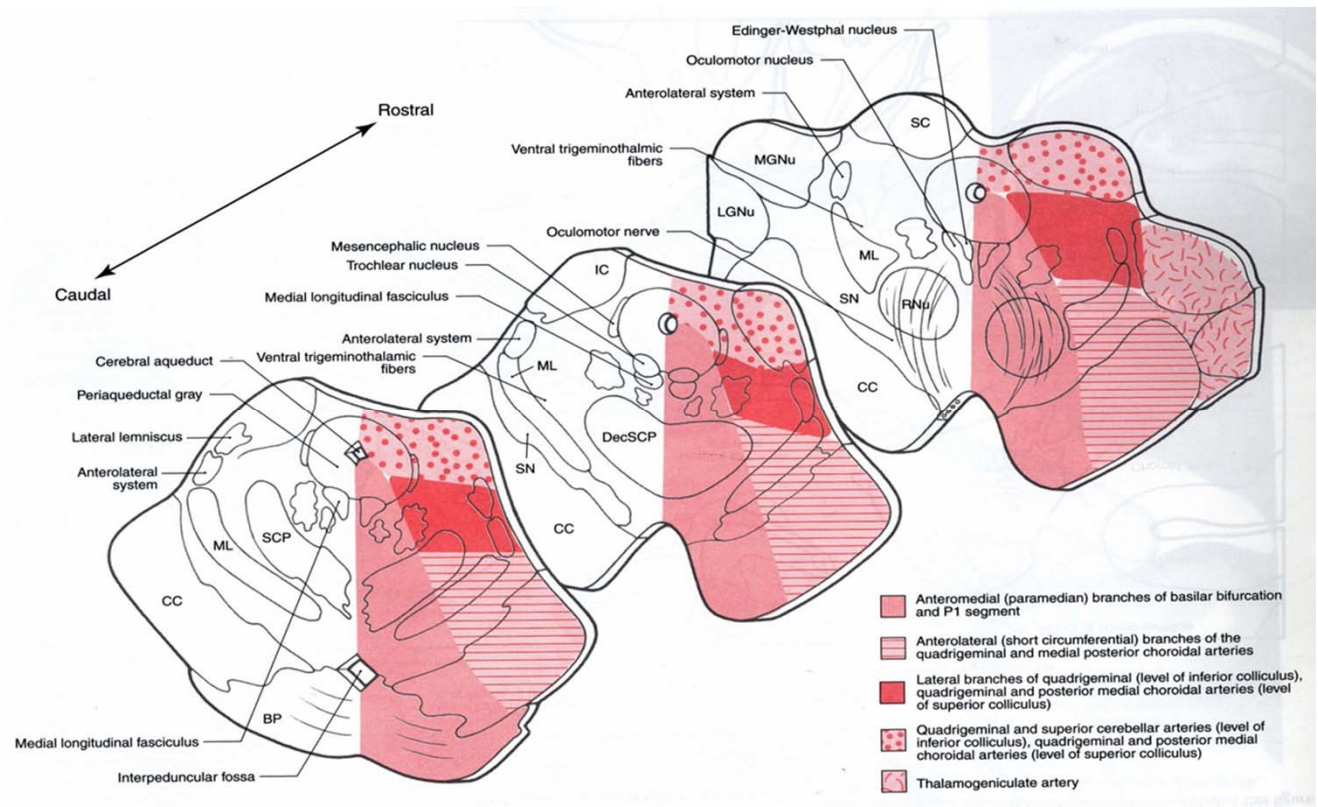
Blood Supply: Pons

- Caudal pons
 - Basilar a.
 - Paramedian
 - Circumferential
 - AICA
- Rostral pons
 - Basilar a.
 - Paramedian
 - Circumferential
 - SCA



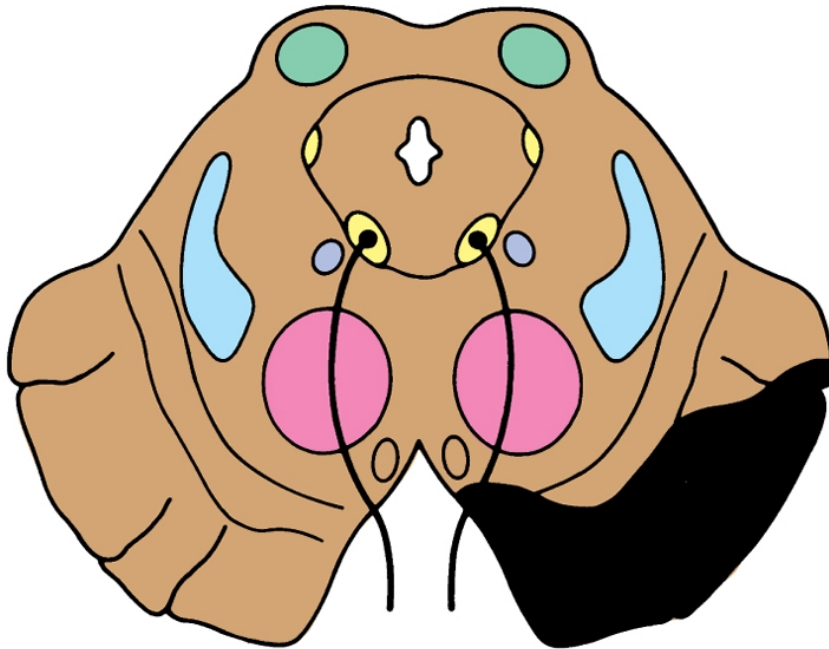
Blood Supply: Midbrain

- Paramedian branches
(Basilar a.)
- PCA
 - Quadrigeminal
- SCA



Midbrain Lesions

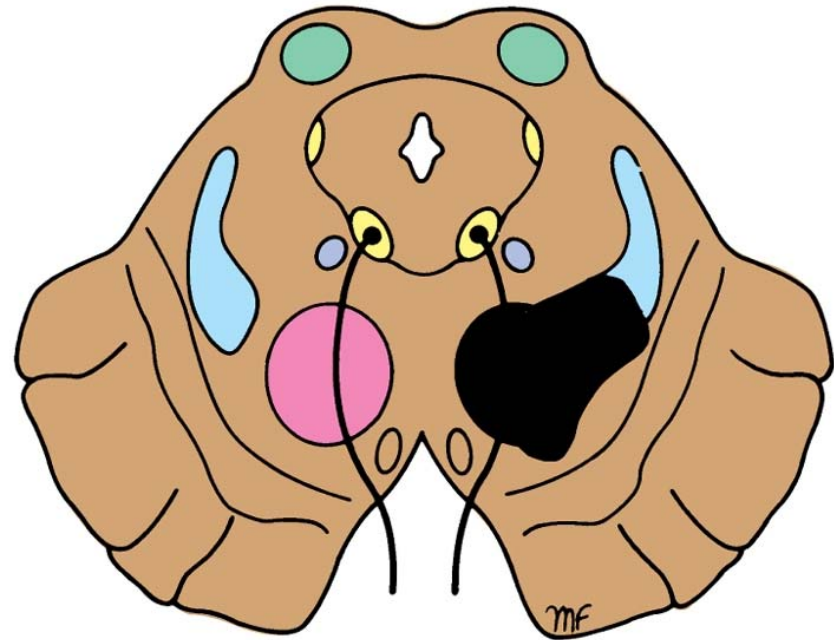
Weber's syndrome



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Benedikt's syndrome



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	Signs/symptoms	Affected structures
Weber's syndrome	Ipsilateral CN III palsy Contralateral hemiplegia	CN III Crus cerebri
Benedikt's syndrome	Ipsilateral CN III palsy Contralateral tremor Contralateral hemianesthesia	CN III Red nucleus Medial lemniscus

