NEUROHISTOLOGY III:
ORGANIZATION OF THE BRAINSTEM

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DEPARTMENT OF HUMAN ANATOMY

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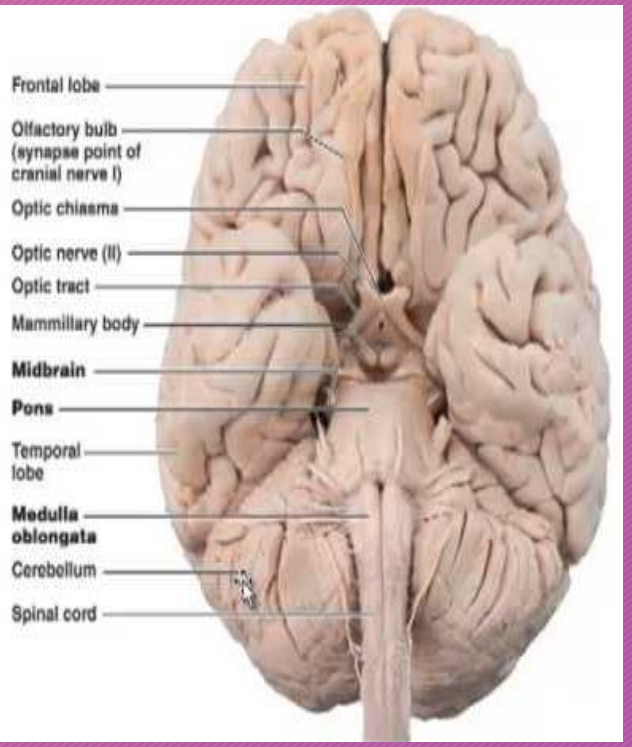
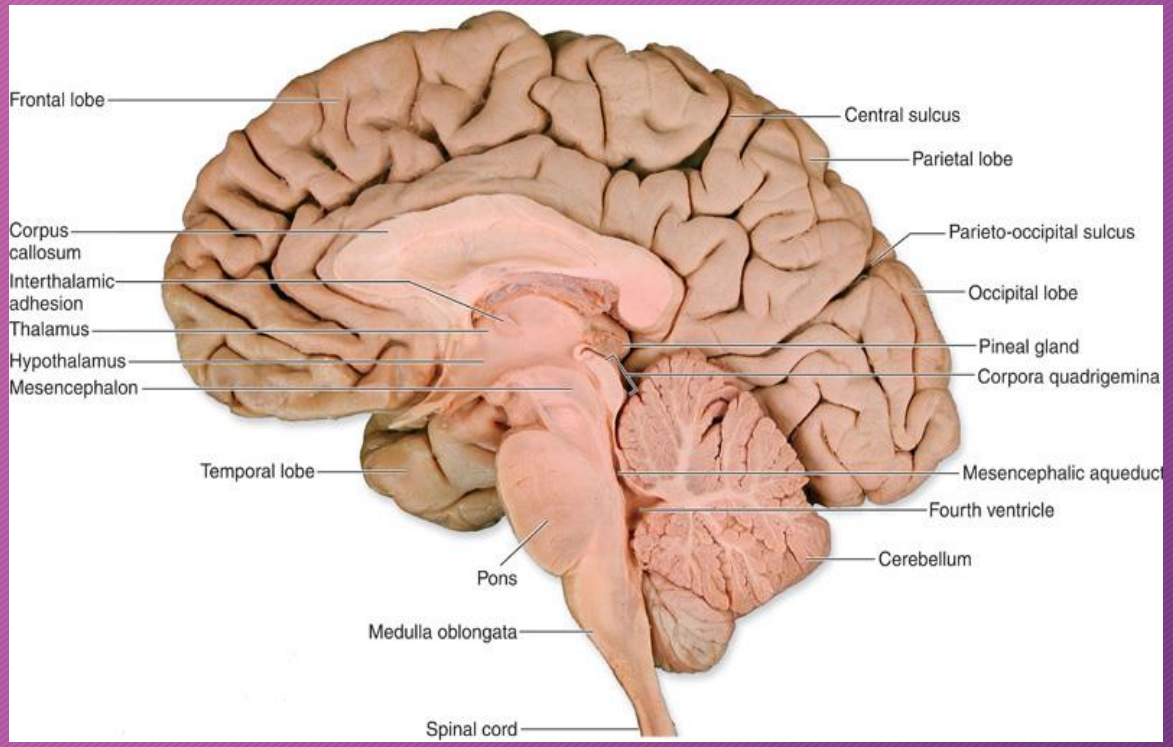
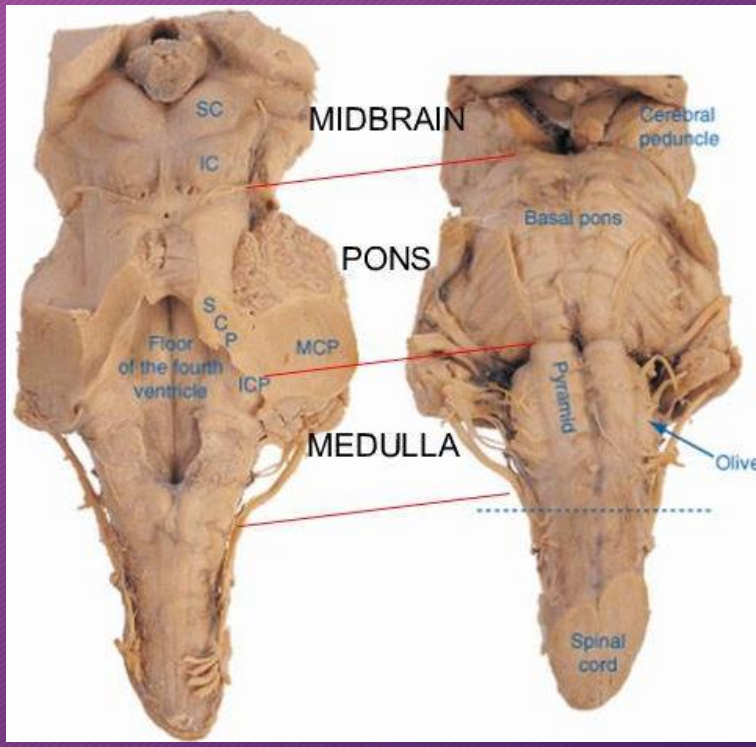
EXPECTED LEARNING OUTCOMES:

1. Name the parts of the brainstem
2. For each part [Midbrain, Pons and Medulla oblongata], describe:
    a) The external features
    b) Internal features – parts/histological zones, major fiber columns, major nuclei, cranial nerve nuclei and their functional components
3. Name major vascular syndromes of the brainstem and state the basis of each
4. State the organization and functions of the brainstem reticular formation

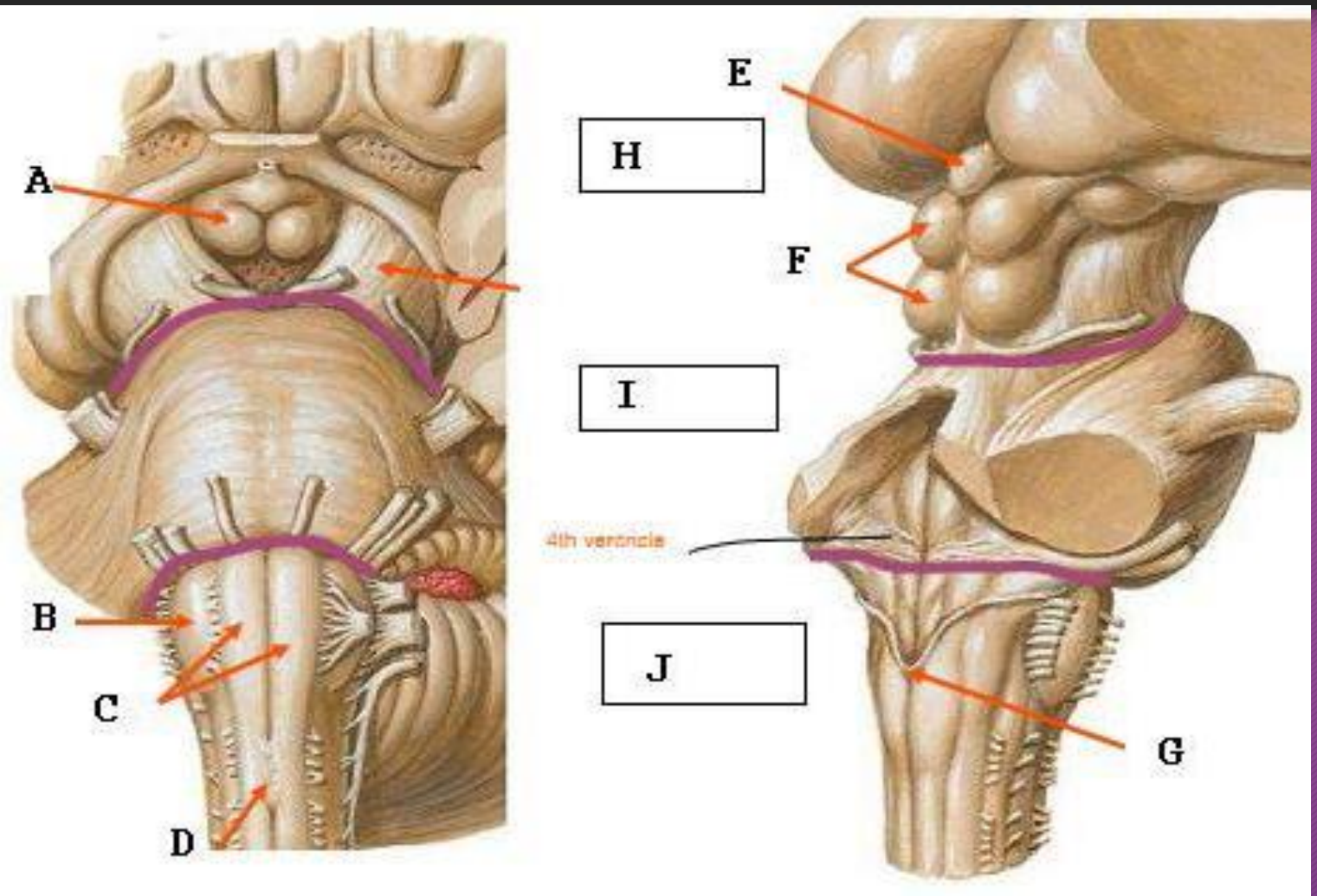
Parts of the Brainstem





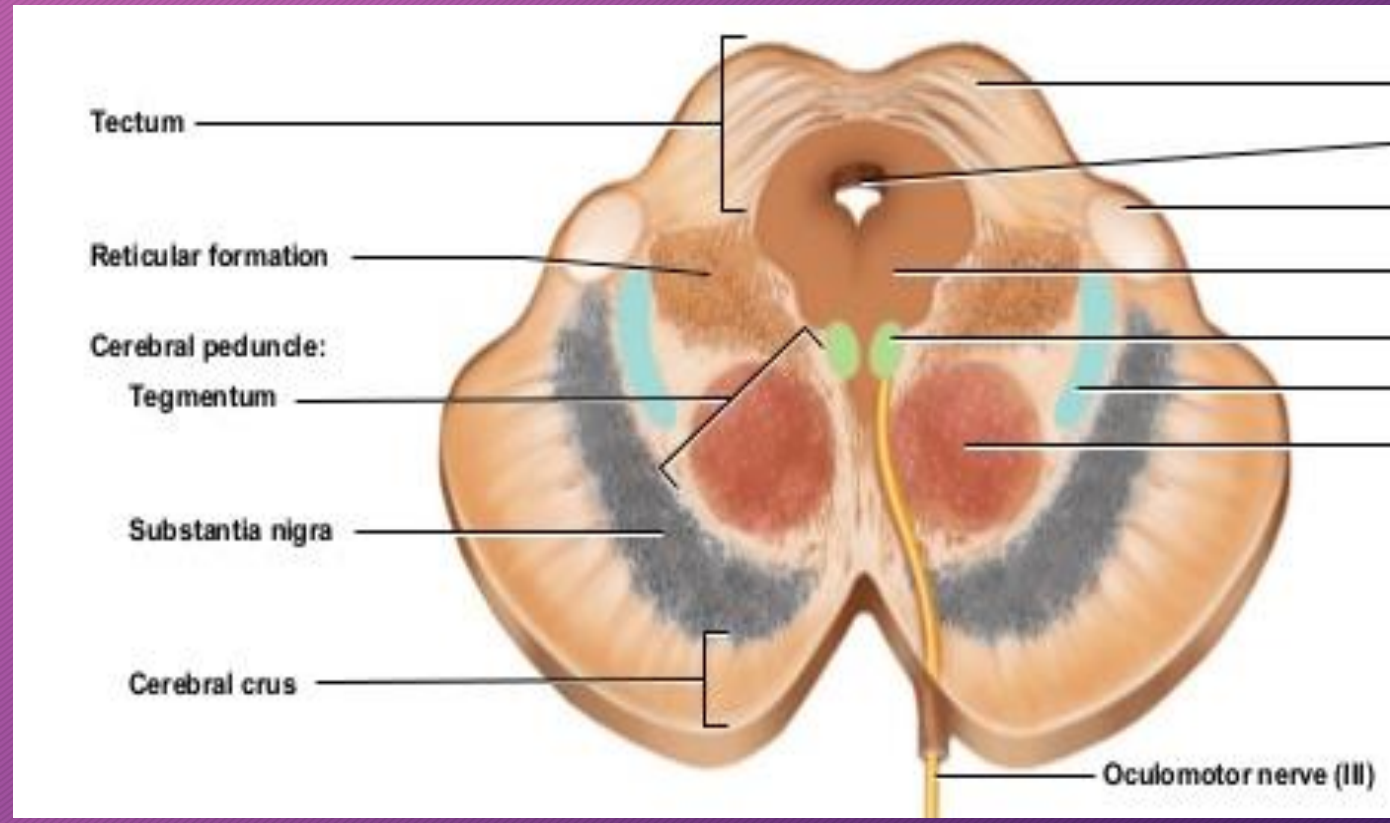


Midbrain – external features

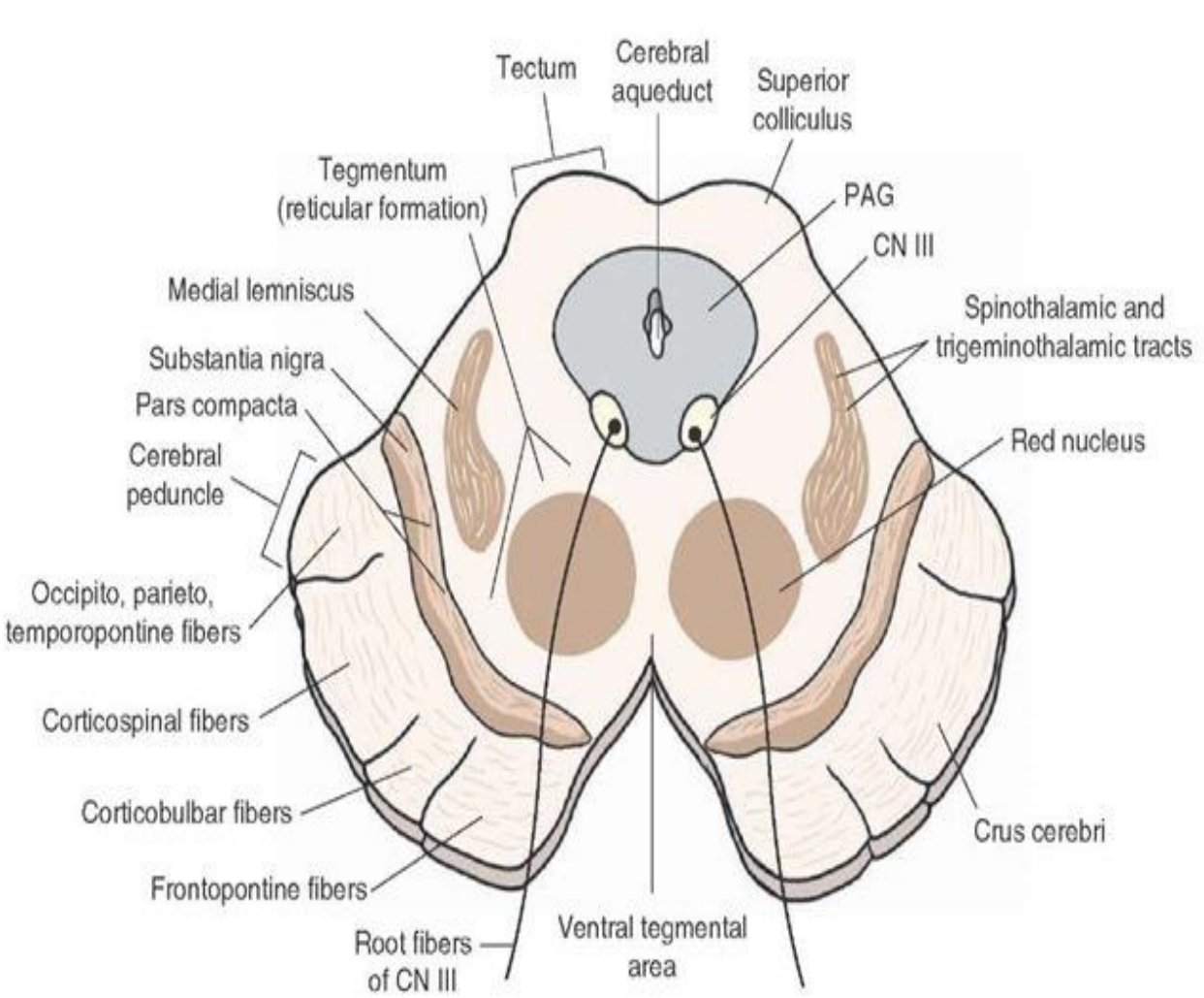


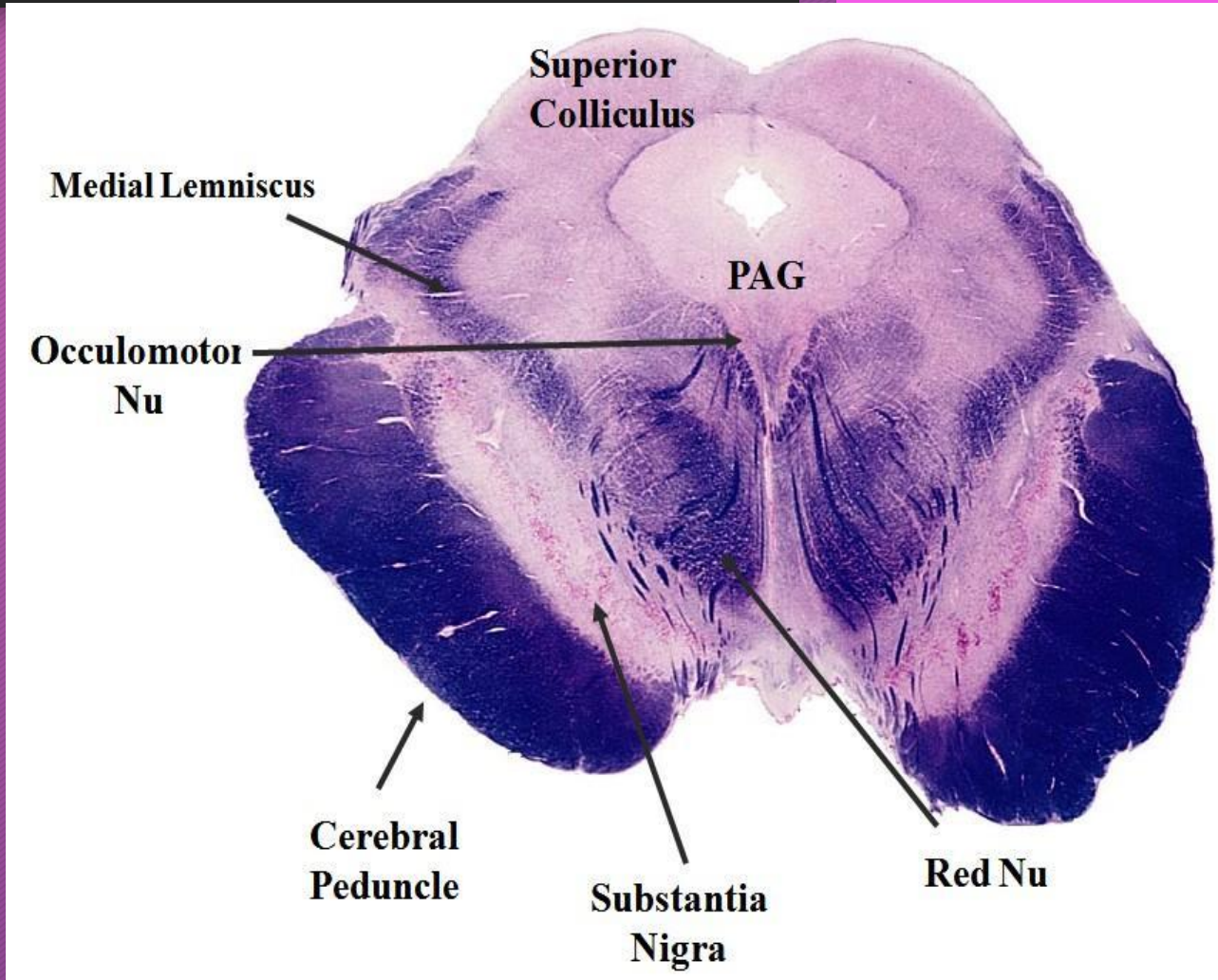
- **Ventral midbrain:**
  - Crus cerebri
  - Interpeduncular fossa
  - Posterior perforated substance
  - Oculomotor nerves
- **Dorsal midbrain:**
  - Colliculi – superior & inferior
  - Brachia – superior & inferior
  - Trochlea nerves