Vascular disorders of BRAIN STEM

Level of brain stem	Disease	Involved artery	Involved nuclei & tracts	Signs & symptoms
Medulla	Lateral medullary syndrome Or Wallenberg syndrome	PICA	Ambiguous, Trigeminal, Vestibular & spinal lemniscus	Dysarthria, Dysphagia, Ipsilateral face anesthesia, Vertigo, Nausea, Vomiting, Nystagmus, Ipsilateral Horner syndrome, Ipsilateral cerebellar signs, contralateral anesthesia
	Alternating hypoglossal(lower) hemiplegia or medial medullary syndrome	Anterior spinal, medullary branch of vertebral artery	Hypoglossal, pyramid, medial lemniscus	Ipsilateral paralysis of tongue, Contralateral hemiplegia, Contralateral loss of conscious proprioception
Pons	Alternating abducent(middle) hemiplegia	A branch of basilar artery	Abducent, corticospinal fascicles	Ipsilateral paralysis of lateral rectus, Contralateral hemiplegia
	Alternating facial hemiplegia	A branch of basilar artery	Facial, corticospinal fascicles	Ipsilateral paralysis of facial muscles, Contralateral hemiplegia
	Alternating trigeminal hemiplegia	A branch of basilar artery	Trigeminal, corticospinal fascicles	Ipsilateral paralysis of chewing muscles, contralateral hemiplegia
	Pontine hemorrhage(acute occlusion of basilar artery leads to death)	-	Bilateral involvement, descending sympathetic pathway	Bilateral abducent, facial, trigeminal loss, Quadriplegia, Bilateral miosis
Midbrain	Blockage of cerebral aqueduct	-	Trochlear, oculomotor	Paralysis of ocular muscles, Hydrocephalus
	Alternating ocular (upper)hemiplegia or Webers syndrome	A branch of posterior cerebral artery	Oculomotor, crus cerebri	Ipsilateral paralysis of oculomotor, contralateral hemiplegia

Region	Syndrome Name	Vascular Supply	Structures Affected
Medial medulla	Medial medullary syndrome	ASA + paramedian branches of vertebral artery	- pyramidal tract - medial lemniscus
Lateral medulla	Lateral medullary (Wallenberg) syndrome	Vertebral artery more commonly than PICA	- inferior cerebellar peduncle - vestibular complex - spinal trigeminal nucleus and tract - spinothalamic tract - descending sympathetic fibers - nucleus ambiguus - nucleus solitarius
Lateral caudal pons	AICA syndrome	AICA	- middle cerebellar peduncle - vestibular nuclei - spinal trigeminal nucleus and tract - descending sympathetic fibers
Ventral pons (bilateral) May extend into medulla and/or midbrain	Locked-in syndrome	Basilar artery	- corticonuclear tracts - corticospinal tracts - CN VI nerve fascicles - pontine nuclei and pontocerebellar fibers - paramedian pontine reticular formation
Ventral midbrain (midbrain basis)	Weber syndrome	Branches of PCA and top of basilar artery	- CN III nerve fascicles - cerebral peduncle - red nucleus (partial)

Reticular Formation

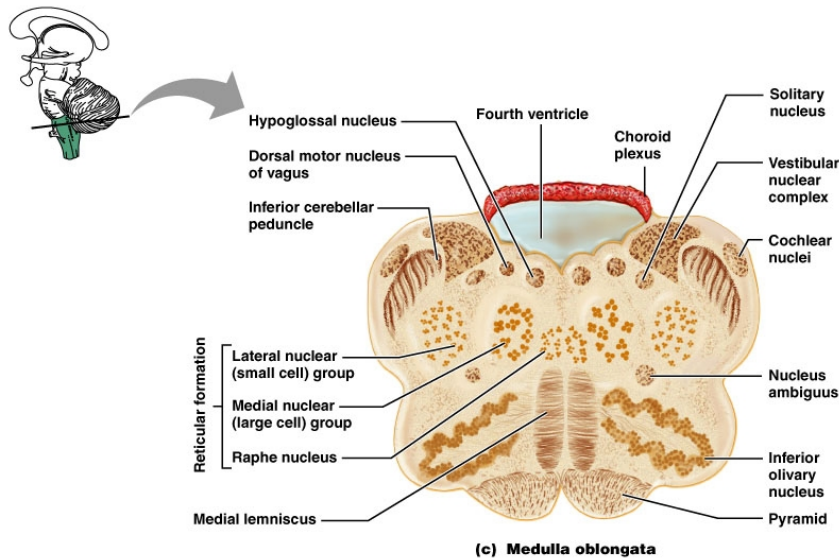
- Scattered nuclei in medulla, pons & midbrain
- Lateral one third have small cells (parvocellular)
 - Receive sensory inputs and cortical inputs
- Medial two thirds have large cells (magnocellular)
 - Output to spinal cord, brainstem nuclei, thalamus, hypothalamus & cerebral cortex

Reticular Formation Functions

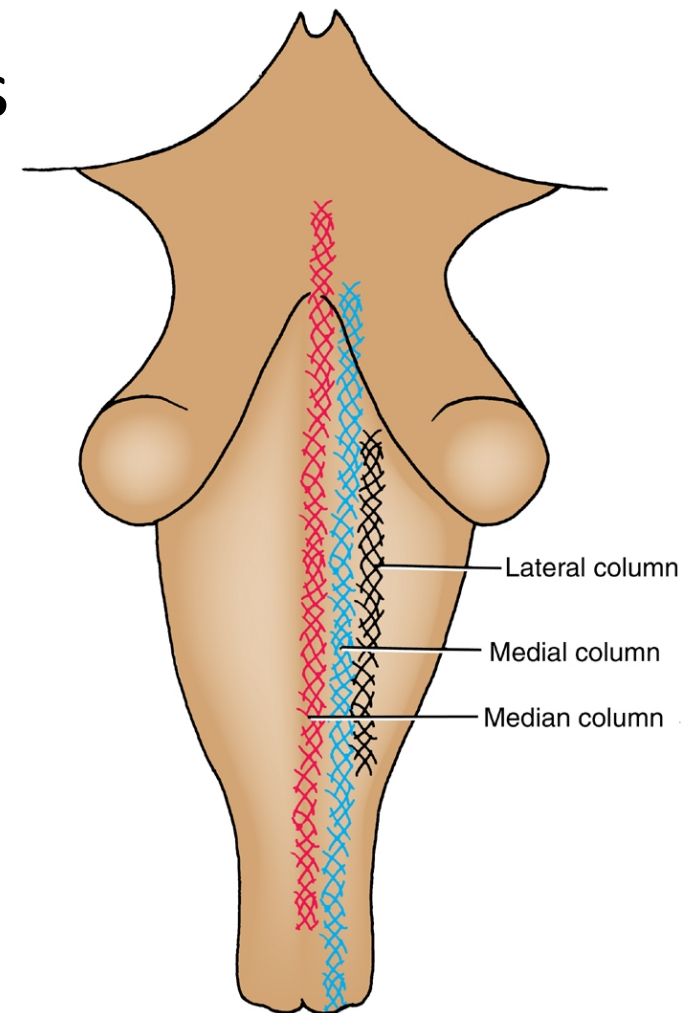
- The reticular formation modulates (excite or inhibit) the activities of:
 - Sensory systems – e.g. pain
 - Motor systems – e.g. muscle tone, segmental reflexes, eye movements
 - Autonomic systems – e.g. respiration, blood pressure, cardiac function
 - Consciousness – e.g. vital centers in the brainstem, awareness, attention & arousal

Organization of Reticular Formation

- Reticular formation organized into three longitudinal columns
 - Midline raphe group
 - Parasagittal medial zone
 - Parasagittal lateral zone



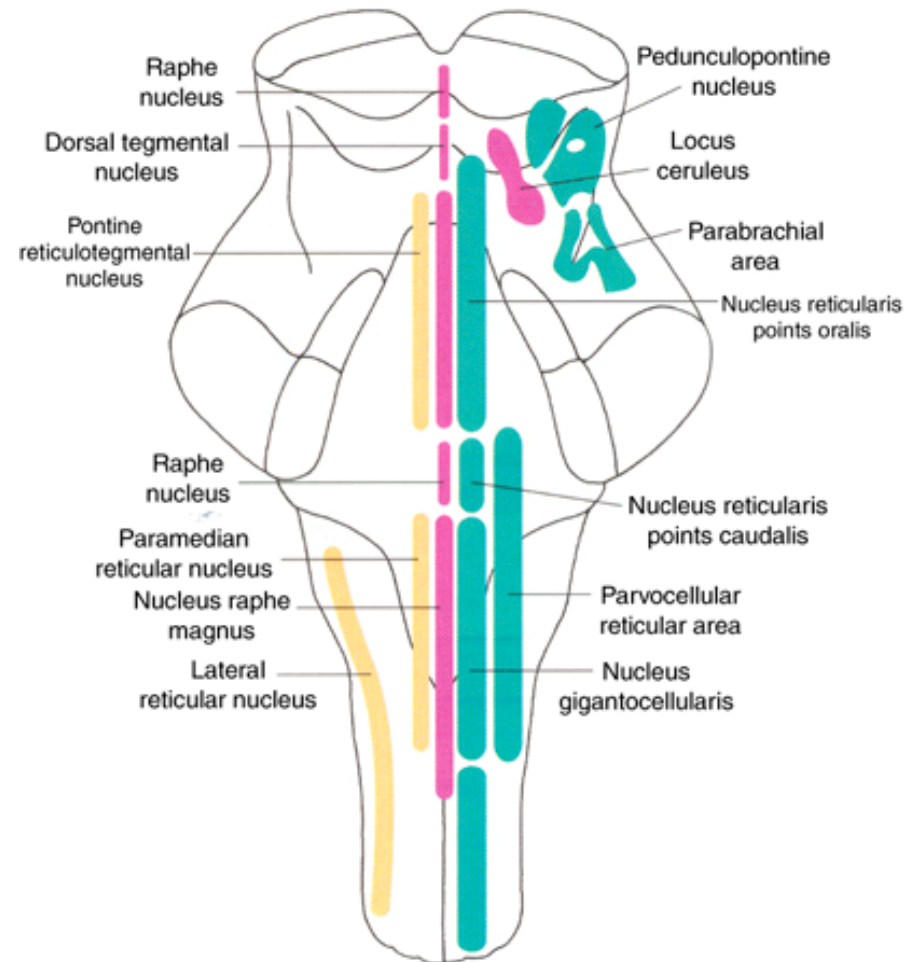
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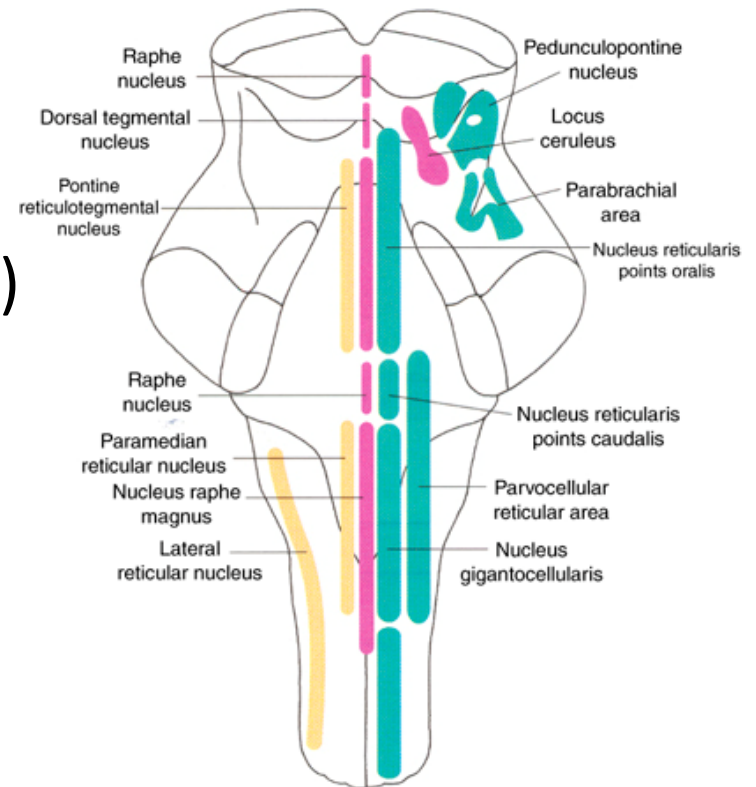
Organization of Reticular Formation

- Fourth set of nuclei that have common cerebellar projections (precerebellar reticular nuclei)
 - Coordination of muscle contraction
 - Paramedian reticular nucleus of the medulla
 - Lateral reticular nucleus of the medulla
 - Reticulotegmental nucleus of the pons



Raphe Nuclei

- **Serotonin** projecting cells
- Rostral group (upper pons & midbrain)
 - Project to cerebellum, cerebrum (cortex, basal ganglia, limbic system)
 - Involved in the regulation of forebrain activity
 - Sleep, memory processing, mood
- Caudal group (lower pons & medulla)
 - Receives nociceptive input from brainstem & spinal cord
 - Involved in the regulation of pain

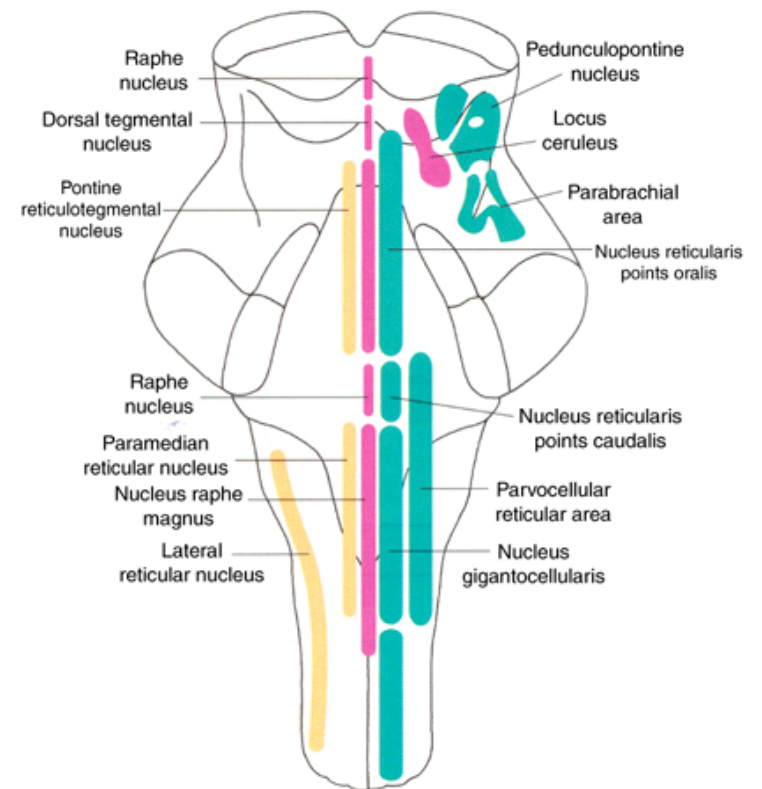


Medial Reticular Zone

- The effector part of the reticular formation
 - Provides most of the ascending & descending projection
- Most inputs come from the lateral reticular zone (sensory somatic & visceral)
- Ascending projections form the Ascending Reticular Activating System (ARAS)
 - Alter the levels of consciousness & state of attention
 - Conscious activities of the cerebral cortex require excitatory influences from the ARAS
- Descending projections regulate muscle tone, spinal reflexes & motor activity through
 - Medial (pontine) reticulospinal tract
 - ↑ muscle tone spinal reflexes
 - Lateral (medullary) reticulospinal tract
 - ↓ muscle tone spinal reflexes

Medial Reticular Zone

- Locus ceruleus in pons
 - contain norepinephrine & extensive projections throughout CNS
 - Ascending projections are part of the ARAS
 - Involved in the mood, memory and regulation of motor activity