Midbrain internal features – histological parts

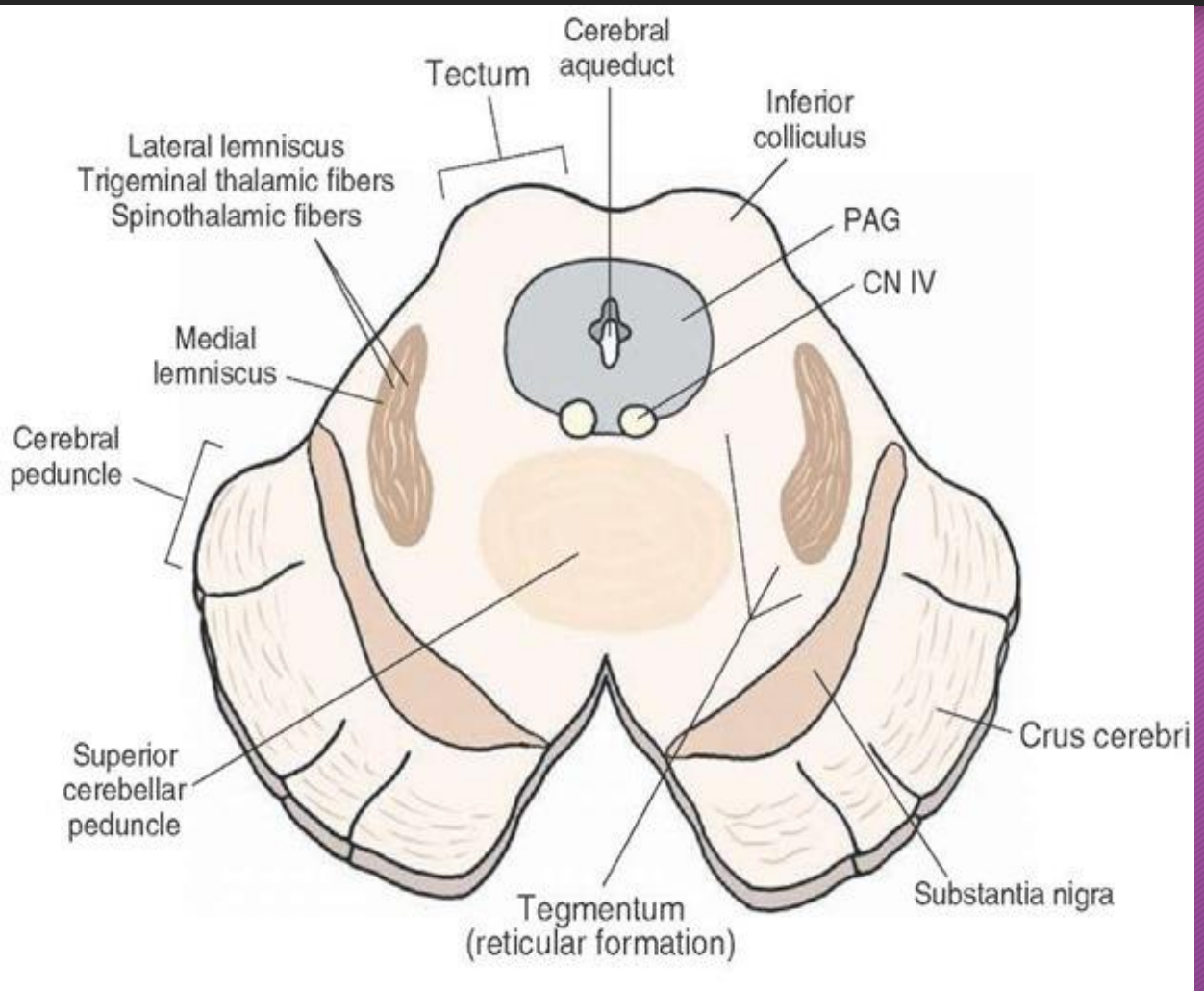


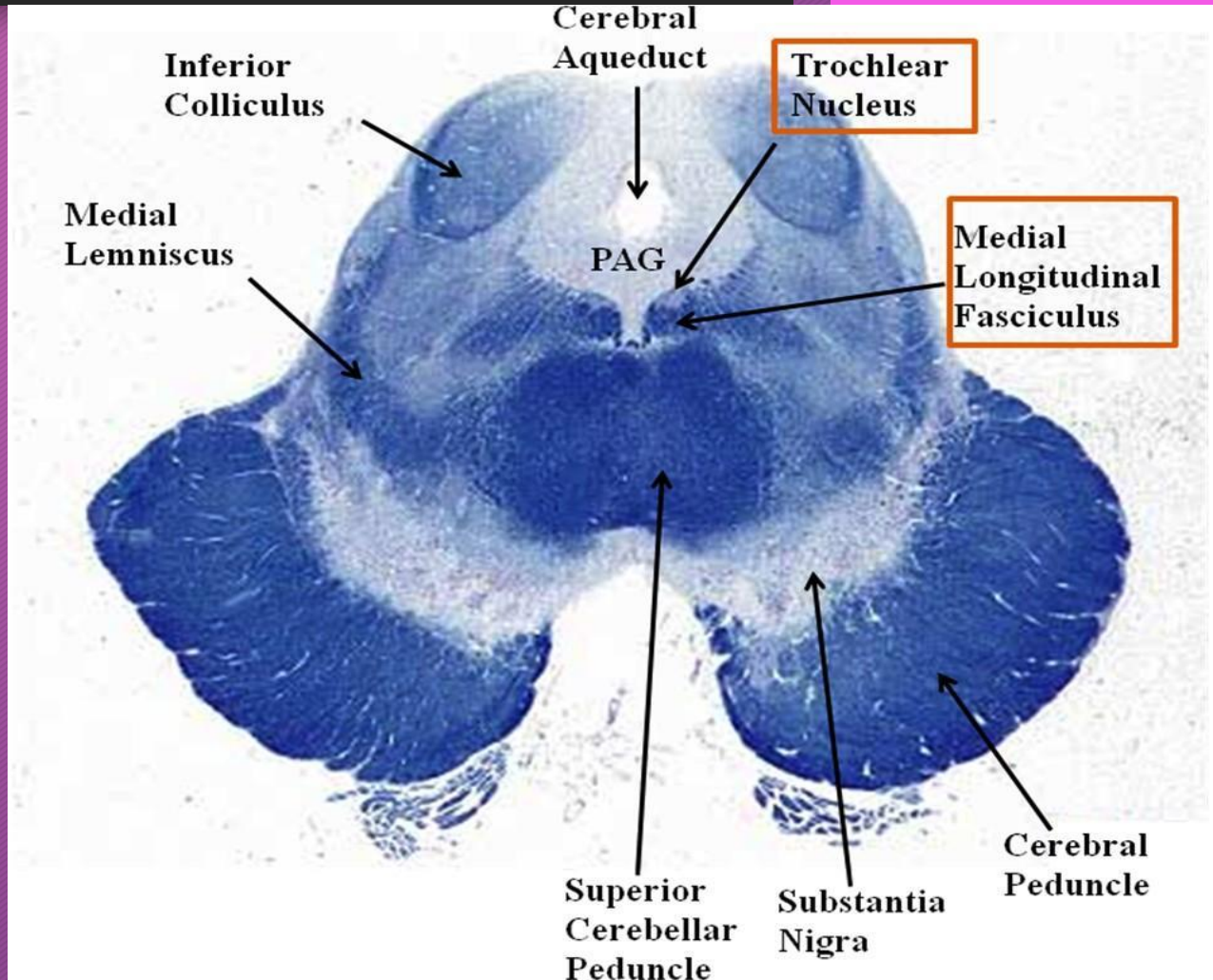
Midbrain – Level of Superior Colliculus





Midbrain – Level of Inferior Colliculus





Midbrain major fibers & nuclei

Major fibers:

- Crus cerebri
- Superior cerebellar peduncle
- Lemniscal systems
- Medial longitudinal fasciculus

Major nuclei

- Superior colliculus
- Inferior colliculus
- Pretectal nucleus
- Substantia nigra
- Red nucleus
- Periaqueductal grey
- Motor nucleus of III
- Edinger Westphal
- Trochlea nucleus

Crus cerebri

- Contains corticobulbar and corticospinal fibers
- Corticobulbar terminate in the brainstem; some are Corticonuclear
- Corticospinal terminate in the spinal cord; form the medullary pyramids
- Corticonuclear and corticospinal occupy the middle two-thirds
- Frontopontine occupy the medial sixth
- The rest (temporo-, parieto-, occipoto-pontine) occupy lateral sixth

Mesencephalic tegmentum

Lower segment

- Grey matter
  - ✓ Periaqueductal grey
  - ✓ Trochlear nucleus
  - ✓ Mesencephalic nucleus of the trigeminal
  - ✓ Reticular formation
- White matter
  - ✓ Decussation of the superior cerebellar peduncles
  - ✓ Medial longitudinal fasciculus
  - ✓ Medial, trigeminal, lateral and spinal lemnisci

Upper segment

- Grey matter
  - ✓ Periaqueductal grey
  - ✓ Oculomotor nucleus
  - ✓ Red nucleus
  - ✓ Mesencephalic nucleus of the trigeminal
  - ✓ Reticular formation
- White matter
  - ✓ Medial longitudinal fasciculus

Red nucleus

- Pink ovoid mass
  - ✓ The tint appears in fresh material (ferric iron pigment in its neurons)
- Afferents
  - ✓ Corticorubral (primary somatomotor and somatosensory areas)
  - ✓ Cerebellorubral (Interposed and dentate nuclei)
- Efferents
  - ✓ Rubrospinal tract
  - ✓ Rubro-olivary
- Control of movement – encode force, velocity and direction parameters (like corticospinal)
  - ✓ Primarily directs activity both during the terminal phase of a movement and preceding a movement
  - ✓ Execution of learnt automated movements

Substantia nigra

- Located between crus cerebri and ascending lemniscal fibres
- Medial part traversed by oculomotor axons
- Divided into pars compacta (dorsally) and pars reticulate (ventrally)
- The pars compacta – Dopaminergic neurons;
  - ✓Provide nigrostriatal fibers, key in pathogenesis of Parkinson's disease
  - ✓Ventral tegmental system of dopaminergic neurons key in adaptive behavior
- The pars reticulata – mainly GABArgic neurons
  - ✓Receive striatonigral and subthalamonigral fibres
  - ✓Project to the ventral anterior and dorsomedial thalamic nuclei
-

Superior colliculus

- Laminated structure; stratum
  - Zonale, cinereum, opticum & lemnisci [griseum medium, album medium, griseum profundum and album profundum]
  - Zonal, superficial grey, optic, intermediate grey, deep grey, deep white and periventricular
- Afferents: Corticotectal (visual cortex), optic tract (retina) & spinotectal
- Efferents: Tectospinal (cervical segments), tectobulbar, tecto-olivary
- Function: Visual reflexes

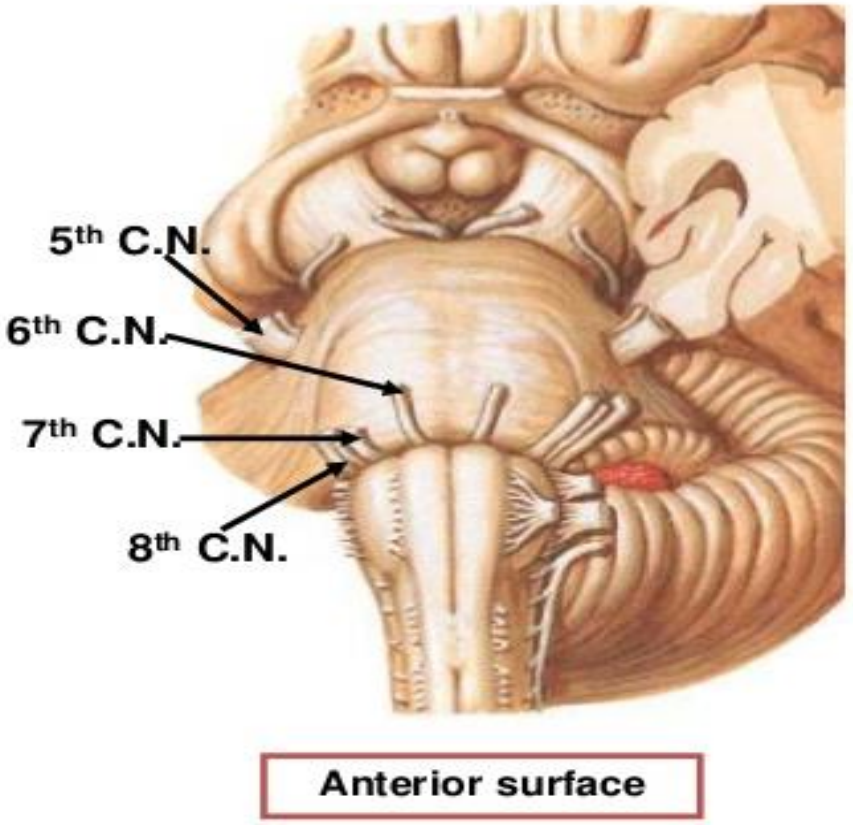
Pretectal nucleus

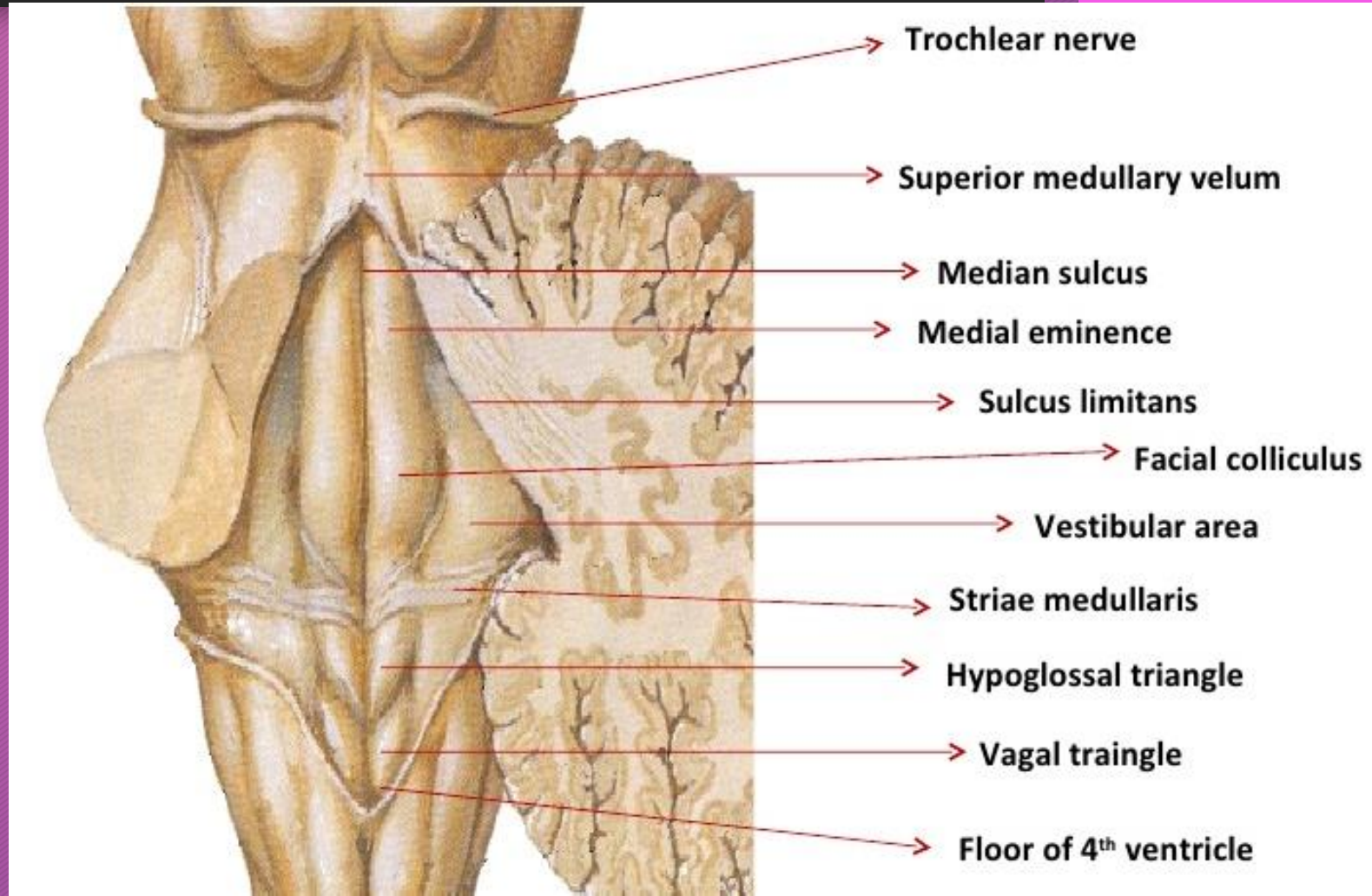
- Located at the junction of the mesencephalon and diencephalon
- Afferents from:
    - Optic tract (retina)
    - Superior colliculus
- Efferent to Edinger-Westphal nuclei bilaterally
- Function – bilateral light reflex

Inferior colliculus

- Afferents
  - Lateral lemniscus
  - Auditory cortex (via medial geniculate body)
- Efferents:
  - Inferior brachium to the MGB
  - Inferior brachium, MGB, auditory radiation to auditory cortex
  - Tectospinal & tectotegmental tracts
- Functions - Auditory reflexes, tonal discrimination & sound localization

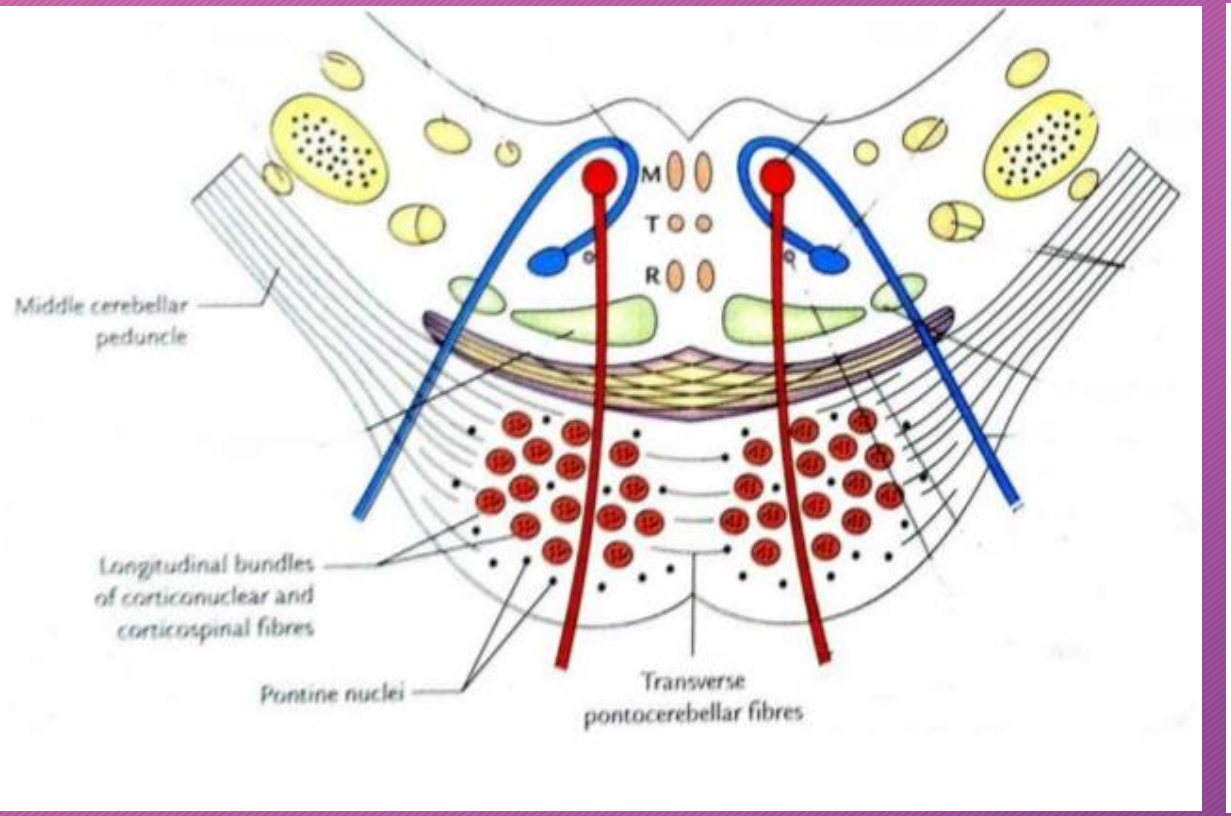
Pons – external features



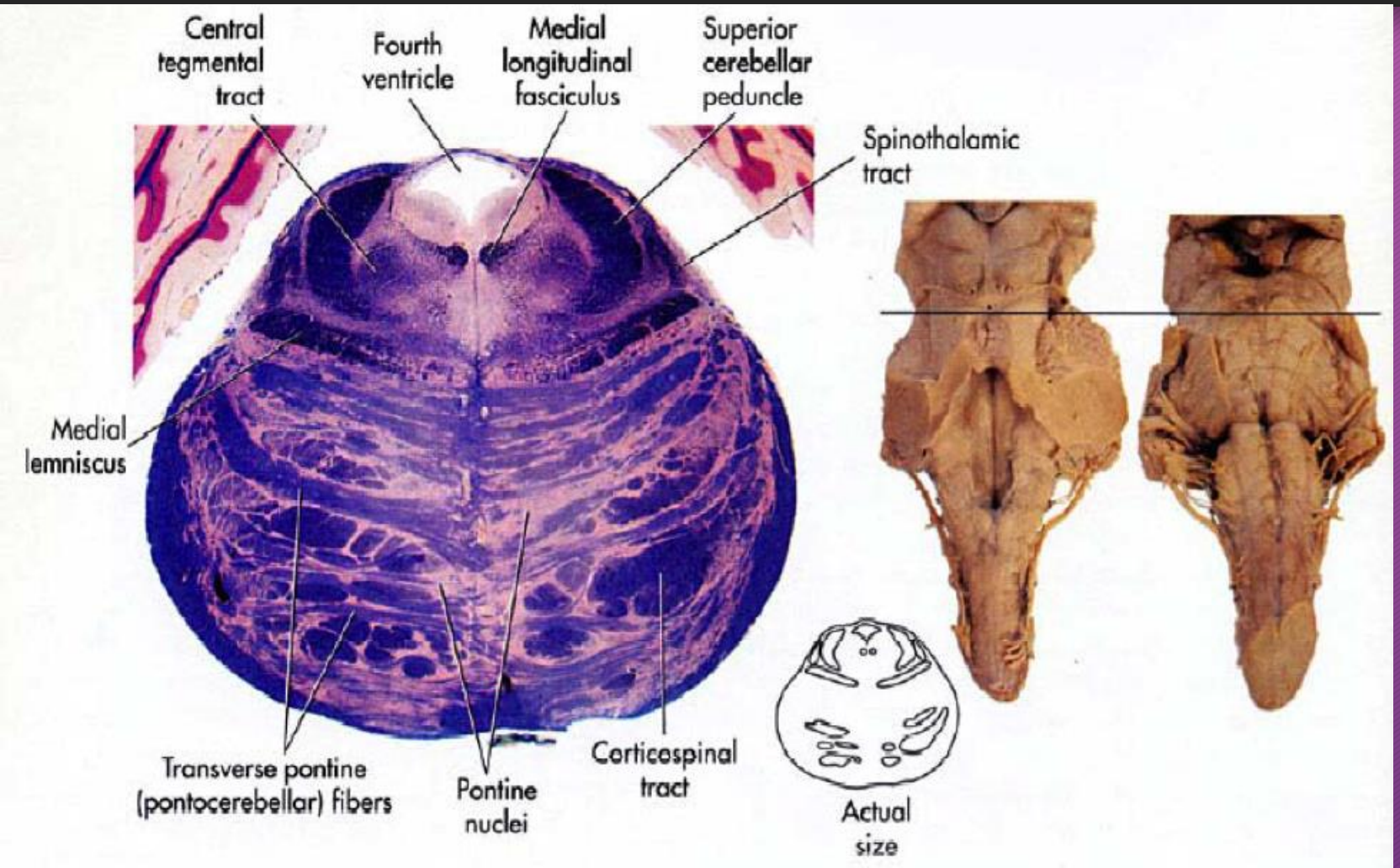


Pons – histological zones

- Basal pons & Pontine tegmentum



Ventral/Basal Pons

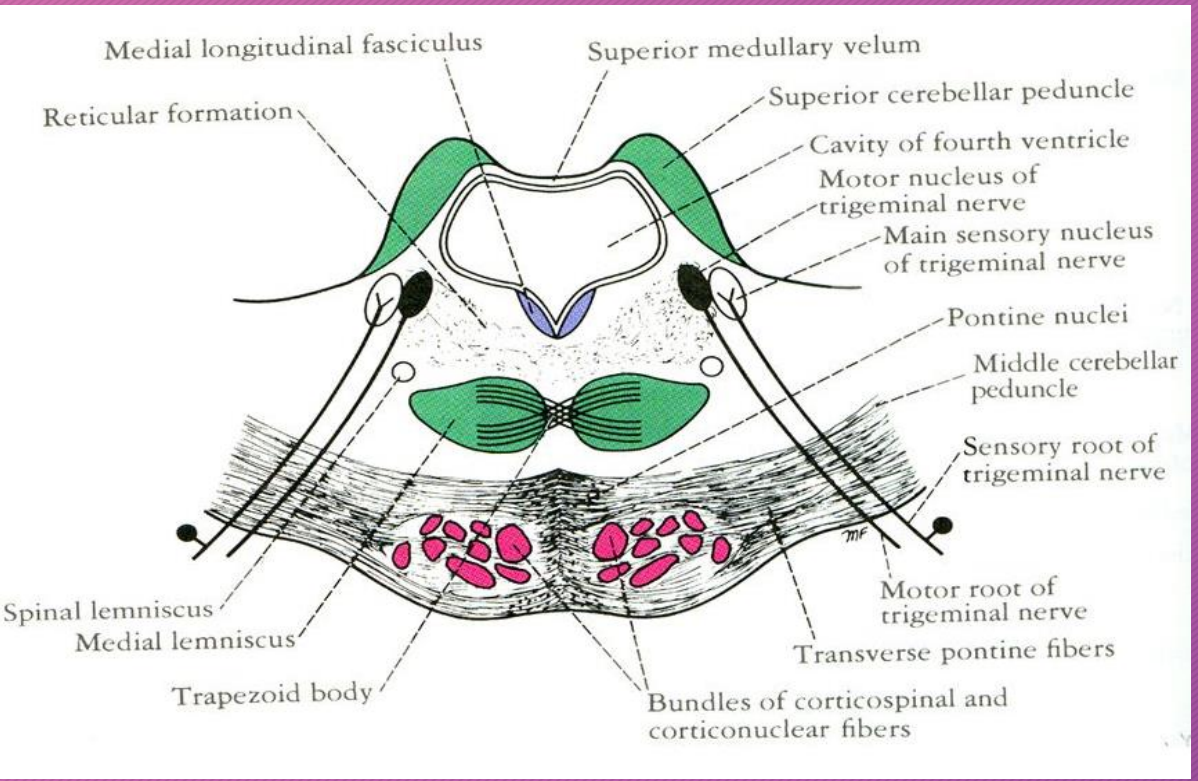


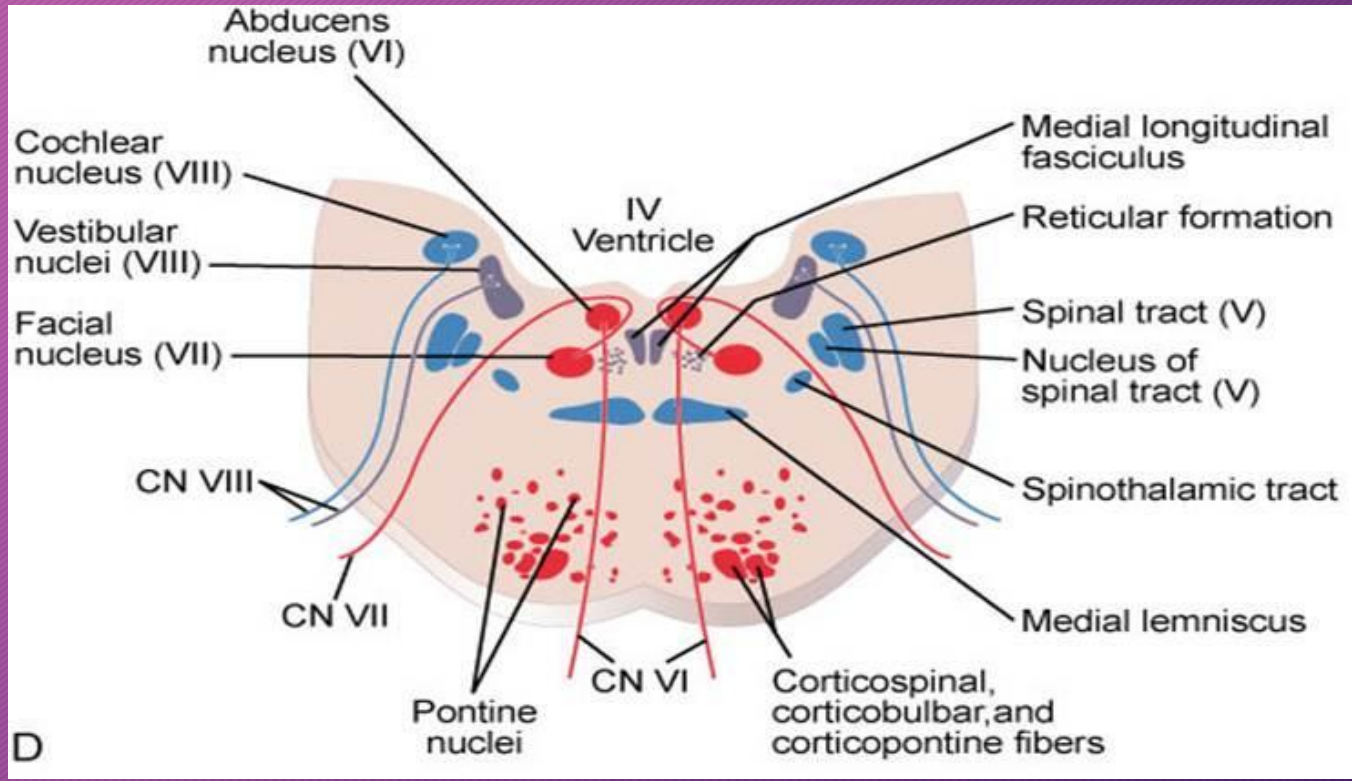
- Longitudinal descending fibres (corticospinal and corticobulbar)
- Scattered pontine nuclei
- Transverse and decussating pontocerebellar fibers

Cortico-ponto-cerebellar fiber system

- Corticopontine fibers
  - ✓ Arise layer V of the premotor, somatosensory, posterior parietal, extrastriate visual and cingulate neocortices
- Pontine nuclei
  - ✓ Scattered throughout the ventral pons
  - ✓ Project to contralateral cerebellar cortex
- Pontocerebellar fibers
  - ✓ From pontine nuclei
  - ✓ Decussate and continue as the contralateral middle cerebellar peduncle
  - ✓ End as mossy fibres in the cerebellar cortex

Pontine tegmentum

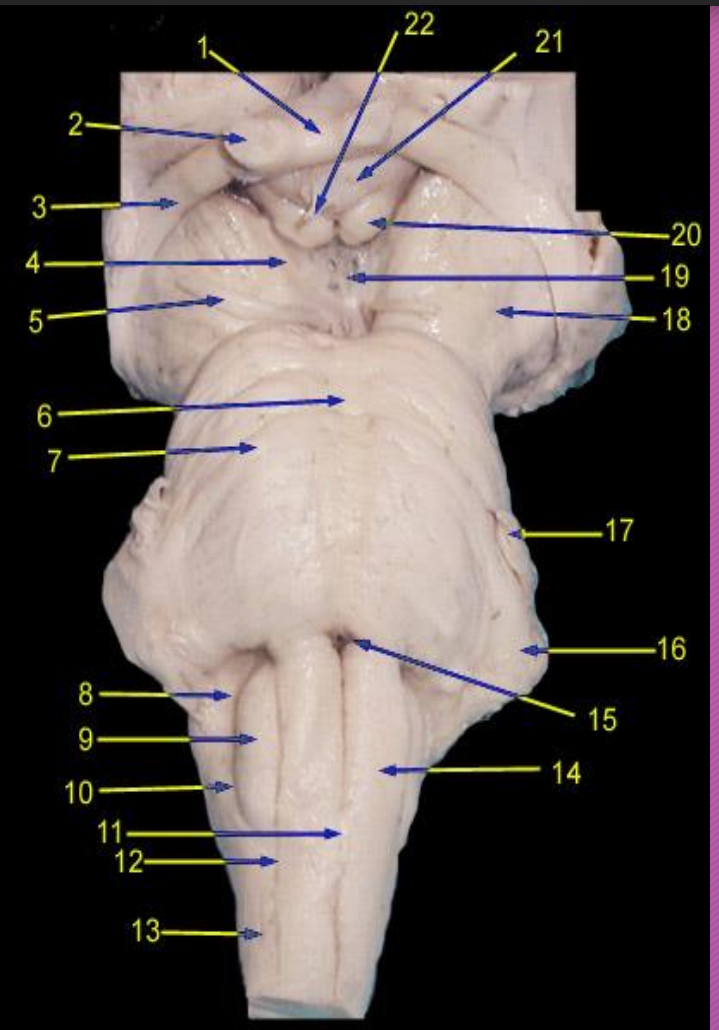


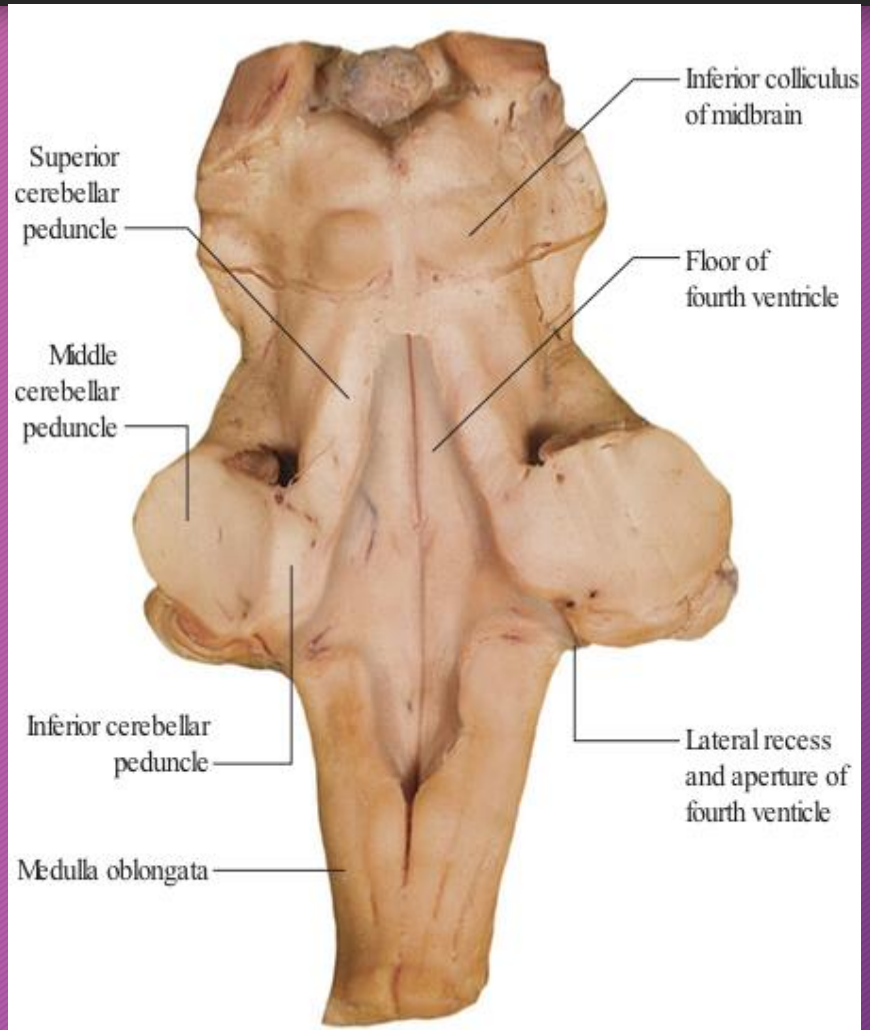


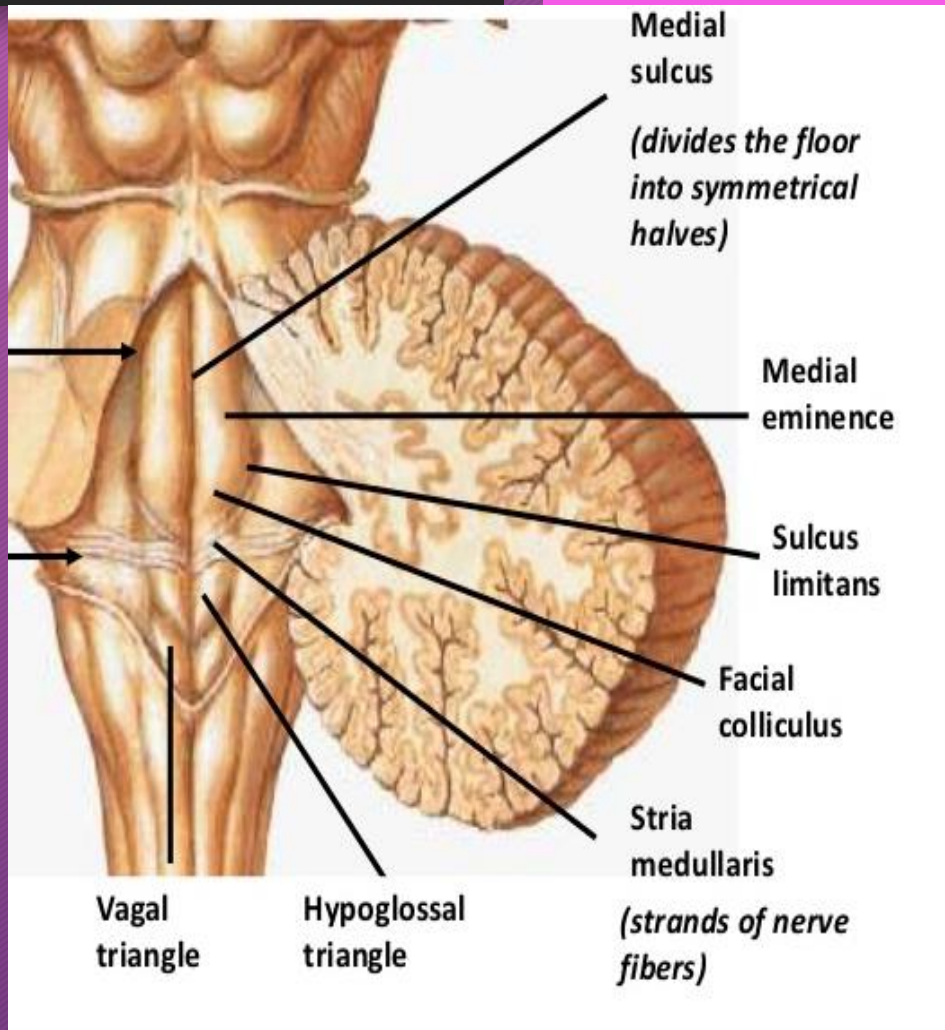
Pontine cranial nerve nuclei

- CN V to VIII**
- GSA - Trigeminal sensory nucleus (Chief/Principal, mesencephalic & spinal)
- SVE – Motor nucleus of V; Motor nucleus of VII
- GSE – Abducens nucleus
- SSA - Cochlear nuclei (dorsal & ventral), Vestibular nuclear complex
- GVE – Salivatory (superior & inferior)