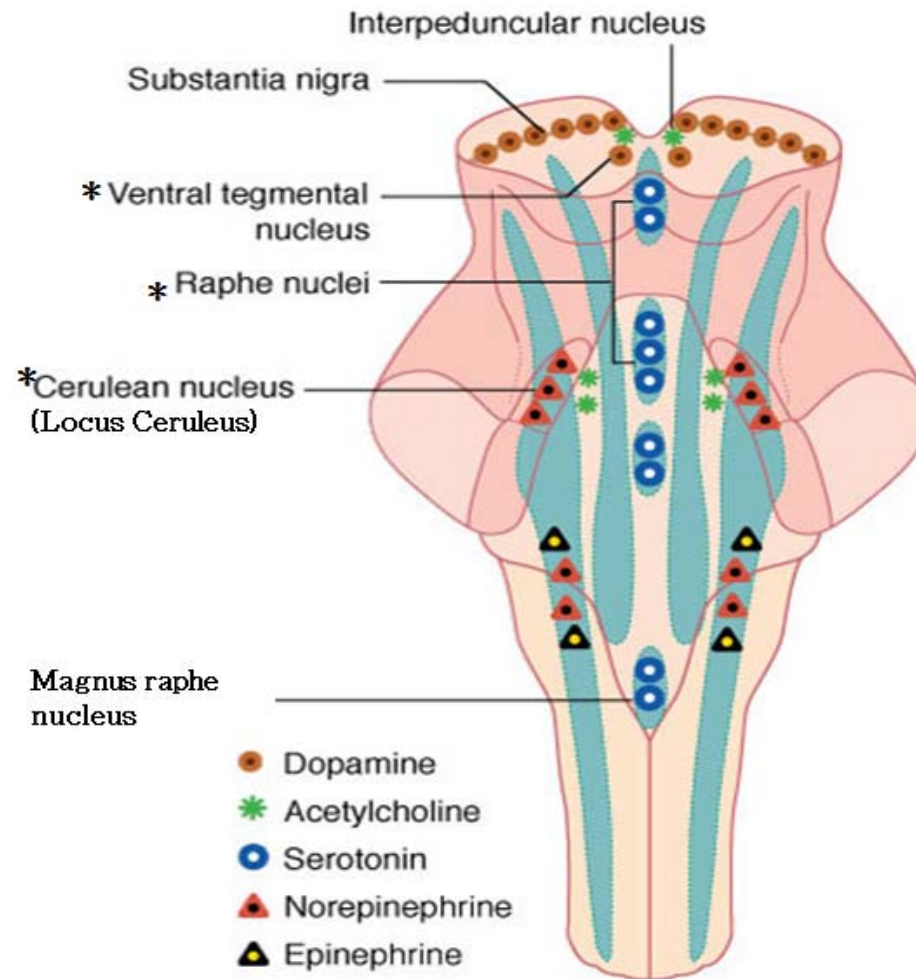


Lateral Reticular Zone

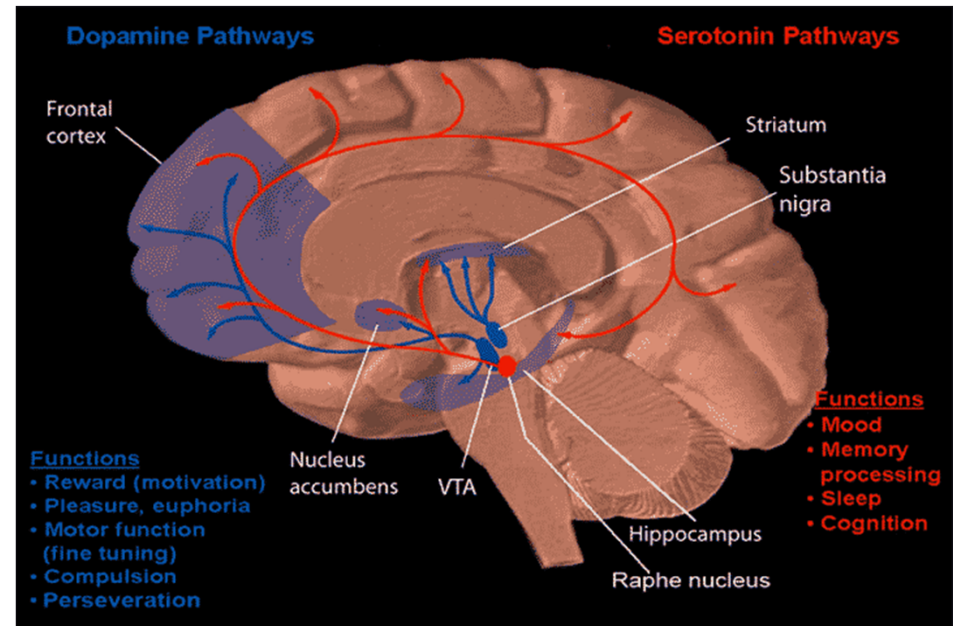
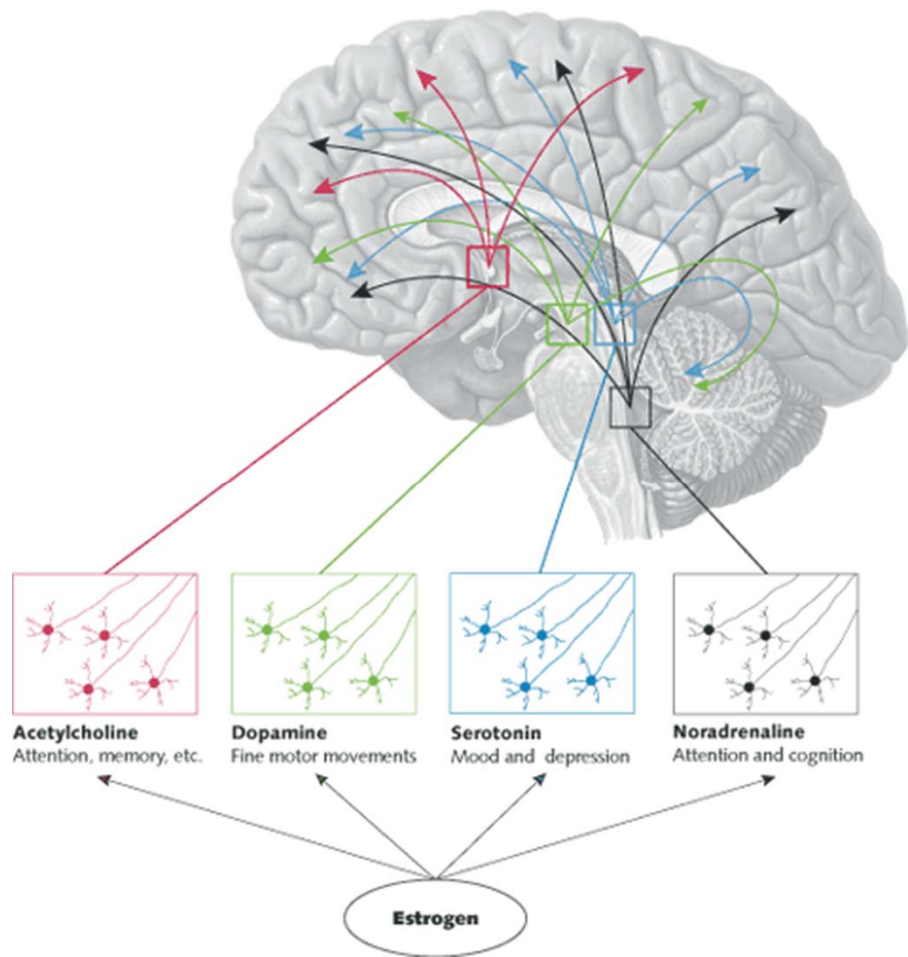
- Receives extensive afferents to mediate cranial nerve reflexes and visceral functions
- Output is mainly to medial zone
- Other projections
 - Pedunculopontine nucleus (acetylcholine neurons)
 - Projects to the substantia nigra, subthalamic nucleus, motor cortex, & medial zone
 - All have important motor control functions