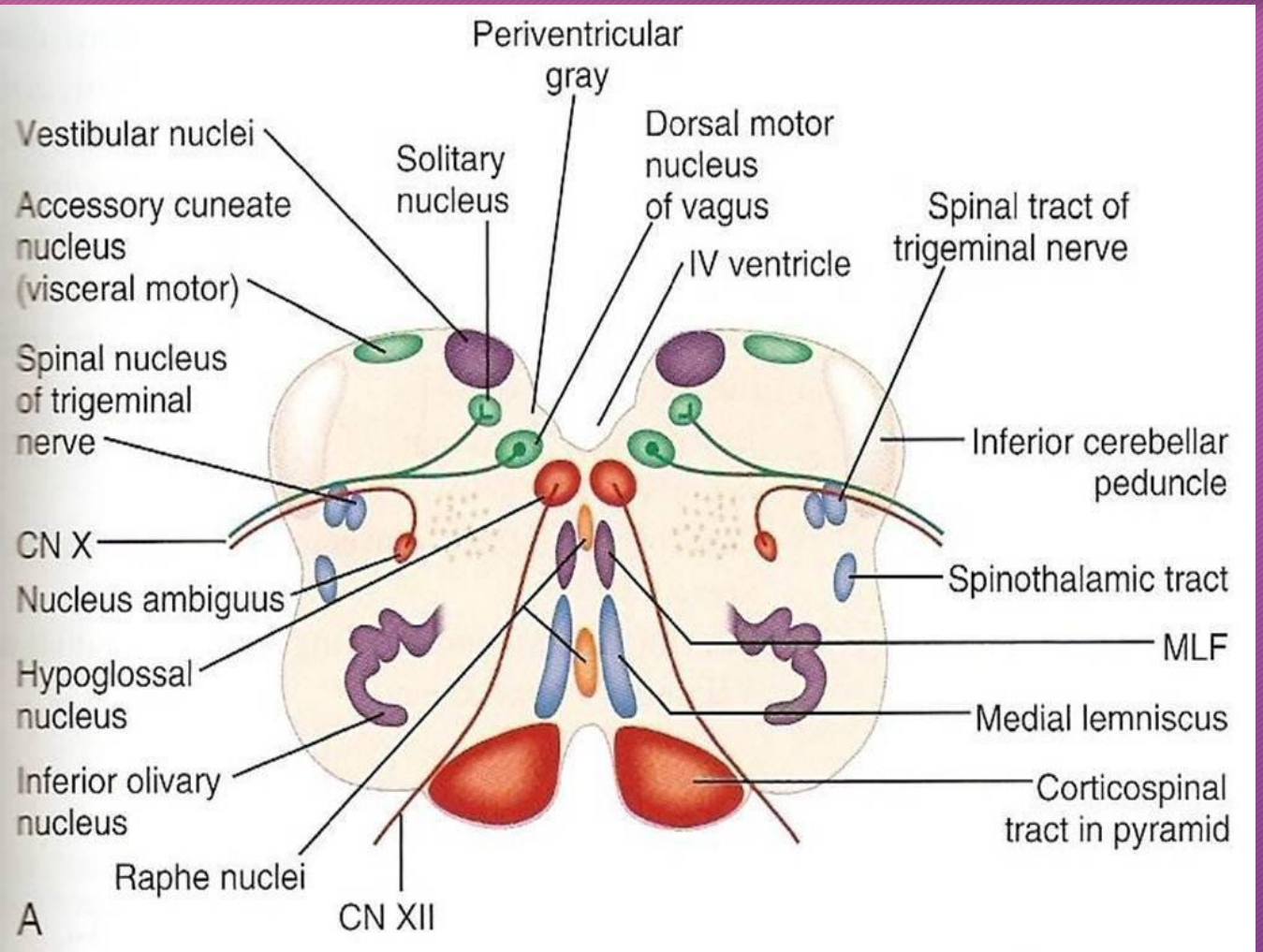
Medulla oblongata – external features

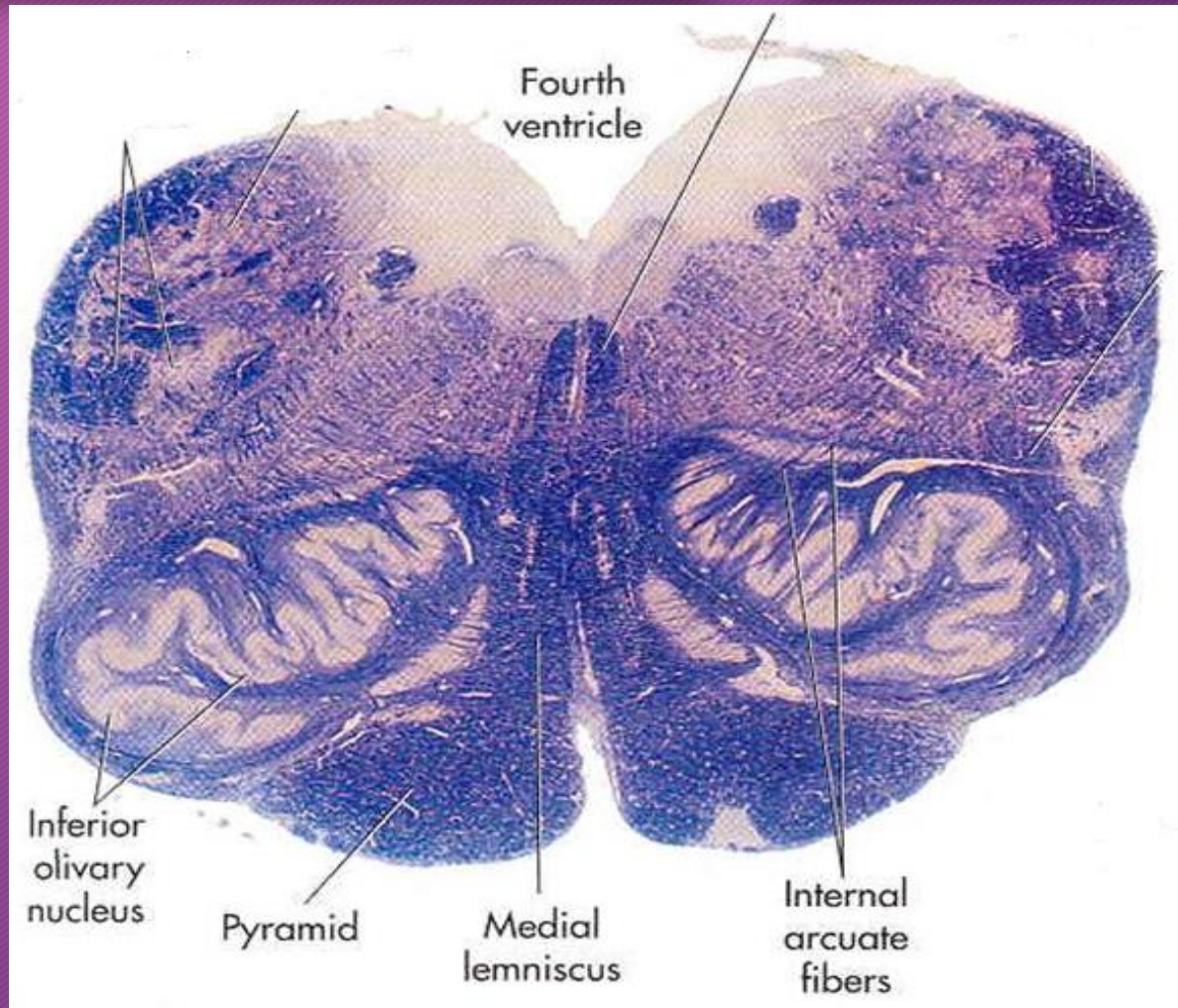




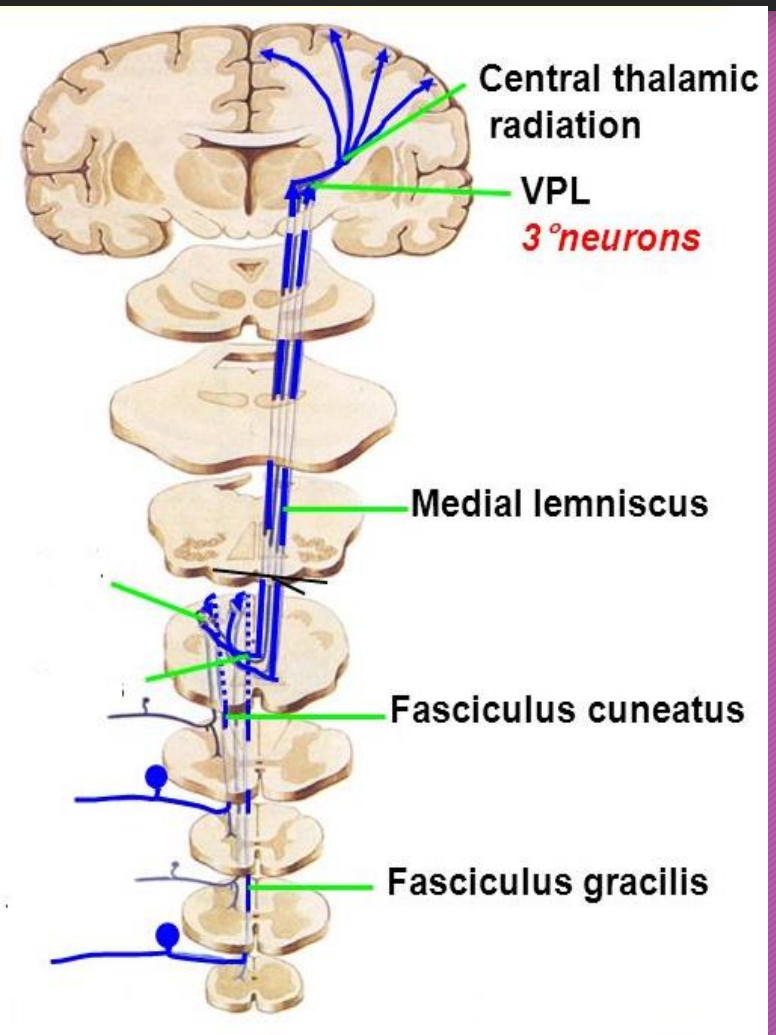


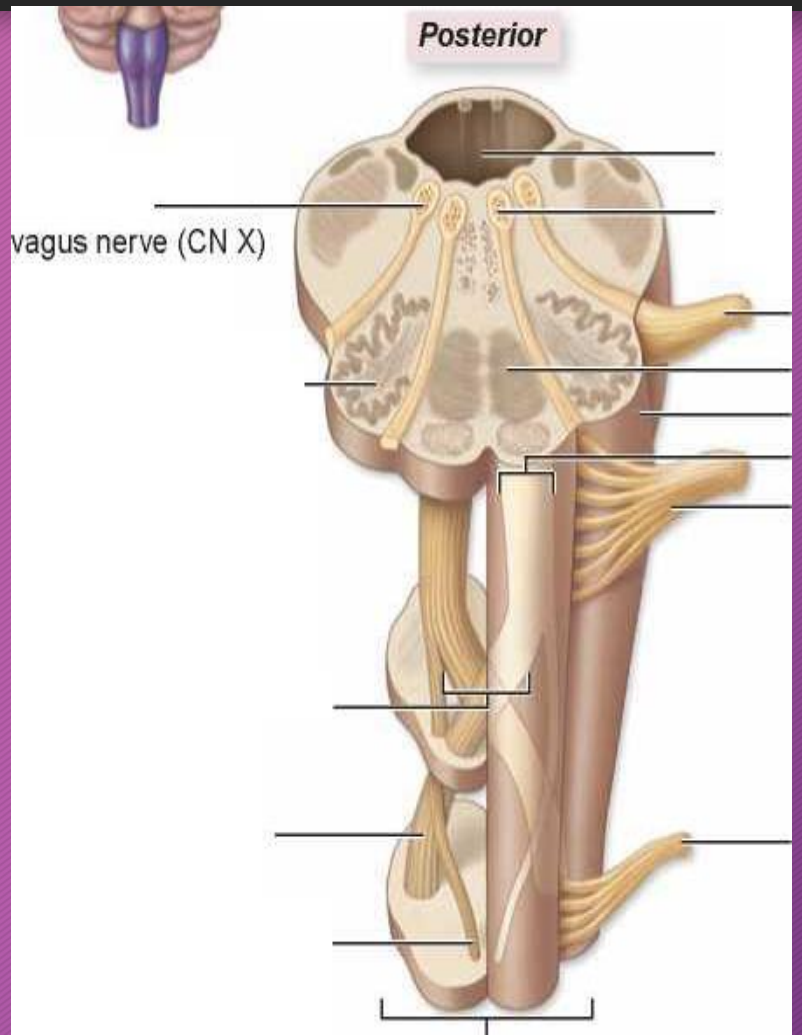
Open (upper) medulla

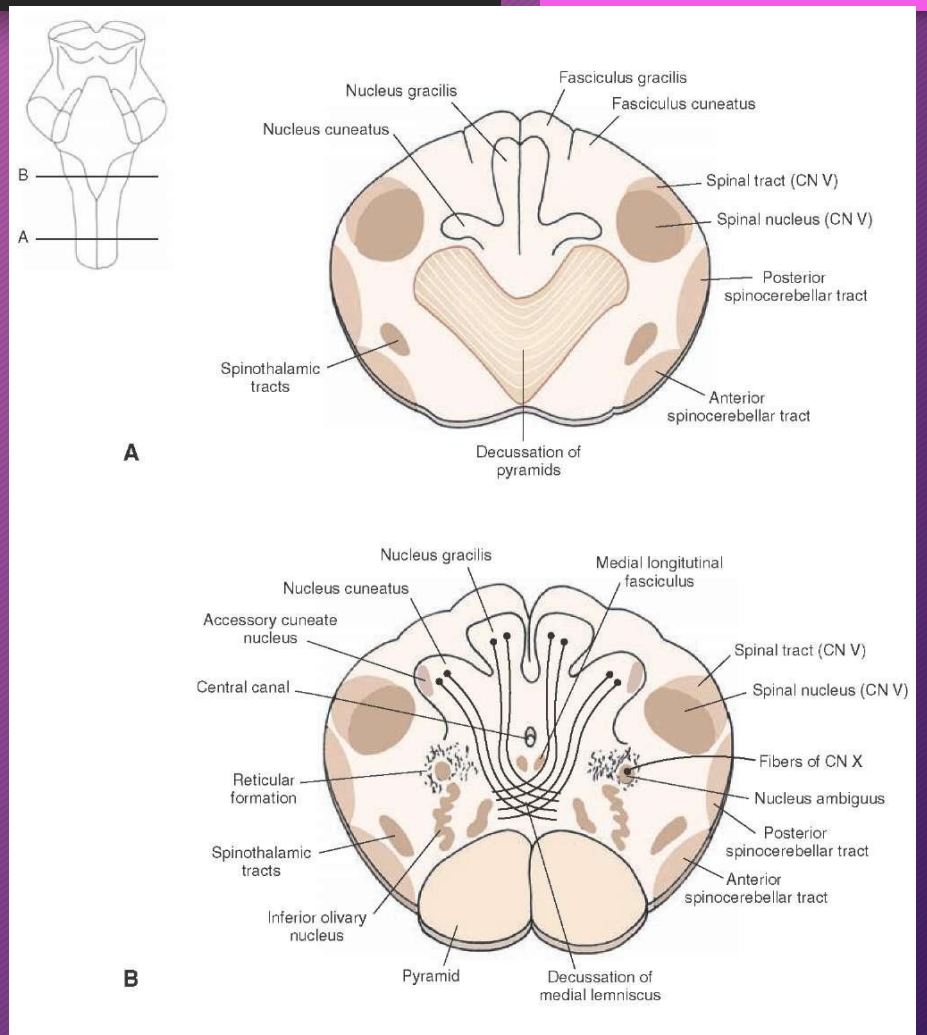




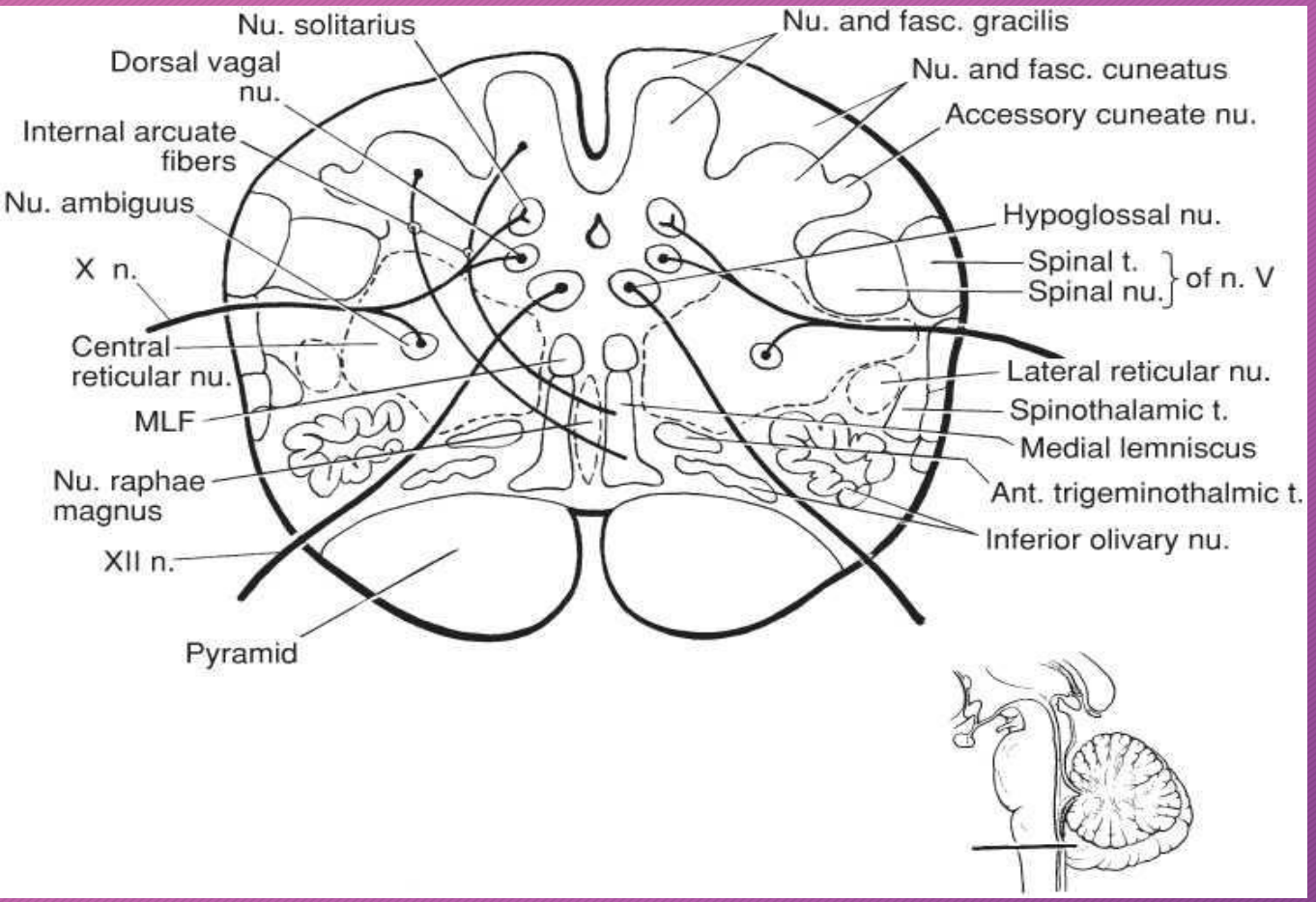
Closed medulla

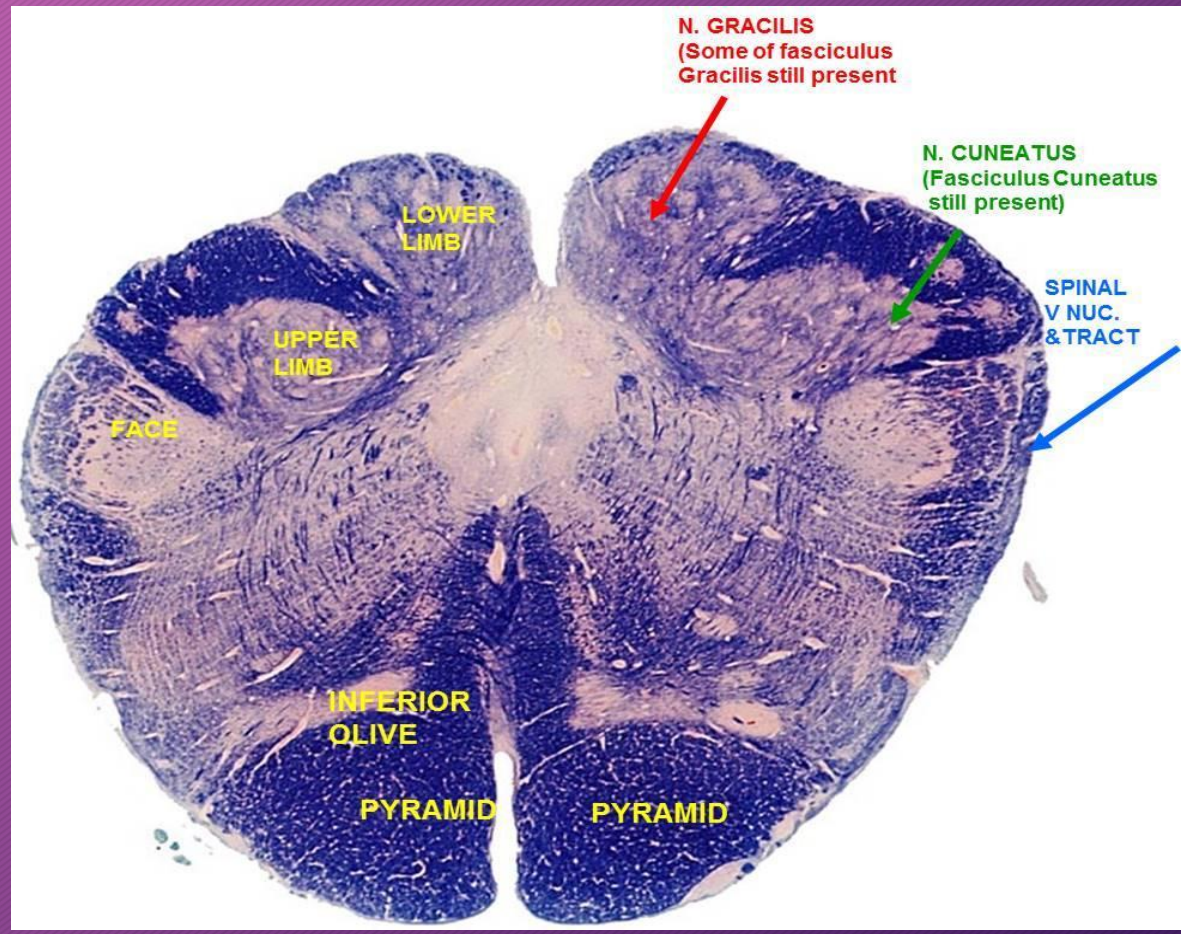




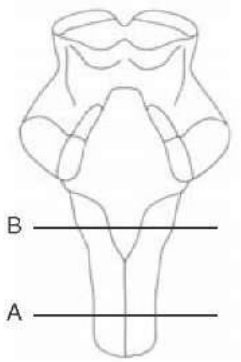


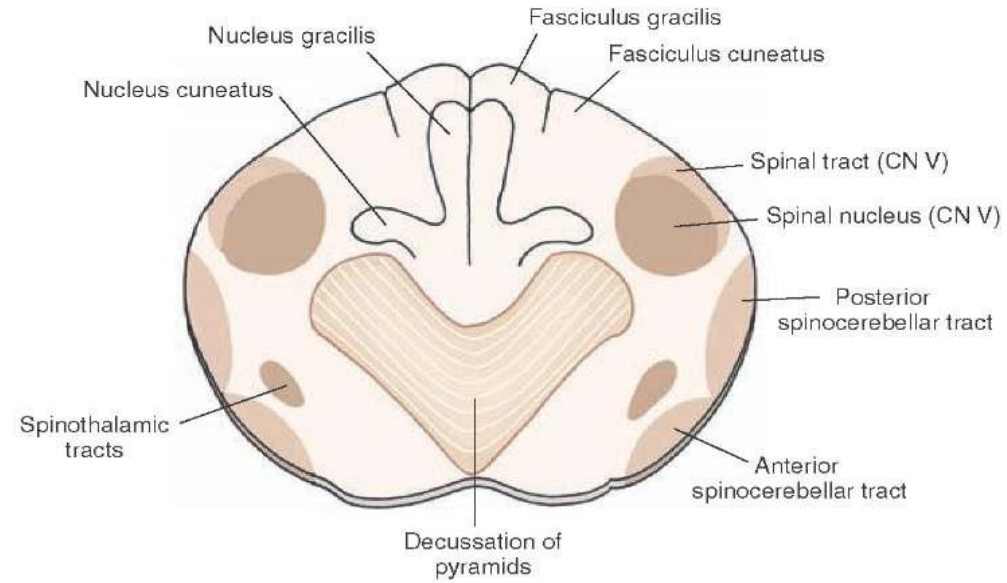
Closed medulla – Level of sensory decussation (mid medulla)





Closed medulla – Level of motor decussation (Lower medulla) 1





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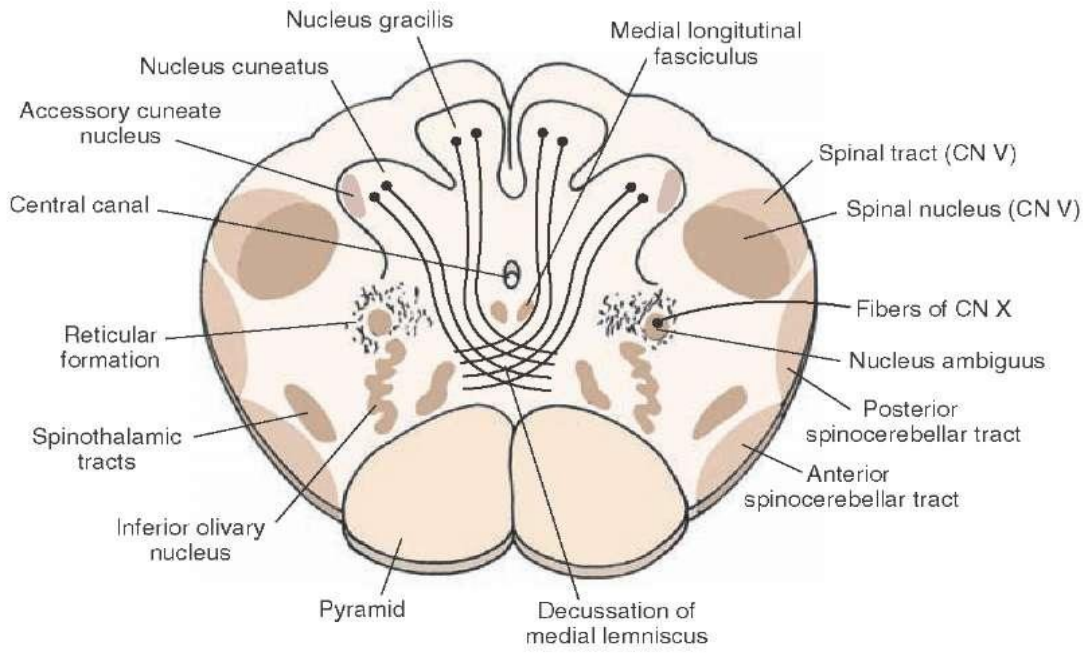

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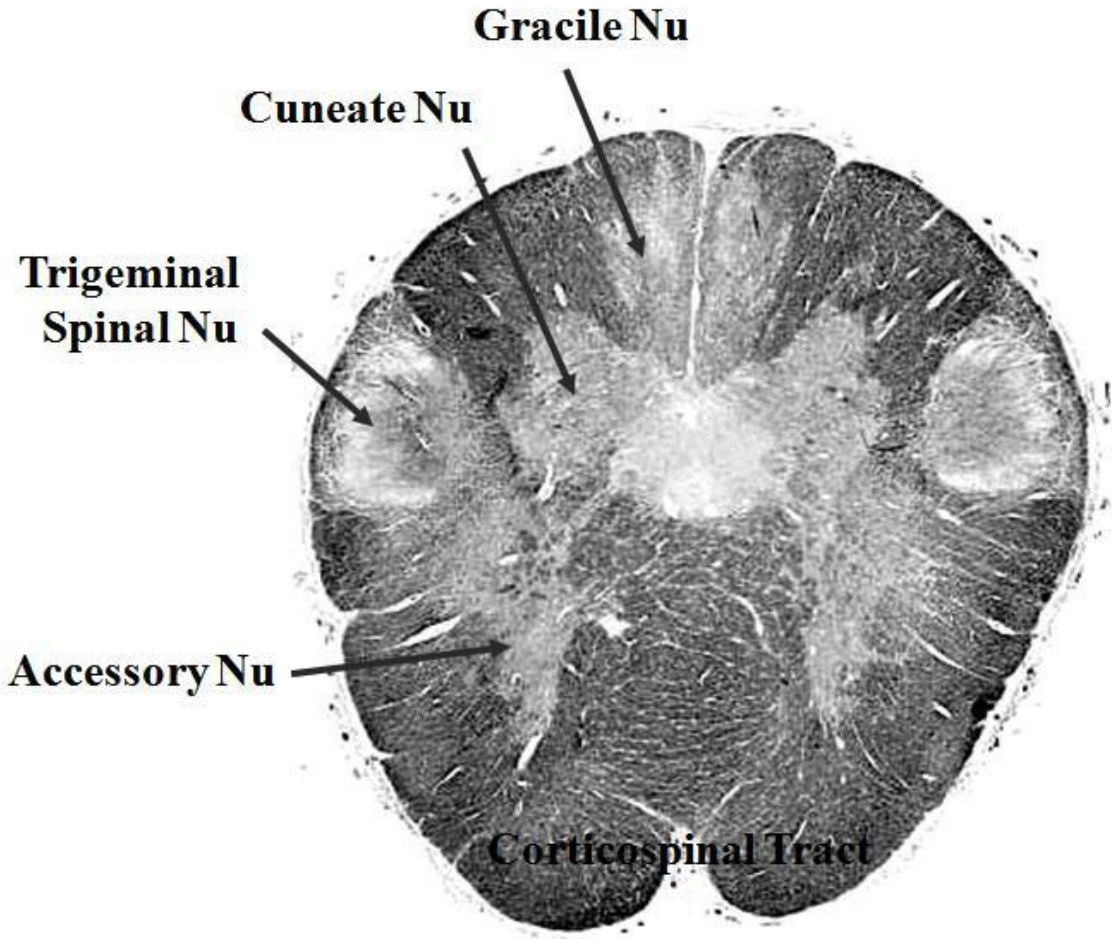