Organization of Reticular Formation

Neurotransmitter Distribution



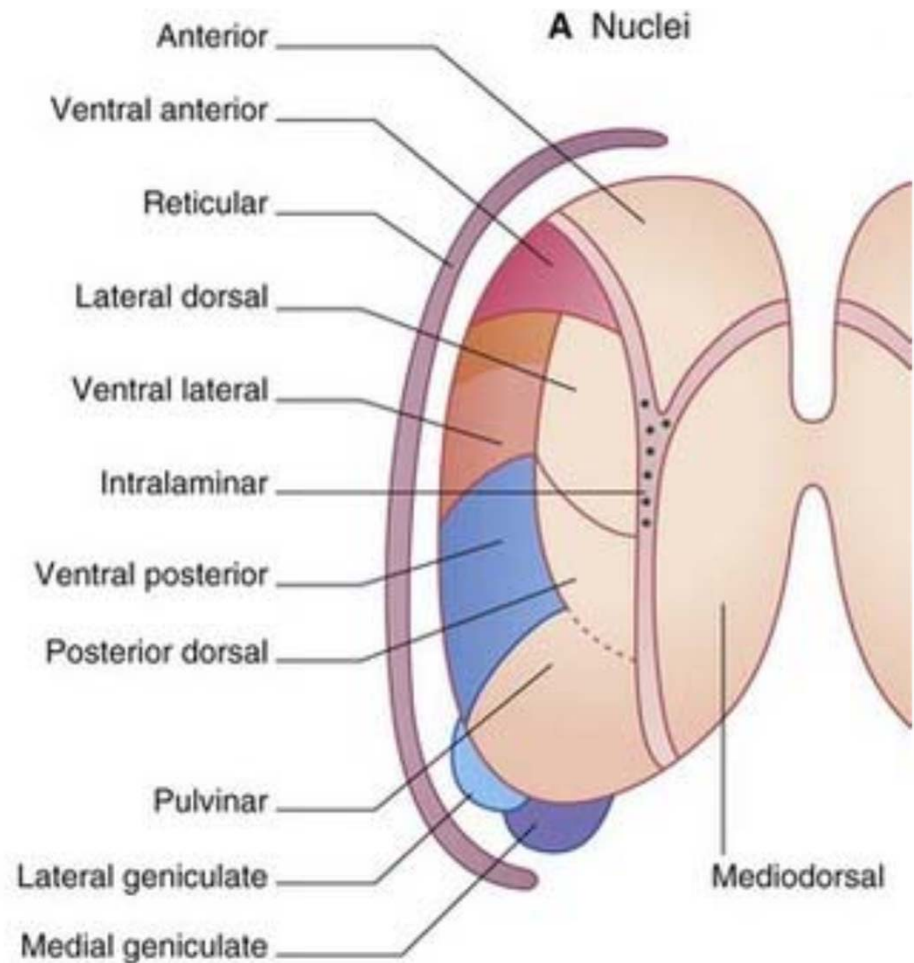
Reticular Formation: Neurotransmitter Pathways & Functions



The Diencephalon

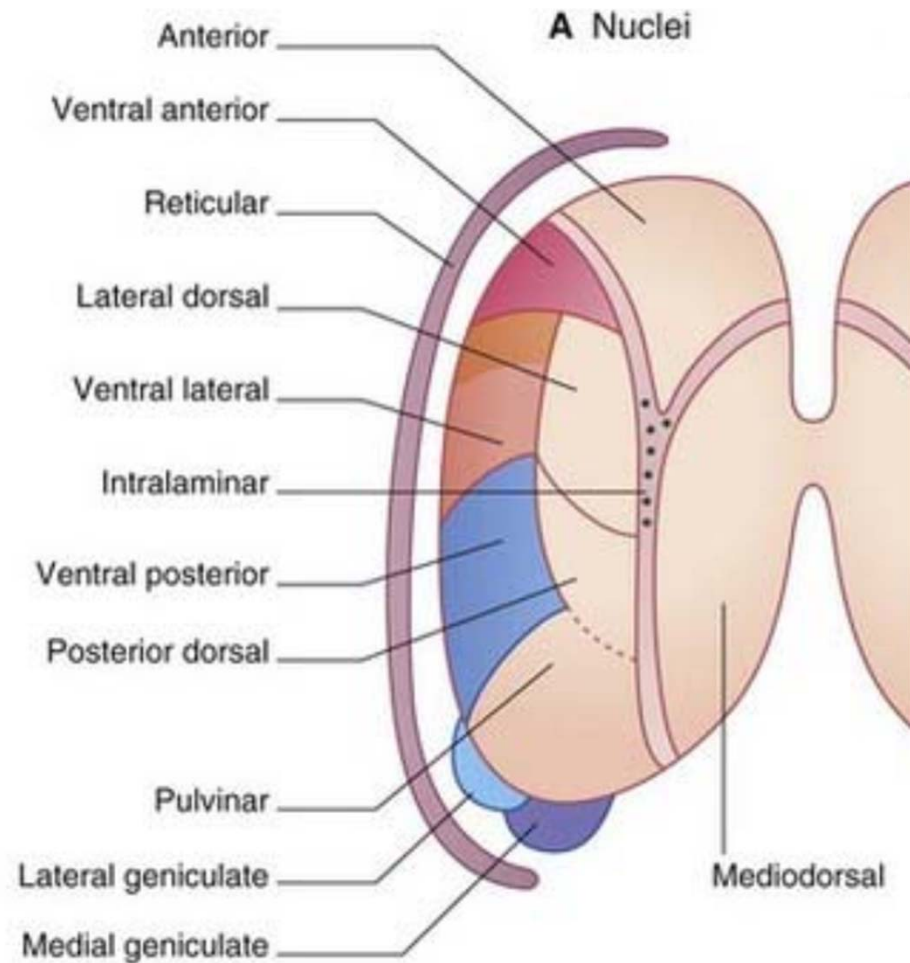
Thalamus: Structure

- From medial to lateral:
 - Medial n.
 - Dorsomedial n.
 - Anterior n.
 - Internal medullary lamina
 - Intralaminar n.
 - Lateral n.
 - External medullary lamina
 - Reticular n.
 - Internal capsule



Thalamus: Lateral Nucleus

- Subdivided into:
 - Dorsal tier
 - Lateral dorsal (LD)
 - Lateral posterior (LP)
 - Pulvinar (Pu)
 - Ventral tier
 - Ventral anterior (VA)
 - Ventral lateral (VL)
 - Ventral posterior (VP)
 - Ventral posterolateral (VPL)
 - Ventral posteromedial (VPM)
 - Posterior nucleus (Po)
 - Medial & lateral geniculate nuclei



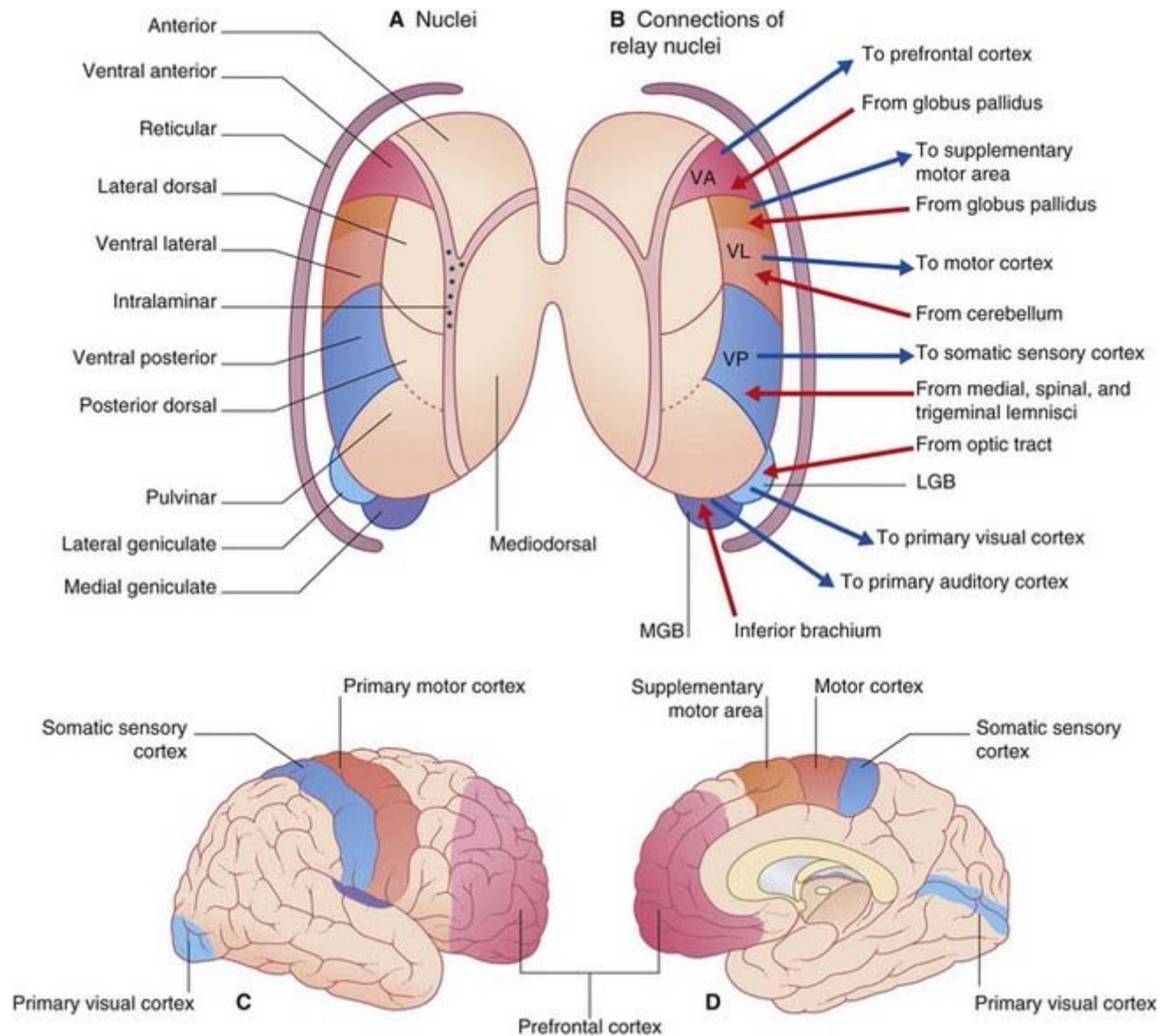
Specific Nuclei

Nucleus	Afferents	Efferents	Functions
Ventral posterior (VP) • Ventral posteromedial (VPM) • Ventral posterolateral (VPL)	Trigeminal lemniscus Solitariothalamic tract Medial lemniscus Spinal lemniscus	To postcentral gyrus (area 3, 1, and 2) To postcentral gyrus (area 3, 1, and 2)	Relay station for impulses from face and head, and taste buds Relay station for exteroceptive (pain, touch, and temperature) and proprioceptive sensations from whole of body except face and head
Ventral anterior (VA)	From globus pallidus through subthalamic fasciculus	To premotor cortex (area 6 and 8)	Relay station for striatal impulses
Ventral lateral (VL) (also called ventral intermediate (VI))	From cerebellum (dentatorubrothalamic fibres and dentatothalamic fibres)	To motor and premotor areas of cerebral cortex (area 4 and 6)	Relay station for cerebellar impulses
Medial geniculate body	Auditory fibres from inferior colliculus	To primary auditory area (area 41 and 42)	Relay station for auditory impulses
Lateral geniculate body	Optic tract	To primary visual cortex (area 17)	Relay station for visual impulses

Non-specific Nuclei

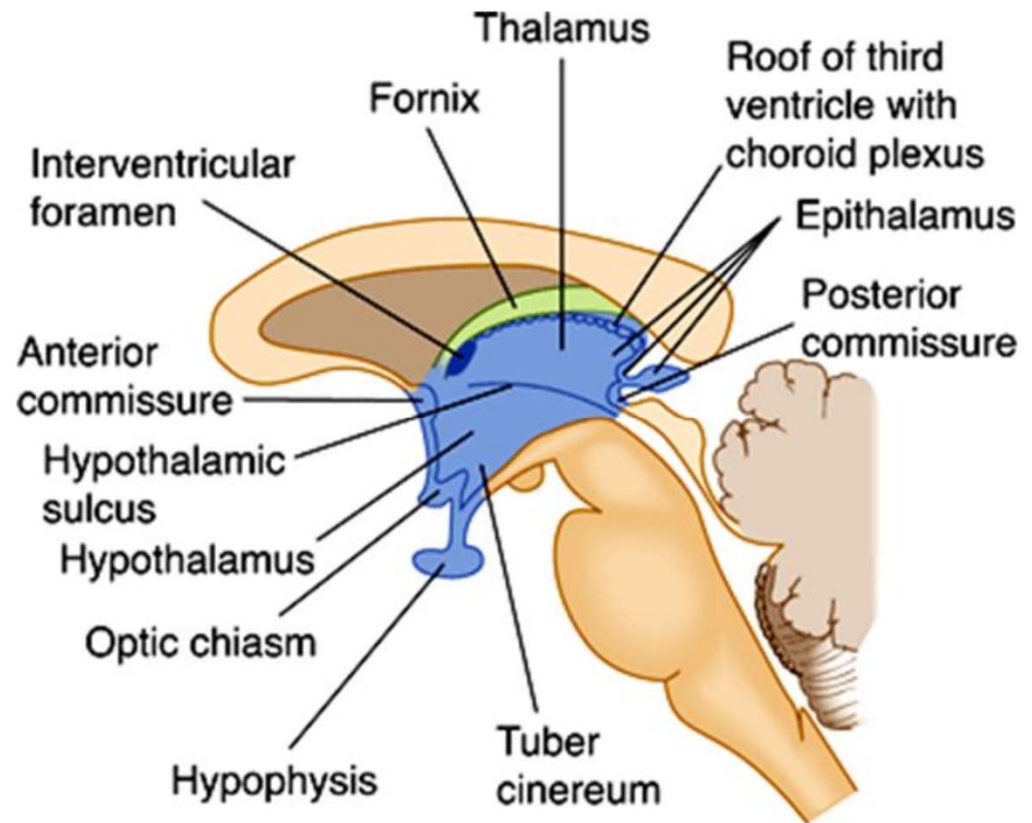
Nucleus	Afferents	Efferents	Functions
Anterior nucleus	Mammillothalamic tract from mammillary body	To cingulate gyrus	Attention and recent memory
Medial dorsal nucleus	From other thalamic nuclei and hypothalamus	To prefrontal area	Associated with mood and emotional balance
Lateral dorsal nucleus	From ventral tier of thalamic nuclei	To precuneus and cingulate gyrus	Integrate sensory information
Lateral posterior nucleus	From ventral tier of thalamic nuclei	Superior parietal lobule	Integrate sensory information
Pulvinar	From ventral tier of thalamic nuclei	To association areas in parietal, occipital and temporal lobes	Correlates visual and auditory information with other sensations

Nucleus	Afferents	Efferents	Functions
Reticular nucleus	From brainstem reticular formation	To whole of cerebral cortex	Forms part of reticular activating system (RAS)
Intralaminar nuclei including centromedian nucleus	From brainstem reticular formation	To other thalamic nuclei and corpus striatum	Involved in awareness of painful stimuli at thalamic level