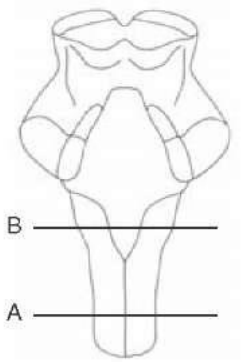

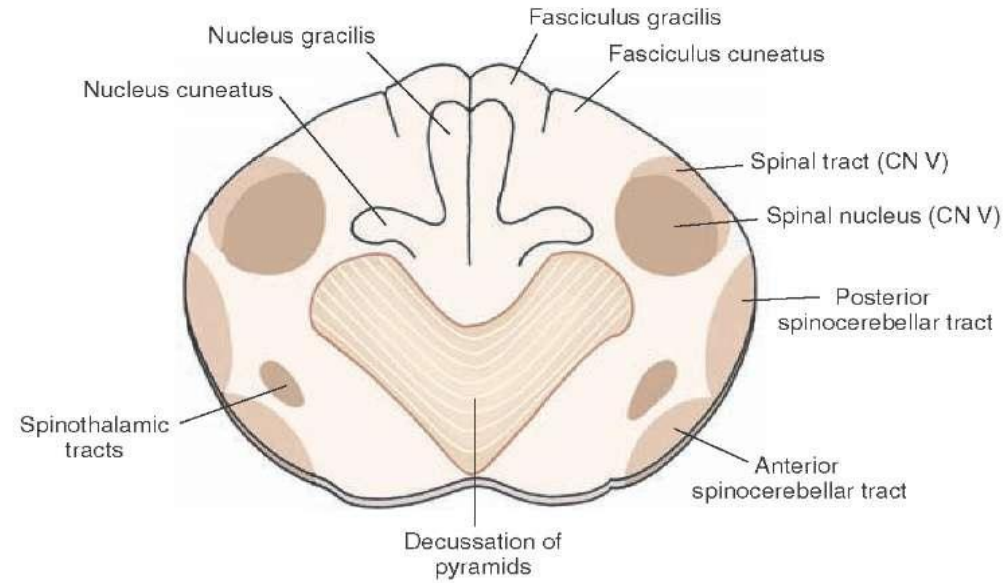

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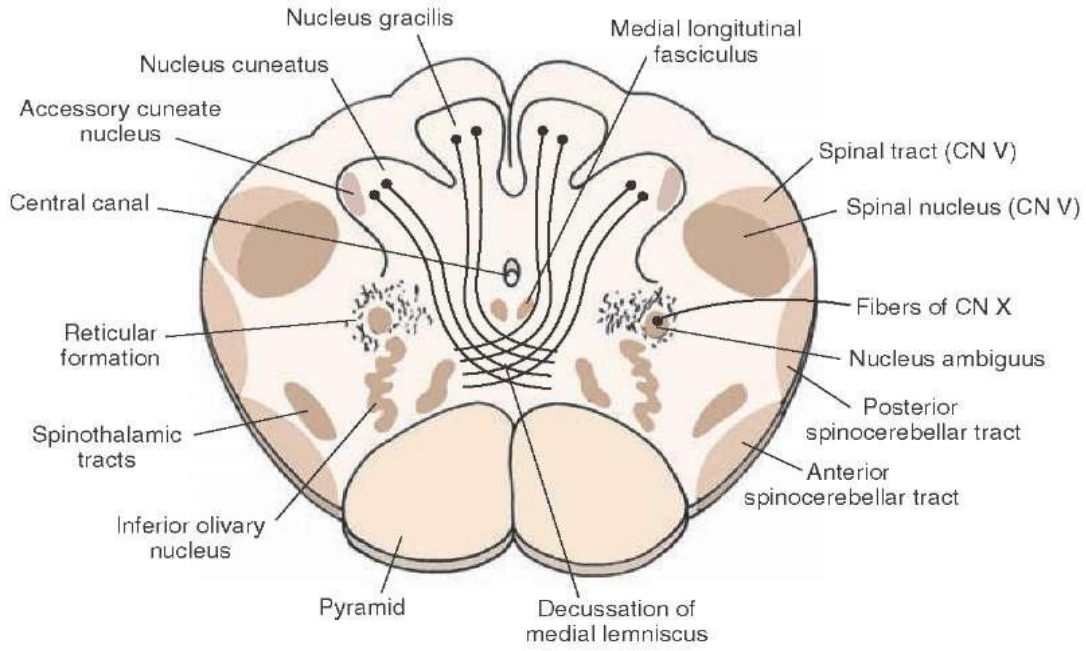

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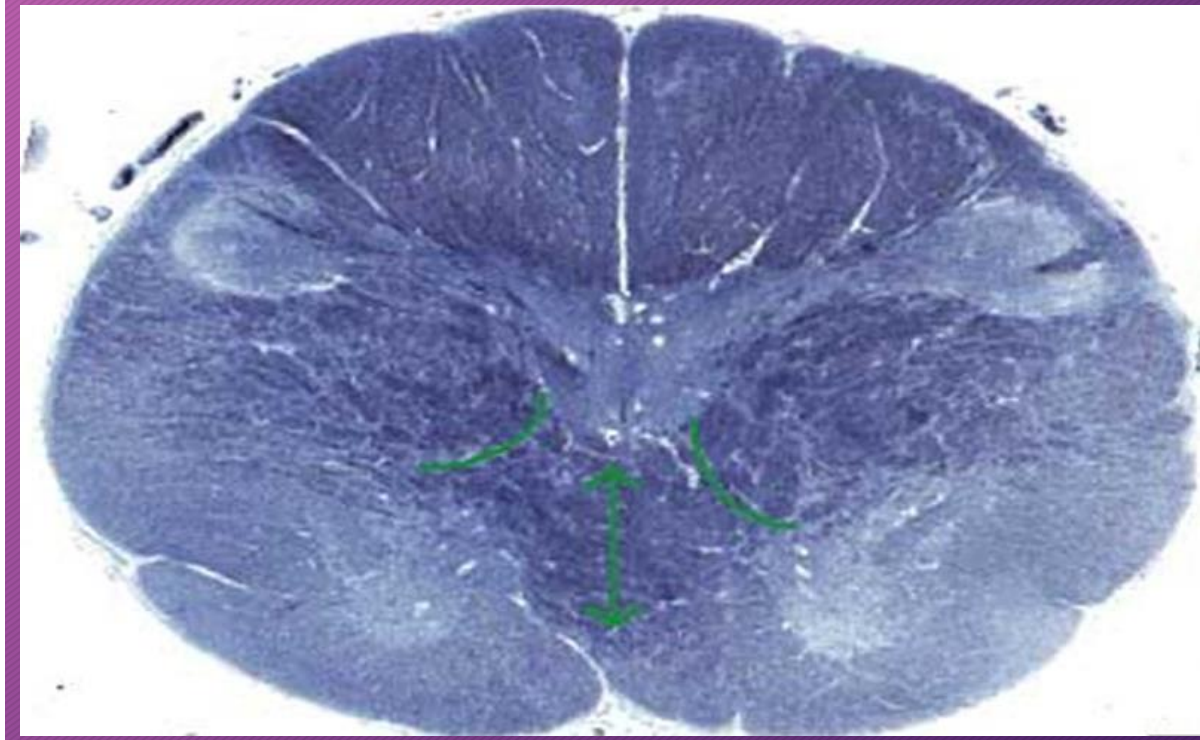
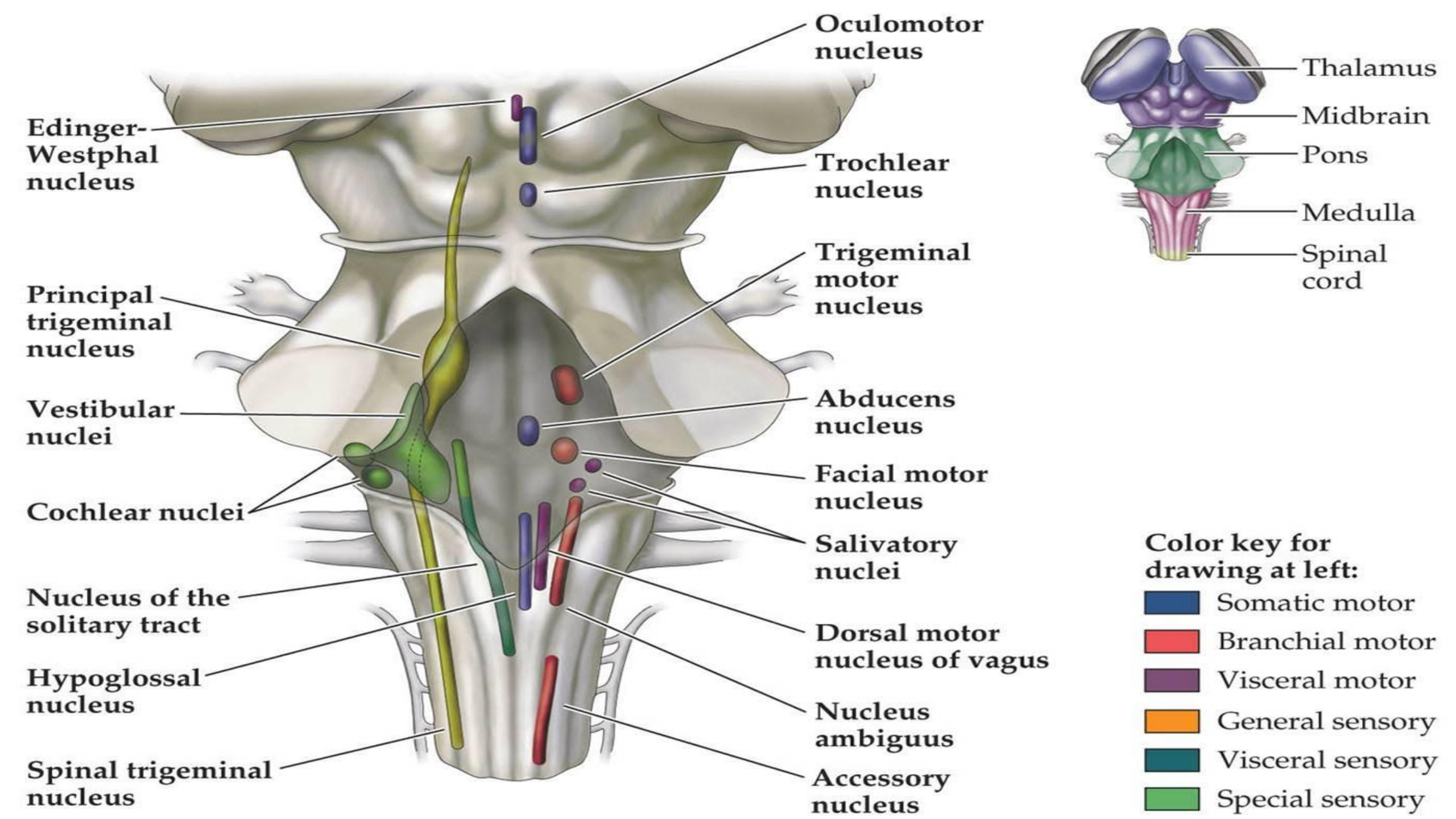
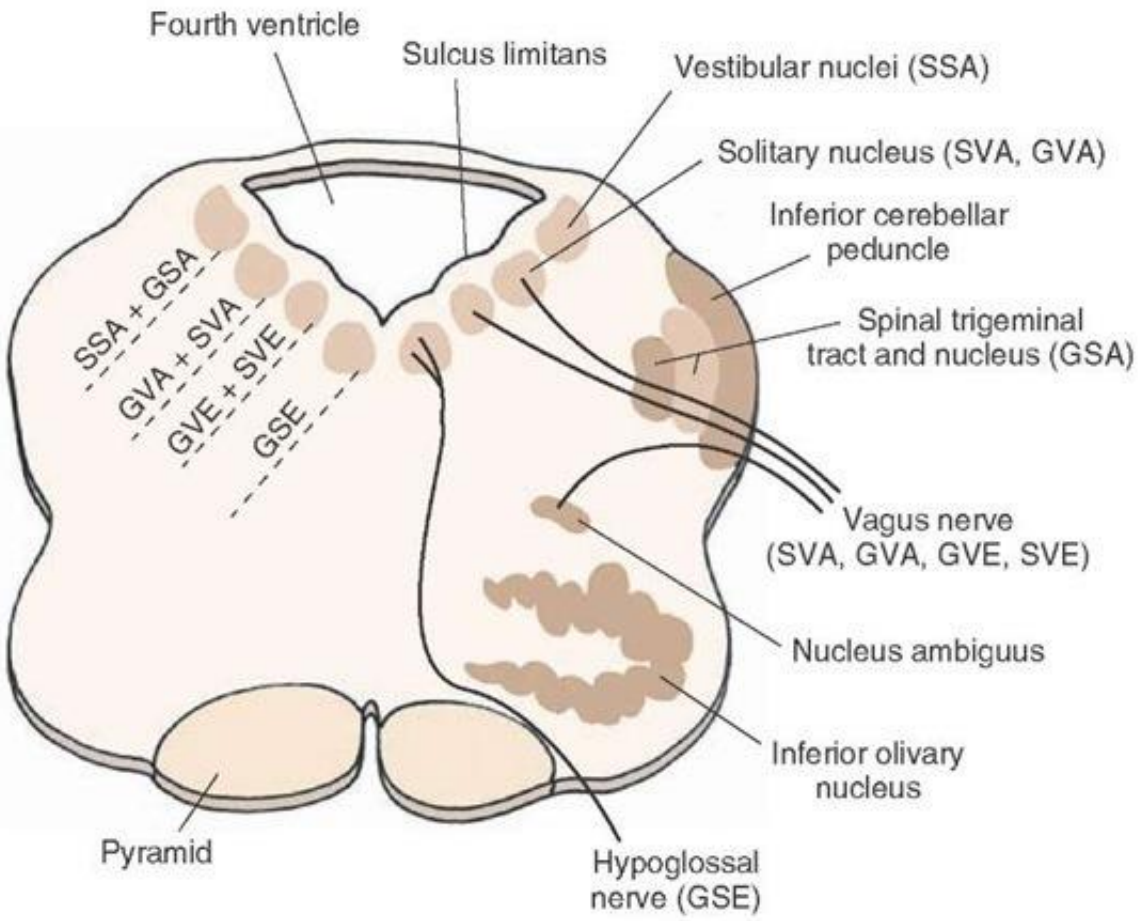
Closed medulla – Level of motor decussation (Lower medulla) 2




Oculomotor nucleus
Edinger-Westphal nucleus
Trochlear nucleus
Trigeminal motor nucleus
Principal trigeminal nucleus
Vestibular nuclei
Abducens nucleus
Cochlear nuclei
Facial motor nucleus
Salivatory nuclei
Nucleus of the solitary tract
Dorsal motor nucleus of vagus
Hypoglossal nucleus
Nucleus ambiguus
Spinal trigeminal nucleus
Accessory nucleus
Thalamus
Midbrain
Pons
Medulla
Spinal cord
Color key for drawing at left:
Somatic motor
Branchial motor
Visceral motor
General sensory
Visceral sensory
Special sensory

Cranial nerve nuclei within the medulla



- GSE – Hypoglossal nucleus
- SVE – Nucleus ambiguous
- GVE – Motor nucleus of X (DVN)
- GVA – Nucleus of the solitary tract
- SVA – Gustatory nucleus
- SSA – Vestibular (medial & inferior)
- GSA – Spinal nucleus of V

Other nuclei within the medulla

- Nucleus gracilis and nucleus cunietus
- Inferior olivary nucleus
- Reticular nuclei (part of reticular formation)

Inferior olivary nucleus

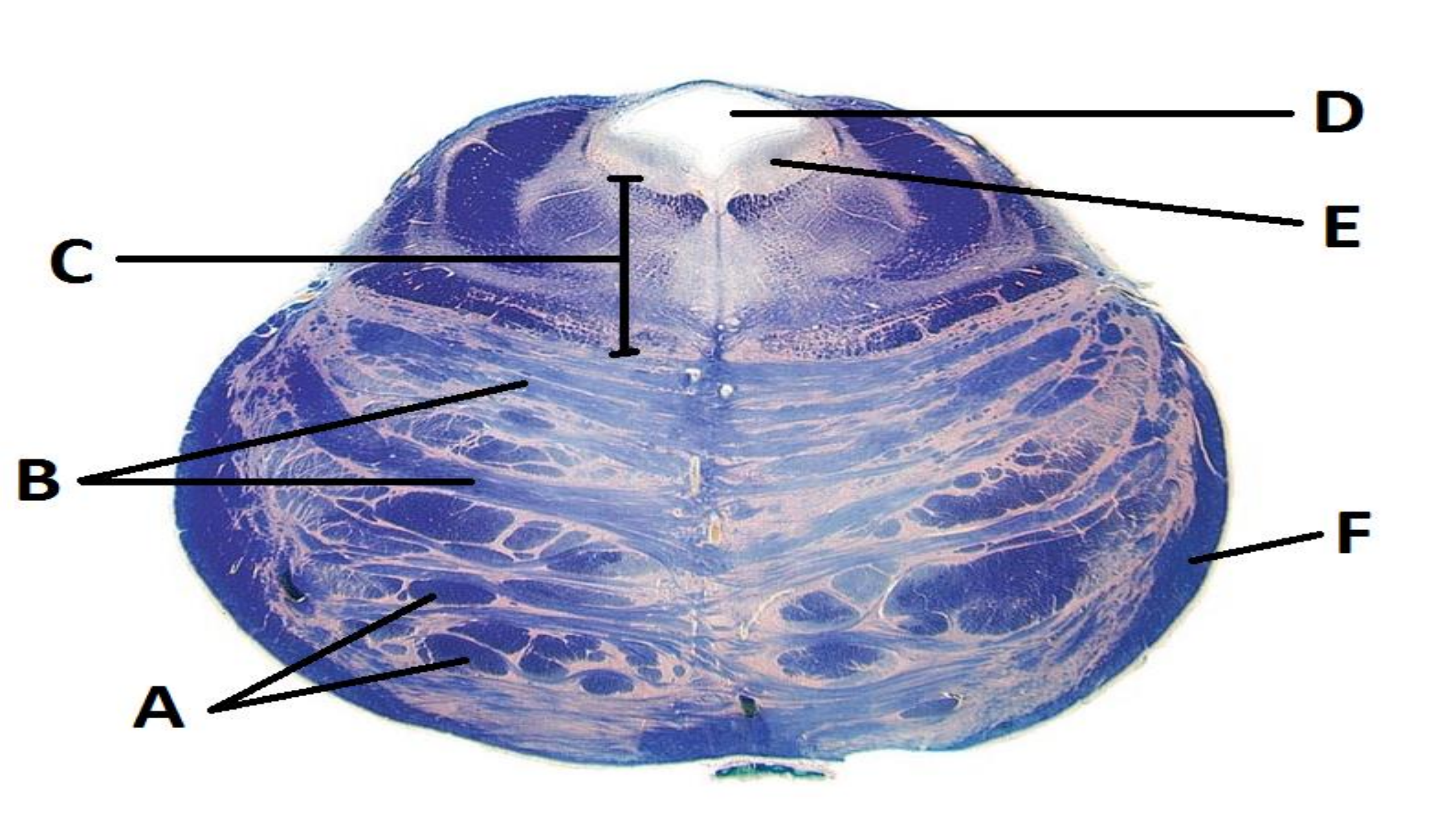
- Olivary nuclear complex - inferior olivary, medial and dorsal accessory
- Part of precerebellar nuclei (others include pontine, vestibular)
- Afferents – both descending and ascending fibers
- Efferents – olivocerebellar via inferior cerebellar peduncle terminate on Purkinje cells as climbing fibres

Review Exercise

For the following images of the central nervous system:

a) State the specific region the slide was obtained from and give reason(s)