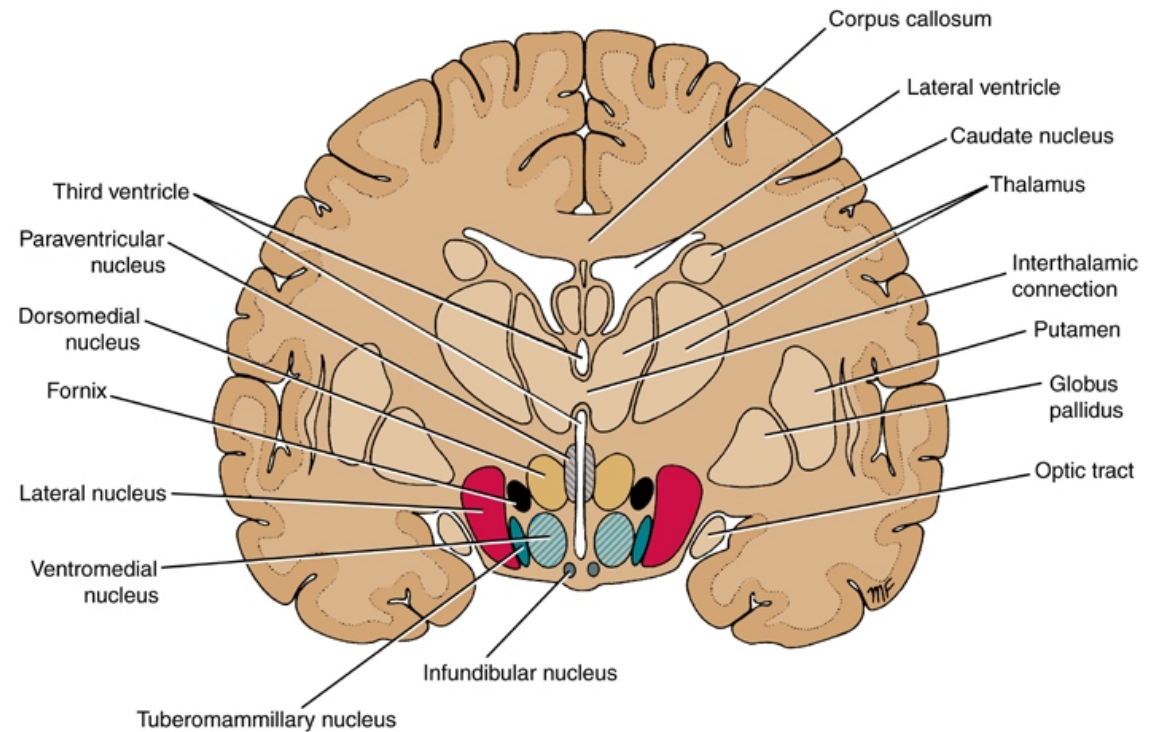
Hypothalamus

- Location
- Boundaries
 - Lamina terminalis
 - Hypothalamic sulcus
 - 3rd ventricle



Hypothalamus: Nuclei

- Divisions
 - In coronal section
 - Periventricular
 - Medial
 - Fornix
 - Lateral

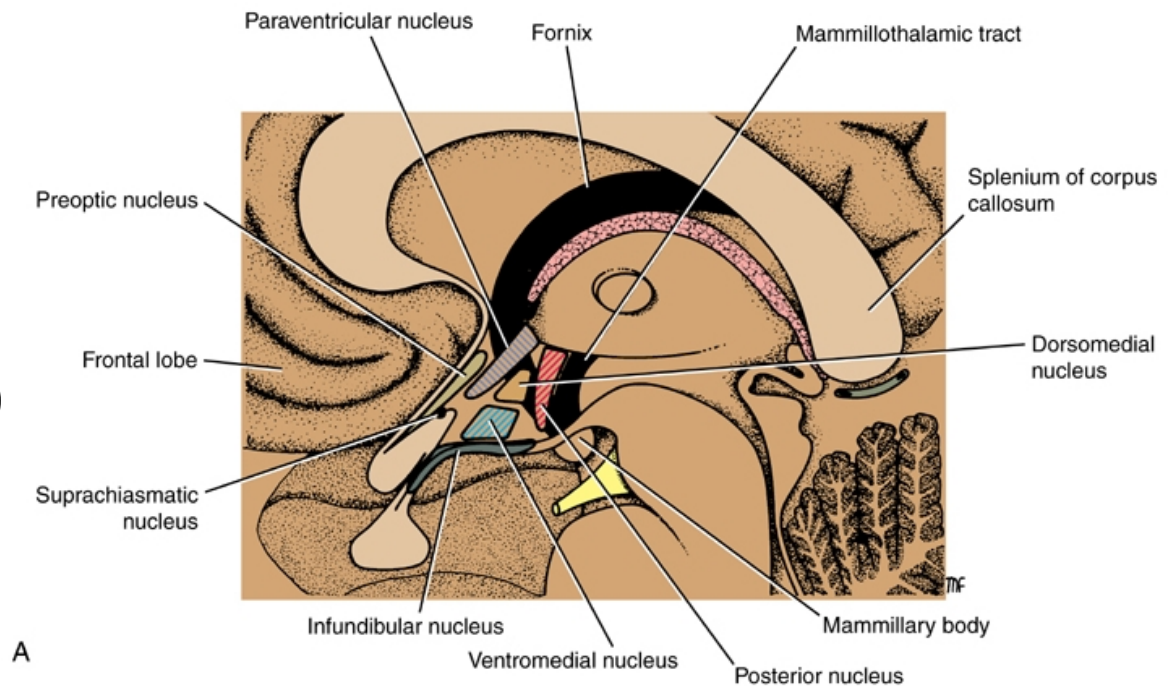


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Hypothalamus: Nuclei

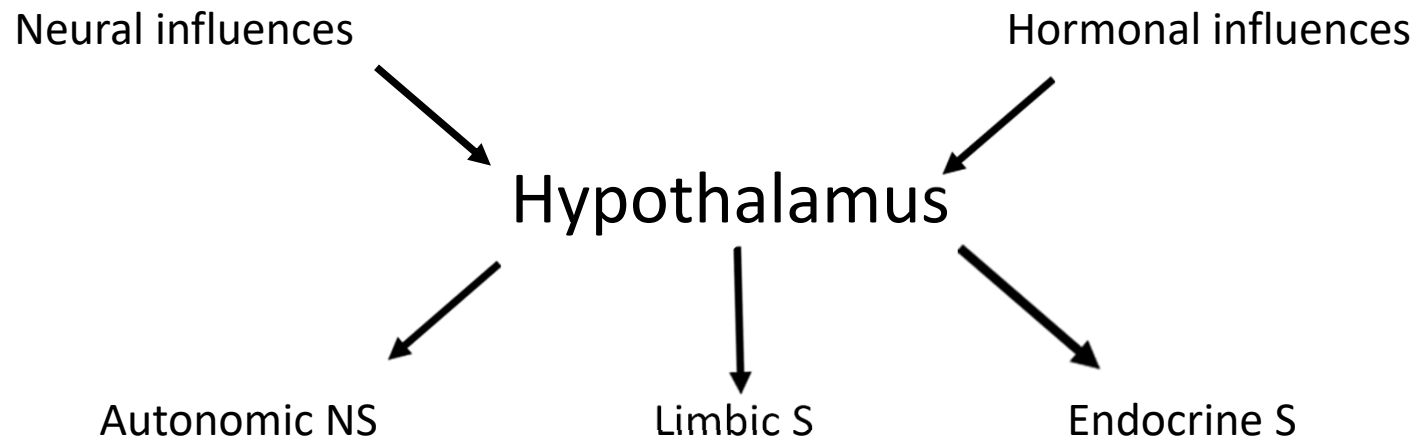
- Divisions

- In sagittal section
- Chiasmatic (anterior, supraoptic)
- Tuberal (middle)
- Mamillary (posterior)