b) Name the structures/parts labelled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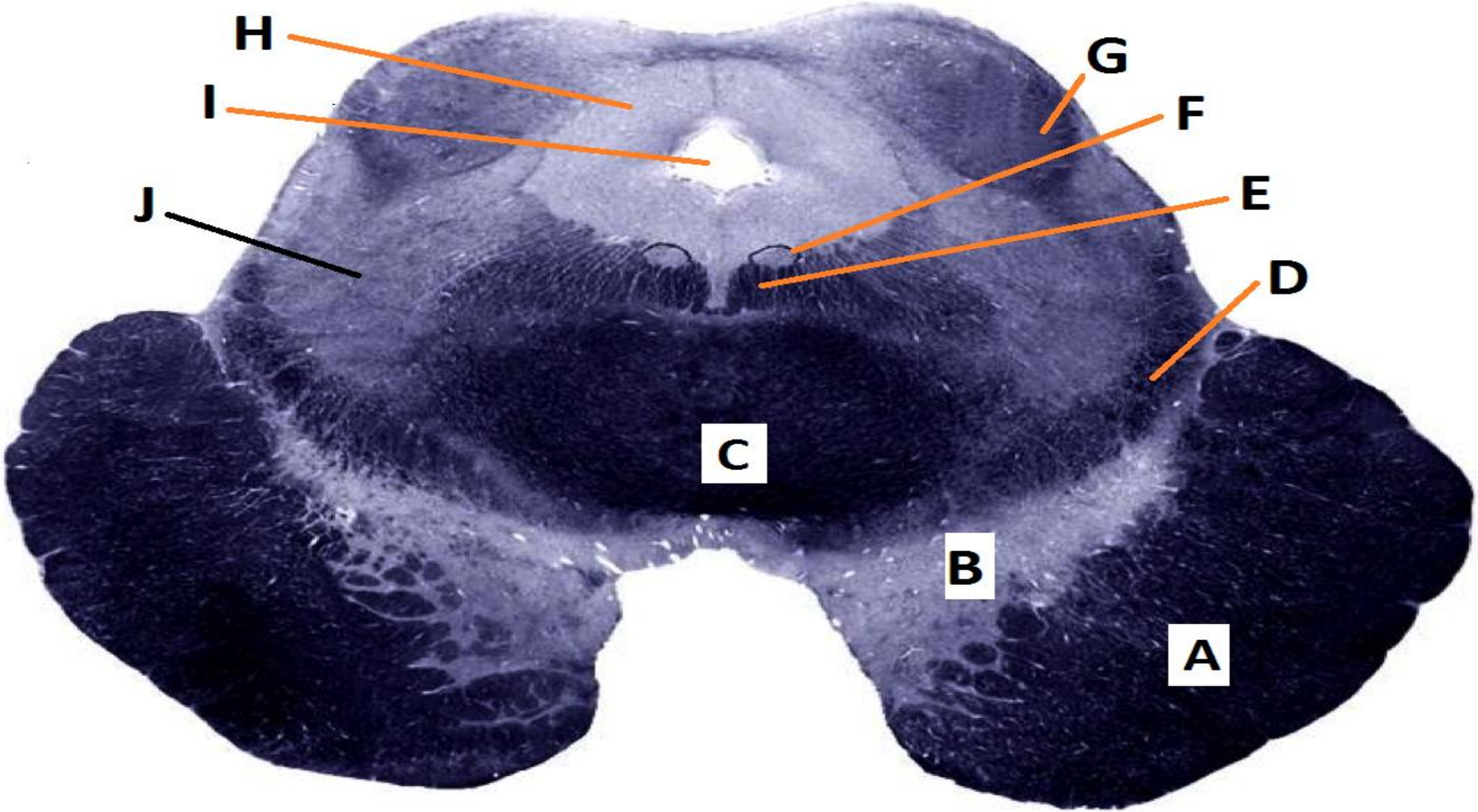
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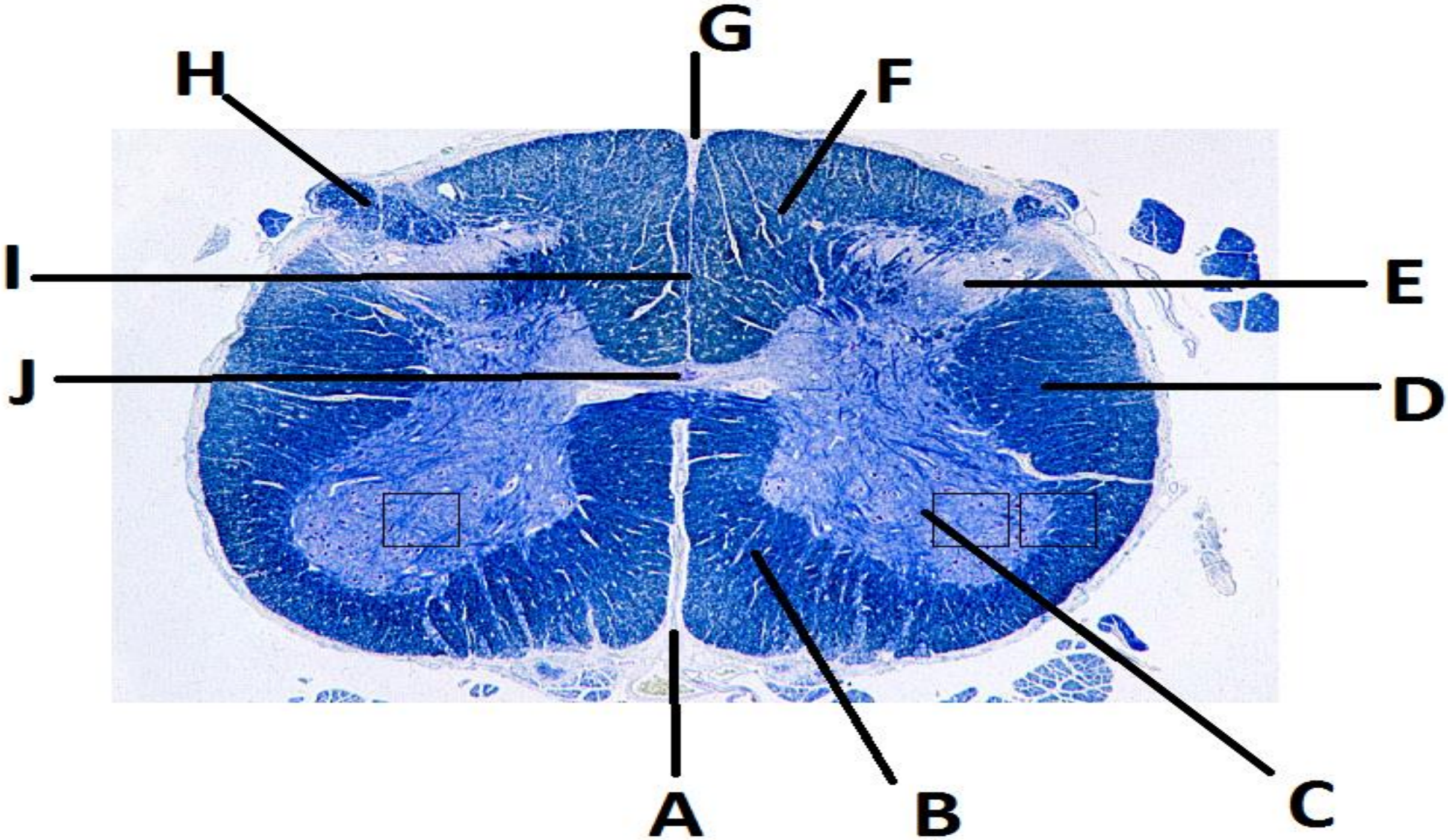
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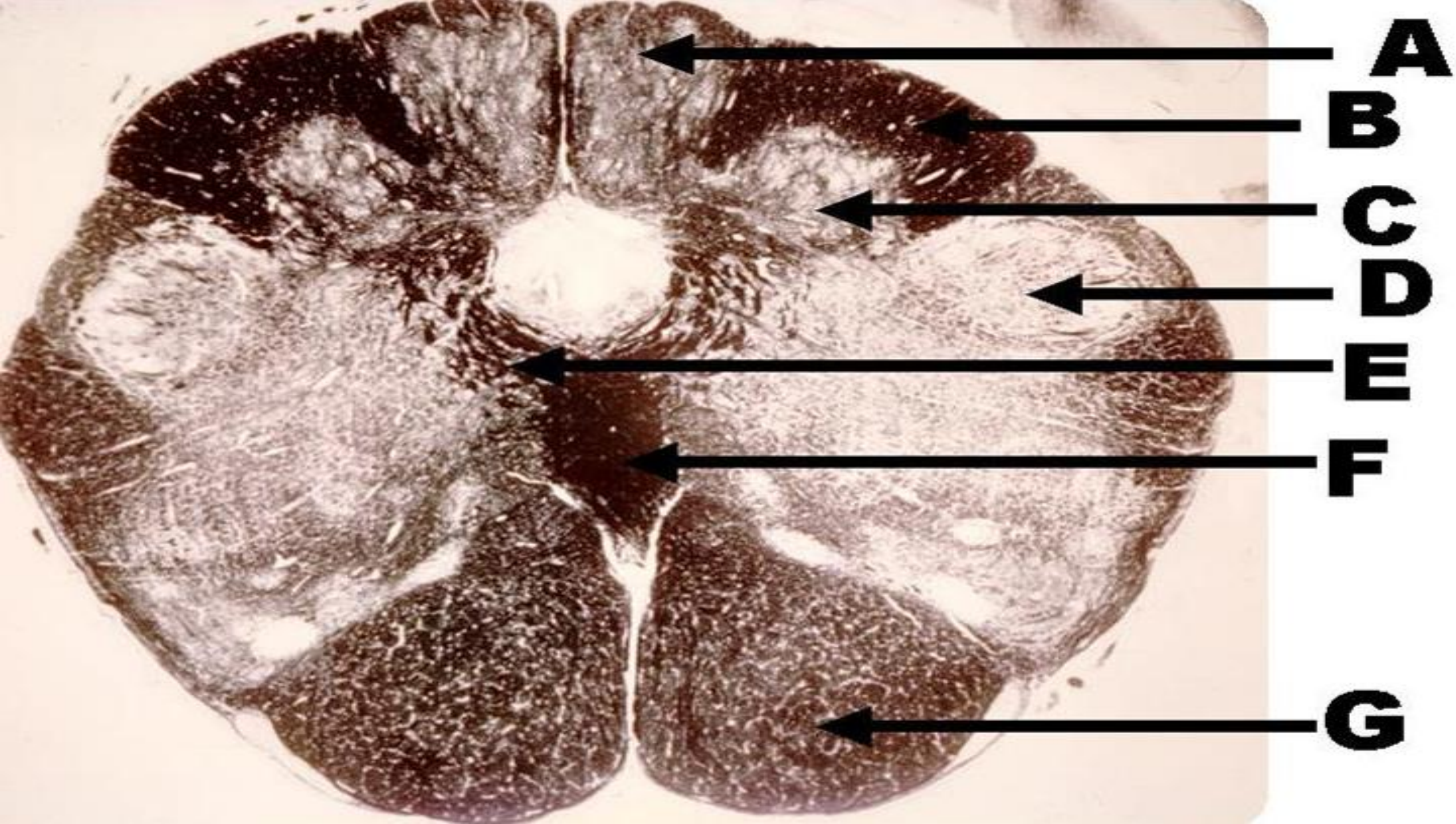
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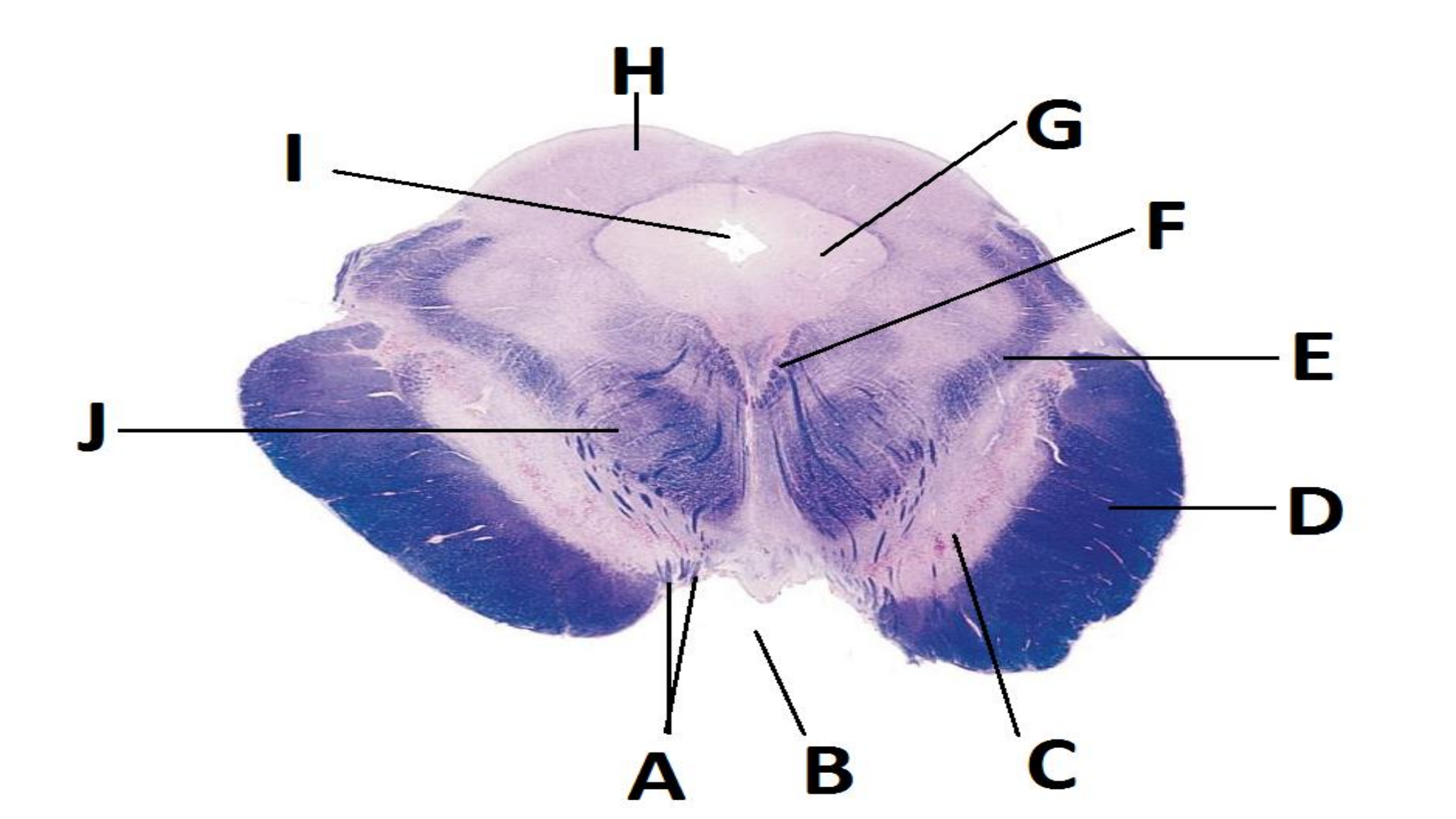
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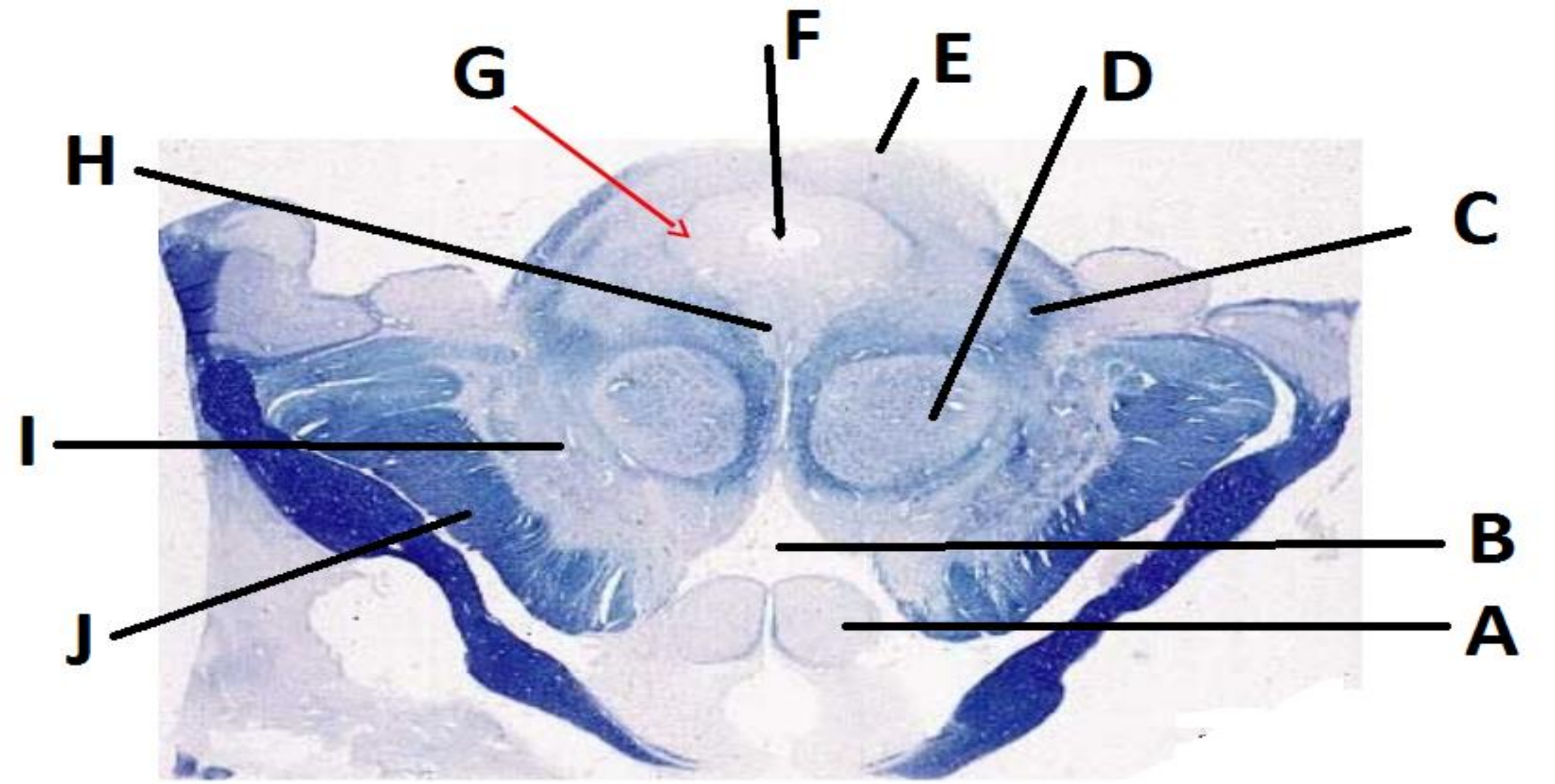
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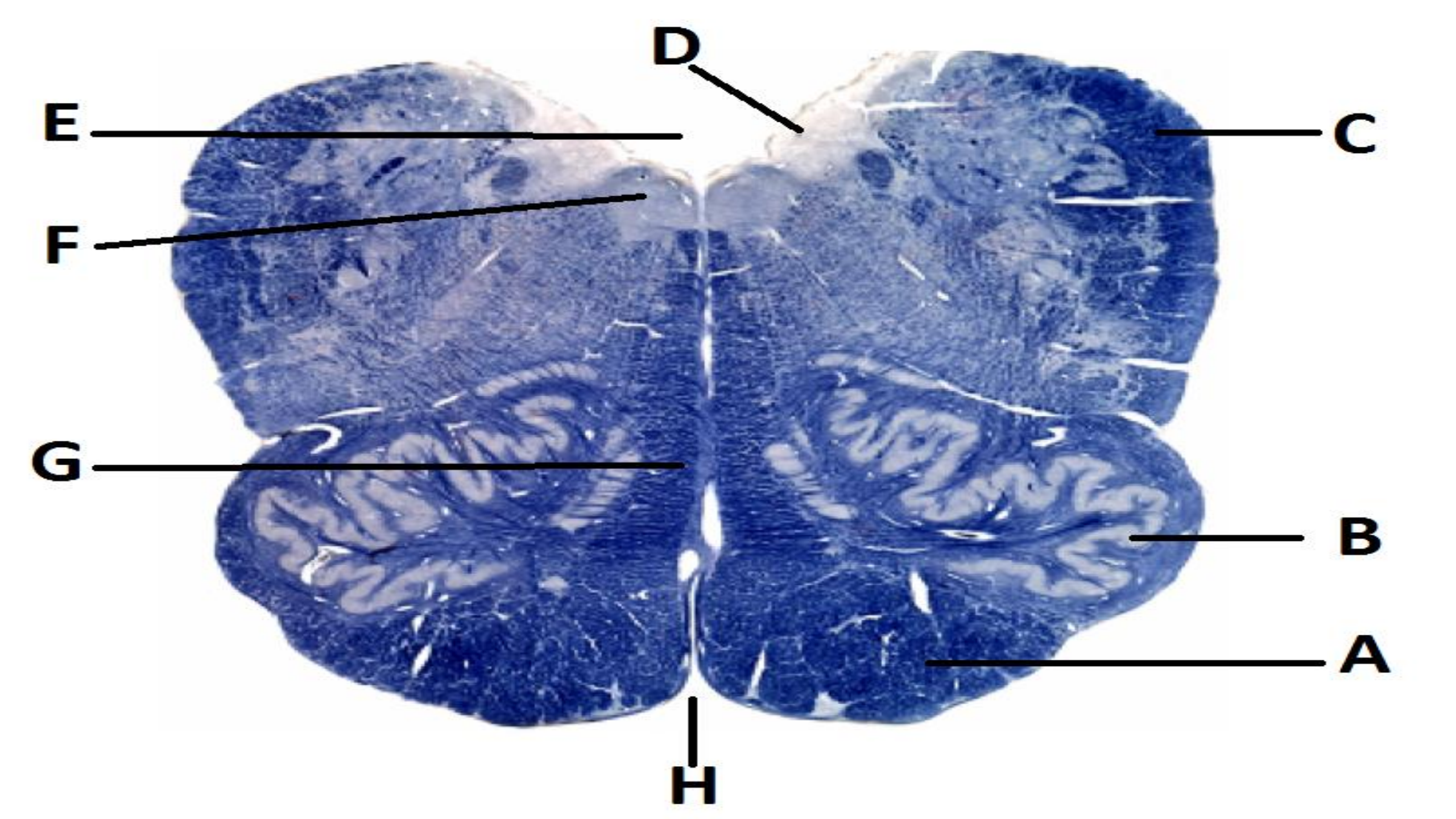
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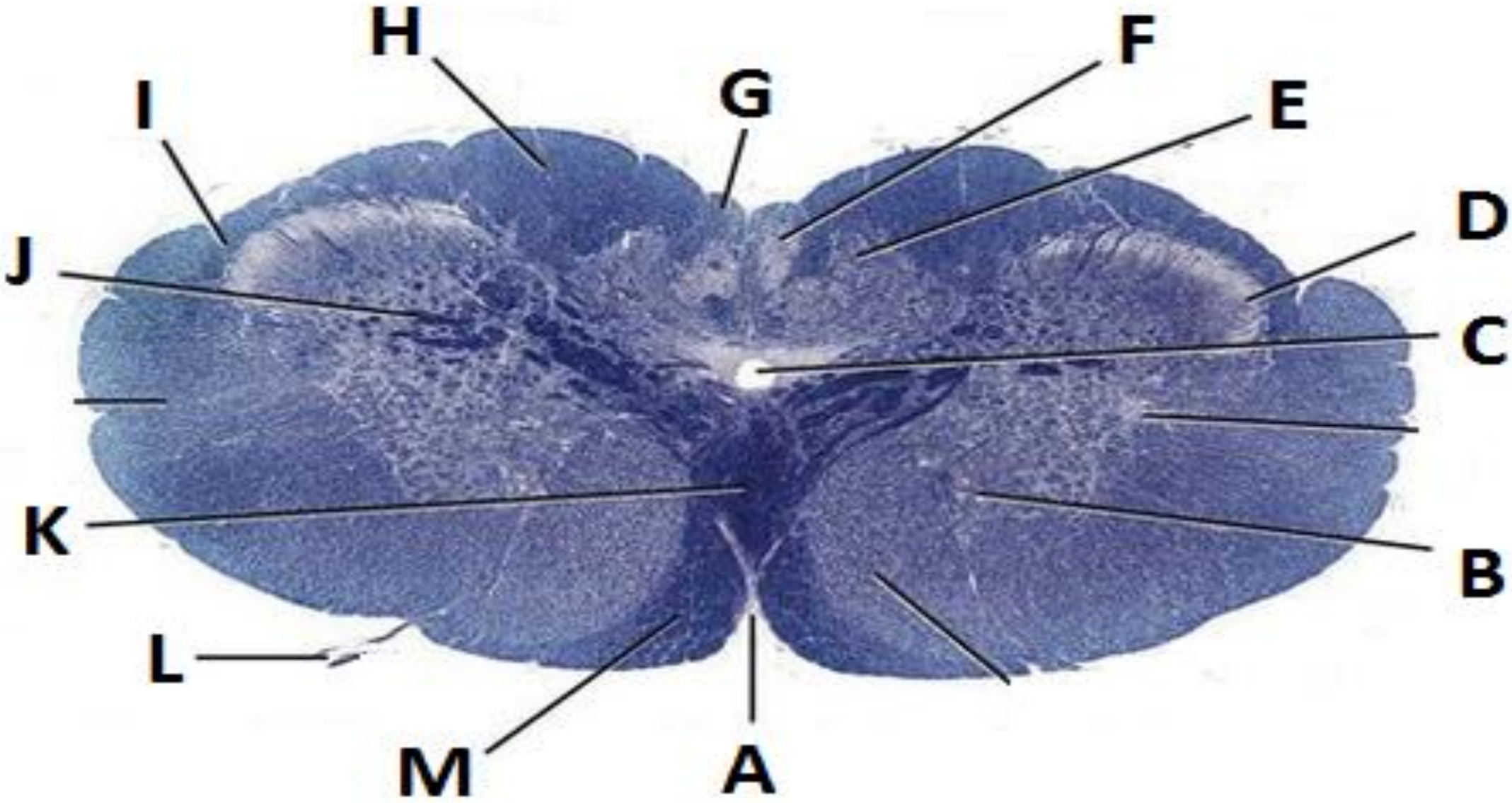
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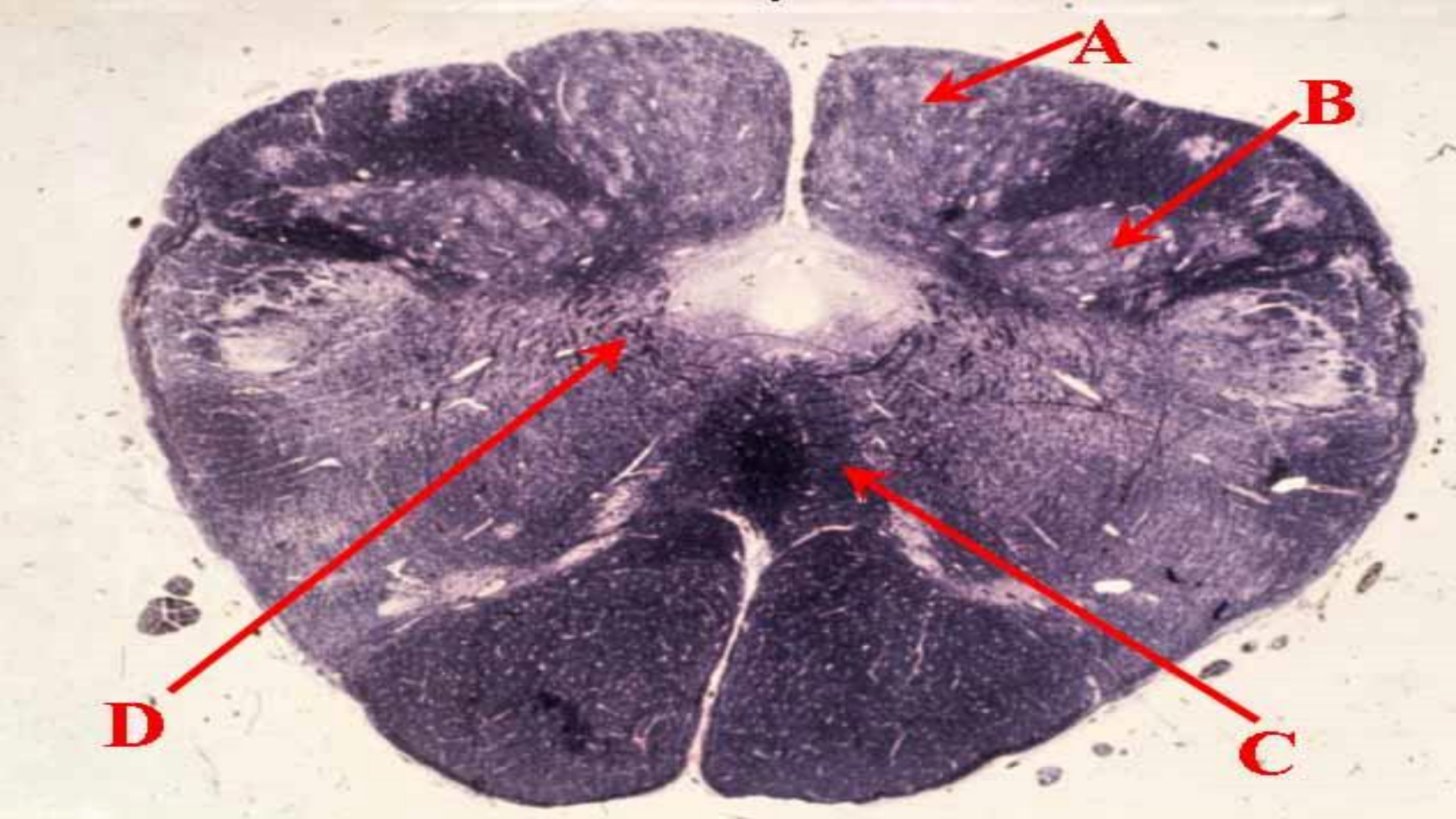
A
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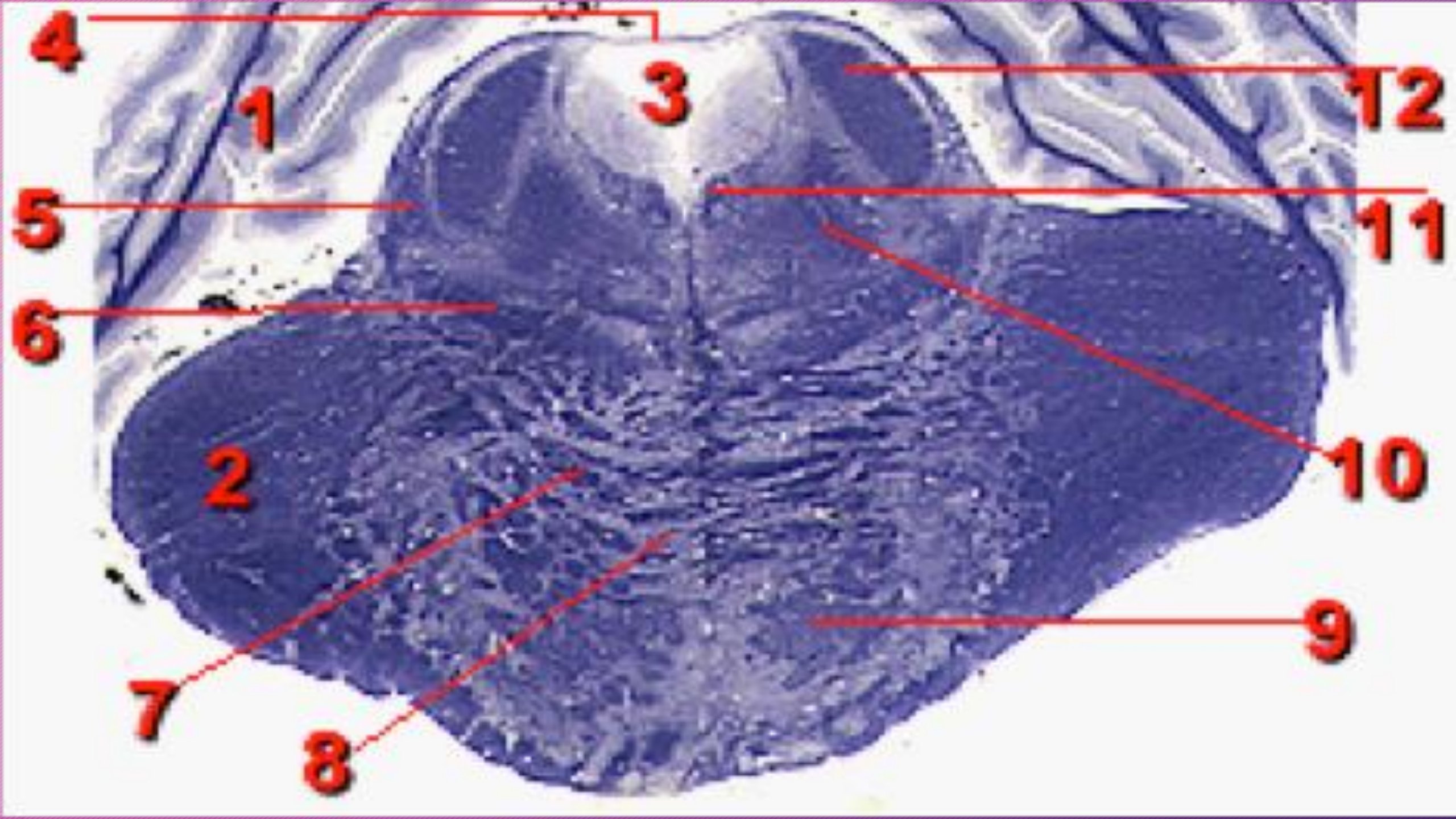
4
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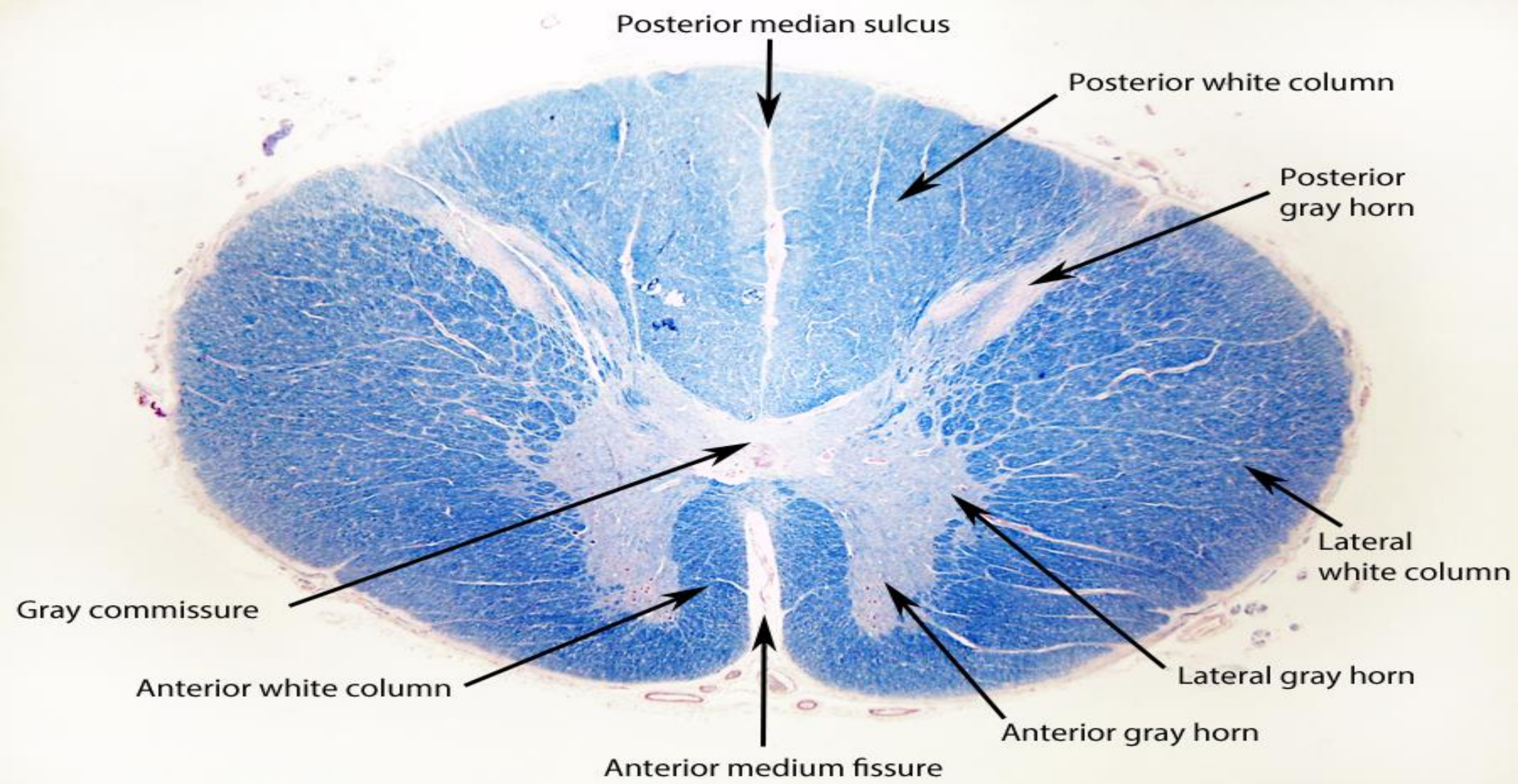
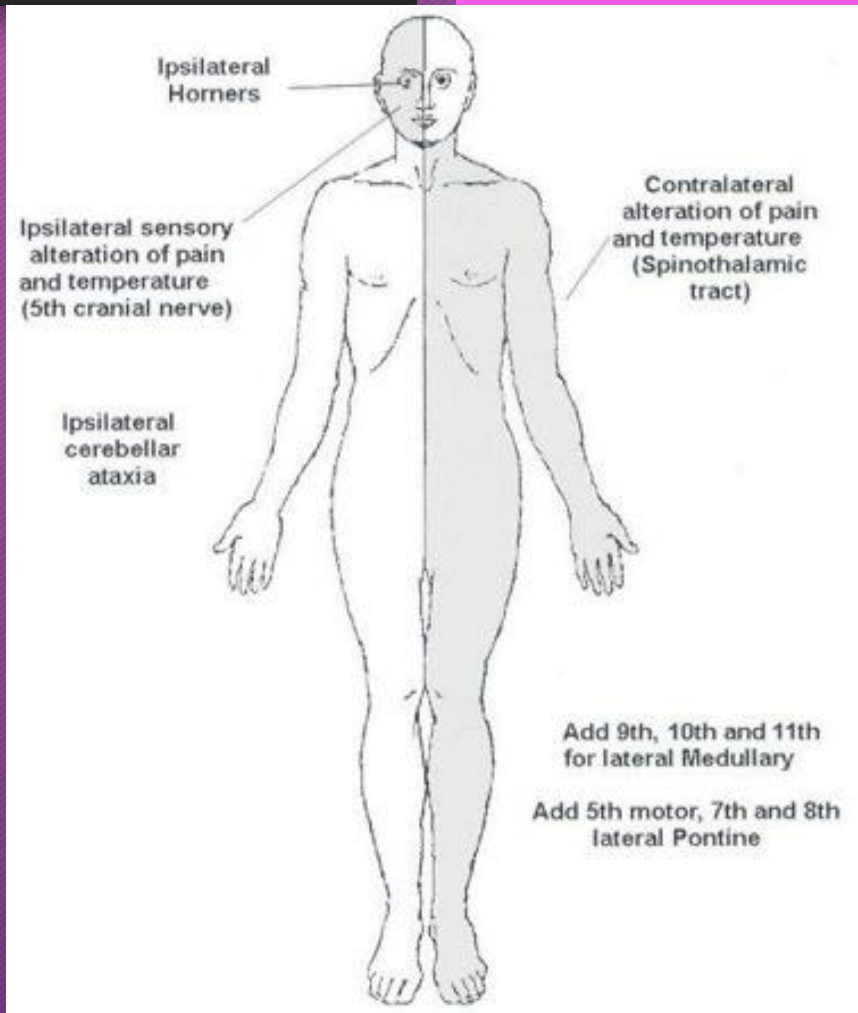
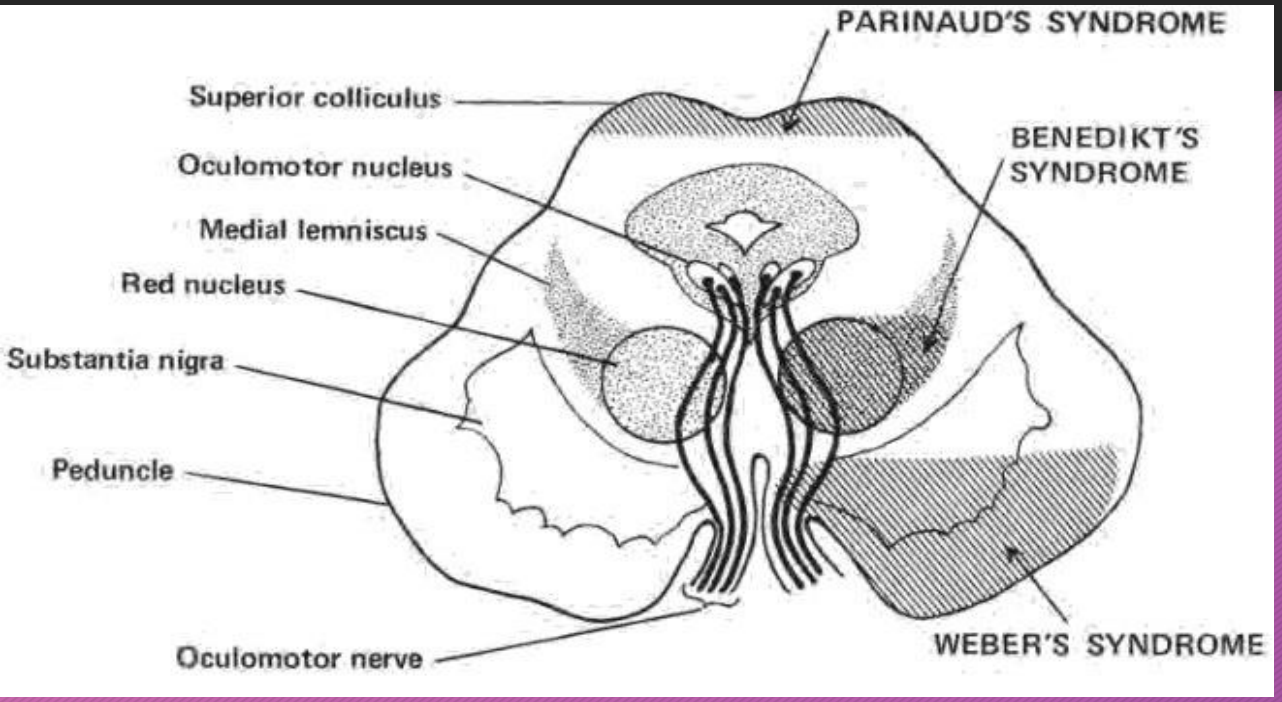