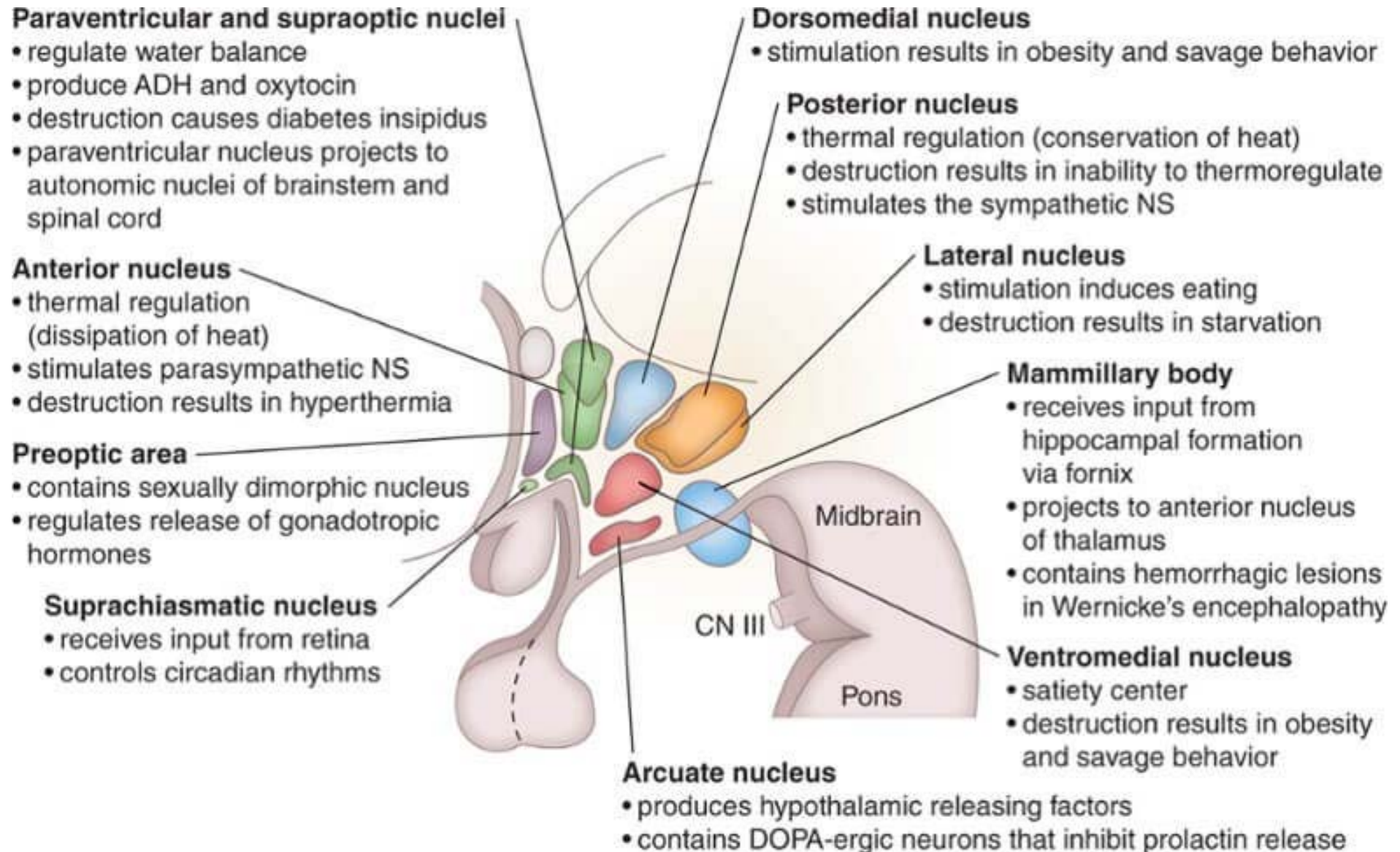


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Hypothalamus: Function



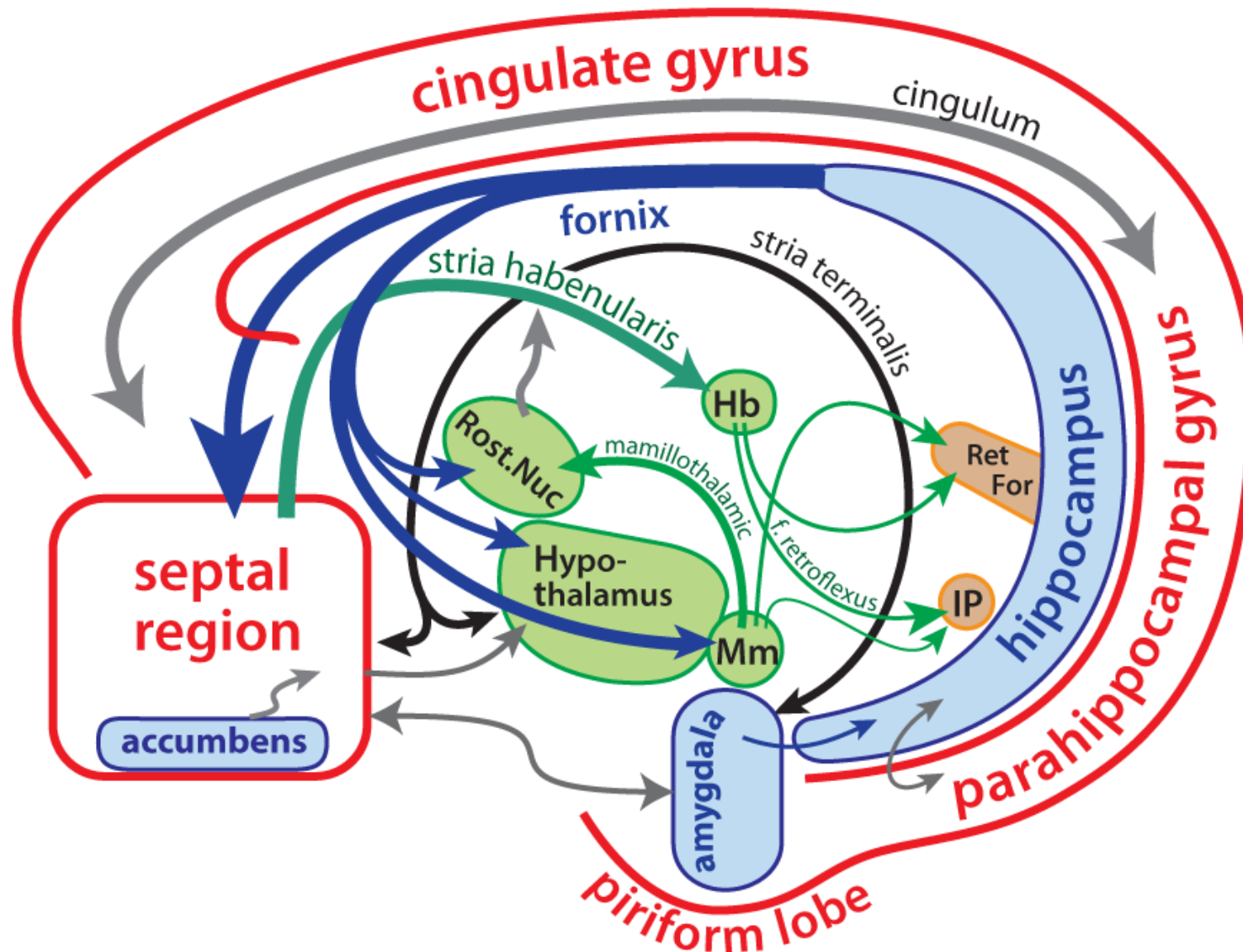
Hypothalamus: Nuclei & Functions



Limbic System

- Includes
 - Cingulate gyrus
 - Parahippocampal gyrus
 - Mamillary body
 - Hippocampus
 - Anterior & dorsomedial thalamic nuclei
 - Amygdala
 - Septal nuclei
 - Nucleus accumbens
 - Substantia innominata
- Involved in complex behaviors
 - To preserve life
 - Motivation
 - Emotions
 - Affective behavior
 - Memory

Limbic System: Components



Limbic System: Circuit of Papez

- Thought to have role in emotions, motivation & affective behavior