Posterior median sulcus
Posterior white column
Posterior gray horn
Lateral white column
Gray commissure
Anterior white column
Lateral gray horn
Anterior gray horn
Anterior medium fissure

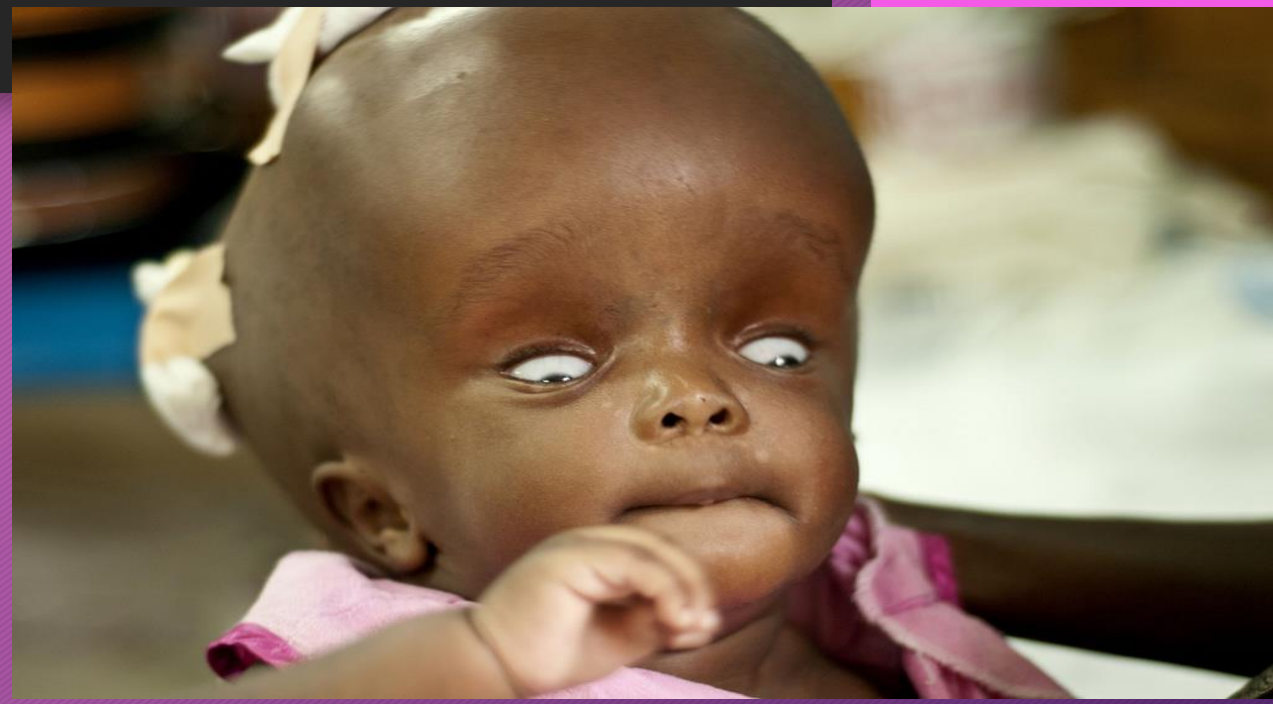
Brainstem stroke syndromes

- Occur secondary to occlusion of small perforating arteries of the posterior circulation
- Characteristic clinical picture according to the involved area
- Ipsilateral cranial nerve palsy at the affected segment
- Contralateral loss of power and sensation in the limbs
- Ipsilateral incoordination of the limbs



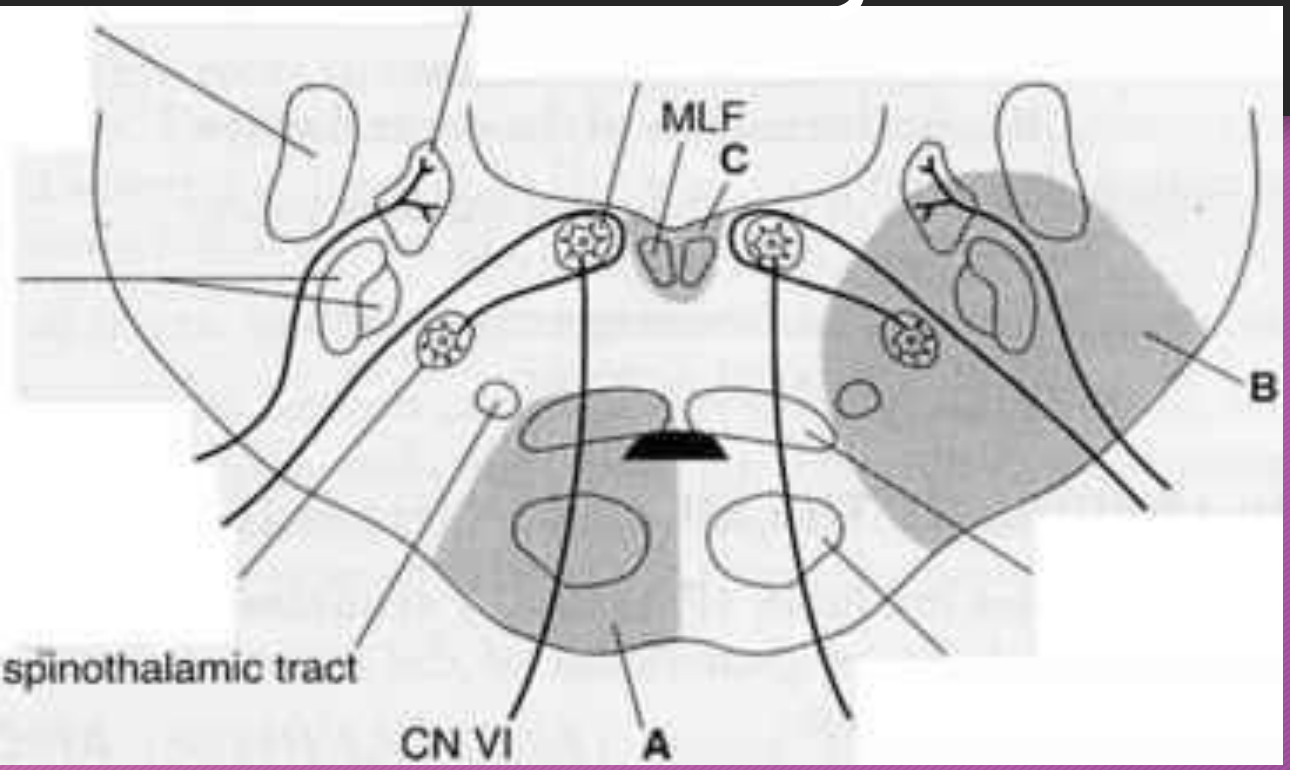
Midbrain syndromes

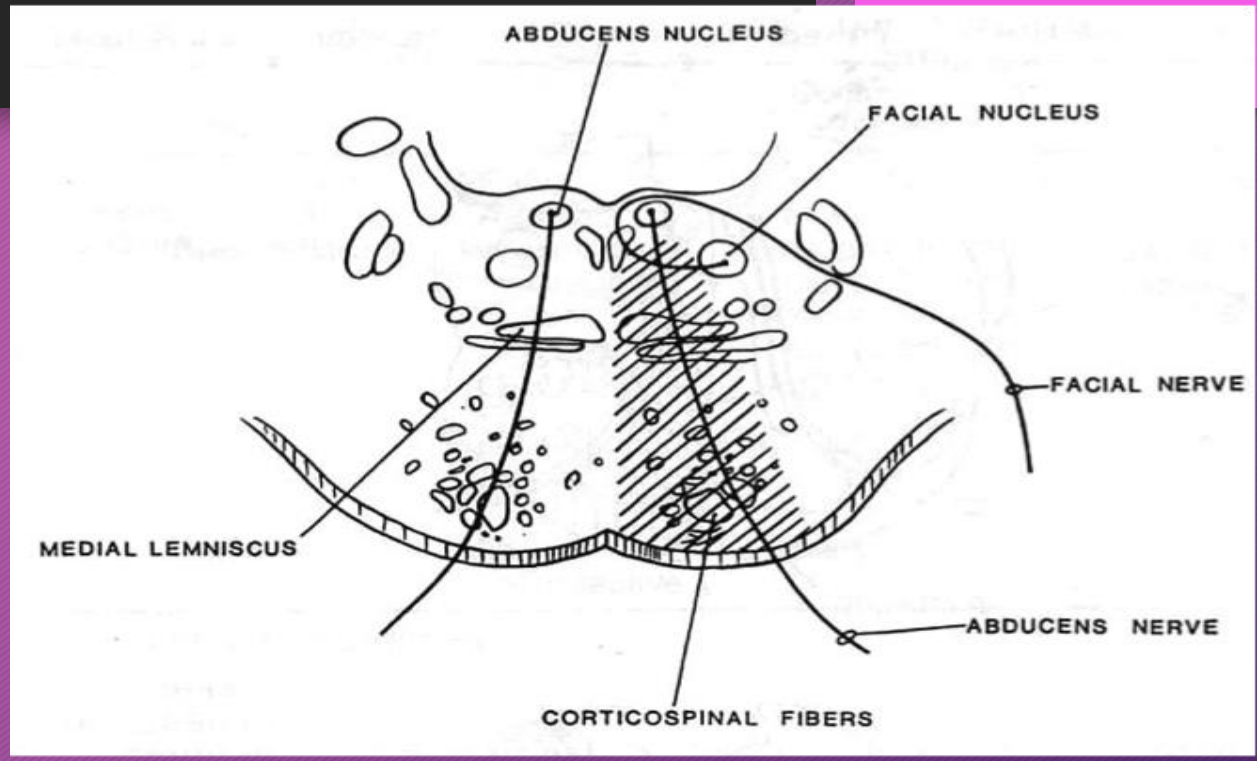




- Weber syndrome (superior alternating hemiplegia) - CN III, corticospinal
- Benedikt syndrome (paramedian midbrain syndrome) - CN III palsy, red nucleus
- Parinaud's Syndrome (dorsal midbrain syndrome, vertical gaze palsy, and Sunset Sign) - the pineal gland compresses the vertical gaze center

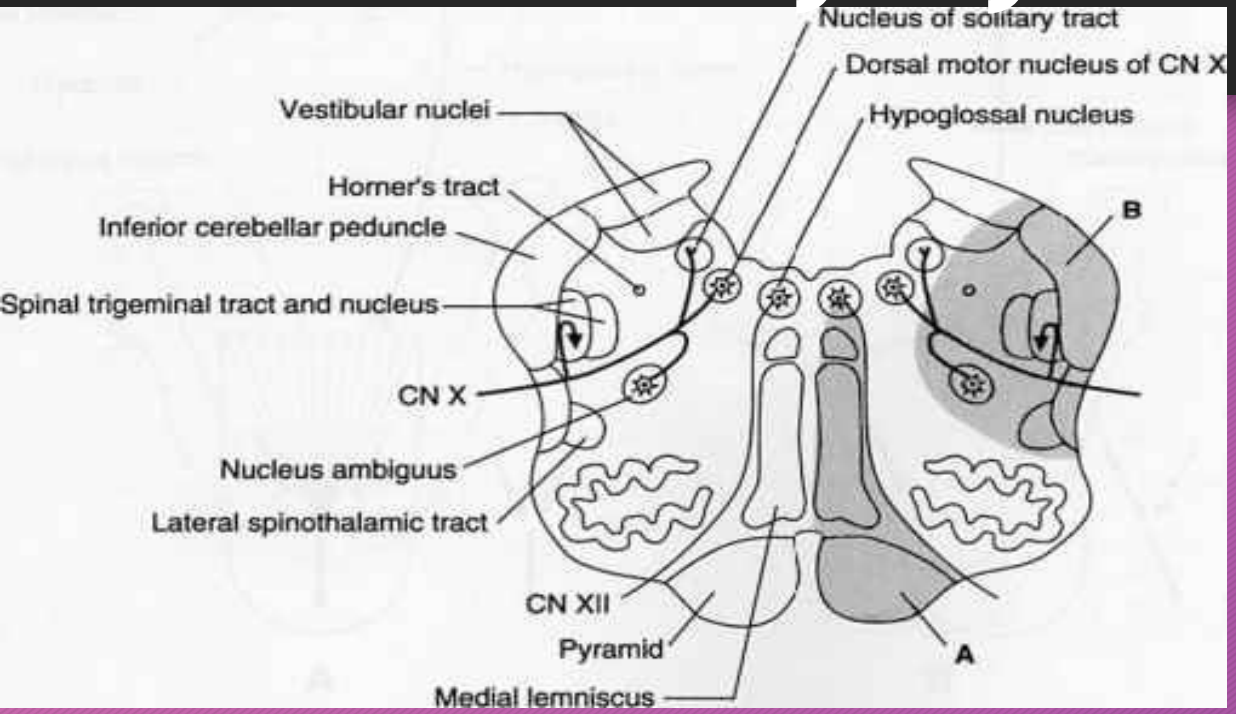
Pontine syndromes





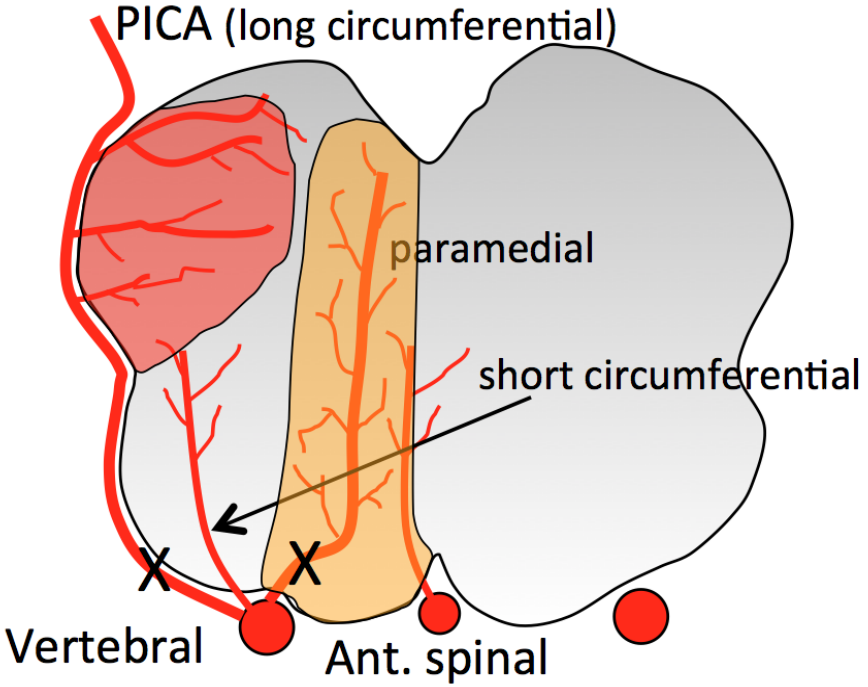
- Lateral pontine syndrome (Marie-Foix syndrome) - perforating branches of the basilar and AICA – corticospinal, spinothalamic tracts, cerebellar tracts, CN VII, CN VIII
- Inferior medial pontine syndrome (Foville syndrome) - paramedian branches of basilar – corticospinal, corticobulbar, medial lemniscus, middle cerebellar peduncle, abducens nerve roots
- Locked in syndrome – basilar thrombosis - ventral brainstem at the level of pons - pyramidal bundles

Medullary syndromes



Lateral medullary syndrome

Medial medullary syndrome

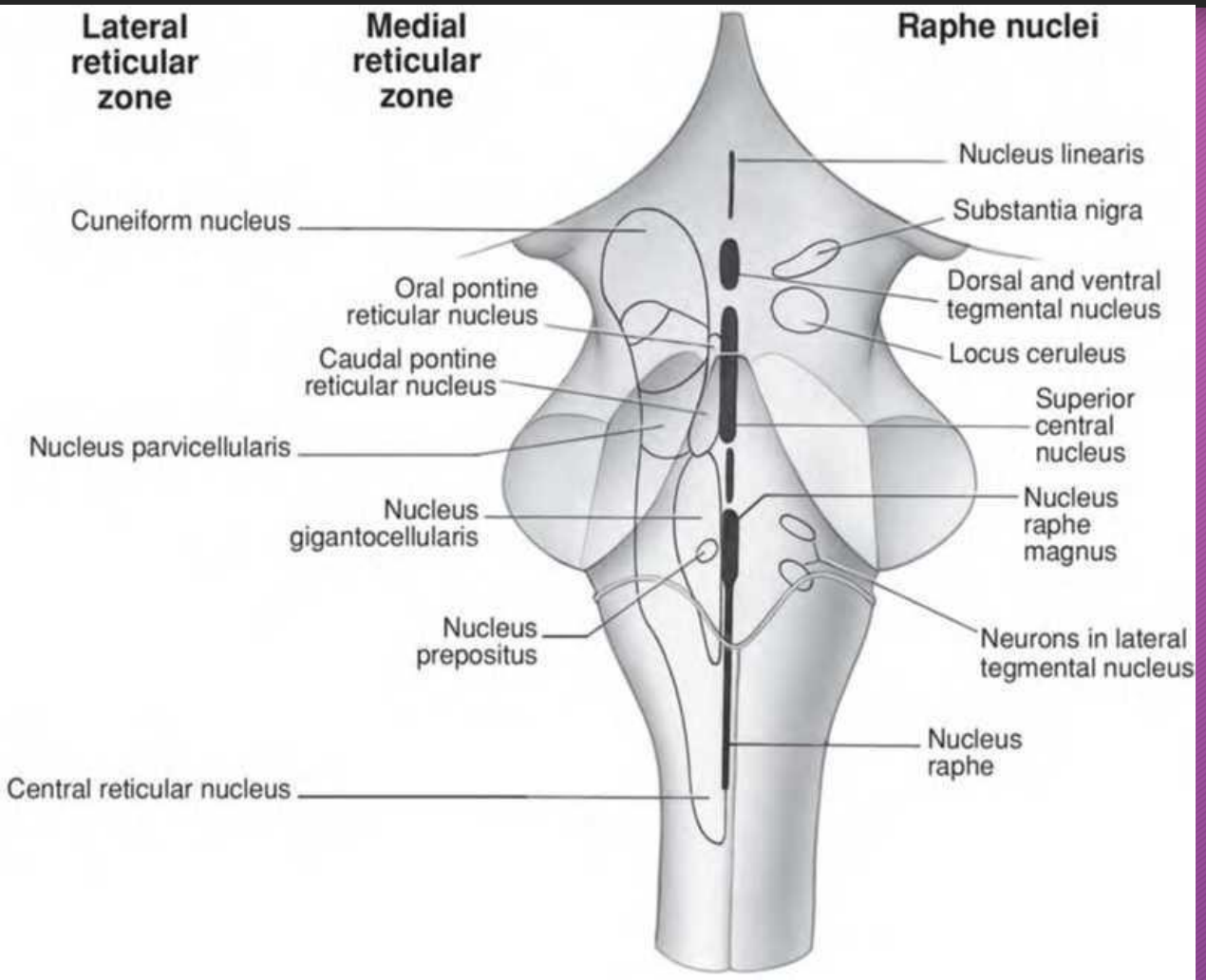


- Lateral medullary syndrome (Wallenberg syndrome) - PICA - Inferior cerebellar peduncle, Vestibular nuclei, Hypothalamospinal, Spinal trigeminal nucleus, Nucleus ambiguus
- Medial medullary syndrome (Dejerine syndrome) – Pyramids, Hypoglossal nucleus,
- Hemimedullary syndrome (Babinski-Nageotte syndrome) - ipsilateral vertebral artery proximal to PICA and anterior spinal artery branches - causes lateral medullary infarct and medial medullary infarct simultaneously

Brainstem Reticular Formation

- Ill-defined collections of neuronal cell bodies (reticular nuclei) with diffuse connections (reticular fibers)
- Continuous core that traverses the whole brain stem
- Phylogenetically ancient
- Have ascending and descending components that are partly crossed and uncrossed
- Divided into three nuclear columns – median, medial & lateral

Brainstem Reticular Formation



- Median column of reticular nuclei (raphe nuclei)

✓Mainly serotoninergic projections

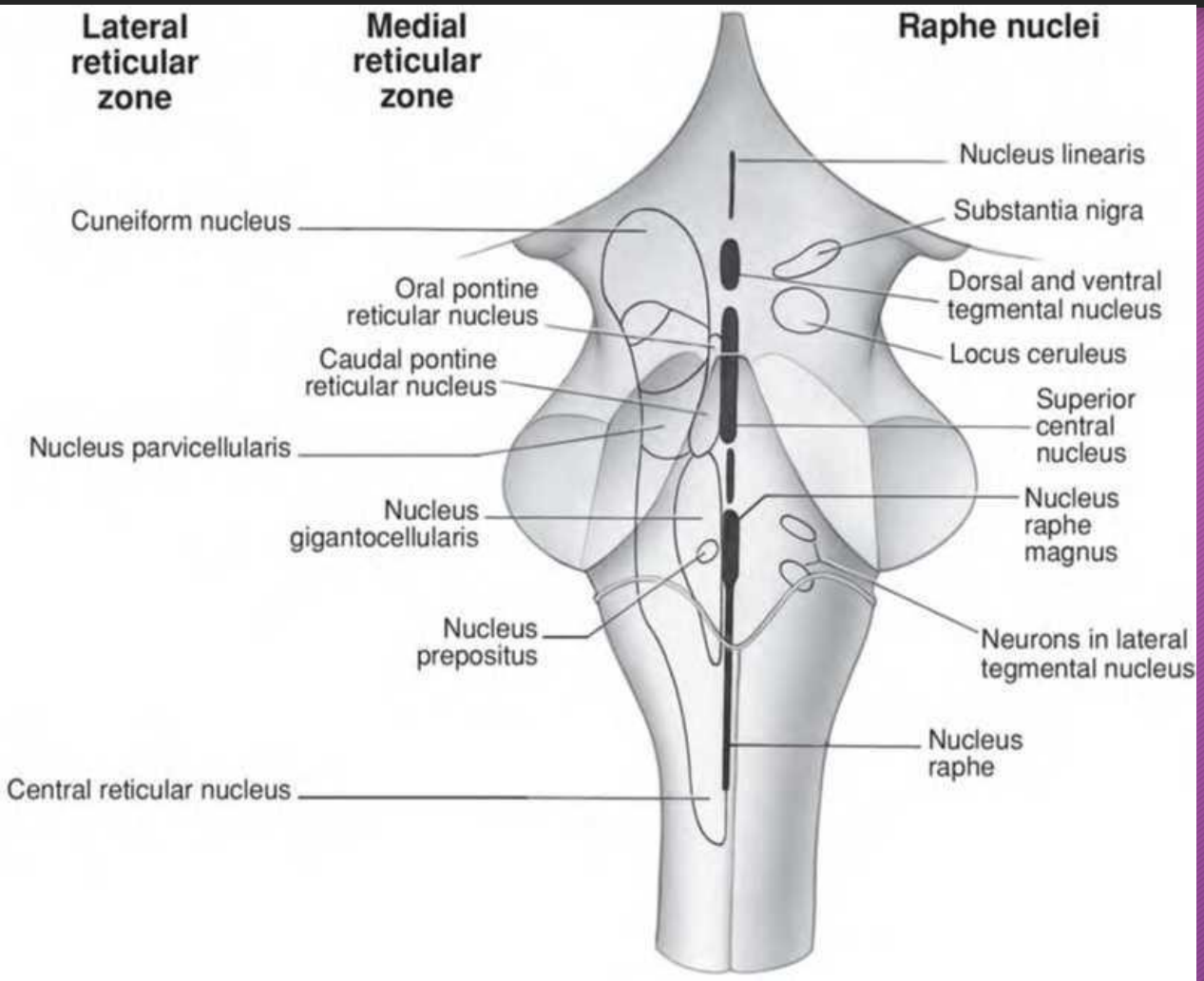
✓Descending analgesic system

✓Control of cardiovascular function

✓Moderate limbic functions

✓Cortical activation and alertness

Brainstem Reticular Formation



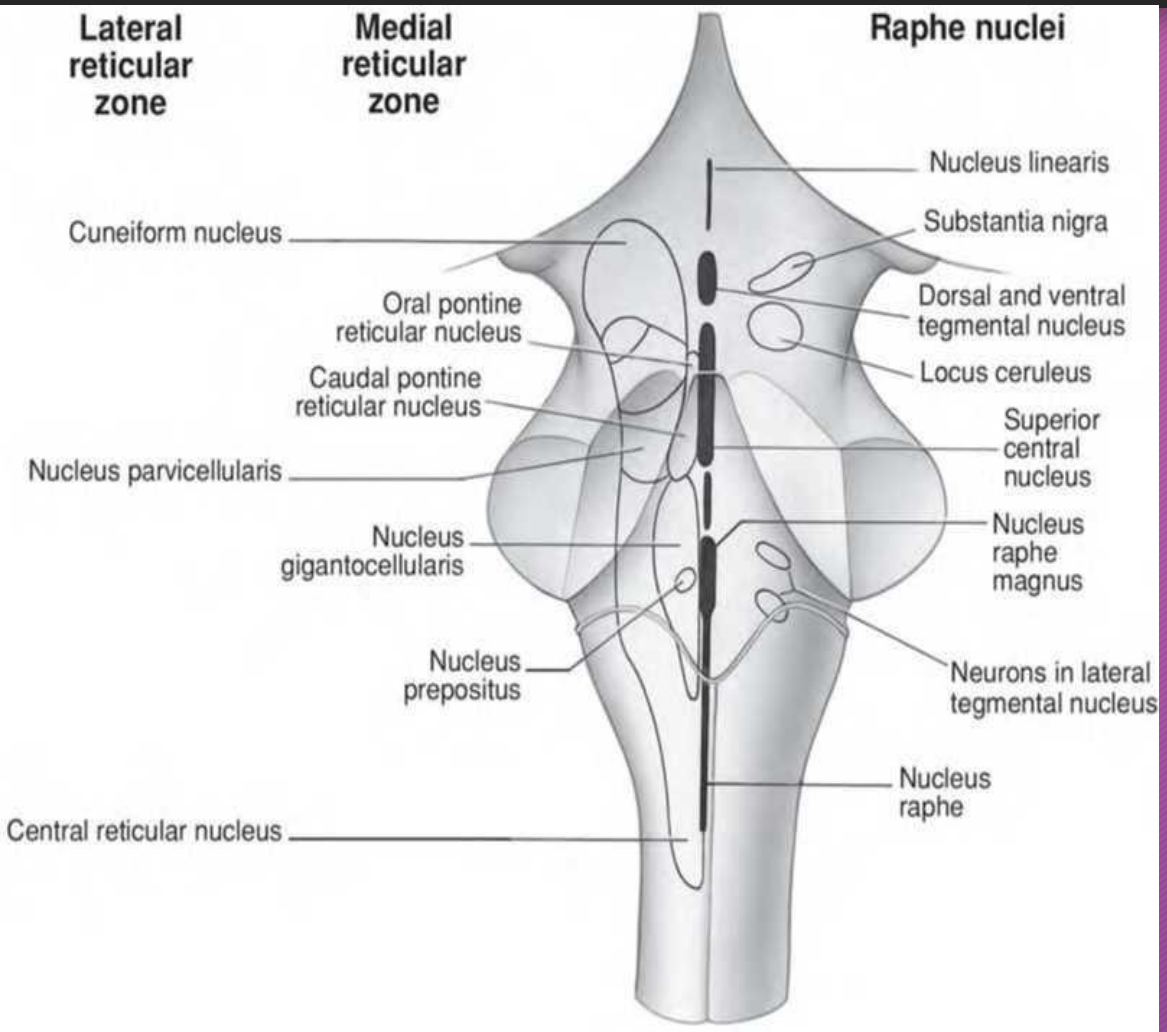
- Medial column of reticular nuclei

✓Give rise to reticulospinal tracts

✓Modulates spinal motor function

✓Modulate segmental nociceptive input

Brainstem Reticular Formation



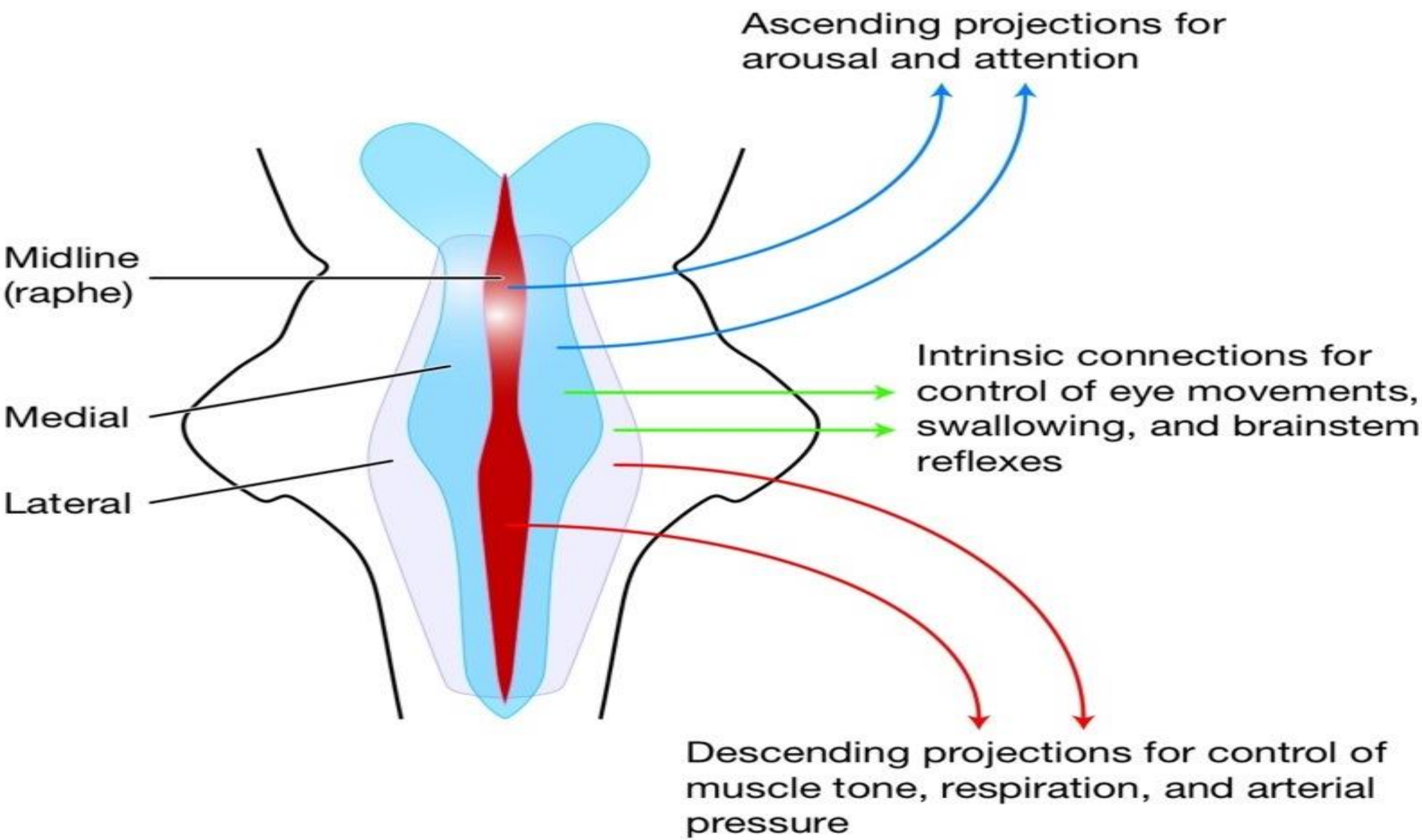
- Lateral column of reticular nuclei

✓Give reticulospinal fibres

✓Visceral alerting responses - cardiovascular, respiratory, baroreceptor & chemoreceptor reflexes

✓Modulation of nociception

✓Micturition centers


Ascending projections for arousal and attention
Midline (raphe)
Medial
Lateral
Intrinsic connections for control of eye movements, swallowing, and brainstem reflexes
Descending projections for control of muscle tone, respiration, and arterial pressure

THANK YOU